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AN ECONOMIC ANALYSIS OF HOSPITAL COSTS IN NEW ZEALAND

A thesis  
submitted in partial fulfilment  
of the requirements for the Degree  
of  
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PHILIP MICHAEL TATCHELL

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University of Waikato

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## ABSTRACT

The main purpose of this study is to apply economic principles and methods to the analysis of New Zealand's hospital services in order to ascertain how the costs of providing those services varies among hospitals and over time. Achievement of this objective at the same time enables an assessment to be made of the relevance of the various theoretical models and empirical techniques that have been employed in recent studies of hospital costs in other countries.

Attention in the initial chapters is devoted to identifying and assessing the quantitative importance of the factors responsible for the rapid and accelerating cost increases associated with the provision of hospital services in recent years. Two main groups of factors are identified - demand and supply-related - and their relative cost impacts are tested first by means of a descriptive historical analysis, and then, following the development of a general behavioural model of hospital cost inflation, by means of econometric techniques.

The results of the estimation process indicate that rising hospital costs are largely due to changes on the supply side, particularly to the rising cost, quantity and quality of the labour and non-labour inputs used by hospitals. Demand variables, particularly changing length of stay and the changing diagnostic mix of patients treated in hospital, are also shown to have had an important, though less substantial impact on hospital cost levels.

The second part of the study is devoted to identifying and examining the factors that give rise to variations in costs among hospitals at a given point in time. Three main groups of factors are identified - patient or output characteristics, institutional characteristics and utilisation levels, and their relative importance in explaining the interhospital cost variations is tested by means of econometric techniques.

The results indicate that variations in the average costs of hospital care are largely explained by the types of patient treated, both by age and diagnosis, by the length of time the patient stayed in hospital, and by the teaching status of the hospital. Considerable attention in this section is also devoted to establishing whether economies of scale exist in New Zealand's hospital industry and to developing and testing a number of alternative measures of hospital output based on similar measures employed in earlier overseas studies.

A number of implications for policy and for further research arise from the findings. On the cost inflation side apart from suggesting possible ways in which to combat and control the rapid rise in hospital costs, considerable emphasis is placed on the need both for more rigorous evaluation of alternative hospital expenditure programmes and for more and better planning of all hospital and health services. Future research, it is argued, should be directed towards assessing the costs and benefits of particular hospital programmes with a view to ensuring the most efficient and effective utilisation of the scarce resources available for hospital care in New Zealand.



On the cost variation side a revised system of allocating finance to Hospital Boards is advocated which would take into account the various differences among hospitals found to be responsible for the wide variations in their average costs. Introduction of such a population-based allocation system would, it is maintained, ensure that the desired objective of an equitable distribution of resources throughout New Zealand is achieved. Further research is required firstly, to develop a simple yet reliable means of accounting for interboard case-mix differences; secondly, to assess more accurately the nature and extent of the impact of teaching on hospital costs; and finally, to ensure that the economies of scale that appear to exist in New Zealand's hospital industry are fully exploited.

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## CHAPTER ONE

### Introduction

The realisation that economic analysis can make a significant contribution towards improving the efficiency of public spending has led in recent years to its application in such diverse fields as transport, defence, natural resources, education and health. The value of economics in these areas lies both in providing a framework and techniques for analysing the use of scarce resources, and in suggesting to policy makers the sort of information best suited to ensuring the efficient operation of public services. The purpose of this study is to apply economic principles and methods to one particular aspect of health care in New Zealand - hospital services - in order to ascertain how the costs of providing those services varies among hospitals and over time.

#### 1.1 Problems and Issues

It has long been realised that a healthy population is an important prerequisite for the economic and social advancement of a country. Disraeli, for example, is quoted as saying that "the health of the people is really the foundation upon which all their happiness and all their powers as a state depends".<sup>1</sup> The achievement and maintenance

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1. Quoted in Kennedy D.P. ed. (1970) p.1.

of good health, however, is an ideal which has given rise to a number of problems in recent years, particularly from an economic point of view. It appears, for example, that there has been a secular trend, in all high income countries, for expenditure on health services to increase as a proportion of national income.<sup>1</sup> Clearly some limit on the continuation of this trend is inevitable in view of the competing claims on resources of other sectors of a country's economy. Restrictions on spending, however, are likely to affect the standard of health care provided, unless compensating improvements are made in the way in which the resources available for health are utilised. Questions about the most effective and efficient use of these resources are being asked more and more frequently, and governments are seeking to ensure the best use of resources by improving longer term planning and budgeting and by encouraging operational research and management studies of health care systems.

Since the greater part of most countries' expenditure on health services is devoted to the provision of hospital care, and since, moreover, hospital costs have been rising more rapidly than other health costs, it is not surprising to find that the main focus of current interest and concern has been on hospital services. In America, for example, the hospital component of the consumer price index (CPI)

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1. Abel-Smith (1967) and more recently Maxwell (1975) have both shown that health expenditures have been rising at a faster rate than GNP in many advanced economies: "typically, a country that had spent 3½ per cent of its national product on health in 1950 was spending 6 per cent of a much larger GNP in 1969" (Maxwell 1975 p.18).

rose at an annual rate of 12.6 per cent between 1965 and 1970 compared with increases of 4.2 per cent in the CPI "All Items" and 6.0 per cent in the medical care component of the index over the same period (Andersen and May 1972 p.65).<sup>1</sup> There is also concern at the increasing proportion of total health expenditure that is devoted to hospitals at the expense of other health services such as primary care, which raises questions as to the relative importance of institutional as against community health care.

New Zealand's experience in recent years reflects these international trends. In the latest year, 1969, for which total (both public and private) health expenditure data are available, current expenditure on all health services totalled \$228 million, which represents 6.7 per cent of national income in that year. This compares with a total expenditure of \$118 million, or 5.8 per cent of National income in 1961. Over the same period expenditure on hospital services increased by 105 per cent from \$61 million to \$125 million, and the proportion of health expenditure devoted to hospital care increased from 51.8 per cent to 54.9 per cent (Ward and Tatchell 1972).

## 1.2 The New Zealand Health Care System

New Zealand's health care system is largely a reflection of her mixed economy, as it encompasses services that are provided by a combination of government, private and

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1. There is evidence of similar trends in a number of other countries in recent years. See Chester, 1972.

voluntary agencies. Currently New Zealand's population of a little over 3 million is served by 196 public hospitals (containing 18,717 beds), 154 private hospitals (4,264 beds) and 15 psychiatric hospitals (9474 beds).<sup>1</sup> The public hospitals are administered by 29 hospital boards whose members are elected locally, but whose finances are provided almost entirely by the Department of Health by means of annual financial allocations to cover maintenance expenditure. The boards' capital expenditures are met from public loans raised through the Local Authorities Loans Board, and guaranteed by the government which also meets the cost of the interest and amortisation on the loans as part of the maintenance grants.

Psychiatric hospitals are also financed entirely by the state, and their administration, following a transition period of five years, is shortly to be transferred from the Department of Health to the hospital boards (in 1977). The private hospitals meet their current running expenses from patient fees, some of which are covered by private insurance schemes, and government subsidies paid on a patient day basis and varying according to the type of patient treated e.g. surgical, medical, geriatric, maternity or psychiatric. Loans for development or expansion of private hospitals are available from the Housing Corporation on the recommendation of the Minister of Health.

With minor exceptions<sup>2</sup> patients are not required to pay

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1. Figures quoted are for the year ended 31 March 1974 - see Hospital Management Data, Department of Health, Wellington, (1974).
  2. These include visitors to New Zealand from outside the Commonwealth who require hospital treatment, and until recently patients admitted to hospital under the terms of the Workers Compensation Act 1956 and the third party provisions of the Transport Act 1962.



fees at the public hospitals so that unless the patient chooses to go to a private hospital, hospital care in New Zealand is provided free of charge to the consumer at the point of consumption. Of course, those patients who are taxpayers contribute indirectly to the cost of hospital care through their taxation payments into the Consolidated Revenue Account from which the financial allocations to hospital boards are drawn.

The remainder of New Zealand's health services are provided by various private agencies - general practitioners, specialists, dentists, and so on, and a number of voluntary organisations. General practitioners and specialists derive their income partly from the patient in the form of a fee-for-service, and partly from the government in the form of benefits for 'General Medical' and 'Specialist' services; these benefits vary in amount according to the type and length of service given to each patient and their age.

Dental services are provided free to all children 16 years of age and under, initially by means of the school dental service, and in adolescent years by means of dental benefit payments to private dentists. Dental treatment for persons over 16 years of age is paid for entirely by the patient. Finally, some health and welfare services are provided by a number of voluntary organisations, many of which receive grants from public funds in addition to other income derived from donations, bequests, and so on.

In view of the considerable role played by government in the financing and provision of Health Services in New Zealand, some measure of control over this expenditure can

be expected. Since the introduction of the Social Security Act, in 1939, which sought to provide for a free Health Service, government pressure for economies and for efficiency in the provision of health services has been evident, particularly in recent years. Escalation of hospital costs was a feature of the years following the removal, in 1957, of the requirement that Hospital Boards should finance part of their costs locally. These persistent cost increases led, in 1967, to the imposition by government of much tighter controls on the maintenance expenditure of hospital boards than had previously been imposed. Hospital boards, since then, have been required to work strictly within allocations approved by the government, rather than, as previously, to receive grants based on each boards own estimates of expenditure.

The growing awareness of the need for research and planning as a basis for ensuring a more efficient utilisation of the resources available for health care has led to the establishment of Health Department research units such as the Management Services Research Unit in Wellington (1973) and the Health Planning and Research Unit in Christchurch (1975), as well as to the formation of numerous consultative committees and government advisory groups. The Labour government's White Paper on health introduced in 1974 and intended as a blueprint for a substantial reorganisation of New Zealand's health services, is also indicative of the widespread concern about the future development of health services in this country along more rational and coordinated lines than has hitherto been the

case.<sup>1</sup> Although the White Paper has been shelved since the change of government in 1975, the impetus for change that it created, and the work of the many consultative groups set up to consider submissions on its proposals, is now being channelled into the recently established "Special Advisory Committee on Health Services Organisation", which is to enquire into and make recommendations to government on health care in New Zealand.

### 1.3 Objectives and Organisation of the Study

Since a comprehensive economic analysis of hospital costs requires consideration of their behaviour both over time and cross-sectionally, the objectives of this study are twofold:

1. to identify and assess the quantitative importance of the factors responsible for the rapid and accelerating cost increases associated with the provision of hospital services in recent years, and
2. to identify and examine the factors that give rise to variations in costs among hospitals at a given point in time.

Achievement of these objectives will at the same time enable us to study two further questions, namely the relevance of the various hospital cost theories and techniques of analysing hospital costs to the New Zealand situation, and, the implications of the results obtained for policy considerations.

There are several factors which make the New Zealand hospital system an ideal testing ground for the various

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1. White Paper "A Health Service for New Zealand" Wellington, (1974).

hospital cost theories and techniques of analysis. In the first place, since the analysis is confined to New Zealand's public hospitals, problems associated with a diversity of ownership and policy do not arise. Nor are there problems of geographical factor-price differences as have arisen, for example, in a number of studies of hospital costs in America, for hospital wages are on a uniform basis throughout New Zealand, and the cost of hospital supplies are similar from region to region. In addition, the period chosen for the intertemporal analysis of hospital costs, 1962 to 1971, was a stable period politically, there being no change of government, and no significant alteration in policy towards the administration and financing of New Zealand's hospitals.

Policy implications of the study arise from both its cost inflation and cost variation aspects. Knowledge of the causes of rising hospital costs, for example, may lead to the selection of more effective policy measures for combating cost increases. Likewise, awareness of the reasons for interhospital cost variations may be helpful in suggesting ways in which the system of allocating finance to hospital boards can be improved. In general, expansion of the theoretical and empirical knowledge of hospital behaviour, costs and production should permit and encourage more informed and better decision making in New Zealand's hospital industry.

The organisation of the remainder of this study reflects closely the twofold objectives outlined above, as it falls into two distinct sections each of which comprises four chapters. Part 1, which is devoted to the intertemporal

analysis of hospital costs, is itself divided into the descriptive and econometric approaches to the subject. Thus, while Chapter Two presents a review of those studies of hospital cost inflation which have sought to identify the factors contributing to rising hospital costs, Chapter Four reviews those studies which have employed econometric techniques in order to determine the quantitative importance of each contributing factor. A similar distinction occurs between the other two chapters in this section, both of which present empirical evidence relating to the process of hospital cost inflation in New Zealand in recent years. Thus, Chapter Three presents an analysis of the nature and extent of hospital cost inflation and identifies the factors that appear to be responsible, while Chapter Five employs econometric techniques to determine the quantitative importance of each factor in explaining the rising cost of running New Zealand's public hospitals.

The second part of the study is devoted to consideration of cost variations among hospitals at a given point in time. Chapters Six and Seven review the considerable volume of literature written on the subject in recent years, while Chapters Eight and Nine present an econometric analysis of hospital cost variations among New Zealand's public hospitals. In Chapter Nine, the final chapter in this section of the study, particular emphasis is placed on examining the performance of a number of alternative hospital output measures in explaining the interhospital cost variations. Finally, Chapter Ten presents a summary of the main results and comments on the policy implications that arise from the study.

## CHAPTER TWO

### A Review of the Literature on Hospital Cost Inflation

#### 2.1 Introduction

Concern with the persistent and accelerating increases in hospital costs experienced by many countries in recent years is reflected in the proliferation of the literature devoted to describing and analysing these trends. This chapter is devoted to reviewing what have been termed the descriptive theories of hospital cost inflation as they endeavour simply to identify those factors alleged to contribute to rising hospital costs. A review of a number of recent econometric analyses of hospital cost inflation, which attempt to determine the quantitative importance of each factor in explaining the cost increases, is given in Chapter Four.

The descriptive theories of hospital cost inflation can conveniently be considered under two broad headings - demand and supply - although it should be noted that this distinction is not intended to be as clear cut as the titles imply, for considerable interaction takes place between the theories many of which draw on elements of another in support of an argument.

#### 2.2 The Demand Related Theories

Much of the responsibility for rising hospital costs

has been attributed to a growth in the demand for hospital services, the extent of which appears to have been broadly similar in a number of countries in recent years.<sup>1</sup> The reasons for this growth in demand have been widely documented and can be considered under two headings: economic and non-economic.

### 2.2.1 Economic Factors

The main economic factors that affect the level of demand for hospital care are the price of hospital services and the incomes of consumers.

#### (i) Price

A broad definition of the price of hospital care includes two components: the price charged by the hospital, which could range from the full price to no charge at all depending on the particular type of health system in question, and the value of the patient's time. Of the two, the former has received greater attention in the literature, particularly with reference to countries such as America where patients are charged for the care they receive. The significance of the patient's time spent travelling to, waiting for and receiving hospital care is also important, especially in countries where no direct charge is imposed on the patient for hospital care.

There is substantial agreement in the literature that the demand for medical care in general and hospital care

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1. See, for example, Reed and Carr (1968), Andersen and Hull (1969) and Davis and Foster (1972).

in particular is relatively inelastic with respect to price.<sup>1</sup> This is due largely to the lack of substitutes for medical care, to the fact that some medical care can be regarded as a necessity regardless of the cost involved, and to the importance of the role of the doctor in recommending the sort of medical care most suited to the needs of each patient, whether it be hospitalisation or simple medication.<sup>2</sup>

Several factors serve to complicate this general conclusion. One such factor, health insurance, has the effect of reducing the effective price to the patient of a period of hospitalisation. In America, where insurance and prepayment plans are widely used, several writers have shown that the extent and type of insurance coverage held by patients can have a marked effect on the utilisation of hospital facilities.<sup>3</sup> In general, the greater the proportion of cost borne by the patient, the lower the utilisation; conversely, the greater the proportion of cost borne by insurance funds, the less significant is the effect of price on utilisation.

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1. See, for example, the surveys of the demand for medical care by Klarman (1965), Feldstein P. (1966), Joseph (1971), Fuchs (1972 e), and Feldstein M. (1974a).
  2. Several writers have examined the role of the doctor in determining the demand for hospital care (Feldstein P. 1966 and Fuchs 1972 e). More recently Feldstein M (1974a) has suggested that although the usual household demand variables of price, insurance and income may influence the patients decision to initiate care, the quantity of care that is then obtained is determined by the physician who acts as an 'agent' on the patient's behalf. This agency relationship, however, is an incomplete one as the physician is concerned not only with the patient's health and welfare but also with his own interests which may include general ethical principles and concern to make good use of hospital resources.
  3. Feldstein M. (1973), Ginsburg and Mannheim (1973), Rosett and Huang (1973) and Newhouse and Phelps (1974).



Another factor which complicates the relationship between price and demand is the type of medical care being discussed. Davis and Russell (1972), for example, have shown that price elasticities differ according to whether one is considering inpatient or outpatient hospital care. The demand for inpatient care appears to be far less responsive to price changes than the demand for outpatient care.<sup>1</sup> It has also been shown, by both Rosenthal (1970) and Joseph (1972 a) that patients with more serious conditions are less sensitive to price considerations than those with the more straightforward conditions (such as tonsillitis and adenoiditis). Both these results serve to emphasise the point made by Davis and Russell (1972) that the conclusion that the demand for medical care is relatively inelastic with respect to price cannot be assumed to hold true when one is considering the component types of care - that is inpatient, outpatient, physician and dental services.

Although most evidence on the demand for hospital inpatient care supports the general conclusion of an inelastic demand with respect to price, agreement on the exact value of the elasticity is not so clear. Some researchers, such as P. Feldstein (1966) and Newhouse and Phelps (1974) found evidence of low price elasticities ranging between zero and -0.2, while others notably Rosenthal (1970), Davis and Russell (1972), and Felstein M. (1971 c) found far higher values ranging between -0.2 and

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1. Davis and Russell (1972) found price elasticities for inpatient care ranging from -0.3 to -0.5, and for outpatient care of about -1.0.

-0.9. The reasons for these variations are probably due almost entirely to differences in the data, assumptions and methodologies used by the various researchers. While some studies, for example, utilised data for hospitals within an individual state (Rosenthal 1970) or district (Newhouse and Phelps 1974), others considered data from all the states of America (Davis and Russell 1972, and Feldstein M. 1971 c). In addition, while some studies utilised cross-section data on individual households,<sup>1</sup> others considered aggregate data at the state level,<sup>2</sup> and still others compared the health demands of a population before and after a change in insurance coverage.<sup>3</sup> It is hardly surprising therefore, to find differences in the price elasticity values. It is perhaps more surprising to find that they do not differ more greatly.

Another aspect of the relationship between the price of and the demand for hospital services is the rise in the price of hospital care relative to the rise in the prices of other goods and services. In a number of countries the prices of hospital care have been rising at a faster rate than the general level of prices as measured by the Consumer Price Index.<sup>4</sup> It might be expected, *ceteris paribus*, that an increase in the relative price of

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1. Rosenthal (1970) and Rosett and Huang (1973).
  2. Feldstein M. (1971c) and Davis and Russell (1972).
  3. Ginsburg and Mannheim (1972) and Newhouse and Phelps (1974).
  4. See Anderson and Neuhauser (1969) who examine cost increases in America, the U.K. and Sweden. See also Chester (1972) who examines cost increases in America, England, Sweden and West Germany, and Feldstein M. (1971 b) who examines the recent American experience.

one good would lead to an attempt by consumers to substitute for it other, less costly goods. However, if demand for the good is inelastic, the only result of a rise in price is an increase in expenditure.

The final aspect of the price-demand relationship is time - the value of the patients time in travelling to, waiting for and receiving hospital treatment. Since discussion of the importance of time as a determinant of demand was initiated by Becker (1965), a number of writers have examined the role of time in determining the demand for medical care.<sup>1</sup> Several interesting results and implications have become apparent. It is clear, for example, that as money price and income lose importance as determinants of demand, which occurs as insurance or other forms of external financing of health services become more pervasive, the value of the consumer's time begins to assume a quasi-price function. This is supported by a recent analysis by Acton (1975) of the demand for free outpatient services in New York city where it was found that time and travel distance elasticities approached, in value, the money-price elasticities found by a number of the researchers mentioned above. It can also be argued that with rising incomes and affluence, and with the growing demand for leisure time, the opportunity cost of time has risen markedly in recent years. Since the opportunity cost

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1. These include Long and P. Feldstein (1967), Morrill and Earickson (1968), Shannon, Bashshur, and Metzner (1969), Leveson (1970), Holtmann (1972), Simon and Smith (1973), Vertinsky and Uyeno (1973), Newhouse and Phelps (1974) and Acton (1975).

of time varies from person to person as a result of differences in income levels and job status in particular, so the time price of hospitalisation varies also. The price tends to be lower for retired people and the unemployed than for those with jobs; it tends to be lower for women than for men, and so on. In addition, those on higher incomes have a higher opportunity cost of time and are likely to demand the less time consuming forms of care. This may, for example, imply substituting private hospital or private physician care for the more time consuming public services. This is borne out in Acton's New York city study (1975).

(ii) Income

The relationship between changing levels of income and the demand for all forms of medical care has also been the subject of considerable research in recent years. There is a general consensus that families with higher incomes tend to spend more on medical care, but that the proportion of income spent on medical care decreases with higher levels of income.<sup>1</sup> There is general agreement, therefore, that the income elasticity of demand for medical care is less than one and positive.

A number of problems of definition and measurement have complicated the analysis of income elasticities in medical care studies. The first concerns the inclusion of expenditure measures as proxies for the quantities of health care demanded. This can only be justified when

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1. This conclusion is reached by a number of writers of survey articles on the demand for medical care, including Feldstein P. and Carr (1964), Klarman (1965), Feldstein P. (1966), Joseph (1971) and Feldstein M. (1974 a).

other factors, such as price and health status remain constant. In America there is evidence of a positive relationship between pricing practices and income in the provision of medical services.<sup>1</sup> If those in higher income groups pay higher prices for the same services (what has come to be known as a 'sliding scale' of fees), and if higher prices result in greater expenditures, income elasticities calculated from expenditure data will result in higher estimates than elasticities based on physical quantities of care, such as outpatient or dental visits.<sup>2</sup> Similarly, if individuals with higher incomes are in better health, this would tend to lower the estimated income elasticities of expenditures.

A second problem concerns the definition and measurement of income, specifically whether the appropriate measure is 'transitory' or 'permanent' income.<sup>3</sup> Transitory income, that is a family's income in any given year, is likely to fluctuate as a result of temporary loss of employment, windfall gains or other unexpected events. One such event may be an illness requiring hospitalisation which will not only result in higher medical care spending but may, at the same time, reduce family income if the illness is suffered by the family's breadwinner. To avoid this

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1. See Kessel (1958).

2. This argument is supported, for physician services, by the research of Andersen and Benham (1970).

3. This concept was initially discussed by Friedman (1957) in his theory of the consumption function. Feldstein P. (1966) examined the importance of the distinction between transitory and permanent income as it relates to medical care.

problem most researchers have, where possible, measured income as 'permanent' - that is as long term expected or normal income. Choice of income measure can have a marked effect on the results obtained for income elasticities. Both Feldstein and Carr (1964) and Andersen and Benham (1970) have shown that the income elasticity of demand for medical care tends to be higher if based on measures of permanent income as against measures of observed income. Omission of expected future income, therefore tends to bias downwards the estimated income elasticity of expenditures.

A similar problem to that encountered in the price elasticity studies arises with the income elasticity studies in that the elasticities vary according to the particular component of care being studied. This has been illustrated by both Feldstein P. (1966) and Andersen and Benham (1970) who analysed income elasticities for hospital, physician and dental services. Of these components, demand for (or expenditure on) dental services exhibited the greatest responsiveness to changes in income. It is also apparent from these and other studies that the greater the proportion of medical care expenses met by third parties (such as insurance or government) the less the importance of income as a determinant of the consumption of medical care, although in the case of insurance, which persons on higher incomes are more likely to be able to afford, the impact of income on demand may be less direct rather than less important.

### 2.2.2 Non-Economic Factors

The non-economic factors which have contributed to the rising demand for hospital care are diagnostic (the changing pattern and incidence of disease), demographic (the changing age, sex, and race composition of the population), attitudinal (the changing public attitudes to medicine), and institutional (the changing supply of hospital beds).

#### (i) Diagnostic Changes

Recent years have witnessed considerable changes in the pattern and incidence of disease. In an early contribution to the field, Roberts (1952) divides disease into three classes: deficiency, acute and chronic. With the almost complete elimination of deficiency diseases (such as chlorosis, rickets and scurvy) in advanced industrialised countries, medical care is now focused on the remaining two classes. Acute diseases (such as typhoid and smallpox) have for the most part become curable and preventable. Chronic diseases (such as cancer and heart disease), on the other hand, are generally regarded as incurable, although recent advances in medical science have resulted in more sophisticated and successful treatments. Roberts summarises the effect of these changes as follows:

Since acute infections arise from the environment and every individual is exposed to the environment from the moment of birth, those who are really cured by medical science are chiefly the young. But the young thus saved survive eventually to join the old and therefore to suffer diseases which cannot be cured (1952, p.90).

The overall effect on the population, therefore, is not only to contribute to its growth, but also to cause a large increase in the number of old people, both absolutely and relative to the total population. Although both these factors serve to increase the demand for hospital care, little attention has been devoted to analysing the extent of the increase in demand and its implications for hospital cost levels.

The effect of diagnostic change on the level of hospital costs is difficult to estimate without knowledge of the costs of treating individual diseases.<sup>1</sup> One can argue intuitively, however, that the direction of the changes towards those diseases which have longer lengths of stay than average, as is true of the chronic diseases, would tend to increase the overall level of costs per case. The effect on the cost per patient day, which is not as sensitive to length of stay variations, is not so clear.

(ii) Demographic Changes

The pattern of utilisation of hospital facilities is determined to a considerable extent by the age, sex and race composition of the population served. Any significant change in those characteristics is therefore likely to affect the pattern of hospital utilisation and hence the level of hospital costs.

A considerable amount of research and literature has been devoted to identifying the demographic and social

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1. Attempts to estimate the costs of treating a handful of common diseases have been made by Scitovsky (1967) and Babson (1973).



factors that affect the demand for hospital care.<sup>1</sup> Little attention, however, has been paid to analysing the effect of changes in those factors on the patterns of hospital utilisation and on hospital costs. Some writers have suggested the possible effects that changes in the age and sex composition of the population may have on the demand for hospital services, but few have attempted to examine the relationship quantitatively. Both Fuchs (1972 c) and Chester (1972), for example, point out that the changing population structure in most developed countries, in particular the proportionate increase in the number of elderly persons, has led to a greatly increased demand for hospital care but neither writer has analysed the changes empirically.

More recently two Canadian researchers, Denton and Spencer (1973 and 1975), have investigated the impact of population change on the cost of health care (specifically on the cost of hospital services, physician services and drugs), using a theoretical model of a complete economic-demographic system. The authors consider two measures of the burden of health care costs - costs as a fraction of total output and cost per capita - in a variety of simulation experiments assuming a number of alternative fertility and migration rates and a constant quality of care. Their analysis suggests that although population

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1. A selection of this literature includes Rosenthal (1964), Wirick and Barlow (1964), Lew (1966), Reinke and Baker (1967), Bice and White (1969), Ro (1969 b), Anderson J. (1973 a), Lazarus (1973), and Mueller and Gibson (1975).

changes can be expected to have a substantial impact on the cost of health care in the longer term, in the shorter term (a decade) increasing health costs are more likely to reflect changes in the quality of services provided rather than any demographic changes. Unfortunately, they do not analyse the component types of health care costs but concentrate on aggregate cost measures. It seems unlikely, however, that there would be any marked difference between the effects of demographic changes on all health costs and on the costs of particular health services such as hospital services, physician services and drugs. Further research is required to examine this hypothesis, as well as the effect of other demographic changes, such as a change in the racial composition of the population and the continuing rural to urban drift of populations in advanced industrialised countries.

(iii) Attitudinal Changes

Very little evidence, beyond mere speculation, has been forthcoming on the attitudes of persons to the various aspects of medical care and the consequences for demand. Feldstein P. (1966), for example, notes that "a recognised health deficiency may not be translated directly into expenditure because of variations in dispositions toward risk-taking and differences in belief in the effectiveness of medical treatment". Feldstein M. (1971 b) has expanded this argument in pointing out that belief in the effectiveness of medical treatment has been growing in recent years, and has stimulated the demand for hospital beds and for higher quality medical care. It is debatable, however, whether, in M. Feldstein's words "the growing faith in the

power of science, and of curative medicine in particular" (ibid p.30) will necessarily increase the demand for hospital beds. A growing awareness of the dangers of ill health may well lead a person to seek primary preventive care, which if effective, is likely to reduce the risk of a more serious illness and possible hospitalisation. On the other hand, Salter (1972) has argued that as people become accustomed to improved treatment and as medical techniques have advanced, treatment is sought for conditions which previously were regarded as beyond cure. In addition, conditions which were regarded as merely minor discomforts to be borne philosophically are now taken to the doctor for treatment. As a result, the proportion of medical care produced and sold in the market has risen, while the proportion provided outside the market by family, friends, and neighbours, has declined.<sup>1</sup> Further research is needed on the relationship between consumer attitudes and demand for medical care, firstly, to identify the nature of consumer attitudes to medical care and any possible changes in those attitudes, and secondly, to analyse the effect of attitudinal changes on the demand for medical care of all kinds.

#### (iv) Institutional Changes

The question of how the availability of hospital beds affects the use of hospital facilities has been a matter for considerable debate since it was first broached by Shain

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1. Fuchs (1972 c) also makes this point in a general paper on the costs of medical care.

and Roemer (1959), who showed that general hospital beds in America are occupied at approximately the same rate regardless of the ratio of beds to population. Roemer (1961) has also shown that the introduction of a new 200 bed hospital in upstate New York appeared to lead, within three years, to an increase of 28 per cent in the number of patient days. No other changes in the community could be found that might have accounted for this rise in hospital use. Critics of this view, notably Rosenthal (1962) have objected principally on the ground that they believe supply changes follow, or are dependent on, changes in demand. Rosenthal found that higher levels of supply are associated with lower pressure on facilities while higher levels of demand are associated with greater pressure on facilities. In a review of the literature on this subject, Klarman (1965, pp.139-141) feels that the studies at hand are not conclusive, and, in particular that the relationship between supply and use is not 'one to one' but somewhat more complex. In a more recent study, Feldstein M. (1967) provides evidence to support the view that causality flows from supply to demand and not vice versa. He notes that the supply and distribution of hospitals in England is largely the result of historical accident and not in response to increasing or changing demands. In addition, Feldstein argues that doctors' decisions on whether or not to admit patients to hospital are affected by the availability of beds and the length of waiting lists: "where beds are scarce and waiting lists long, more work is done on an outpatient basis and the length of stay is relatively short; if the number of beds

is increased the hospitalisation rate and the length of stay also increase" (ibid p.196). Feldstein M. (1974 e) later argues, in a review of availability studies, that the most plausible explanation of the effect of availability on demand is that which emphasises the role of the doctor, who responds to a relative scarcity of beds by reducing the number of doctor-originated hospital admissions. Again, further research is called for to examine more closely the way in which this sort of non-price rationing operates.

### 2.3 The Supply Related Theories

In addition to the pressures of demand, much of the responsibility for rising hospital costs has been attributed to the rising cost of the factors of production - both labour and non-labour - used by hospitals.

#### 2.3.1 The Rising Cost of Labour Inputs

Recent years have witnessed substantial increases in the labour costs of hospital care which result from a growth in hospital staff numbers and rising wage levels. This trend appears to have been experienced in a number of countries, arousing considerable interest and concern.<sup>1</sup>

Rising hospital staff numbers, which have been increasing both in absolute terms and in relation to the

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1. A selection of relevant literature includes Brown (1956), Klarman (1964 and 1970 b), Segal (1966 b), Feldstein M. (1971 b), Andersen and May (1972), Davis (1972b), Davis and Foster (1972), Salter (1972), Phillip (1973) and Cooper (1975b).

number of occupied hospital beds,<sup>1</sup> have been attributed to technical and scientific progress and also to a reduction in the number of hours worked. Brown (1956) and Segal (1966 b) both attribute the need to employ more and better trained staff to major advances made in medical science, while Andersen and May (1972) point to the widening role of the hospital in explaining the increases:

hospitals are providing varieties of care which require greater numbers of personnel to serve a given number of patients..... staffing increases result, in part, from the continuing trend for the hospital to provide the patient with more amenities during his stay (1972, p.71).

Some of the increase in hospital staff numbers may also reflect the substantial growth of outpatient services which has been taking place in a number of countries.<sup>2</sup>

Despite the growth in staff numbers, however, the greater part of the increase in labour costs appears to be due to rising wage levels. Davis (1972), for example, puts the ratio for America at about three to one: "about three fourths of the increase in labour expenses is accounted for by increases in average earnings of employees, and about one fourth of the increase represents an increase in the number of employees per day of care" (Ibid, p.4).<sup>3</sup>

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1. It has also been noted that a higher proportion of the total labour force is being employed in the hospital industry reflecting the general movement of labour in to the service sectors of advanced economies. See, for example, Kuznets (1966), Fuchs (1968), and Baumol and Oates (1972).
  2. See, for example, Davis and Russell (1972), Davis and Foster (1972), and Phillip (1973).
  3. A similar trend has been occurring in Britain's National Health Service: see Cooper (1975a and b).

Three theories have been advanced to explain the rise in the average annual earnings of hospital staff. The first attributes the rise to a change in the overall skill level of hospital staff, the second to a catching up of hospital wages with those of other sectors of the economy, and the third to a lag in productivity gains in the hospital sector compared with the gains made in other industries.

(i) The Level of Staff Skill

A change in the composition of hospital staff towards the relatively higher paid and more highly skilled occupations can be expected, *ceteris paribus*, to lead to a higher total wage bill, and therefore, to a higher level of average annual earnings. Research on this matter has produced conflicting evidence. Feldstein (1971 b), in his study of the rising cost of hospital care presented evidence which indicated a fall in the average level of skill between 1963 and 1966, whereas Davis and Foster (1972), in a similar exercise, found a slight rise in skills between 1962 and 1966. In commenting on the apparent conflict in these results, Davis and Foster point out that their employee classifications are likely to be "less homogeneous with respect to skill level than the occupational classifications used by Feldstein" (Ibid, p.32). In addition, Davis and Foster base their results on data from all American hospitals, rather than just the major metropolitan area hospitals which Feldstein uses. The changes in skill mix found in both studies, however, are slight during the short periods (5 years) covered. One factor that may be acting to reduce the extent of the

changes in skill mix may be the tendency, noted but not tested by Andersen and May (1972), for hospitals to hire 'lower priced personnel' to perform tasks formerly done by higher paid personnel in order to keep total cost increases as small as possible. In view of the conflicting evidence already collected and the rather short periods analysed, the question of changing skill mix and its impact on hospital wage levels remains largely unresolved.

(ii) The Catching-up Hypothesis

The hypothesis that the wages of hospital staff have for a long time been lower than those of comparable occupations and have been catching them up in recent years, is one which has been proposed and substantiated by a number of writers. Klarman (1964), for example, argues that this hypothesis is consistent with developments in the American hospital sector in the middle and late 1940's and in the late 50's, although he feels that "additional and alternative explanations of the hospital cost increase are needed" (ibid p.230). Feldstein (1971 b), also presents evidence to suggest that not only have hospital wages been catching up with the national average but that in some instances they have exceeded the wages paid to comparable occupations. Davis and Foster (1972) show that what catching up there has been in hospital wages in America appears to have been in those occupations whose wages have been excessively low relative to comparable occupations - particularly 'dietary' and 'household and property' staff.

Several reasons have been given for the faster increase in hospital wages compared with those in comparable



occupations. Feldstein (1971 b) argues that the impetus for wage increases originates from three sources: the economy as a whole ( a fall in the unemployment rate, the spread of unionisation, and a rise in the wages of the mobile occupational groups such as clerical, household and maintenance staff); the hospital industry (the rapid expansion of demand for hospital staff and the consequent rise in their relative wages); and the individual hospital (the existence of 'philanthropic wage setting', whereby individual hospitals raise the wages of hospital personnel above the levels necessary to obtain the staff they require). Although the latter reason is probably specific to the American hospital system, the remaining reasons are applicable to other health systems.<sup>1</sup>

(iii) Productivity Gains

For many years now the weight of evidence and opinion has been firmly in favour of the view that productivity gains in the personal service sectors of the economy lag behind gains in other industries.<sup>2</sup> Evidence of such a lag has been presented by Fuchs (1968) in his study of the American 'Service Economy'. Fuchs' estimates of increases in output per man between 1929 and 1965 in the three sectors of the American economy are as follows:

|             |      |
|-------------|------|
| Agriculture | 3.4% |
| Industry    | 2.2% |
| Service     | 1.1% |
| <hr/>       |      |
| All sectors | 1.9% |

(Source: Fuchs 1968, p.51)

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1. In the American system individual hospitals are able to offer wages above certain minimum levels, but the wages offered by hospitals in a publicly owned and operated health system (such as Britain's National Health Service) are the same throughout the whole country for specific occupations.
  2. See, for example, Baumol (1967).

This situation in which one sector of the economy persistently lags behind the rest in terms of productivity growth has significant implications for cost levels: "the products of that sector must invariably rise in cost relative to cost levels in the rest of the economy, and that rise will be persistent and cumulative" (Baumol and Oates, 1972, p.49). This is because only a small part of the higher cost of labour inputs can be absorbed through the increase in productivity, the remainder being translated into higher costs per unit of output.

Productivity increases in the hospital sector have been found to be low due largely, it is argued, to the personal service nature of hospitals (see e.g. Brown 1956). Hospitals are labour intensive institutions and offer little scope for the introduction of labour saving devices; indeed in many instances, technical innovations in the hospital require more rather than less labour in order to function effectively. In a much cited study by Lytton (1959), a comparison of the trends in productivity (defined as the volume of output per unit of labour input) of various government agencies revealed increases in all but one agency, the Veterans Administration Hospitals, which registered a decline in productivity of 11 per cent from 1947 - 1958.

As several writers have pointed out, however, the fact that output, measured as the number of patient days, per unit of labour input has declined does not necessarily imply a fall in productivity.<sup>1</sup> Changes in the intensity, scope

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1. See, for example, Lave J. (1966) and Berki (1972).

and quality of care, in the length of stay, and in the skills of the staff, will all have combined to make the patient day a very different product over the period which Lytton has discussed. The patient day, then, can be regarded as 'no more than a first approximation of the output of a hospital' (Lave J. 1966, p.67). Fuch's estimate of the increase in 'real output per man' of only 0.9 per cent per year in the American Medical Care Industry between 1929 and 1965 (Fuchs 1968, p.117) is also subject to the same criticism: "changes in the patterns and outcomes of hospital care between 1929 and 1965 make a shambles of his measures of real output and input" (Berki, 1972, p.64).

Alternative measures of productivity employed in other studies show the service sector in a more favourable light. Dhrymes (1963), for example, in his study of productivity in the American economy uses a production function approach and presents evidence to suggest that productivity in the service sector increased more than productivity in the manufacturing sector between 1947 and 1958. M. Feldstein (1967), in his cross section study of National Health Service hospitals in England, also uses the production function approach. He calculates a productivity index ( $P_i^*$ ) for each individual hospital in 1961 which is the ratio of its observed output, defined as a weighted sum of the number of cases treated in each diagnostic category, to the output expected on the basis of the inputs of nurses, doctors, beds and other variable inputs (ibid, p.45). His results indicate that of the 177 hospitals being studied, 17 had low productivity ( $P_i^* \leq 80$ ) and 21 had high

productivity ( $P^*_{\geq 120}$ ); the remaining hospitals exhibited little difference between observed and expected output. Feldstein's productivity index was intended, along with his measures of 'costliness' and 'input efficiency' to be an index "of hospital performance in the selection and use of resources" (1967, p.50). Although a useful measure of the comparative productivity of individual hospitals, the technique cannot be generalised to the whole hospital sector because of the nature of the index which uses an average performance level as its basic reference point. In the absence of suitable comparative information from other sectors of the economy, calculation of a productivity index for the hospital sector is therefore impossible.

Another approach to measuring productivity change has been introduced by Barzel (1969 a).<sup>1</sup> Starting with the premise that the American Bureau of Labour Statistics' Medical Care Price Index is a poor reflection of productivity change, Barzel develops a price index for medical care based on changes in the price of health insurance plans. His results indicate that "the rate of increase of productivity in the medical services has exceeded somewhat the overall productivity increase in the rest of the economy" (ibid, p.1014). This approach, however, is subject to the same criticism that was levelled at the earlier studies of Lytton (1959) and Fuchs (1968), that no allowance is made in the measures for

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1. This approach has also been adopted by Reder (1969).

technological progress and quality change.

Measurement of productivity in the medical care sector, and in hospitals in particular, has been fraught with problems both of definition and of methodology. In the first place little agreement has been reached on what is to be measured - the relevant inputs and outputs. Secondly, the problem of the changing quality of care and technological progress and their effect on both the inputs and outputs of a hospital is one that, although acknowledged as being important, has not been accounted for in measures of productivity to date. It seems that in the absence of reliable measures the hypothesis of productivity lags in the hospital sector must remain a matter of speculation.

#### 2.3.2 The Rising Cost of Non-Labour Inputs

In addition to the increase in hospital labour costs, many countries have experienced substantial rises in the cost of non-labour inputs. A full description of these includes capital costs (depreciation, interest and rent) as well as other running costs (supplies, food, drugs, linen and so on). Many countries, particularly those whose hospitals are financed largely from public funds (such as Canada and Britain) do not allow for the inclusion of capital costs in their estimates of hospital expenditure, thereby understating the true cost of running the hospitals. In America, on the other hand, hospital capital expenses are recorded and have been the focus of much attention. Davis (1972), for example, has shown that although capital costs constitute only a small proportion (about five per

cent) of the total running costs of a representative sample of America's hospitals, they nevertheless increased more rapidly between 1962 and 1966 than both labour costs and other running costs (depreciation, interest and rent rose by 52 per cent in this period).

One explanation for this relatively sharp rise in capital costs has been proposed by Lee (1971), who argues that a considerable part of the increase in sophisticated and specialised equipment in American hospitals is largely unnecessary. Much wasteful duplication, he believes, arises from the efforts of hospital administrators to maximise their own utility and the status of their hospital through the addition of expensive and highly specialised equipment. The point at which capital equipment in hospitals becomes wasteful, however, is difficult to define. The fact that a hospital has an expensive piece of equipment that is rarely used does not necessarily imply wastage as it may be desirable from society's point of view that such a facility is available even if only on a stand by basis.<sup>1</sup>

Increases in the costs of other non-labour hospital inputs have also been substantial in recent years, and are the result of rises in both the quantities of inputs used and their prices. Unfortunately, the quantity of non-labour inputs used cannot be measured in physical terms as can, say, labour inputs, as they are neither as homogeneous nor as easily identifiable. Furthermore, in many countries, few statistics are available on the

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1. This has been termed 'option demand' by Weisbrod (1964).

quantities and prices of the materials and supplies used by hospitals. An alternative means of estimating the relative contribution of rising prices and quantities to rising non-labour costs is to assume that the composite average price of these commodities moves in a similar manner to the Consumer Price Index, the Wholesale Price Index, or some components of one of these. Feldstein (1971 b), among others, has undertaken this exercise for American hospitals during the years 1955 to 1968, and his results indicate that the increase in non-labour costs was due mainly to a substantial increase in the quantity of non-labour inputs utilised, and only fractionally to rises in their prices.

Two theories have been advanced to explain the rapid rise in the quantity and, to a lesser extent, the prices of non-labour inputs: the expanding and advancing technology of medicine, and the inefficient and wasteful utilisation of resources.

(i) Expanding and Advancing Medical Technology

The twentieth century has witnessed a revolution in the science and techniques of medicine which has continued and gathered momentum over the years. There are two distinct aspects to this process of change, for it can be regarded as a combination of a widening and deepening of hospital services. A widening of hospital services refers to the duplication or expansion of existing services and facilities, such as beds, surgical procedures and laboratory tests, which is required in order to keep pace with a growing population, while a deepening of services is said to have taken place when more or more

intensive services are provided for each day of hospital care. It is the latter of these two elements of technological change that has so transformed the nature of hospital care during recent years. Dramatic advances in medical science have led to the introduction into hospitals of more sophisticated equipment, drugs and supplies, of more highly trained and specialised medical personnel, and of more complicated and diverse diagnostic and surgical procedures.

Although a few authors have documented these trends in full,<sup>1</sup> measurement of the effects of technological advance poses some difficult problems. One approach has been to identify a number of changes in hospital care which could reasonably be expected to reflect technological progress. These include an increase in the number and type of sophisticated treatment facilities and services offered by hospitals (Phillip 1973); a change in the quantity and quality of clinical laboratory tests and radiology diagnostic procedures performed per admission (ibid); and a change in the composition of hospital staff to include more specialised and highly trained treatment staff (Heydebrand 1973).

An alternative approach involves outlining and comparing "several types of expenses which could reasonably be expected to be more responsive to changes in technology than other types of expenses" (Davis and Foster 1972, p.55). Thus, one might expect 'responsive' expenses to include those associated with skilled medical and treatment staff,

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1. See, for example, Roberts (1952), and more recently, Heydebrand (1973).



with the rapidly growing laboratory and radiology departments, and with treatment activities in general. Those expenses least likely to be affected by technological progress would include those associated with housekeeping, engineering, dietary and administrative activities, that is with the non-treatment functions.

Perhaps a more fruitful approach than simply identifying the process of technological change, is to measure the end-result effects of medical advance on health levels. There is reason to believe, for example, that mortality, which is but one of a number of indicators of a country's health status, is levelling off in many advanced countries, particularly in certain age groups, notably adult males. Fuchs (1974a) in his study of mortality in developed countries argues not only that the traditional negative association between mortality and real income per capita appears to be disappearing in developed countries, but that the marginal contribution of medical care to life expectancy appears to have been very small in recent years. Fuchs argues that the reason for the current difference in mortality across, and within developed countries, is "primarily related to life-style: diet, exercise, smoking, drinking, psychological stress, etc." (Ibid, p.174).

Other writers have also noted an apparent levelling off in the returns, in the form of improved health levels, to medical advance. Chester (1972), for example, argues that medical progress is suffering the effects of diminishing returns: "every new medical discovery permits greater achievement in the saving or prolonging of human

life, but at steadily accelerating costs" (ibid, p.78). Roberts (1952) argues that medical advance is obedient to a law of perpetual expansion. This, coupled with the view that there is no reason to believe that man must inevitably be able to cure all diseases, or that our resources are unlimited, leads Roberts to conclude that we are facing a twin paradox "of unlimited progress toward an unattainable objective, unlimited expansion against an inexhaustible circumference" (ibid, p.192). He summarises the situation in the following way:

The increasing cost of ill-health is due primarily and paradoxically to the advancement of medicine which is spurred to perpetual acceleration by the perpetual acceleration of scientific discovery. To this process there can be no end, except that which is imposed by limitations in the available resources (ibid, p.191).

Rapid technological change, then, appears to be accompanied not only by an expansion in the scope of hospital services, but also by the introduction of new and more sophisticated diagnostic and technical procedures. Both of these developments bring with them increasing average and total costs. The widening role of the hospital reflected in such things as the growth of outpatient facilities and educational functions, tends to increase total hospital costs, while the more intense, higher quality care offered per patient day results in higher unit costs, and all, it appears, with diminishing returns in terms of improved health levels in the population as a whole.

#### (ii) Inefficient and Wasteful Use of Resources

Two areas of concern relating to inefficient and

wasteful utilisation of resources have been examined, principally in America: the excessive use of laboratory and x-ray procedures, and the problem of excessive surgery. Since both require the use of increased quantities of labour and non-labour hospital inputs, they impart an upward pressure on hospital costs.

A number of writers believe that the proliferation of laboratory and x-ray procedures in recent years "has .... increased the opportunity for their excessive, unnecessary, and unwise misuse" (Russe, 1969, p.223). Several reasons for this have been suggested. Griner and Liptzin (1971) argue that excessive use of laboratory tests is due to "concern over missing unsuspected diagnoses or unexpected changes in the patient's clinical condition, medico-legal considerations, innate curiosity, and the need to 'work up' a patient completely to satisfy one's peers or supervising physicians" (ibid, p.162). Rourke (1972) believes the reasons for the rise in the volume of laboratory and x-ray procedures is twofold - the tendency for medical students to demand more procedures per patient than average, and the additional procedures carried out "to blunt the threat of malpractice suits" (ibid, p.106). Russe (1969), gives a number of reasons for the proliferation of testing - the change in the function of the procedures from being purely a 'back up' to the history and physical examination, to being used to suggest the nature of an illness; the development of automated techniques; the inexperience, in some instances, of the person ordering the tests; the ordering of little known procedures by the doctor so as to impress the attending physician with his erudition; and

the repetition of tests when the results do not agree with "the clinicians preconceived and sometimes erroneous ideas about the result" (ibid, p.230). These writers do note, on the other hand, that in many instances abuses may occur when not enough tests are conducted to confirm or reject a diagnosis.<sup>1</sup>

There is considerable evidence to suggest that a large number of unnecessary operations have been and are being performed in American hospitals, for which a number of explanations have been advanced. A comparative study (Bunker 1970) of the United States and England and Wales indicates that rates of surgery may be a function of the number of surgeons.<sup>2</sup> On a per capita basis Bunker shows that the United States had both twice as many surgeons and twice as many operations as England in 1967.<sup>3</sup> Of particular significance were the comparative surgical rates for elective versus critical surgery. While there was little difference in the rate of critical surgery, elective surgery (such as hysterectomies and tonsillectomies) was typically performed much more frequently in America than in England. Bunker argues that "fee-for service,"<sup>4</sup> solo

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1. Method of payment for laboratory and x-ray procedures may also affect their usage: payment on a fee-for-service basis may help to reduce excessive testing, while third party financing from insurance or government sources may foster it.
  2. This hypothesis is supported by Lewis (1969), Fuchs (1972 d), and Blackstone (1974).
  3. The exact figures are 18 surgeons per 100,000 population in England as compared with 39 in America; and for operations, 3,770 per 100,000 in England and 7,400 in America (Bunker, 1970, p.136).
  4. Monsma (1970), in his study of the demand for physician services in America concludes that there is overutilisation of surgery under the fee-for-service system of physician remuneration since the fee-for-service form of pricing provides the financial incentive for the doctor to perform unnecessary work.

practice and a more aggressive therapeutic approach appear to contribute to the greater number of operations in the United States", while "the more frequent use of consultation, closely regulated and standardised surgical practices and restrictions in facilities and numbers of surgeons appear to contribute to the lower rates of operations in England and Wales" (Ibid, p.135).

Blackstone (1974) believes that the large difference in the numbers of surgeons per capita in England and America reflects an oversupply of surgeons in America, which in turn results in unnecessary surgery being performed, a wastage of resources, as well as an increase in mortality directly attributed to the unnecessary work. Lewis (1969) argues that there seems to be a strong relationship between a hospital's bed capacity and the frequency of surgery. In his study of 73 hospitals in Rochester, New York, Lewis shows that a kind of Parkinson's law exists: "patient admissions for surgery expand to fill beds, operating suites, and surgeons' time" (ibid, p.883).

One qualification that needs to be made arises from the difficulty of deciding whether a particular operation is necessary. As Bunker points out in his comparative study, his results do not allow him to determine whether American surgeons operate too often or the British too infrequently. Indeed, few studies have examined closely and critically the efficacy of particular operations.<sup>1</sup>

## 2.4 Summary

It is clear from this review of what have been termed

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1. Exceptions include Sparling (1962) and Bolande (1969).

the descriptive studies of hospital cost inflation that a multiplicity of factors are responsible for the substantial increases in hospital costs experienced by many countries in recent years. Pressures of rising demand as well as substantial changes in the quality, quantity and technology of the hospital's factors of production all appear to have contributed to rising hospital costs. The factors identified in this chapter as contributing to hospital cost inflation are summarised in tabular form (Table 2.1), along with brief comments on the evidence relating to each, on the problems encountered by researchers, and a selection of the relevant literature. Presentation of the evidence on intertemporal cost variations in this way clarifies a number of points about what might be termed the state of the literature relating to hospital inflation.

It is clear that much of the evidence is fragmentary, as few studies examine more than one or two of the determinants of hospital cost inflation at a time. It is also apparent that the evidence relating to many of the factors is either speculative (e.g. diagnostic, demographic, and attitudinal changes), conflicting (e.g. rising hospital staff skill levels, and productivity gains), or subject to serious shortcomings (e.g. technological change). Much additional research is required into the many aspects of hospital cost inflation before satisfactory explanations can be arrived at concerning its process and causes.

Nevertheless the descriptive studies reviewed here have served the useful function of identifying those factors which are most likely to contribute to rising hospital costs.

TABLE 2.1

## A SUMMARY OF THE FACTORS RESPONSIBLE FOR HOSPITAL COST INFLATION

| Factor                         | Findings                                                                                                                                                                                                                                                       | Problems Encountered                                                                                                                                                                                                 | Selection of Relevant Literature                                                                                                                                                                                                    |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>A. Demand Related</b>       |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                      |                                                                                                                                                                                                                                     |
| <b>1. Economic Factors</b>     |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                      |                                                                                                                                                                                                                                     |
| (a) Price                      | Demand for hospital care is relatively inelastic with respect to price; the prices of hospital care have been rising at a faster rate than CPI in many countries; time assumes an important quasi-price function the lower the nominal price of hospital care. | Complications arise from : the effect of insurance and third party financing; type of medical care being discussed; differences in data, assumptions an methodologies employed; effects of time and travel distance. | Klarman (1965), Feldstein P. (1966), Rosenthal (1970), Feldstein M. (1971 and 1974a), Davis and Russell (1972), Fuchs (1972e), Ginsburg and Mannheim (1972), Rosett and Huang (1973), Phelps and Newhouse (1974), and Acton (1975). |
| (b) Income                     | Families with higher incomes tend to spend more on medical care, and the proportion of family income spent on medical care decreases with higher levels of income.                                                                                             | Problems arise mainly from the search for appropriate measures of the quantity of medical care demanded and income.                                                                                                  | Feldstein P. and Carr (1964), Kharman (1965), Feldstein P. (1966), Andersen and Benham (1970), Joseph (1971), and Feldstein M. (1974a).                                                                                             |
| <b>2. Non-Economic Factors</b> |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                      |                                                                                                                                                                                                                                     |
| (a) Diagnostic Change          | Change in the pattern of diseases being treated towards proportionally more chronic diseases which are generally incurable though treatable. Effect on demand and costs uncertain.                                                                             | Measurement of diagnostic change as yet unresolved.                                                                                                                                                                  | Roberts (1952), Scitovsky (1967), and Babson (1973).                                                                                                                                                                                |
| (b) Demographic Change         | Changing population structure (age, sex, and race) may be responsible, in the long term, for growing demand for and rising cost of hospital care.                                                                                                              | Few investigators have gone beyond speculation to test this hypothesis empirically.                                                                                                                                  | Chester (1972), Fuchs (1972c) and Denton and Spencer (1973 and 1975).                                                                                                                                                               |
| (c) Attitudinal Change         | General 'feeling' that attitudes towards medical care have become more favourable in recent years which has led to increase in demand for all health care.                                                                                                     | No empirical evidence of a change in attitudes or of its effect on demand for hospital care.                                                                                                                         | Feldstein P. (1966), Feldstein M. (1971b) Fuchs (1972c), and Salter (1972).                                                                                                                                                         |
| (d) Institutional Change       | Evidence mainly supports the view that the supply of hospital beds affects the level of demand for hospital services, although the exact nature of the relationship is uncertain.                                                                              | Complications arise when consideration is given to the role of the doctor in rationing patients demands for hospital care.                                                                                           | Shain and Roemer (1959), Roemer (1961), Rosenthal (1962), Klarman (1965), Feldstein M. (1967 and 1974a).                                                                                                                            |

TABLE 2.1 cont'd

| Factor                           | Findings                                                                                                                                                                | Problems Encountered                                                                                                                                                                                                                                                                                                              | Selection of Relevant Literature                                                                                                                                                                                                                                                                    |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>B. Supply Related</b>         |                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                     |
| <b>1. Labour Input Costs</b>     |                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                     |
| (a) Staff Numbers                | Rising hospital staff numbers are attributed to advances in medical science, to a reduction in hours worked, and generally to the widening role of the hospital.        | No evidence linking rising hospital staff numbers with hypotheses explaining the increases.                                                                                                                                                                                                                                       | Brown (1966), Segal (1966b), Andersen and May (1972), Davis and Russell (1972), Davis and Foster (1972), and Phillip (1973).                                                                                                                                                                        |
| (b) Wage Levels                  | Rise in average annual earnings of hospital staff attributed to:<br>(i) Rising level of staff skills<br><br>(ii) Catching-up hypothesis<br><br>(iii) Productivity gains | Conflicting evidence and brevity of periods analysed do not allow firm conclusions to be drawn.<br><br>Not all hospital occupations have had faster than average increases in earnings.<br><br>Problems of definition and methodology combined with data limitations have led to unreliable measures and conflicting conclusions. | Feldstein (1971b), Andersen and May (1972), and Davis and Foster (1972).<br><br>Klarman (1964), Feldstein (1971b), and Davis and Foster (1972).<br><br>Brown (1956), Lytton (1959), Dhrymes (1963), Lave J. (1966), Feldstein M. (1967), Fuchs (1968), Barzel (1969a), and Baumol and Oates (1972). |
| <b>2. Non-Labour Input Costs</b> |                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                     |
| (a) Technological Change         | Evidence of both a widening and deepening of hospital facilities and services.                                                                                          | Problems arise from difficulties of measuring process and extent of technological change in hospitals.                                                                                                                                                                                                                            | Roberts (1952), Chester (1972), Davis and Foster (1972), Heydebrand (1973), Phillip (1973), and Fuchs (1974).                                                                                                                                                                                       |
| (b) Inefficiency and Waste       | Evidence of an excessive use of laboratory and x-ray procedures, and of a large number of unnecessary operations being performed.                                       | Although statistically there appears to be evidence of unnecessary activities, there has been little close examination of the efficacy of particular procedures or operations.                                                                                                                                                    | Sparling (1962), Bolande (1969), Lewis (1969), Russe (1969), Bunker (1970), Monsma (1970), Griner and Liptzin (1971), Fuchs (1972d), Rourke (1972), and Blackstone (1974).                                                                                                                          |



The task of assessing more rigourously the quantitative impact of each of these factors on hospital cost levels over time has been undertaken in a number of recent econometric analyses. These studies are reviewed in Chapter Four following an analysis of the extent and causes of hospital cost inflation in New Zealand during a recent 10 year period.

## CHAPTER THREE

### Hospital Cost Inflation in New Zealand

#### 3.1 Introduction

This chapter is devoted to an analysis of the nature and extent of hospital cost inflation in recent years, and the identification of the factors responsible for that inflation. It begins with a description of the extent of hospital cost inflation in New Zealand in a recent ten year period. This is followed by an examination of the factors, both demand and supply related, thought to be responsible for the cost increases.

#### 3.2 The Extent of Hospital Cost Inflation in New Zealand

The cost of running New Zealand's public hospitals has increased substantially in recent years (Table 3.1). Total hospital maintenance costs rose by 147.9 per cent or 9.5 per cent annually, from \$44.2 million in 1962 to \$109.6 million in 1971. Comparison with the Consumer Price Index,<sup>1</sup> moreover, suggests that, in common with overseas experience, the rate of inflation in New Zealand's hospital costs was considerably greater than the rise in the general

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1. Two recent studies have questioned whether this measure is a meaningful price index for medical care and have derived alternative measures based on the costs of treatment of specific illnesses (Scitovsky 1967) and on changes in the prices of insurance plans (Barzel 1969 a).

TABLE 3.1

Measures \*Of Hospital Cost Inflation in New Zealand 1962-71

|                                                                                                                          | Total<br>Hospital<br>Maintenance<br>Costs(a) | Average<br>Cost<br>Per<br>Case(a) | Average<br>Cost<br>Per<br>Patient<br>Day (a) | Average<br>Cost<br>Per<br>Adjusted<br>Patient<br>Day(a) | Consumer<br>Price<br>Index(b)<br>(All Groups)<br>1965 = 1000 |
|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-----------------------------------|----------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------|
|                                                                                                                          | (\$m)                                        | (\$)                              | (\$)                                         | (\$)                                                    |                                                              |
| 1962                                                                                                                     | 44.2                                         | 170.1                             | 9.9                                          | 6.7                                                     | 916                                                          |
| 1963                                                                                                                     | 47.9                                         | 179.2                             | 10.7                                         | 7.1                                                     | 935                                                          |
| 1964                                                                                                                     | 52.9                                         | 190.9                             | 11.5                                         | 7.6                                                     | 967                                                          |
| 1965                                                                                                                     | 59.2                                         | 206.8                             | 12.7                                         | 8.0                                                     | 1000                                                         |
| 1966                                                                                                                     | 67.6                                         | 230.2                             | 14.2                                         | 9.0                                                     | 1028                                                         |
| 1967                                                                                                                     | 75.0                                         | 247.1                             | 15.6                                         | 9.7                                                     | 1090                                                         |
| 1968                                                                                                                     | 77.3                                         | 243.8                             | 15.6                                         | 9.7                                                     | 1137                                                         |
| 1969                                                                                                                     | 83.0                                         | 254.9                             | 16.6                                         | 10.2                                                    | 1193                                                         |
| 1970                                                                                                                     | 91.9                                         | 277.2                             | 18.1                                         | 11.1                                                    | 1271                                                         |
| 1971                                                                                                                     | 109.6                                        | 321.0                             | 21.5                                         | 12.8                                                    | 1403                                                         |
| % change<br>(1962-71)                                                                                                    | 147.9                                        | 88.7                              | 117.2                                        | 91.0                                                    | 53.2                                                         |
| % change<br>(Annual)                                                                                                     | 9.5                                          | 6.6                               | 8.1                                          | 6.7                                                     | 4.3                                                          |
| Sources: (a) Derived from New Zealand Department of Health,<br><u>Hospital Statistics</u> Wellington (for years 1962-71) |                                              |                                   |                                              |                                                         |                                                              |
| (b) New Zealand Department of Statistics, <u>Official<br/>Yearbook</u> Wellington (1973, p. 670)                         |                                              |                                   |                                              |                                                         |                                                              |
| *These measures are defined in Appendix 3A to this Chapter.                                                              |                                              |                                   |                                              |                                                         |                                                              |

level of prices. Unfortunately, as there is no index of hospital prices for the years in question<sup>1</sup> it is not possible to make a more meaningful comparison between inflation in the hospital sector and in the wider economy.

Increases in average costs were less substantial and varied according to the output unit used - the 'case', the 'patient day' or the 'adjusted patient day'. Of these, the latter measure, a combination of inpatient days and outpatients, more accurately represents the output of the hospital, the scope of whose activities has expanded beyond the traditional inpatient and community services. All three average cost measures do, however, suffer from one common disadvantage: the unit of output in each case is far from being homogeneous both in a given year and, more particularly, over a period of years. Thus, for example, a 'patient day' of hospital care in 1971 is unlikely to be the same as its 1962 equivalent - medical advances in particular have brought about significant changes in hospital care during that period. Changes such as these should be born in mind when making comparisons of unit costs over a period of years.

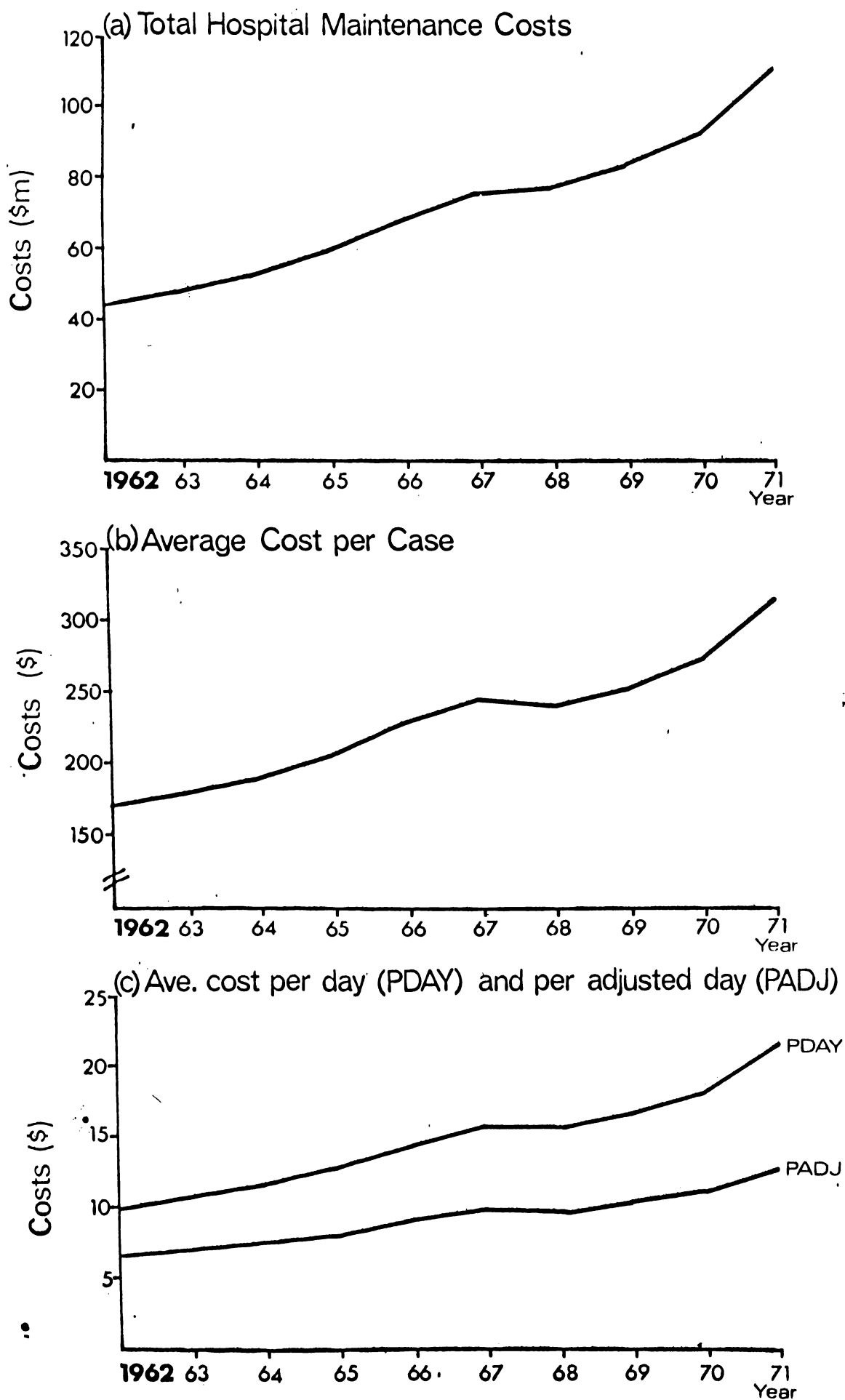
Graphical depiction of the changes in total hospital costs and in the three average cost measures (Figure 3.1) serves to illustrate the pattern and process of hospital cost inflation between 1962 and 1971. The effect of government policy in 1967 to control escalating hospital expenditure can be seen clearly in all three graphs.

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1. A hospital price index based on the intensive study of one of New Zealand's hospital boards has recently been compiled by the Health Department with 1972 as the base year.

FIGURE 3.1

## The Process of Hospital Cost Inflation 1962-1971



Hospital boards have been required since that year to work within allocations drawn up by an Allocations Committee and approved by the Government, whereas previously they had received grants based on their own estimates of expenditure.<sup>1</sup> Although initially these controls contained the rise in hospital costs between 1967 and 1968 to 3.1 per cent which, for the only time in the decade, was less than the rise in the CPI (4.3 per cent), the graphs show that hospital costs subsequently rose at an accelerating rate, particularly in the period 1970 to 1971.

The reasons for New Zealand's hospital cost inflation are now analysed using the same framework as that of Chapter Two.

### 3.3 The Demand Related Causes

Evidence of a rising level of demand for hospital services in New Zealand between 1962 and 1971 is given in Table 3.2. The increase in inpatient utilisation has been moderate (31.3 per cent), and despite an increase in the number of inpatients both in total and per head of population, there has been a small drop (-3.1 per cent) in the number of inpatient days per capita brought about by a 13.4 per cent fall in the average length of stay. Outpatient utilisation, on the other hand, has grown

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1. Although Private Hospitals are beyond the scope of this study, it would be remiss to ignore the importance of the Private Hospital sector in providing inpatient care for a significant proportion of the population in New Zealand. Private hospital beds grew in number from 2879 in 1962 (15.1 per cent of all hospital beds) to 3740 in 1971 (17.2 per cent of all hospital beds), in which year a total of 51,875 general patients were treated (16.5 per cent of all general patients admitted to hospitals in New Zealand). See: N.Z. Hospital Statistics for years 1962 and 1971 and N.Z. Board of Health Report (1974). See also Appendix Table A-12 for statistical details of Private Hospitals and beds in New Zealand.

TABLE 3.2  
Changes in Hospital Utilisation 1962-71

| Year               | Population | Inpatients | Inpatient days | Outpatient visits | Inpatients per 1000 population | Inpatient days per 1000 population | Outpatient visits per 1000 population | Average length of stay* (days) | Occupancy rate* | Case flow rate* |
|--------------------|------------|------------|----------------|-------------------|--------------------------------|------------------------------------|---------------------------------------|--------------------------------|-----------------|-----------------|
|                    | (m)        | (000)      | (000)          | (000)             |                                |                                    |                                       |                                | %               |                 |
| 1962               | 2.44       | 260.0      | 4483.3         | 2110.9            | 107                            | 1840                               | 866                                   | 17.2                           | 75.6            | 16.0            |
| 1963               | 2.50       | 267.4      | 4494.4         | 2291.0            | 107                            | 1798                               | 948                                   | 16.8                           | 75.8            | 16.5            |
| 1964               | 2.55       | 277.2      | 4599.5         | 2368.2            | 109                            | 1803                               | 928                                   | 16.6                           | 78.1            | 17.2            |
| 1965               | 2.60       | 286.4      | 4645.3         | 2756.5            | 110                            | 1783                               | 1058                                  | 16.2                           | 77.6            | 17.4            |
| 1966               | 2.67       | 293.6      | 4746.1         | 2795.0            | 110                            | 1777                               | 1047                                  | 16.2                           | 77.4            | 17.5            |
| 1967               | 2.70       | 303.7      | 4821.2         | 2908.4            | 113                            | 1788                               | 1078                                  | 15.9                           | 77.1            | 17.7            |
| 1968               | 2.74       | 317.3      | 4954.6         | 3008.4            | 116                            | 1810                               | 1099                                  | 15.6                           | 78.7            | 18.4            |
| 1969               | 2.76       | 325.6      | 5013.7         | 3110.1            | 118                            | 1818                               | 1128                                  | 15.4                           | 79.0            | 18.7            |
| 1970               | 2.79       | 331.5      | 5073.9         | 3235.9            | 119                            | 1820                               | 1160                                  | 15.3                           | 77.8            | 18.5            |
| 1971               | 2.85       | 341.4      | 5089.0         | 3491.9            | 120                            | 1783                               | 1223                                  | 14.9                           | 77.6            | 19.0            |
| % change (1962-71) | 17.2       | 31.3       | 13.5           | 65.4              | 12.1                           | -3.1                               | 41.2                                  | -13.4                          | -               | 18.8            |
| % change (annual)  | 1.6        | 2.7        | 1.3            | 5.1               | 1.1                            | -0.3                               | 3.5                                   | - 1.2                          | -               | 1.8             |

Source: Derived from NZ Department of Health, Hospital Statistics, Wellington (for years 1962-71)

\* These measures are defined in Appendix 3A of this chapter.

considerably both in total number (65.4 per cent) and per head of population (41.2 per cent), indicative of the wider role that the hospital has assumed. This increase in the extent and scope of hospital care has had the effect of increasing the total cost of providing that care.

The fall in length of stay from 17.2 to 14.9 days has been accompanied by an 18.8 per cent rise in the number of patients treated per bed per year - the case flow rate. There has at the same time been a relatively stable occupancy rate despite the falling length of stay, due possibly to a reduction in the interval between discharge and admission of patients brought about by the rising pressure on beds resulting from the growth in the number of inpatients.

The relatively fast growth in outpatient visits reflects the trend noted in a number of other countries, although many of the reasons advanced for the increases are not relevant to the New Zealand situation. Price and income related causes, for example, and such occurrences as the growth of insurance coverage for emergency room services in America, cannot be considered relevant to New Zealand where Public Hospital services are provided free of charge to the patients. Likewise, the reduction in hospital occupancy rates noted in America, which has induced physicians to treat more patients on an outpatient basis, has not been occurring in New Zealand: occupancy rates in New Zealand hospitals have fluctuated slightly during the period studied (see Table 3.2), but without any discernible trend.

Perhaps the most relevant factor in explaining the



growth in the utilisation of outpatient facilities in New Zealand is the change that has taken place in the technology and practice of medicine. Advanced laboratory and x-ray facilities as well as certain groups of specialities requiring complex and expensive equipment, such as radiotherapy and renal dialysis, are generally provided only by the hospital. Consequently patients are being referred to outpatient departments in ever increasing numbers by doctors and hospital visiting staff for essential supplementary services which are not available in the doctors surgery. Moreover, many of these patients are referred to outpatient departments for a course of treatment involving a number of visits, which adds an additional impetus to the growth in outpatient numbers.

### 3.3.1 The Economic Factors - Price and Income

In all but a very few instances public hospital care in New Zealand is provided free of charge at the point of consumption, a circumstance which normally can be expected to create a situation of excess demand. Research has shown that the extent of the excess is not as great as it might perhaps be if all persons who felt ill actively sought treatment from the health sector. Fry (1973) has recently estimated, on the basis of a range of surveys in England, that 16 per cent of all symptoms of ill health result in no action, 63 per cent in some attempt at self care, and 20 per cent in a visit to a doctor. The rationing process, therefore, begins with the individual himself, and is carried on by the doctor on whose advice

the patient may or may not be admitted to hospital.

One deterrent to seeking care may be the cost of time associated with travelling to, waiting for and receiving care. The cost of time becomes an important determinant of the demand for all forms of medical care the lower the price charged to the patients. In a system such as New Zealand's therefore, the cost of time assumes a quasi-price function and is likely to have a considerable influence not only on whether or not medical attention is to be sought, but also on the type of care that is sought. One reason for the rising demand for private hospital care in New Zealand may well be that private care is generally less time consuming than public care, a factor that persons on higher incomes with higher opportunity costs of time are likely to take into account when deciding on which form of care they prefer.

The effect of income on demand, as with price, is unlikely to be significant in a state financed hospital system. The only effect is probably an indirect one, for rising real incomes imply a rising standard of living, and a higher level of education, both of which lead to a growing awareness and concern about one's health and wellbeing, and ultimately, therefore, to an increased utilisation of hospital and other health facilities.<sup>1</sup>

### 3.3.2 The Non-Economic Factors

Since the economic factors appear to be of little

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1. Unfortunately there is no evidence to support these a priori hypotheses about the role of economic factors in determining the demand for hospital services in New Zealand.

direct importance in determining the rise in the demand for hospital care in New Zealand the non-economic factors assume a greater significance.

(i) Diagnostic changes

The changing pattern of diseases can be examined in New Zealand as extensive and detailed data on disease incidence and diagnostic mix are available. Table 3.3 shows the numbers and proportions of patients discharged from or dying in public hospitals and their lengths of stay in 1962 and 1968, by the 18 major disease groupings.<sup>1</sup> Although this tabulation does not neatly divide the disease groups into the acute and chronic, certain trends in the disease pattern are apparent. One group of acute diseases - the infective and parasitic diseases - is on the decline both absolutely and proportionately, but a second group - accidents, poisonings and violence - has increased substantially. It is also apparent that the length of stay for patients in certain disease groups - mental and personality disorders, diseases of the nervous system and sense organs and diseases of early infancy - has increased despite the general trend towards a reduction in the length of stay.

In order to assess the changes that have taken place over the seven year period more easily, the diseases are grouped on the basis of the direction and extent of the proportionate changes that have occurred. The numbers and

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1. The International Classification of Diseases (1955 revision) on which these calculations are based, was revised in 1969 making comparison with more recent years impossible.

TABLE 3.3

Patients Discharged From or Dying in Hospital and Average Length of Stay, by Major Disease Groups in 1962 and 1968

| Disease Group<br>I.C.D. (1955)                     | 1962   |       | Average<br>Length of<br>Stay<br>(days) | 1968   |       | Average<br>Length of<br>Stay<br>(days) |
|----------------------------------------------------|--------|-------|----------------------------------------|--------|-------|----------------------------------------|
|                                                    | Number | %     |                                        | Number | %     |                                        |
| 1. Infective and Parasitic Diseases                | 5380   | 2.7   | 40.5                                   | 5061   | 2.1   | 31.0                                   |
| 2. Neoplasms                                       | 14347  | 7.3   | 18.7                                   | 18495  | 7.6   | 17.7                                   |
| 3. Allergic Diseases                               | 5000   | 2.5   | 19.2                                   | 7329   | 3.0   | 16.2                                   |
| 4. Diseases of Blood                               | 982    | 0.5   | 21.1                                   | 1269   | 0.5   | 17.5                                   |
| 5. Mental and Personality Disorders                | 4136   | 2.1   | 19.6                                   | 6174   | 2.5   | 20.2                                   |
| 6. Diseases of the Nervous System and Sense Organs | 12958  | 6.6   | 32.1                                   | 18033  | 7.4   | 34.5                                   |
| 7. Diseases of the Circulatory System              | 16427  | 8.4   | 24.7                                   | 23667  | 9.8   | 23.3                                   |
| 8. Diseases of the Respiratory System              | 23672  | 12.1  | 10.8                                   | 25622  | 10.6  | 10.5                                   |
| 9. Diseases of the Digestive System                | 24331  | 12.4  | 12.0                                   | 25285  | 10.4  | 11.0                                   |
| 10. Diseases of the Genito Urinary System          | 15249  | 7.8   | 12.1                                   | 18118  | 7.5   | 9.9                                    |
| 11. Complications of Pregnancy                     | 10250  | 5.2   | 7.6                                    | 10225  | 4.2   | 7.4                                    |
| 12. Diseases of the Skin and Cellular Tissues      | 5363   | 2.7   | 14.1                                   | 5496   | 2.3   | 11.7                                   |
| 13. Diseases of the Bones and organs of movement   | 9355   | 4.8   | 30.0                                   | 11970  | 4.9   | 28.1                                   |
| 14. Congenital Malformations                       | 3308   | 1.7   | 21.1                                   | 4734   | 2.0   | 17.2                                   |
| 15. Diseases of early infancy                      | 2154   | 1.1   | 16.1                                   | 2626   | 1.1   | 20.0                                   |
| 16. Symptoms, Senility and illdefined conditions   | 11849  | 6.0   | 20.4                                   | 13942  | 5.7   | 17.4                                   |
| 17. Accidents, poisonings and Violence             | 29545  | 15.1  | 13.1                                   | 42091  | 17.4  | 11.7                                   |
| 18. Special Admissions                             | 1904   | 1.0   | 7.1                                    | 2393   | 1.0   | 7.6                                    |
| Totals                                             | 196210 | 100.0 | 17.4                                   | 242530 | 100.0 | 16.5                                   |

Source: N.Z. Department of Health Medical Statistics Part III  
Wellington (for years 1962 and 1968).

proportions of patients in the three resulting groups, as well as their average lengths of stay are given in Table 3.4. Diseases in Group A, which have been increasing as a proportion of all diseases, have also had the longest lengths of stay, whereas Group B diseases, which have been decreasing proportionately, have had the shortest lengths of stay. The rate of decrease in length of stay also differs between groups: group A has had the slowest reduction in length of stay (4.6 per cent) followed by group C (9.4 per cent) and group B (11.9 per cent). In the absence of information on the costs of treating specific diseases in hospital, it can only be surmised that changes in the disease pattern towards those diseases which have longer than average lengths of stay is likely to increase the overall level of cost per case.<sup>1</sup>

(ii) Demographic Changes

Changing disease patterns are partly a reflection of the changing demographic composition of the population, a further non-economic determinant of demand. Table 3.5 indicates the extent and direction of the change in the age-sex composition of New Zealand's population and the changing pattern of hospital utilisation by these demographic groups. Several trends are apparent. In the first place it is clear that while there has been an absolute increase over the period 1961-1971<sup>2</sup> in all age and

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1. This hypothesis, as well as the relationship between changing disease patterns and average cost per patient day, is tested more rigorously in Chapter Five.
  2. This period and the years 1961, 1966 and 1971 have been chosen to correspond with the years in which the censuses of the population were conducted, affording accurate and substantial data on demographic changes in New Zealand.

TABLE 3.4

Major Disease Groups Combined and their Lengths of Stay in 1962 and 1968

|                                                                     | Number of Inpatients                                                                                                                                                                                                                                                                                                                                                                                                               |        | Proportion of Inpatients |      | Average Length of Stay (Days) |      | % Change in Length of Stay |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------|------|-------------------------------|------|----------------------------|
|                                                                     | 1962                                                                                                                                                                                                                                                                                                                                                                                                                               | 1968   | 1962                     | 1968 | 1962                          | 1968 | %                          |
| Group A - Diseases which have increased proportionately (a)         | 71374                                                                                                                                                                                                                                                                                                                                                                                                                              | 102028 | 36.4                     | 42.1 | 20.4                          | 19.5 | -4.6                       |
| Group B - Diseases which have decreased proportionately (b)         | 68996                                                                                                                                                                                                                                                                                                                                                                                                                              | 71689  | 35.1                     | 29.6 | 13.2                          | 11.8 | -11.9                      |
| Group C - Diseases exhibiting little or no proportionate change (c) | 55840                                                                                                                                                                                                                                                                                                                                                                                                                              | 68813  | 28.5                     | 28.3 | 18.7                          | 17.1 | -9.4                       |
|                                                                     | Source: Table 3.3<br>(a) Group A diseases include: Allergic, Mental and Personality, Nervous and Sense Organs, Circulatory System, Congenital Malformations and Accidents.<br>(b) Group B diseases include: Infective and Parasitic, Respiratory, Digestive, Complications of Pregnancy, Skin and Cellular.<br>(c) Group C diseases include: Neoplasms, Blood, Genito Urinary, Bones, Early Infancy, Senility, Special Admissions. |        |                          |      |                               |      |                            |

TABLE 3.5

An Age-Sex Breakdown of Population and Hospital Inpatients 1961, 1966 and 1971

| Age    | Sex | Population (a) |        |        | Total Number of Inpatient Days (b) |        |        | Population Percentages |       |       | Inpatient Days Per Head of Population |      |      | Average Length of Stay (Days) (b) |      |      |
|--------|-----|----------------|--------|--------|------------------------------------|--------|--------|------------------------|-------|-------|---------------------------------------|------|------|-----------------------------------|------|------|
|        |     | 1961           | 1966   | 1971   | 1961                               | 1966   | 1971   | 1961                   | 1966  | 1971  | 1961                                  | 1966 | 1971 | 1961                              | 1966 | 1971 |
|        |     | (000)          | (000)  | (000)  | (000)                              | (000)  | (000)  | %                      | %     | %     |                                       |      |      |                                   |      |      |
| 0-4    | M   | 149.0          | 157.0  | 151.9  | 175.9                              | 185.7  | 191.7  | 6.2                    | 5.8   | 5.3   | 1.18                                  | 1.18 | 1.26 | 13.2                              | 11.7 | 10.4 |
|        | F   | 143.0          | 149.7  | 145.9  | 138.7                              | 142.6  | 147.2  | 5.9                    | 5.6   | 5.1   | 0.97                                  | 0.95 | 1.01 | 14.0                              | 12.6 | 11.2 |
| 5-14   | M   | 259.2          | 289.3  | 312.6  | 170.4                              | 169.0  | 163.2  | 10.7                   | 10.8  | 10.9  | 0.66                                  | 0.58 | 0.52 | 11.6                              | 9.6  | 8.8  |
|        | F   | 247.7          | 276.4  | 299.2  | 125.3                              | 123.4  | 119.1  | 10.3                   | 10.4  | 10.4  | 0.51                                  | 0.45 | 0.40 | 11.3                              | 9.3  | 8.6  |
| 15-44  | M   | 483.1          | 550.5  | 591.6  | 374.6                              | 384.9  | 376.6  | 20.0                   | 20.5  | 20.7  | 0.78                                  | 0.70 | 0.64 | 13.1                              | 10.8 | 9.6  |
|        | F   | 465.7          | 526.3  | 571.0  | 430.9                              | 460.4  | 450.5  | 19.4                   | 19.7  | 20.0  | 0.93                                  | 0.87 | 0.79 | 10.5                              | 9.5  | 8.4  |
| 45-64  | M   | 230.5          | 251.6  | 270.9  | 409.8                              | 439.9  | 432.8  | 9.5                    | 9.4   | 9.5   | 1.78                                  | 1.75 | 1.60 | 21.4                              | 18.1 | 15.7 |
|        | F   | 228.1          | 253.1  | 275.3  | 361.5                              | 408.4  | 401.8  | 9.4                    | 9.5   | 9.6   | 1.59                                  | 1.61 | 1.46 | 20.9                              | 18.0 | 15.7 |
| 65+    | M   | 91.5           | 95.4   | 103.8  | 605.5                              | 656.8  | 727.4  | 3.7                    | 3.5   | 3.6   | 6.62                                  | 6.89 | 7.00 | 36.6                              | 33.0 | 31.2 |
|        | F   | 117.2          | 127.7  | 140.3  | 704.7                              | 830.1  | 919.4  | 4.9                    | 4.8   | 4.9   | 6.01                                  | 6.50 | 6.55 | 46.7                              | 43.1 | 40.7 |
| Totals |     | 2415.0         | 2676.9 | 2862.6 | 3497.4                             | 3801.3 | 3929.7 | 100.0                  | 100.0 | 100.0 | 1.45                                  | 1.42 | 1.37 | 18.8                              | 16.9 | 15.4 |

Source: (a) N.Z. Department of Statistics Census of Population and Dwellings Wellington (for years 1961, 1966, and 1971).

(b) N.Z. Department of Health Medical Statistics Part III Wellington (for years 1961, 1966, and 1971).

sex group numbers, not all groups have increased proportionately. While the teenage and middle age groups have increased as a proportion of the total population, those persons 65 and over have shown little change,<sup>1</sup> and the very young have shown a proportionate decrease. Secondly, the pattern of utilisation by these groups, as measured by the number of days stay per head of population, has also been changing. There had been a decrease in the number of days stay per head in all age and sex groups except those 65 and over for whom utilisation has increased from 6.62 days for men and 6.01 for women to 7.00 and 6.55 respectively. The changes are all the more significant when one observes that persons aged 65 and over stay in hospital more than twice as long, on average, as any other age and sex group. These developments are, to a large extent, the result of the changing pattern of diseases noted in Chapter Two by Roberts (1952) and the differential success that medical science has had with the two main groups of diseases - the acute and the chronic. "The acute it prevents and cures; the chronic, broadly speaking, it can neither prevent nor cure, though it can considerably prolong the lives of sufferers" (ibid, p.90).

In order to assess the effect of changes in the age-sex composition of the population on the level of hospital costs, other developments, in particular changes in technology and

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1. Although there has been little change in the proportion of persons 65 and over, a closer look at this group shows an increase in the very old (75 and over). In addition, the longer life expectancy of women has resulted in a gradual change in the proportion of elderly women to men (N.Z. Department of Health, 1969, p.51).



in the pattern of diseases being treated, are assumed to remain constant. The level of hospital costs will therefore depend on the amount of resources devoted to treating each group, and hence, ultimately, on the nature and severity of the diseases most commonly associated with each group. Measurement of these two elements poses problems. One measure of resource use, length of stay, has its drawbacks, for one cannot assume that longer stay necessarily implies greater resource utilisation - the intensity of each patient day of care should also be accounted for. Comparison of the cost per patient day associated with each age and sex group would be a better measure, but unfortunately no data are collected on the costs of treating individual patients in New Zealand hospitals. Similarly, although data are collected on the diseases for which patients are admitted to hospital, no record is kept of the cost of treating different case types. Thus, while one can describe in detail the diseases associated with each age and sex group, one can only guess at their cost.

Perhaps the most marked difference between the disease patterns of the age and sex groups is that between the elderly group and the other groups. As we have seen, the elderly group has a disease pattern dominated by "the degenerative conditions, arteriosclerosis with its attendant heart disease, and cancer of various sites" (N.Z. Health Dept. 1969, p.54). We have also seen that these patients stay in hospital a great deal longer and use many more bed days per capita than average. It is likely then that the cost per case of the older, longer stay age group will be

considerably higher than average. Any increase in the proportionate size of this group will therefore have inflationary consequences for the level of hospital costs. Conclusions about possible difference in cost per patient day between the age and sex groups however cannot be made without knowledge of the intensity of resource use associated with each group.

Two further characteristics which affect the pattern of hospital utilisation are the racial composition of the population, and the urban-rural distribution of the population. Table 3.6 presents population and hospital utilisation figures for the two main racial groups in New Zealand. Unfortunately a lack of published material on hospital utilisation by race prior to 1968 and in more recent years has restricted the information presented to the years 1968 and 1969. The hospital utilisation figures in Table 3.6 do, however, show a higher rate of hospital utilisation per 1000 population by the Maori compared with the European, although for both groups the rate has fallen over the two year period. Certain differences in disease incidence between the two groups are known to exist: the incidence of tuberculosis, diseases of the ear, rheumatic fever, pneumonia and bronchitis is higher among Maoris than Europeans. In contrast, the incidence of malignant neoplasms, vascular lesions of the central nervous systems, arteriosclerotic and degenerative heart disease and diseases of the arteries is considerably higher among Europeans than Maoris.<sup>1</sup>

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1. These observations are based on data on diagnosis by race recorded in the Department of Health's Medical Statistics Report (1969 and 1970).

TABLE 3.6

A Comparison of Hospital Utilisation by Race  
in 1968 and 1969\*

|                                | Maoris |       | Europeans |        | Total  |        |
|--------------------------------|--------|-------|-----------|--------|--------|--------|
|                                | 1968   | 1969  | 1968      | 1969   | 1968   | 1969   |
| Population Numbers (000)       | 215.9  | 222.2 | 2540.3    | 2561.8 | 2756.2 | 2784.0 |
| Population Percentages (%)     | 7.8    | 8.0   | 92.2      | 92.0   | 100.0  | 100.0  |
| Hospital Inpatients (000)      | 25.2   | 25.7  | 214.9     | 215.9  | 240.1  | 241.6  |
| Inpatients per 1000 Population | 116.8  | 115.8 | 84.6      | 84.3   | 87.1   | 86.8   |
| Total Inpatient Days (000)     | 400.1  | 396.6 | 3574.4    | 3489.8 | 3974.5 | 3886.4 |
| Average Length of Stay         | 15.9   | 15.4  | 16.6      | 16.2   | 16.6   | 16.1   |

Source: N.Z. Department of Health, Medical Statistics, Part III, Wellington (for years 1968 and 1969).

\* Some of the figures in this table differ from those presented in earlier tables as a result of data base differences between the 'Hospital Statistics' and 'Medical Statistics' reports. The latter report includes only those patients who died or were discharged from hospital during a given year and excludes those patients in hospital at the end of a year as well as maternity and 'non-hospital' patients.

European patients appear to remain in hospital longer than Maori patients, although, again, the average length of stay for both groups has fallen. The apparent trend towards a larger proportionate Maori population suggested in the table is consistent with a well documented trend which has been occurring since the turn of the century, and which is largely due to the high birth rates of Maoris compared with

Europeans. Maori numbers have increased from 45,549 in 1901, to 227,414 in 1971 which represents a proportionate increase from 5.6 per cent to 8.0 per cent of the total population.<sup>1</sup>

The effect of changes in the racial composition of the population on the level of hospital costs depends on any variation there might be between the types of diseases associated with each racial group.<sup>2</sup> As with the age sex groups, however, lack of data on the costs of treating different diagnoses prevents further analysis of the costs of these particular diseases.

The final demographic factor that is thought to influence the demand for hospital care is the continuing urban drift of populations which is occurring throughout the world.<sup>3</sup> In New Zealand, between 1961 and 1971, the proportion of the population in urban areas rose from 76.4 per cent to 81.5 per cent, accompanied by a corresponding fall in the proportions of the population in rural areas (Table 3.7). The distribution of the population between the North and South Island also changed during this period, due largely to the more rapid population growth in the North of the North Island compared with the remainder of New Zealand.

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1. N.Z. Department of Statistics, Census (1971), p.10.
  2. Several New Zealand studies have shown that the incidence of certain diseases varies between Maoris and Europeans, and between Maoris and other Polynesians. See, for example, Prior et al. (1966), Beavan (1974), and Prior (1974).
  3. For evidence of this movement see Roberts (1952), Chester (1972), and Fuchs (1972 c).

TABLE 3.7

Rural-Urban and Inter-Island Movement in New Zealand  
In 1961, 1966 and 1971

| Year                                                                                                         | Urban Population |               | Rural Population |               | North of North Island Population |               | South of North Island Population |               | South Island Population |               |
|--------------------------------------------------------------------------------------------------------------|------------------|---------------|------------------|---------------|----------------------------------|---------------|----------------------------------|---------------|-------------------------|---------------|
|                                                                                                              | No. (m)          | as % of total | No. (m)          | as % of total | No. (m)                          | as % of total | No. (m)                          | as % of total | No. (m)                 | as % of total |
| 1961                                                                                                         | 1.84             | 76.4          | 0.57             | 23.6          | 1.00                             | 41.3          | 0.69                             | 28.5          | 0.73                    | 30.2          |
| 1966                                                                                                         | 2.12             | 79.3          | 0.55             | 20.7          | 1.14                             | 42.7          | 0.75                             | 28.0          | 0.78                    | 29.3          |
| 1971                                                                                                         | 2.33             | 81.5          | 0.53             | 18.5          | 1.26                             | 44.2          | 0.79                             | 27.5          | 0.81                    | 28.3          |
| Source: N.Z. Department of Statistics, <u>Census of Population and Dwellings</u> , Wellington (1971), pp3-4. |                  |               |                  |               |                                  |               |                                  |               |                         |               |

The effect of changing population distribution on the level of hospital costs is not entirely predictable. On the one hand, the rise in the number of persons living in urban areas brings with it an increase in the incidence of certain diseases, particularly those associated with the stresses of urban living, such as heart diseases and mental and personality disorders. On the other hand, the higher population density of urban areas may lead to a reduction in the admission rate and average length of stay because of the wider availability of alternative ambulatory care as well as the shorter travel distances to hospital in urban compared with rural areas. Since the former situation is more likely to increase costs per case while the latter tends to decrease them, the overall effect on costs is not certain.

### (iii) Attitudinal Changes

Changing public attitudes to medical care in New Zealand is a trend that has been noted by the New Zealand Health Department which describes them in the following manner:

Due to expanded means of mass communication and rising standards of education, the public are becoming increasingly exposed to information and viewpoints of very variable quality on a wide range of medical topics..... Patients and relatives know sufficient of the mysteries and superficial science of medicine to assume a more informed interest in their maladies. (N.Z. Dept. of Health, 1969, p.59.)

A more informed, more affluent public, being more interested and concerned about their health and welfare can be expected to demand more medical care of all kinds, thereby increasing their utilisation of hospital and other health facilities. There is, however, no evidence to

support this apparent change of attitude in New Zealand, apart from a recent study by Dixon et al (1974) which attempts simply to ascertain the attitudes of the public to the present provision of hospital and other health services in New Zealand, particularly with regard to the relative merits of the public and private hospital sectors. Future follow-up studies along similar lines will go some way towards monitoring changing public attitudes to medical care in New Zealand.

The final non-economic factor responsible for rising levels of demand for hospital care is the effect of the availability of beds on demand. As in many other countries, the current pattern of hospital distribution in New Zealand is largely a legacy from the late nineteenth century, which was characterised by "a scattered and relatively sparse population, with slow and poor communications and the simpler clinical demands of the medical service of the time" (N.Z. Department of Health, 1969, p.16). In 1971 New Zealand's public hospitals numbered 199<sup>1</sup> and were divided among 31 hospital boards of varying geographical area and population size. Table 3.8 lists these boards and presents figures to show the differences in population size, in hospital bed availability and in hospital utilisation in 1971. Bed availability and usage varies considerably from board to board: there is a marked tendency for board areas with large, expanding, predominantly

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1. 73 of these hospitals are classified as 'general', while the remaining 126 are 'special', that is maternity and non-acute hospitals and old people's homes.

TABLE 3.8

Availability and Utilisation of Hospital Beds  
By Hospital Boards in 1971

| Hospital Board   | Population | Beds Available Per 1000 Population | Beds Used Per 1000 Population | Occupancy rate % |
|------------------|------------|------------------------------------|-------------------------------|------------------|
| Ashburton        | 24504      | 11.2                               | 8.1                           | 72.3             |
| Auckland         | 696330     | 4.3                                | 3.4                           | 79.1             |
| Bay of Plenty    | 33801      | 5.6                                | 4.2                           | 75.0             |
| Cook             | 39911      | 10.0                               | 7.6                           | 76.0             |
| Dannevirke       | 12484      | 12.4                               | 7.9                           | 63.7             |
| Hawkes Bay       | 98241      | 6.8                                | 5.2                           | 76.5             |
| Maniototo        | 2737       | 12.0                               | 7.8                           | 65.0             |
| Marlborough      | 28570      | 9.4                                | 7.3                           | 77.7             |
| Nelson           | 58042      | 6.0                                | 4.8                           | 80.0             |
| North Canterbury | 319097     | 4.8                                | 3.9                           | 81.3             |
| Northland        | 95857      | 8.4                                | 6.3                           | 75.0             |
| Opotiki          | 6558       | 10.0                               | 5.3                           | 53.0             |
| Otago            | 126486     | 7.3                                | 5.7                           | 78.1             |
| Palmerston North | 113090     | 6.5                                | 5.5                           | 84.6             |
| South Canterbury | 56575      | 8.4                                | 7.1                           | 84.5             |
| Southland        | 111149     | 6.4                                | 4.9                           | 76.6             |
| South Otago      | 17138      | 11.7                               | 7.4                           | 63.3             |
| Taranaki         | 92881      | 7.4                                | 5.7                           | 77.0             |
| Taumarunui       | 13520      | 11.2                               | 8.0                           | 71.4             |
| Tauranga         | 55944      | 6.3                                | 5.1                           | 81.0             |
| Thames           | 28866      | 11.4                               | 9.1                           | 79.8             |
| Vincent          | 8520       | 10.1                               | 5.3                           | 52.5             |
| Waiapu           | 4978       | 8.8                                | 5.3                           | 60.2             |
| Waikato          | 289313     | 6.3                                | 4.8                           | 76.2             |
| Waipawa          | 13127      | 12.1                               | 9.2                           | 76.0             |
| Wairarapa        | 45090      | 7.7                                | 5.4                           | 70.1             |
| Wairoa           | 11299      | 11.7                               | 7.5                           | 64.1             |
| Waitaki          | 22510      | 9.6                                | 6.5                           | 67.7             |
| Wanganui         | 74482      | 7.4                                | 5.5                           | 74.3             |
| Wellington       | 320707     | 6.0                                | 4.8                           | 80.0             |
| West Coast       | 33112      | 13.7                               | 9.3                           | 67.9             |
| Totals           | 2854919    | 6.3                                | 4.9                           | 77.8             |

Source: Derived from N.Z. Department of Health, Hospital Statistics, Wellington (1971).



urban populations, such as Auckland, North Canterbury, Palmerston North and Wellington, to have a lower number of beds per 1000 population than board areas with small, relatively static, predominantly rural populations, such as Ashburton, Maniototo, Waipawa and West Coast.

Occupancy rates also vary considerably, though with no apparent pattern. Hospital boards with low bed availability might be expected to use those beds more fully than boards with high bed availability, but there are no clear statistical signs of this relationship. Auckland hospital board, for example, which has a relatively low level of bed availability, has an occupancy rate similar to that of boards such as Thames and Waipawa with a relatively high bed availability. This apparent lack of association between bed availability

TABLE 3.9  
Simple Correlations Between Availability  
and Utilisation Measures

|                   | Population | Beds<br>Available | Beds<br>Used | Occupancy<br>Rate |
|-------------------|------------|-------------------|--------------|-------------------|
| Population        |            |                   |              |                   |
| Beds<br>Available | -0.64      |                   |              |                   |
| Beds Used         | -0.48      | 0.73              |              |                   |
| Occupancy<br>Rate | -0.06      | 0.02              | 0.04         |                   |

Source: Table 3.8

and occupancy is borne out by the low correlation ( $r = 0.02$ ) between the two measures (Table 3.9), leading to the conclusion that the extent of hospital utilisation is not affected by the relative scarcity of beds in a hospital board area.<sup>1</sup>

### 3.4 The Supply Related Causes

Much of the blame for the recent rapid rise in hospital costs in New Zealand has been apportioned to the rising cost of the inputs - both labour and non-labour - used in the production of hospital services (Table 3.10). Labour cost increases in total (186.4 per cent) and per patient day (152.4 per cent) during the 10 year period were substantially greater than the corresponding increases in non-labour costs (84.7 per cent and 62.7 per cent respectively). The labour component of hospital maintenance costs also rose over the period from 62.2 per cent to 71.8 per cent, accompanied by a corresponding fall in the non-labour component. Figure 3.2, which illustrates the comparative movements in average labour and non-labour hospital costs per patient day, shows clearly this tendency

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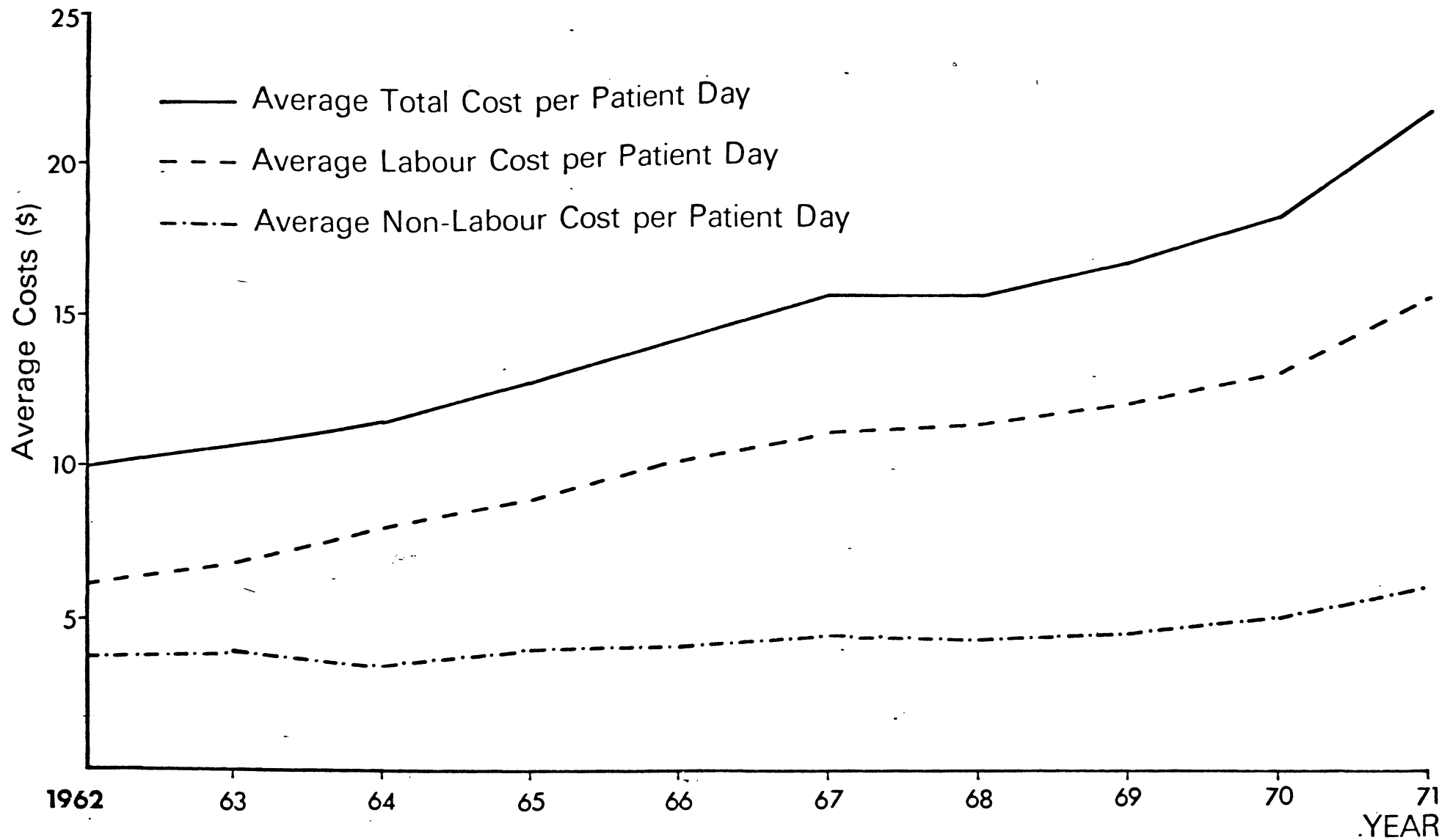
1. Feldstein M. reached a similar conclusion in his study of the British National Health Service (1967 ch.7).

TABLE 3.10  
Inflation in Hospital Labour and Non Labour Costs 1962-71

| Year                  | Total<br>Hospital<br>Maintenance<br>Costs | Total<br>Labour<br>Costs | Total<br>Non Labour<br>Costs | Labour<br>Costs as a<br>Percentage<br>of Total<br>Costs | Non Labour<br>Costs as a<br>Percentage<br>of Total<br>Costs | Total Cost<br>Per Patient<br>Day | Labour<br>Cost per<br>Patient<br>Day | Non Labour<br>Cost Per<br>Patient<br>Day |
|-----------------------|-------------------------------------------|--------------------------|------------------------------|---------------------------------------------------------|-------------------------------------------------------------|----------------------------------|--------------------------------------|------------------------------------------|
|                       | (\$m)                                     | (\$m)                    | (\$m)                        | (%)                                                     | (%)                                                         | (\$)                             | (\$)                                 | (\$)                                     |
| 1962                  | 44.2                                      | 27.5                     | 16.7                         | 62.2                                                    | 37.8                                                        | 9.86                             | 6.13                                 | 3.73                                     |
| 1963                  | 47.9                                      | 30.5                     | 17.4                         | 63.7                                                    | 36.3                                                        | 10.65                            | 6.78                                 | 3.87                                     |
| 1964                  | 52.9                                      | 36.9                     | 16.0                         | 69.8                                                    | 30.2                                                        | 11.50                            | 8.02                                 | 3.47                                     |
| 1965                  | 59.2                                      | 41.4                     | 17.8                         | 69.9                                                    | 30.1                                                        | 12.74                            | 8.91                                 | 3.83                                     |
| 1966                  | 67.6                                      | 48.1                     | 19.5                         | 71.2                                                    | 28.8                                                        | 14.24                            | 10.13                                | 4.10                                     |
| 1967                  | 75.0                                      | 53.8                     | 21.3                         | 71.7                                                    | 28.3                                                        | 15.55                            | 11.15                                | 4.41                                     |
| 1968                  | 77.3                                      | 56.0                     | 21.4                         | 72.4                                                    | 27.6                                                        | 15.60                            | 11.30                                | 4.31                                     |
| 1969                  | 83.0                                      | 60.0                     | 23.0                         | 72.3                                                    | 27.7                                                        | 16.55                            | 11.96                                | 4.58                                     |
| 1970                  | 91.9                                      | 66.0                     | 25.9                         | 71.8                                                    | 28.2                                                        | 18.11                            | 13.00                                | 5.10                                     |
| 1971                  | 109.6                                     | 78.7                     | 30.9                         | 71.8                                                    | 28.2                                                        | 21.53                            | 15.46                                | 6.07                                     |
| % Change<br>(1962-71) | 147.9                                     | 186.4                    | 84.7                         | -                                                       | -                                                           | 117.2                            | 152.4                                | 62.7                                     |
| % Change<br>(Annual)  | 9.5                                       | 11.1                     | 6.4                          | -                                                       | -                                                           | 8.1                              | 9.7                                  | 5.0                                      |

Source: Derived from N.Z. Department of Health, Hospital Statistics, Wellington (for years 1962-71)

FIGURE 3.2  
Increasing Hospital Labour and Non-Labour Costs Per Patient Day 1962-1971



for labour costs to increase as a proportion of total hospital costs. The graph also shows that the level of average total costs is largely determined, and increasingly so, by the extent of average labour costs.

#### 3.4.1 The Rising Cost of Labour Inputs

The substantial increases in the costs of the labour inputs required to run New Zealand's public hospitals in recent years are due to the growth in hospital staff numbers and to rising wage levels (Table 3.11). Hospital staff numbers have risen in absolute terms by 36.7 per cent from 21.3 thousand in 1962 to 29.1 thousand in 1971, and per occupied bed by 20.2 per cent from 1.73 to 2.08 over the 10 year period. These increases are largely due to the widening role of the hospital, particularly in its expanding outpatient and community functions, and to the many medical and technical advances in hospital care, both of which require an increase in the number of staff employed. Table 3.11 also shows that an increasing proportion of the total New Zealand labour force is being employed in the hospital industry, from 23.3 per thousand in 1962 to 26.1 per thousand in 1971, reflecting the general trend noted in many advanced countries for labour to move into the service sectors of the economy.

The average annual earnings of New Zealand's hospital staff rose by 109.6 per cent in the period 1962 to 1971, an annual rate of 7.7 per cent. The three hypotheses advanced to explain this increase are the changing level of staff skills, the catching-up process, and the lag in

TABLE 3.11

## Hospital Staff Numbers and Earnings 1962-71

| Year                  | Total Full Time<br>Equivalent Hospital<br>Staff* |                             |                        | Average<br>Annual<br>Earnings* |
|-----------------------|--------------------------------------------------|-----------------------------|------------------------|--------------------------------|
|                       | Total<br>Number                                  | Per 1000<br>Labour<br>Force | Per<br>Occupied<br>Bed |                                |
|                       | (000)                                            |                             |                        | (\$)                           |
| 1962                  | 21.3                                             | 23.3                        | 1.73                   | 1292                           |
| 1963                  | 22.4                                             | 24.0                        | 1.82                   | 1365                           |
| 1964                  | 23.1                                             | 24.1                        | 1.84                   | 1600                           |
| 1965                  | 24.3                                             | 24.5                        | 1.91                   | 1701                           |
| 1966                  | 25.6                                             | 25.0                        | 1.97                   | 1876                           |
| 1967                  | 26.5                                             | 25.2                        | 2.01                   | 2029                           |
| 1968                  | 26.3                                             | 25.2                        | 1.94                   | 2130                           |
| 1969                  | 27.5                                             | 25.9                        | 2.00                   | 2184                           |
| 1970                  | 28.0                                             | 25.7                        | 2.02                   | 2355                           |
| 1971                  | 29.1                                             | 26.1                        | 2.08                   | 2708                           |
| % Change<br>(1962-71) | 36.7                                             | 12.0                        | 20.2                   | 109.6                          |
| % Change<br>(Annual)  | 3.2                                              | 1.1                         | 1.8                    | 7.7                            |

Source: Derived from N.Z. Department of Health,  
Hospital Statistics, Wellington (for  
years 1962-71).

\* These measures are defined in Appendix 3A  
to this chapter.

productivity gains.

(i) The Level of Staff Skills

An indication of the extent and direction of any changes in hospital staff skills can be obtained through an examination of the occupational composition of the hospital labour force and the level and distribution of its earnings. The eleven occupational groupings analysed are aggregates of many different occupations<sup>1</sup> and therefore are not ideally suited for the purpose of examining the distribution of skills as the level of skills may be changing within each broad grouping. However, it is possible to determine whether or not there has been a shift from the less technical non-treatment occupations to the more technical treatment occupations.

A comparison of the growth in treatment and non-treatment staff numbers (Table 3.12) indicates a faster growth rate in the former group, particularly the "other treatment" group which, although relatively small in numbers, increased by 127.2 per cent over the period. Some of the non-treatment staff (e.g. housekeeping and ground-staff) showed a decrease in numbers, particularly in 1968 as a direct result of the tight controls introduced by government in that year on the financial allocations to hospital boards. Cuts were made in non-treatment staff numbers rather than in the more essential treatment staff.<sup>2</sup>

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1. A detailed description of the staff categories included under each of the eleven groups is given in Appendix 3B to this chapter. This classification is used by the Health Department and is the one on which the Health Department Statistics are based.
  2. Source: private correspondence, Waikato Hospital Board, Hamilton.

TABLE 3.12  
Numbers of Full-time Equivalent Hospital Staff by Occupation 1962-71\*

| Year               | Treatment Staff |                                  |         |                 |                 | Non-Treatment Staff          |             |               |         |             |         |                   |                     | All Staff Total |
|--------------------|-----------------|----------------------------------|---------|-----------------|-----------------|------------------------------|-------------|---------------|---------|-------------|---------|-------------------|---------------------|-----------------|
|                    | Medical         | Other Professional and Technical | Nursing | Other Treatment | Treatment Total | Institutional Administration | Engineering | House Keeping | Dietary | Maintenance | Grounds | Laundry and Linen | Non-Treatment Total |                 |
| 1962               | 736.3           | 1657.3                           | 10042.5 | 384.3           | 12820.3         | 1447.0                       | 497.3       | 2675.8        | 1478.8  | 664.8       | 351.3   | 1329.8            | 8444.5              | 21264.8         |
| 1963               | 819.3           | 1754.3                           | 10686.8 | 400.0           | 13660.3         | 1491.0                       | 518.3       | 2791.8        | 1506.3  | 679.5       | 355.8   | 1350.0            | 8692.5              | 22352.8         |
| 1964               | 878.8           | 1941.5                           | 11051.3 | 410.5           | 14282.0         | 1558.3                       | 553.3       | 2775.3        | 1537.8  | 648.5       | 349.5   | 1375.8            | 8798.3              | 23080.3         |
| 1965               | 943.0           | 2093.8                           | 11679.3 | 405.0           | 15121.0         | 1702.3                       | 563.3       | 2884.0        | 1607.3  | 680.0       | 345.5   | 1425.3            | 9207.5              | 24328.5         |
| 1966               | 925.5           | 2339.5                           | 12626.3 | 423.0           | 16314.3         | 1807.5                       | 554.3       | 2822.8        | 1616.8  | 687.8       | 340.8   | 1480.3            | 9310.0              | 25624.3         |
| 1967               | 1002.5          | 2536.5                           | 12852.8 | 478.0           | 16869.8         | 1949.8                       | 564.8       | 2927.0        | 1644.8  | 698.5       | 346.3   | 1506.5            | 9637.5              | 26507.3         |
| 1968               | 1053.0          | 2604.8                           | 13085.3 | 575.5           | 17318.5         | 1927.0                       | 574.3       | 2522.0        | 1519.8  | 642.3       | 330.0   | 1444.5            | 8959.8              | 26278.3         |
| 1969               | 1093.5          | 2833.5                           | 13827.0 | 610.8           | 18364.8         | 2002.0                       | 584.0       | 2612.8        | 1503.0  | 666.5       | 331.3   | 1418.0            | 9117.5              | 27482.3         |
| 1970               | 1140.0          | 3047.0                           | 14110.3 | 617.0           | 18914.3         | 2188.8                       | 598.5       | 2340.5        | 1528.0  | 684.5       | 319.0   | 1446.0            | 9105.3              | 28019.6         |
| 1971               | 1309.1          | 2896.0                           | 14350.0 | 873.2           | 19428.3         | 2403.1                       | 736.5       | 2262.5        | 1663.2  | 685.1       | 328.2   | 1554.5            | 9633.1              | 29061.4         |
| % Change (1962-71) | 77.8            | 74.7                             | 42.9    | 127.2           | 51.5            | 66.1                         | 48.1        | - 15.5        | 12.5    | 3.1         | - 6.6   | 16.9              | 14.1                | 36.7            |
| % Change (Annual)  | 5.9             | 5.8                              | 3.6     | 8.6             | 4.3             | 5.2                          | 4.0         | - 1.5         | 1.2     | 0.3         | - 0.7   | 1.6               | 1.3                 | 3.2             |

Source: Derived from N.Z. Department of Health Hospital Statistics Wellington, (for years 1962-71)

\*See the Appendix 3B to this Chapter for details of occupations included under each of these broad headings.



The slower growth of non-treatment staff numbers could also be due to the greater scope for the introduction of labour saving devices in these occupations, in contrast to the treatment occupations.

The marked swing towards the more skilled treatment staff and away from the less skilled non-treatment staff is illustrated in Table 3.13. Treatment staff composed 66.9 per cent of total staff numbers in 1971 compared with 60.3 per cent in 1962. All treatment groups showed proportionate increases and nursing, which is by far the largest treatment group rose from 47.2 per cent in 1962 to 49.4 per cent of the total in 1971. The largest non-treatment group, the administrative staff, increased from 6.8 to 8.3 per cent over the same period, while all the remaining non-treatment groups apart from engineers showed proportionate declines in numbers.

When full time equivalent hospital staff numbers are expressed in relation to the number of occupied beds (Table 3.14), the shift towards the more technical treatment occupations is once again apparent. Treatment staff per occupied bed increased by 33.7 per cent from 1.04 to 1.39 persons, while non-treatment staff, after a considerable drop in 1968, regained their original level of 0.69 persons per occupied bed. 'Other treatment' staff (100 per cent increase) and administrative staff (41.7 per cent increase) again showed the largest increases in the two main categories of staff.

Turning from the composition of the hospital labour force to an analysis of the level and distribution of its earnings, Table 3.15 presents estimates of the average

TABLE 3.13  
Percentage Distribution of Full-time Equivalent Hospital Staff 1962-71

| Year | Treatment Staff |                                  |         |                 |                 | Non-Treatment Staff          |             |               |         |             |         |                   |                     | All Staff Total |
|------|-----------------|----------------------------------|---------|-----------------|-----------------|------------------------------|-------------|---------------|---------|-------------|---------|-------------------|---------------------|-----------------|
|      | Medical         | Other Professional and Technical | Nursing | Other Treatment | Treatment Total | Institutional Administration | Engineering | House Keeping | Dietary | Maintenance | Grounds | Laundry and Linen | Non-Treatment Total |                 |
|      | %               | %                                | %       | %               | %               | %                            | %           | %             | %       | %           | %       | %                 | %                   | %               |
| 1962 | 3.5             | 7.8                              | 47.2    | 1.8             | 60.3            | 6.8                          | 2.3         | 12.6          | 7.0     | 3.1         | 1.7     | 6.3               | 39.7                | 100.0           |
| 1963 | 3.7             | 7.9                              | 47.8    | 1.8             | 61.1            | 6.7                          | 2.3         | 12.5          | 6.7     | 3.0         | 1.6     | 6.0               | 38.9                | 100.0           |
| 1964 | 3.8             | 8.4                              | 47.9    | 1.8             | 61.9            | 6.8                          | 2.4         | 12.0          | 6.7     | 2.8         | 1.5     | 6.0               | 38.1                | 100.0           |
| 1965 | 3.9             | 8.6                              | 48.0    | 1.7             | 62.2            | 7.0                          | 2.3         | 11.9          | 6.6     | 2.8         | 1.4     | 5.9               | 37.8                | 100.0           |
| 1966 | 3.6             | 9.1                              | 49.3    | 1.7             | 63.7            | 7.1                          | 2.2         | 11.0          | 6.3     | 2.7         | 1.3     | 5.8               | 36.3                | 100.0           |
| 1967 | 3.8             | 9.6                              | 48.5    | 1.8             | 63.6            | 7.4                          | 2.1         | 11.0          | 6.2     | 2.6         | 1.3     | 5.7               | 36.4                | 100.0           |
| 1968 | 4.0             | 9.9                              | 49.8    | 2.2             | 65.9            | 7.3                          | 2.2         | 9.6           | 5.8     | 2.4         | 1.3     | 5.5               | 34.1                | 100.0           |
| 1969 | 4.0             | 10.3                             | 50.3    | 2.2             | 66.8            | 7.3                          | 2.1         | 9.5           | 5.5     | 2.4         | 1.2     | 5.2               | 33.2                | 100.0           |
| 1970 | 4.1             | 10.9                             | 50.4    | 2.2             | 67.5            | 7.8                          | 2.1         | 8.4           | 5.5     | 2.4         | 1.1     | 5.2               | 32.5                | 100.0           |
| 1971 | 4.5             | 10.0                             | 49.4    | 3.0             | 66.9            | 8.3                          | 2.5         | 7.8           | 5.7     | 2.4         | 1.1     | 5.3               | 33.1                | 100.0           |

TABLE 3.14

Full-time Equivalent Hospital Staff Per Occupied Bed 1962-71

| Year               | Treatment Staff |                                  |         |                 |                 | Non-Treatment Staff          |             |               |         |             |         |                   |                     | All Staff Total |
|--------------------|-----------------|----------------------------------|---------|-----------------|-----------------|------------------------------|-------------|---------------|---------|-------------|---------|-------------------|---------------------|-----------------|
|                    | Medical         | Other Professional and Technical | Nursing | Other Treatment | Treatment Total | Institutional Administration | Engineering | House Keeping | Dietary | Maintenance | Grounds | Laundry and Linen | Non-Treatment Total |                 |
| 1962               | 0.06            | 0.14                             | 0.82    | 0.03            | 1.04            | 0.12                         | 0.04        | 0.22          | 0.12    | 0.05        | 0.03    | 0.11              | 0.69                | 1.73            |
| 1963               | 0.07            | 0.14                             | 0.87    | 0.03            | 1.11            | 0.12                         | 0.04        | 0.23          | 0.12    | 0.06        | 0.03    | 0.11              | 0.71                | 1.82            |
| 1964               | 0.07            | 0.15                             | 0.88    | 0.03            | 1.14            | 0.12                         | 0.04        | 0.22          | 0.12    | 0.05        | 0.03    | 0.11              | 0.70                | 1.84            |
| 1965               | 0.07            | 0.17                             | 0.92    | 0.03            | 1.19            | 0.13                         | 0.04        | 0.23          | 0.13    | 0.05        | 0.03    | 0.11              | 0.72                | 1.91            |
| 1966               | 0.07            | 0.18                             | 0.97    | 0.03            | 1.25            | 0.14                         | 0.04        | 0.22          | 0.12    | 0.05        | 0.03    | 0.11              | 0.72                | 1.97            |
| 1967               | 0.08            | 0.19                             | 0.97    | 0.04            | 1.28            | 0.14                         | 0.04        | 0.22          | 0.12    | 0.05        | 0.03    | 0.11              | 0.73                | 2.01            |
| 1968               | 0.08            | 0.19                             | 0.97    | 0.04            | 1.28            | 0.14                         | 0.04        | 0.19          | 0.11    | 0.05        | 0.02    | 0.11              | 0.66                | 1.94            |
| 1969               | 0.08            | 0.21                             | 1.01    | 0.04            | 1.34            | 0.15                         | 0.04        | 0.19          | 0.11    | 0.05        | 0.02    | 0.10              | 0.66                | 2.00            |
| 1970               | 0.08            | 0.22                             | 1.02    | 0.04            | 1.36            | 0.16                         | 0.04        | 0.17          | 0.11    | 0.05        | 0.02    | 0.10              | 0.66                | 2.02            |
| 1971               | 0.09            | 0.21                             | 1.03    | 0.06            | 1.39            | 0.17                         | 0.05        | 0.16          | 0.12    | 0.05        | 0.02    | 0.11              | 0.69                | 2.08            |
| % Change (1962-71) | 50.0            | 50.0                             | 25.6    | 100.0           | 33.7            | 41.7                         | 25.0        | -27.3         | -       | -           | -33.3   | -                 | -                   | 20.2            |
| % Change (Annual)  | 4.1             | 4.1                              | 2.3     | 7.2             | 3.0             | 3.6                          | 2.3         | - 2.4         | -       | -           | - 2.9   | -                 | -                   | 1.8             |

Source: Derived from N.Z. Department of Health Hospital Statistics Wellington, (for years 1962-71)

TABLE 3.15

Average Annual Earnings of Hospital Staff 1962-71

| Year               | Treatment Staff |                                  |         |                 |                 | Non-Treatment Staff          |             |               |         |             |         |                   |                     | All Staff Total |
|--------------------|-----------------|----------------------------------|---------|-----------------|-----------------|------------------------------|-------------|---------------|---------|-------------|---------|-------------------|---------------------|-----------------|
|                    | Medical         | Other Professional and Technical | Nursing | Other Treatment | Treatment Total | Institutional Administration | Engineering | House Keeping | Dietary | Maintenance | Grounds | Laundry and Linen | Non-Treatment Total |                 |
|                    | \$              | \$                               | \$      | \$              | \$              | \$                           | \$          | \$            | \$      | \$          | \$      | \$                | \$                  | \$              |
| 1962               | 4081            | 1500                             | 936     | 1672            | 1212            | 1582                         | 2045        | 1273          | 1319    | 1846        | 1448    | 1163              | 1415                | 1292            |
| 1963               | 4004            | 1583                             | 1023    | 1777            | 1296            | 1678                         | 2100        | 1308          | 1365    | 1940        | 1519    | 1223              | 1473                | 1365            |
| 1964               | 4043            | 1618                             | 1441    | 1836            | 1636            | 1722                         | 2110        | 1381          | 1428    | 2124        | 1604    | 1271              | 1542                | 1600            |
| 1965               | 4540            | 1759                             | 1510    | 1975            | 1745            | 1836                         | 2404        | 1440          | 1500    | 2123        | 1671    | 1356              | 1629                | 1701            |
| 1966               | 5230            | 1729                             | 1767    | 2142            | 1965            | 1933                         | 2557        | 1585          | 1662    | 2360        | 1813    | 1140              | 1719                | 1876            |
| 1967               | 5361            | 1880                             | 1907    | 2051            | 2112            | 2093                         | 2649        | 1673          | 1820    | 2465        | 1835    | 1535              | 1882                | 2029            |
| 1968               | 5815            | 2005                             | 1995    | 1985            | 2229            | 2238                         | 2736        | 1686          | 1835    | 2536        | 1886    | 1525              | 1940                | 2130            |
| 1969               | 6137            | 2040                             | 1995    | 2303            | 2259            | 2317                         | 2845        | 1758          | 1956    | 2538        | 1888    | 1675              | 2032                | 2184            |
| 1970               | 6764            | 2234                             | 2128    | 2355            | 2432            | 2410                         | 3113        | 1951          | 2017    | 2812        | 2136    | 1791              | 2195                | 2355            |
| 1971               | 7336            | 2722                             | 2410    | 2647            | 2799            | 2858                         | 3511        | 2338          | 2142    | 2831        | 3356    | 1917              | 2525                | 2708            |
| % Change (1962-71) | 79.8            | 81.5                             | 157.5   | 58.3            | 130.9           | 80.7                         | 71.7        | 83.7          | 62.4    | 53.4        | 131.8   | 64.8              | 78.4                | 109.6           |
| % Change (Annual)  | 6.1             | 6.2                              | 9.9     | 4.7             | 8.7             | 6.1                          | 5.6         | 6.3           | 4.9     | 4.3         | 8.8     | 5.1               | 5.9                 | 7.7             |

Source: Derived from N.Z. Department of Health Hospital Statistics Wellington, (for years 1962-71)

annual earnings of hospital staff. While initially non-treatment staff earned more (\$1415) on average than treatment staff (\$1212), this situation was reversed in 1964, and by 1971 the average annual earnings of non-treatment staff stood at \$2525 and of treatment staff at \$2799. This partly reflects the addition of more highly skilled and trained treatment staff who would command higher salaries and partly an increase in relative wages. The level of average earnings in 1971 ranged from \$7336 (medical staff) to \$1917 (laundry and linen staff).

The greatest percentage increases in wages went to Nurses (157.5 per cent) who for many years have been regarded as one of the lowest paid professional groups in New Zealand. This is apparent from their earnings, particularly in the early 1960's - in 1962 the average annual salary of a hospital nurse was \$936, well below the average for all staff of \$1292. Their substantial salary increases since then can be regarded as a catching-up process with the other groups, although their 1971 average figure of \$2410 is still below the average for all staff of \$2708.

There appears to be a consistent trend not only toward a hospital labour force composed of proportionately more treatment staff, but also toward more highly paid occupations. This trend can be tested more rigorously, through the use of index numbers, by comparing the actual increase in the average annual earnings of hospital staff groups, with the increase that would have occurred had the composition of the hospital labour force remained unchanged. The approach used here is similar to that employed by Feldstein M. (1971 b) and Davis and Foster

(1972) in their analyses of the changing skill mix of staff in American hospitals.

Two indices are defined. An Unadjusted Earnings Index ( $I_1$ ) which relates average annual earnings in a given year for occupational groups to average annual earnings in the base year (1962):

$$I_1 = \frac{\sum_{i=1}^k E_{i,t} S_{i,t} / \sum_{i=1}^k S_{i,t}}{\sum_{i=1}^k E_{i,62} S_{i,62} / \sum_{i=1}^k S_{i,62}} \cdot 1000$$

where

$E_{i,t}$  = average annual earnings of staff group  $i$  in year  $t$

$E_{i,62}$  = average annual earnings of staff group  $i$  in 1962

$S_{i,t}$  = number of full time equivalent staff in staff group  $i$  in year  $t$

$S_{i,62}$  = number of full time equivalent staff in staff group  $i$  in 1962

and  $i = 1, \dots, k$

The second index ( $I_2$ ) is an Adjusted Earnings Index which indicates how much earnings would have risen over the ten year period if the composition of the hospital labour force had remained the same as it was in the initial year:

$$I_2 = \frac{\sum_{i=1}^k E_{i,t} S_{i,62} / \sum_{i=1}^k S_{i,62}}{\sum_{i=1}^k E_{i,62} S_{i,62} / \sum_{i=1}^k S_{i,62}} \cdot 1000$$

which simplifies to:

$$I_2 = \frac{\sum_{i=1}^k E_{i,t} S_{i,62}}{\sum_{i=1}^k E_{i,62} S_{i,62}} \cdot 1000$$

If a change toward a higher level of skills has taken place over the period, the unadjusted earnings index will rise more rapidly than the adjusted index. Comparison of the two indices (Table 3.16) shows that this in fact did occur, as the unadjusted index rose by 109.6 per cent, while the adjusted index rose 103.9 per cent. The conclusion is, therefore, that the composition of hospital staff has shifted towards relatively higher paid and more highly skilled occupations. This change can be regarded as an improvement in 'effective labour input',<sup>1</sup> defined as the ratio between the unadjusted and adjusted earnings indices. Effective labour input in New Zealand's hospitals, therefore, increased by 2.8 per cent over the 10 year period thereby increasing the relative contribution that staff per occupied bed made to the increase in labour cost per patient day. Table 3.17 shows that the 109.6 per cent increase in the average annual earnings of hospital staff represents an 84.4 per cent contribution to rising labour cost per patient day, while the 20.2 per cent increase

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1. See Feldstein M. (1971 b, p.56), who found a falling effective labour input of 2.5 per cent for American Metropolitan-Area hospitals between 1963 and 1966.

TABLE 3.16

Average Annual Earnings Indices(a)  
For Hospital Staff 1962-71

| Year                  | Unadjusted<br>Earnings<br>Index<br>(I <sub>1</sub> ) | Adjusted<br>Earnings<br>Index<br>(I <sub>2</sub> ) |
|-----------------------|------------------------------------------------------|----------------------------------------------------|
| 1962                  | 1000                                                 | 1000                                               |
| 1963                  | 1057                                                 | 1054                                               |
| 1964                  | 1238                                                 | 1232                                               |
| 1965                  | 1317                                                 | 1307                                               |
| 1966                  | 1452                                                 | 1447                                               |
| 1967                  | 1570                                                 | 1559                                               |
| 1968                  | 1649                                                 | 1623                                               |
| 1969                  | 1690                                                 | 1665                                               |
| 1970                  | 1823                                                 | 1790                                               |
| 1971                  | 2096                                                 | 2039                                               |
| % Change<br>(1962-71) | 109.6                                                | 103.9                                              |
| % Change<br>(Annual)  | 7.7                                                  | 7.4                                                |

Source: Tables 3.12 and 3.15

(a) Base Year 1962 = 1000

in staff numbers per occupied bed represents a 15.6 per cent contribution to rising labour cost per patient day. When the 2.8 per cent improvement in effective labour input is taken into account, the relative contribution of staff per occupied bed to rising labour cost per patient day is increased from 15.6 per cent to 18.4 per cent, thereby reducing the contribution of average annual earnings from 84.4 per cent to 81.6 per cent. Increasing labour cost per patient day, then, was largely the result of the rising average annual earnings of hospital staff



TABLE 3.17  
Components of the Rise in Labour Cost  
Per Patient Day 1962-71

| Components                                | Percentage Increase 1962-71 | Percentage Contribution To Rising Labour Cost Per Patient Day | Adjusted Percentage Contribution To Account For Rising Staff Skills |
|-------------------------------------------|-----------------------------|---------------------------------------------------------------|---------------------------------------------------------------------|
|                                           | %                           | %                                                             | %                                                                   |
| Average annual earnings of hospital staff | 109.6                       | 84.4                                                          | 81.6                                                                |
| Hospital staff per occupied bed           | 20.2                        | 15.6                                                          | 18.4                                                                |
| Labour cost per patient day               | 152.4                       | 100.0                                                         | 100.0                                                               |

during the period 1962 to 1971.

(ii) The Catching-up Hypothesis

A comparison between the average annual earnings of staff in hospitals and in other industries between 1962 and 1971 (Table 3.18), shows that although the earnings of hospital staff, both treatment and non-treatment, have increased more rapidly, this 'catching-up' has not brought hospital earnings up to those in the rest of the economy.<sup>1</sup>

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1. Comparison between such broad occupational groupings does have its problems. In particular the age and sex composition of the groups may be very different. A large proportion of hospital staff, for example, are female and relatively young (the nursing staff). Both these factors would tend to impart a downward bias on the average annual earnings of all hospital staff relative to other broad occupational groups. Problems such as these, should be borne in mind when comparisons of average earnings are being made.

TABLE 3.18  
Average Annual Earnings of Staff in Hospitals  
and Other Industries 1962-71

|                    | Staff in Other Industries (a) |                                 | Hospital Staff     |                 |                     |
|--------------------|-------------------------------|---------------------------------|--------------------|-----------------|---------------------|
|                    | All Industries                | Personal and Community Services | All Hospital Staff | Treatment Staff | Non-Treatment Staff |
|                    | (\$)                          | (\$)                            | (\$)               | (\$)            | (\$)                |
| 1962               | 1658                          | 1092                            | 1292               | 1212            | 1415                |
| 1963               | 1723                          | 1154                            | 1365               | 1296            | 1473                |
| 1964               | 1736                          | 1172                            | 1600               | 1636            | 1542                |
| 1965               | 1924                          | 1234                            | 1701               | 1745            | 1629                |
| 1966               | 1983                          | 1264                            | 1876               | 1965            | 1719                |
| 1967               | 2095                          | 1315                            | 2029               | 2112            | 1882                |
| 1968               | 2166                          | 1655                            | 2130               | 2229            | 1940                |
| 1969               | 2308                          | 1468                            | 2184               | 2259            | 2032                |
| 1970               | 2492                          | 1528                            | 2355               | 2432            | 2195                |
| 1971               | 2946                          | 2730 <sup>(b)</sup>             | 2708               | 2799            | 2525                |
| % Change (1962-71) | 77.7                          | 39.8 <sup>(c)</sup>             | 109.6              | 130.9           | 78.4                |
| % Change (Annual)  | 5.9                           | 3.4                             | 7.7                | 8.7             | 5.9                 |

(a) Source: N.Z. Department of Statistics, Prices, Wages and Labour Statistics, Wellington (for years 1962-71)

(b) The considerable increase in this figure compared with earlier years is due to a change in the occupational composition of the group to include Professional and Administrative occupations.

(c) Increase from 1962-70 only because of (b) above.

However, when comparison is made between the earnings of hospital staff and those of staff in the domestic and personal service sector of the economy, hospital staff appear to be considerably better off. This may be due, in part, to the different occupational composition of the two groups as 'domestic and personal' service staff prior to 1971 did not include professional and administrative employees, two groups which generally receive higher earnings than average and which are included amongst the hospital staff numbers. Inclusion of these employees in the 1971 labour statistics increased the average annual earnings of the domestic and personal service staff to \$2730, a similar figure to that for hospital staff in that year.

Part of the responsibility for the gains in the earnings of hospital staff relative to other sectors of the economy is due to the expansion in the demand for hospital staff. It has already been shown (see Table 3.11 above) that an increasing proportion of the labour force is being employed in hospitals due not only to the introduction of new and more sophisticated techniques requiring more staff per occupied bed, but also to the expansion of the role of the hospital particularly in the provision of outpatient services. In order to attract additional, and as it appears, more skilled staff away from other industries and into the hospitals, higher and more competitive wages are required. Economy wide influences have also contributed to the rising earnings of hospital staff. Five 'General Wage Orders', for example, were granted between 1962 and 1971 giving wage increases to all

salary and wage earners amounting to a total of 19 per cent.<sup>1</sup>

(iii) Productivity Gains

Most research on productivity changes in New Zealand has been directed towards the manufacturing and farming sectors.<sup>2</sup> Moreover, when mention is made of the service sector of the economy, the distinction between the 'Distribution and Personal services', and 'other services' (which include the Professional services, Health, Education, Government Administration and Finance) is rarely made. An exception is a comparatively early study of Blyth (1961) of New Zealand's economic growth in the period 1950-60, in which he finds evidence of a slow national rate of productivity growth (output per head of the labour force) of 1.2 per cent per annum. Lack of sufficient information on the 'other service' sector of the economy, however, led Blyth to arbitrarily assume that its rate of productivity growth was zero. In view of the many problems encountered in measuring the productivity of New Zealand's service sector, the question of productivity gains in the hospital industry and their effect on the level of average hospital earnings remains unresolved.

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1. The dates on which these orders came into effect, and the amounts of the orders are as follows: 26 July 1962, 2.5%; 10 September 1964, 6%; 1 December 1966, 2.5%; 19 August 1968, 5%; 23 November 1970, 3%. (N.Z. Department of Labour 1962, 1963,....., 1971). For a detailed description of the institutional framework, legislation and procedural steps behind minimum wage adjustments in New Zealand see The N.Z. Official Yearbook (1966) and Mardle (1968).
  2. See, for example, Blyth (1961 and 1965), Blyth and Hamer (1963), and more recently the comparative international study of Eatwell, Llewellyn and Tarling (1974). For a recent review of productivity studies of New Zealand's farming sector, see Johnson R. (1972).

### 3.4.2 The Rising Cost of Non-Labour Inputs

During the period 1962 to 1971 the cost of non-labour inputs for New Zealand's hospitals rose by 84.7 per cent (Table 3.10), while the proportionate contribution of non-labour costs fell from 37.8 per cent of total hospital running costs to 28.2 per cent.<sup>1</sup> A more detailed breakdown of these aggregate cost figures (Table 3.19) reveals some interesting differences in the cost rises of the various hospital inputs, which range from the substantial rise of 221.2 per cent in the cost of treatment inputs, to the relatively low increase of 34.2 per cent in the cost of dietary inputs. Above average cost increases were also recorded for Institutional Administration and Household purposes. These increases are the result of increases in both the prices and quantities of inputs but unfortunately the quantity of non-labour inputs cannot be measured in physical terms in the same way as labour inputs. The physical units are neither as homogenous nor as easily identifiable, nor are any statistics kept on the quantities of non-labour inputs used and their prices in New Zealand.<sup>2</sup> Estimates of the quantity of non-labour inputs (Table 3.19),

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1. Non-labour inputs, for the purposes of this study, include items such as supplies, dressings, drugs, chemicals, instruments, appliances, x-ray films, heat, light, power, food and so on, but exclude capital items such as depreciation, rent and interest due to a lack of suitable data.
  2. It is hoped that, with the recent construction of a preliminary hospital price index (N.Z. Department of Health, 1974), statistics on the quantities and prices of non-labour hospital inputs will be collected systematically on a New Zealand-wide basis.

TABLE 3.19  
Estimated Total Costs of Non-labour Inputs<sup>(1)</sup> 1962-71

| Year                  | Treatment | Heat<br>Light<br>Power<br>and<br>Water | Institut-<br>ional<br>Adminis-<br>tration | Household<br>Expenses | Dietary | Actual<br>Total<br>Non<br>Labour<br>Costs <sup>(2)</sup> | Wholesale<br>Price<br>Index<br>(1958=1000) | Non<br>Labour<br>Inputs<br>in 1958<br>Prices |
|-----------------------|-----------|----------------------------------------|-------------------------------------------|-----------------------|---------|----------------------------------------------------------|--------------------------------------------|----------------------------------------------|
|                       | (\$m)     | (\$m)                                  | (\$m)                                     | (\$m)                 | (\$m)   | (\$m)                                                    |                                            |                                              |
| 1962                  | 2.6       | 2.5                                    | 1.2                                       | 3.7                   | 3.9     | 16.7                                                     | 1016                                       | 16.4                                         |
| 1963                  | 2.9       | 2.5                                    | 1.1                                       | 4.0                   | 4.0     | 17.4                                                     | 1050                                       | 16.6                                         |
| 1964                  | 3.1       | 2.8                                    | 1.3                                       | 4.4                   | 4.1     | 16.0                                                     | 1097                                       | 14.6                                         |
| 1965                  | 3.7       | 2.8                                    | 1.4                                       | 4.9                   | 4.4     | 17.8                                                     | 1109                                       | 16.1                                         |
| 1966                  | 4.1       | 3.1                                    | 1.6                                       | 5.5                   | 4.5     | 19.5                                                     | 1120                                       | 17.4                                         |
| 1967                  | 4.9       | 3.3                                    | 1.7                                       | 6.0                   | 4.6     | 21.3                                                     | 1122                                       | 19.0                                         |
| 1968                  | 5.2       | 3.3                                    | 1.7                                       | 5.9                   | 4.5     | 21.4                                                     | 1206                                       | 17.7                                         |
| 1969                  | 6.0       | 3.5                                    | 1.8                                       | 6.4                   | 4.4     | 23.0                                                     | 1271                                       | 18.1                                         |
| 1970                  | 7.0       | 3.8                                    | 2.1                                       | 7.3                   | 4.6     | 25.9                                                     | 1335                                       | 19.4                                         |
| 1971                  | 8.4       | 4.0                                    | 2.4                                       | 8.7                   | 5.3     | 30.9                                                     | 1446                                       | 21.4                                         |
| % Change<br>(1962-71) | 221.2     | 61.2                                   | 108.8                                     | 135.5                 | 34.2    | 84.7                                                     | 42.3                                       | 30.0                                         |
| % Change<br>(Annual)  | 12.4      | 4.9                                    | 7.6                                       | 9.0                   | 3.0     | 6.4                                                      | 3.6                                        | 2.7                                          |

Source: N.Z. Department of Health, Hospital Statistics, Wellington (for years 1962-71)  
and N.Z. Department of Statistics, Official Yearbook, Wellington (1973, p. 671).

(1) See Appendix 3C of this chapter for details of these inputs.

(2) The discrepancy between the actual and estimated total non labour costs is due primarily to the exclusion of the item 'Buildings and Grounds' for which no division between labour and non labour costs is given in the Hospital Statistics.

derived by deflating non-labour costs by the Wholesale Price Index, which is thought to be the best available measure of changes in the costs of non-labour hospital inputs, suggest that these inputs rose by 30 per cent from 1962 to 1971 while their prices rose 42.3 per cent. The rates of increase in the quantities of inputs used under each input category varied considerably, with by far the largest increase being in treatment inputs. The two reasons advanced to explain the increase in the cost of non-labour inputs are the changing technology of medicine and the inefficient and wasteful utilisation of resources.

(i) Expanding and Advancing Medical Technology

There is no doubt that numerous advances have been made in the medical technology of New Zealand's hospital care in recent years, a number of which have been highlighted by the Health Department in a recent review of New Zealand's hospital services (1969). The growing concern with heart disease, for example, has led to the intensive study of its causes and "to the development of special departments to deal with the diagnosis and treatment of these conditions: special cardiac x-ray units for heart catheterisation and other specialised techniques, open heart surgery units for the surgical treatments of cardiac conditions, and coronary care units where patients are admitted for investigation and treatment with the aid of specialised monitoring and resuscitative equipment" (ibid, p.54).

Other proxy measures of advancing medical technology are the improvements in the skill level of staff in New Zealand's hospitals, and the rapid growth in the quantity of x-ray and pathological procedures undertaken. Evidence

of the former has already been given above, while Table 3.20 gives figures in support of the latter. The most notable feature of this table is the rapid growth in the number of pathological tests conducted in New Zealand hospitals, due mainly to the striking developments in Pathology in recent years. The Health Department's Review (1969) describes these developments as follows:

Within Pathology itself the specialities of biochemistry, haematology, microbiology, and morbid anatomy have developed and separated rapidly and hospitals are required to provide these services not only for their own inpatients but also to serve the needs of outpatients and the patients of private Practitioners" (ibid, p.27).

The rise in the number of x-ray procedures, both diagnostic and therapeutic, has also been substantial. Here again the Health Department gives the following reasons for their growth:

Rapid advances in cardiac and vascular surgery and in neurosurgery have contributed to the increasing load on diagnostic x-ray services and to marked demand for the sophisticated equipment and the personnel necessary for its operation and maintenance. Concurrently there has also been progress in the basic diagnostic x-ray services .....(as well as in the field of) radio-isotopes, and the scanning techniques associated with the use of these substances for diagnostic purposes (ibid, p.28).

One further indication of changing medical technology is given by comparing certain categories of hospital costs which one would expect to be responsive to changes in technology with other categories that are unlikely to be affected. Tables 3.15 and 3.19 indicate that, by and large, this is the sort of pattern that New Zealand has been experiencing. There have, for example, been above average increases in treatment costs, in the numbers and earnings of skilled treatment



TABLE 3.20  
Proxy Measures of Technological Change 1962-71

| Year               | X-Rays: Diagnostic Examinations |                       | X-Rays: Therapy Treatments |                       | Pathology: Tests |                       | Pathology: Post Mortems |                       |
|--------------------|---------------------------------|-----------------------|----------------------------|-----------------------|------------------|-----------------------|-------------------------|-----------------------|
|                    | Number                          | Per 1000 Patient Days | Number                     | Per 1000 Patient Days | Number           | Per 1000 Patient Days | Number                  | Per 1000 Patient Days |
|                    | (000)                           |                       | (000)                      |                       | (000)            |                       | (000)                   |                       |
| 1962               | 659.7                           | 147.1                 | 96.6                       | 21.6                  | 2058.8           | 459.2                 | 4.3                     | 1.0                   |
| 1963               | 701.9                           | 156.2                 | 95.1                       | 21.2                  | 2286.4           | 508.7                 | 4.3                     | 0.9                   |
| 1964               | 766.7                           | 166.7                 | 100.2                      | 21.8                  | 2673.3           | 581.2                 | 4.7                     | 1.0                   |
| 1965               | 807.9                           | 173.9                 | 96.6                       | 20.8                  | 3346.7           | 720.5                 | 4.5                     | 1.0                   |
| 1966               | 835.0                           | 175.9                 | 132.1                      | 27.8                  | 3844.5           | 810.0                 | 4.9                     | 1.0                   |
| 1967               | 858.1                           | 178.0                 | 111.4                      | 23.1                  | 4703.8           | 975.6                 | 6.1                     | 1.3                   |
| 1968               | 806.2                           | 162.7                 | 119.1                      | 24.0                  | 5002.7           | 1009.7                | 5.9                     | 1.2                   |
| 1969               | 894.5                           | 178.4                 | 134.7                      | 26.9                  | 5911.8           | 1179.1                | 6.0                     | 1.2                   |
| 1970               | 899.1                           | 177.2                 | 135.2                      | 26.6                  | 6289.2           | 1239.5                | 6.0                     | 1.2                   |
| 1971               | 952.4                           | 187.1                 | 154.2                      | 30.3                  | 7380.6           | 1450.3                | 6.0                     | 1.2                   |
| % Change (1962-71) | 44.4                            | 27.2                  | 59.6                       | 40.3                  | 258.5            | 215.8                 | 38.8                    | 20.0                  |
| % Change (Annual)  | 3.7                             | 2.4                   | 4.8                        | 3.4                   | 13.6             | 12.2                  | 3.4                     | 1.8                   |

Source: Derived from New Zealand Department of Health, Hospital Statistics, Wellington (for years 1962-71)

staff and in the numbers of laboratory and radiology procedures. On the other hand, the increases in the cost of housekeeping, dietary and administrative activities have been moderate by comparison.

(ii) Inefficient and Wasteful Use of Resources

There is no published evidence to suggest inefficient or wasteful utilisation of resources in New Zealand's hospitals, which is not to say, however, that it does not occur. It is often argued, for example, that centrally administered and financed health and hospital systems, such as New Zealand's, suffer from the common disadvantage that there is a lack of incentive to minimise waste and hence cost or to maximise efficiency in the use of resources.<sup>1</sup> One factor that may help to prevent waste and inefficiency is the existence of a system of national and regional specialties which is intended to ensure that sophisticated and expensive medical equipment is only available in certain hospital boards. Thus, for example, in 1968 cardiology and cardiac surgery were available only in the Auckland and Wellington hospital boards; neuro-surgical units were available only in the Auckland, Wellington and Otago boards; and plastic surgery was provided only by units in the Auckland, Wellington and North Canterbury boards. Should patients from outside these board areas require treatment involving a national

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1. This argument has frequently been raised in the controversy over whether hospital and health services should be provided and financed publicly or privately. See, for example, Jewkes (1961), Lees (1960 and 1961) and Feldstein M. (1963 b).

or regional specialty they are transported to the nearest hospital board equipped with the relevant facility. Lack of published evidence on hospital efficiency in New Zealand does not allow any conclusions to be made. Nevertheless, a number of writers have recently called for improvements in the efficiency and effectiveness of the hospital and other health services.<sup>1</sup>

### 3.5 Summary

This chapter has presented an analysis of the extent and causes of hospital cost inflation in New Zealand. Substantial increases have occurred during the ten year period under study in both the total and average costs of running New Zealand's public hospitals, and the rate of increase appears to be accelerating rather than abating.

It has been shown on the demand side that while changing prices and incomes appear to have had little effect, the non-economic factors such as changing disease patterns, changing age and race composition, changing attitudes and the availability of beds have had a marked impact on the demand for hospital care, which has risen considerably during the period studied. The exact effect of this growth in demand on the level of hospital costs, however, is not clear, although certain changes - in diagnostic mix and in age composition, for example - lead

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1. See, for example, Heggie (1970), Glennie (1974), Morris (1974) and Burch (1975), as well as N.Z. Government, "A Health Service for New Zealand" (1974).

one to suspect that rising demand exerts an upward pressure on hospital cost levels. This hypothesis is tested more rigorously in Chapter Five.

On the supply side there is evidence of a substantial rise in the costs of both labour and non-labour hospital inputs. New Zealand's rising hospital labour costs appear to be due to a growth in staff numbers and also to a rapid increase in staff earnings, which reflect a small improvement in skill levels and a movement towards parity with the earnings of occupations in other sectors of the economy. Rising non-labour hospital costs are due primarily to the many advances made in the science and technology of medicine which have led to the introduction of more sophisticated equipment and techniques for the treatment of patients.

It is apparent from the analysis presented in this chapter that many of the forces which have been responsible for rising hospital costs in other countries of the world have also played their part in determining the level of hospital costs in New Zealand. The significance of the various factors is analysed in Chapter Five.

## APPENDIX TO CHAPTER 3

APPENDIX 3A: Explanation of terms used in Chapter 3

1. Total hospital maintenance costs per year - equivalent to the 'institutional maintenance payments' listed in NZ Department of Health Hospital Statistics.
2. Average cost per case - total hospital maintenance costs per year divided by the number of inpatients treated per year.
3. Average cost per patient day - total hospital maintenance costs per year divided by the total number of inpatient days per year.
4. Average cost per adjusted patient day - total hospital maintenance costs per year divided by the number of adjusted patient days (i.e. inpatient days + outpatients) per year.
5. Average length of stay - total inpatient days per year divided by the total number of inpatients per year.
6. Occupancy rate - beds used per year divided by beds available per year x 100.
7. Case flow rate - total number of inpatients per year divided by the number of available beds per year.
8. Full-time equivalent hospital staff - one quarter the number of part-time employees per year added to the number of full-time employees per year. The assumption that four part-time staff are equivalent to one full-time staff member is an estimate based on information received from the Health Department and substantiated by comparisons with statistics for more recent years (since 1971) which are expressed as full-time equivalents based on the number of hours worked by staff.
9. Average annual earnings - total salary payments to hospital staff per year divided by the number of full-time equivalent hospital staff per year.

### APPENDIX 3B: Occupations included under Broad Staff Groupings

#### Treatment Staff

- a) Medical - Consultants, Registrars and other Physicians.
- b) Other Professional and Technical - Dental Officers, X-ray workers, Laboratory Workers, Physiotherapists and Students, Dental Technicians, Clinical Photographers, Orthopaedic Technicians, Occupational Therapists and Occupational Therapy Aids, Pharmacists and Apprentice Pharmacists, Other Technical Staffs.
- c) Nursing - Matrons, Tutor Sister, Supervisors, Ward and Theatre Sisters, Staff Sisters, Staff Nurses, Registered Nurses, Community Nurses, Nurse Aids, Student Nurses, Maternity Nurses, Midwifery Students, and Other Nurses.
- d) Other Treatment Staff - Theatre Attendants, Medical Orderlies, etc., Medical Social Workers employed substantially with inpatients; Medical, Technical or Nursing Staff engaged in Sterile Supply Units, Solutions Manufacturing Units, Blood Transfusion and similar Units.

#### Non-Treatment Staff

- a) Institutional Administration Staff - Telephonists, Enquiry Clerks, Clinic Clerks, Medical Record Clerks, Typists and Clerical and Administration Staff attached to institutions, House Managers, Storemen, Stores Clerks, Motor Mechanics, Drivers, Personnel Officers, Manager or Master of Old People's Homes, Supply Officer, Transport Officer.
- b) Engineering Staff - Engineers, Electricians, Firemen, Stokers, Plant Mechanics (Fitters), Engine Drivers, Trimmers, and Other Boiler Plant Employees.
- c) Housekeeping Staff - Staff engaged in cleaning, dishwashing, removal of refuse; distribution of stores, linen, dispensary supplies; waiting at tables, serving meals etc.; general portering, household or domestic duties; home sisters and supervisors engaged solely in duties relating to the Nurses' Home.
- d) Laundry and Linen Service Staff - Laundry Manager, Laundresses, Laundrymen, Linenkeepers, Seamstresses and Linenmaids.

- e) Dietary Staff - Dieticians and Students, Food Supervisors, Chefs, Cooks, Kitchenmaids, Kitchenhands, Butchers and Bakers.
- f) Maintenance Staff - Works Superintendent, Carpenters, Painters, Plumbers, Plasterers, Labourers, etc.
- g) Grounds Staff - Gardeners, Groundsmen, Labourers employed in the upkeep of grounds.

#### APPENDIX 3C: Details of Non-Labour Inputs

- a) Treatment - dressings, drugs and chemicals, instruments and appliances, x-ray films, and other materials and expenses.
- b) Heat, light, power and water - materials, supplies, repairs and renewals.
- c) Institutional administration - supplies and expenses, including postage, office printing and stationery supplies etc.
- d) Household expenses - uniforms and materials, bedding and crockery, repairs and renewals, and contract services.
- e) Dietary - food supplies.

## CHAPTER FOUR

### Econometric Studies of Hospital Cost Inflation

#### 4.1 Introduction

In contrast to descriptive studies of hospital cost inflation which seek simply to identify those factors which appear to be responsible for rising hospital costs, econometric analyses employ multiple regression techniques in order to estimate the relative impact of a number of relevant variables on the level of hospital costs over time. This chapter is devoted to a review of a number of recent econometric studies of hospital cost inflation, all of which have been undertaken in America. It begins with a description of the data and methods employed and the results obtained in each study, and concludes with a critical evaluation of these studies.

#### 4.2 The Studies and their Results

In one of the earliest econometric analyses of hospital cost inflation, Lave and Lave (1970 d) sought to identify a number of the characteristics associated with hospitals experiencing rapidly rising costs. Using semi-annual data for the period 1961 to 1967 for 74 Pennsylvanian hospitals they estimated a number of cost functions with two alternative procedures. The first involved the estimation of individual functions for each hospital relating



average cost to measures of utilisation, size, and time; after this a search was made to identify the causes of the variation in the estimated parameters among hospitals. The second, which was based on the assumption that there was no interhospital variation in cost functions, estimated a single cost function from pooled cross-section time-series data for the seven year period.

Results for the former procedure showed that average costs increased at a mean rate of 3.28 per cent per year, that variable cost was on average 40 per cent of total cost, and that there was no evidence of a significant relationship between average cost and hospital size. The factors that explained the variance in the inflation coefficient across hospitals were found to be the initial cost level (hospitals with high initial average costs tended to have relatively smaller rates of cost increase); the size of the hospital (large hospitals tended to have relatively larger rates of cost increase); the initial utilization rate (hospitals with high initial utilization tended to have relatively smaller rates of cost increase); and the teaching function of the hospital (hospitals with 'advanced' and 'regular' teaching programs averaged a higher rate of cost inflation than hospitals with no teaching program). Results for the latter procedure in most respects supported these results, although the utilization and size variables became insignificant, and the role of the initial level of cost was altered: "hospitals with initial high cost .... had higher rates of cost increase during 1961-64 and lower rates of cost increase during 1965-67" (Ibid, p.392). A later study by

the same authors (1970 b), which included annual data on 35 additional hospitals from Eastern Pennsylvania, produced broadly similar results.

The main objective of these two studies - to identify those variables which accounted for the faster than average cost increases displayed by some Pennsylvanian hospitals - sets them apart from subsequent analyses, all of which are concerned with identifying the main determinants of the cost increases for all hospitals over time.

In a number of studies Feldstein M. (1971 b, 1971 c, 1974a) has argued that the rising level of demand for hospital services constitutes the most significant single cause of hospital inflation in the United States in recent years. Increasing demand for hospital care, according to Feldstein, results both from people's desire to purchase a greater number of days of hospital care at a given price, and also from their willingness to pay more for a given improvement in 'perceived quality' which he defines as "increases in the efficiency of medical care, increases in the comfort of hospital stay, and changes in medical practice that patients believe increase the efficiency of care, even if they do not in fact" (1971b p.24). The response of hospitals to this increased demand is to increase the number of inputs per patient day - more staff, more equipment and more supplies - rather than to increase the number of bed days of care. These increases in the quality of resource inputs account for the major share of the increased cost per patient day experienced by American hospitals.

Feldstein (1971 c) has incorporated these arguments

into a formal econometric model of the American hospital industry which includes equations to describe the determinants of the demand for hospital care, the process of price adjustment to changing demand, the relationship between the prices charged for hospital services and their cost, and the adjustment of hospital capacity in the long run. Using a pooled cross section of time series for individual states for the period 1958-1967 Feldstein has estimated what is essentially a model of "dynamic price adjustment to excess demand" (ibid, p.854). Quality of care and the price of hospital services are assumed to adjust, with a lag, to an equilibrium price chosen by the hospital, subject to the constraint on the quality and quantity of care that is implied by the new demand curve.

Feldstein's results indicate a rather slow price and quality response: "only about one-fourth of the gap between actual and equilibrium price is eliminated each year" (1974 a, p.396). This relatively slow response Feldstein argues, suggests that "rather substantial price increases may continue for some time, even if there is no additional stimulus to demand" (1971 c, p.870). The results also point to a substantial price elasticity of demand for hospital bed days, and a positive relationship between the availability of beds and the quantity of bed days demanded. In addition, Feldstein shows that a high ratio of general practitioners to population is associated with a lower demand for hospital care, while a high specialist to population ratio is associated with a higher demand.

Several studies have employed reduced form models to explain the determinants of hospital cost inflation. Salkever

(1972), in the first of these studies, examines the determinants of the costs of 86 non-federal hospitals in South Eastern New York State for the years 1961 to 1967. A behavioural model of hospital cost inflation is developed which comprises a demand function, a factor-supply function, a production function, a product mix function and a hospital preference function. In its reduced form, the model assumes that average cost per patient day is a multiplicative function of the factors affecting the demand for hospital services, measures of factor costs, hospital preferences and last year's level of average cost. The empirical results indicate that a variety of factors contributed to cost inflation in these hospitals, including increased insurance coverage, the advent of Medicare, and the rising general level of inflation as measured by the consumer and wholesale price indexes. Salkever also found that average cost per patient day responds slowly to changes in these factors - 'estimated adjustment speeds' found were consistently less than 10 per cent per year. As with Feldstein's findings, the implication of this result is that recent hospital cost inflationary rates will be slow to disappear even if no significant new inflationary forces come into play in the near future.

Two studies by Davis also utilize a reduced form specification to examine the causes of hospital cost inflation in America. The first (Davis 1973 a) is an analysis of three alternative hypotheses of hospital inflation - the demand-pull hypothesis, the labour cost-push hypothesis, and, in particular, the cost-plus reimbursement hypothesis. Davis develops a theoretical

model to explain the cost-reimbursement theory which predicts that hospital costs will not be increased unless the number of patients covered by third party insurance schemes that reimburse hospital costs exceeds 95 per cent of all patients treated. This hypothesis which is tested with a single reduced form equation and with aggregate hospital data for each state for the years 1965, 1967 and 1968, is rejected on the basis of the empirical results presented. Variables that Davis found to be important in explaining rising hospital costs are average bed size, factor costs and complexity of case-mix.

Davis' second study (1974) represents an attempt to clarify the contribution of demand, labour market conditions and changing technology to the determination of hospital costs in the United States. A structural model of the hospital industry is used as a basis for the construction of a reduced form equation which relates the level of each hospital's average costs to a variety of demand, case-mix, wage and technology variables. This equation is estimated using pooled time-series cross-section data on 200 non-profit hospitals for the period 1962 to 1968. The results indicate that of the predicted increase in costs per hospital admission, demand variables account for 45 per cent of the increase, case-mix variables 7 per cent, increases in the average earnings of hospital employees a further 10 per cent, while technological changes over time are responsible for the remaining 38 per cent of the increase.

Baron in his study of cost inflation in American hospitals (1974) based his specification of the hospital cost function on the assumption that hospitals seek to

minimise the cost of satisfying an exogenous demand for hospital care. Baron specified a Cobb-Douglas function with six factor inputs - nursing labour hours, ancillary labour hours, professional labour hours, general labour hours, administrative labour hours, and capacity - from which a cost function was derived. An additional parameter,  $\lambda$ , was introduced to take into account technological change in hospital production and changes in the nature of the case mix of hospitals over time. The hospitals studied were also grouped "in order to account, to some extent, for differences in case mix and factor inputs among hospitals" (Ibid, p.42). Estimation of the cost functions using pooled time-series cross-section data for 218 short term general medical and surgical hospitals over the period 1968 to 1971 was undertaken in order to ascertain the amount of hospital cost inflation associated with changes in three determinants of cost: factor prices, technology and case mix, and output levels. No attempt was made to determine the cause of the factor price inflation - indeed, the particular specification used does not allow such conclusions to be made.

The empirical results indicate that the majority of the increase in average costs for the sampled hospitals over the four year period was associated with factor price increases, while changes in technology and case-mix also resulted in significant cost increases, all of which were offset to a relatively minor extent by the effects of increases in hospital output.

Baron also raises the question as to whether this increase in average cost was caused by factor price inflation,

or, indirectly by the increase in demand and its effect on factor prices - the argument earlier advanced by Feldstein (1971 c). Baron feels it is debatable whether or not the relatively modest increase in the demand for hospital care since 1968 has resulted in the substantial increase in factor prices experienced. His results, however, cannot be used in support or refutation of Feldstein's theory, mainly because of the different time periods, hospitals and techniques used in the two studies, and he concludes that resolution of the impact of demand on hospital costs must await further empirical investigation.

#### 4.3 Discussion

In spite of the wide disparity of approach used in these econometric studies of hospital cost inflation a number of common elements can be identified. From a methodological point of view there are similarities in the estimation techniques employed, since all the studies make use of pooled cross-section time-series data specified in multiplicative form and analysed using a double logarithmic transformation so as to yield linear equations. The various equations are then estimated either by an instrumental variables approach (Salkever, 1972, and Feldstein, 1971c) or by ordinary least squares procedures (Lave and Lave, 1970d , Davis, 1974, and Baron, 1974).

There are also common features in the results obtained. Increases in the level of demand for hospital care and changes in input prices, for example, are two factors which are commonly found to be responsible for rising hospital

costs. Of the two, demand appears to be the more important contributing factor in all studies except that of Baron (1974), who does not specifically include demand as an explanatory variable in his model of hospital cost inflation. The actual role assigned to increasing demand for hospital care, however, varies from study to study despite the similarity of results. For while Feldstein (1971c) attributes the whole of hospital cost inflation to the pressure of rising demand, Davis (1974) and Salkever (1972) attribute it to a range of variables including rising demand, labour market conditions, changing technology, changing case-mix and hospital preferences. The question of the relationship between rising levels of demand and increasing factor prices is also debatable particularly in view of the recent modest increases in demand and comparatively large increases in factor prices.

One problem common to all these studies is the lack of detailed diagnostic data for American hospitals which could be used as a basis for the development of a hospital case-mix measure. Absence of this information has led either to the exclusion of the variable altogether or to the inclusion of various proxy measures which attempt to capture the possible inflationary effect of changing case-mix on the level of hospital costs over time. Davis, for example, adjusts for differences in case-mix and in the complexity of cases of particular types, by including in her earlier study (1973) length of hospital stay and the proportion of hospitals possessing various specialised facilities, and in her more recent study (1974) 'redisual mean stay' which she defines as the length of hospital stay



not explained by the various economic, sociodemographic and availability variables appearing in the demand equations, affiliation with a medical school, and the composition of hospital personnel, variously defined. Use of length of stay as a proxy for case-mix complexity is based on the assumption that the longer the stay, *ceteris paribus*, the more complex the diagnosis. Such an assumption however, although used in other related studies (Roemer et al. 1968), has been shown to be unrealistic by Lave and Lave (1971), who argue that complexity of diagnosis is related to the rarity of the condition, the skill of the physician, and the supporting personnel and equipment needed to treat the condition. They construct a measure of case complexity based on an index for charges for surgical procedures which is assumed to reflect "the skill demanded of the surgeon, the amount of his time required, and the difficulty of the procedure" (Ibid, p.25). Correlations between this comparatively direct method of measurement and the length of stay measure used by Roemer et al. are low, suggesting that the Roemer index is not a good surrogate for case complexity.

A further study which attempts to overcome the problem posed by the absence of case-mix information is that of Baron (1974) who groups the hospitals in his sample on the basis of their teaching status, their bed size and the skill mix of their labour inputs in an attempt to control for casemix differences among hospitals. Since the parameter  $\lambda$ , which Baron includes in his equations to account for technological, casemix and quality changes in hospitals over time, is consistently negative for all

hospital groups and for both output measures (admissions and patient days) he argues that "over the 1968-71 period either the casemix changed towards more complex cases, technological progress was negative, and/or the quality of care improved" (ibid p.42). His results indicate that about 30 per cent of the actual increase in average cost per admission and per patient day is accounted for by changes in technology, case-mix and quality of care. While this technique does not permit the assessment of the inflationary impact of each of these changes individually, it provides a useful second-best approximation of the cost effects of the less tangible changes that take place in hospitals over a period of years. Refinement and improvement of these measures will only be possible when detailed diagnostic information becomes readily available for each hospital.

One interesting feature of these studies is the wide variety of approaches adopted in the specification of models of hospital cost inflation, which include the complete structural model developed by Feldstein, the behavioural reduced-form models of Salkever and Davis, the production/cost function model of Baron, and the comparative cost function model of Lave and Lave. With one exception these studies share the common objective of determining the importance of a number of factors in explaining the recent substantial increases in the level of hospital costs in the United States. Lave and Lave, in contrast, are concerned with identifying those variables which account for the faster than average cost increases displayed by certain Pennsylvanian hospitals.

Specification of these models, however, has given rise to a number of problems and criticisms. One such problem is the incomplete specification of the structural models of the hospital system from which the reduced-form equations are derived in the studies of Salkever (1972) and Davis (1974). Both researchers have defined their structural equations in general functional form. Salkever, for example, defines the demand function in his model as:

$$Q_d = f(p_i, D_{1i}, \dots, D_{ni})$$

where  $Q_d$ , the number of days of hospital care demanded is assumed to be a function of a number of demand parameters including price ( $p_i$ ), various demographic and economic variables, and the availability of doctors and hospital beds ( $D_{ni}$ ). Davis divides the demand for hospital care into admissions per capita (ADMPC) and mean length of stay (MS) and defines two demand functions as follows:

$$ADMPC = f(RP, INS, RINC, MDPC, \%GP, BEDSPC, DENS, YOUNG, WHITE, EDYR)$$

$$\text{and} \quad MS = f(RP, INS, RINC, MDPC, \%GP, BEDSPC, DENS, YOUNG, WHITE, EDYR)$$

where once again demand for hospital care is assumed to be a function of various economic (price,  $RP$ , insurance coverage,  $INS$ , income,  $RINC$ ) demographic (race,  $WHITE$ , age,  $YOUNG$ , and density of the population,  $DENS$ ) and availability factors (general practitioners,  $MDPC$ ,  $\%GP$ , and hospital beds  $BEDSPC$ ).

Neither researcher is able to predict, a priori, the effect of changes in a particular parameter on the level of hospital costs by using this sort of specification. This would require the inclusion of additional assumptions into

the model which define the hypothesised relationship between, say, changes in income and the demand for hospital care, and the consequent effect on the level of hospital costs. The type of specification employed in the two studies simply permits the determination of whether a change in a particular variable implies an increase or decrease in the level of hospital costs over time. Thus, to determine whether or not a relationship exists between income and the level of hospital costs, income is included as an explanatory variable in what might more accurately be termed the quasi-reduced-form equations of the two studies.

The role accorded to price in the various models of hospital cost inflation also varies considerably from study to study. Feldstein (1971a) assigns a major role to price in his analysis, for he suggests that hospital cost inflation can be explained by "a model of dynamic price adjustment to excess demand" (ibid, p.854). Feldstein's model is essentially market based as it assumes that the demand for and supply of hospital care can be balanced by what is described as an 'equilibrating' price, which differs from the actual price charged in a situation of disequilibrium. If the actual price is lower, for example, there will be pressure to increase it towards the equilibrating price, although with a lag that reflects the hospital's uncertainty about its equilibrating price and its desire to moderate the speed of price increases. A situation of increasing demand for hospital care therefore permits the hospital to increase its actual prices without causing the occupancy of hospital beds to fall below the

desired level, and without jeopardising the hospital's need to cover costs. Feldstein's results indicate that while the equilibrating price rose 135 per cent from 1958 to 1967, largely as a result of increased insurance coverage, the actual price (defined as the average cost per patient day) only rose 91 per cent, implying that prices would have continued to rise substantially after 1967 even if the equilibrating price had remained constant at its 1967 level.

Salkever also assigns an important role to price in his behavioural model of hospital cost inflation as he assumes that the decision making bureaucracy of a hospital attempts to maximise its preferences (e.g. in terms of the number of its beds, or of its organisational goals), by choosing the appropriate optimal values for its price and factors of production, which in turn determine the optimal value for average cost per day. Davis, in contrast, while noting that price affects the demand for hospital care, and that there is a direct relationship between hospital prices and average cost levels, nevertheless does not include price as a variable in the reduced form equation relating unit costs to various demand, casemix, wage and technology variables. The remaining studies of Lave and Lave, and Baron, because of their particular objectives and the methods employed, do not include price in their models of hospital cost inflation. It is clear, however, that the indirect effect of price on average hospital costs through its influence on the demand for hospital care, is an important factor in explaining the course of hospital cost inflation in the United States.

#### 4.4 Summary

It is only in comparatively recent years that the analysis of hospital cost inflation has been undertaken with the assistance of econometric models and methods. This chapter has reviewed the few econometric studies published to date all of which have examined the process and causes of cost inflation in hospitals in the United States. Despite the variety of approaches employed, several common elements have been noted such as the estimation techniques employed, the problem caused by the absence of diagnostic information, and the substantial amount of agreement found in the results.

The econometric studies of hospital cost inflation represent an important advance on the descriptive analyses reviewed earlier, as they allow estimates of the relative impact of several important variables on the level of hospital costs to be made. Furthermore, they permit the prediction of future trends in cost increases and thereby provide a useful basis from which to evaluate policies designed to curb further cost increases.

## CHAPTER FIVE

An Econometric Analysis of Hospital Cost Inflation in  
New Zealand

## 5.1 Introduction

It is apparent, from the analysis presented so far, that a multiplicity of factors is responsible for the rapid rise in hospital costs experienced in New Zealand, as well as in a number of other countries, in recent years. Up to this point the primary objective has been to identify these factors, and to discuss the possible direction and extent of their influence on hospital costs levels. The purpose of this chapter is to determine, more rigourously, by means of econometric techniques, the quantitative importance of each factor in explaining the rising cost of running New Zealand's public hospitals.

The chapter begins with a description of the model to be estimated and the data and variables included in the analysis; the functional form and estimation techniques are then described. The final sections of the chapter are devoted to the presentation and discussion of the empirical results, and include an assessment of the relative cost effects of the various explanatory variables grouped together by means of factor analysis.

The model is applied to the whole of the public hospital sector in New Zealand over the period 1962 to 1971.

The hospitals are analysed in groups according to the Hospital Board region in which they are located - figure 5.1 shows the North Island and its 19 Boards while figure 5.2 depicts the South Island and the remaining 12 Board regions. Hospitals within these Boards numbered 219 in 1962 and 199 in 1971, while bed numbers in those years stood at 16,248 and 17,964.<sup>1</sup>

## 5.2 The Model

To date the published literature on hospital cost inflation, as noted in the previous Chapter, related exclusively to the American hospital system, and more particularly, to its 'private' sector. It is therefore important, when developing a model of New Zealand's public hospital sector, to consider any relevant similarities and differences between the two systems.

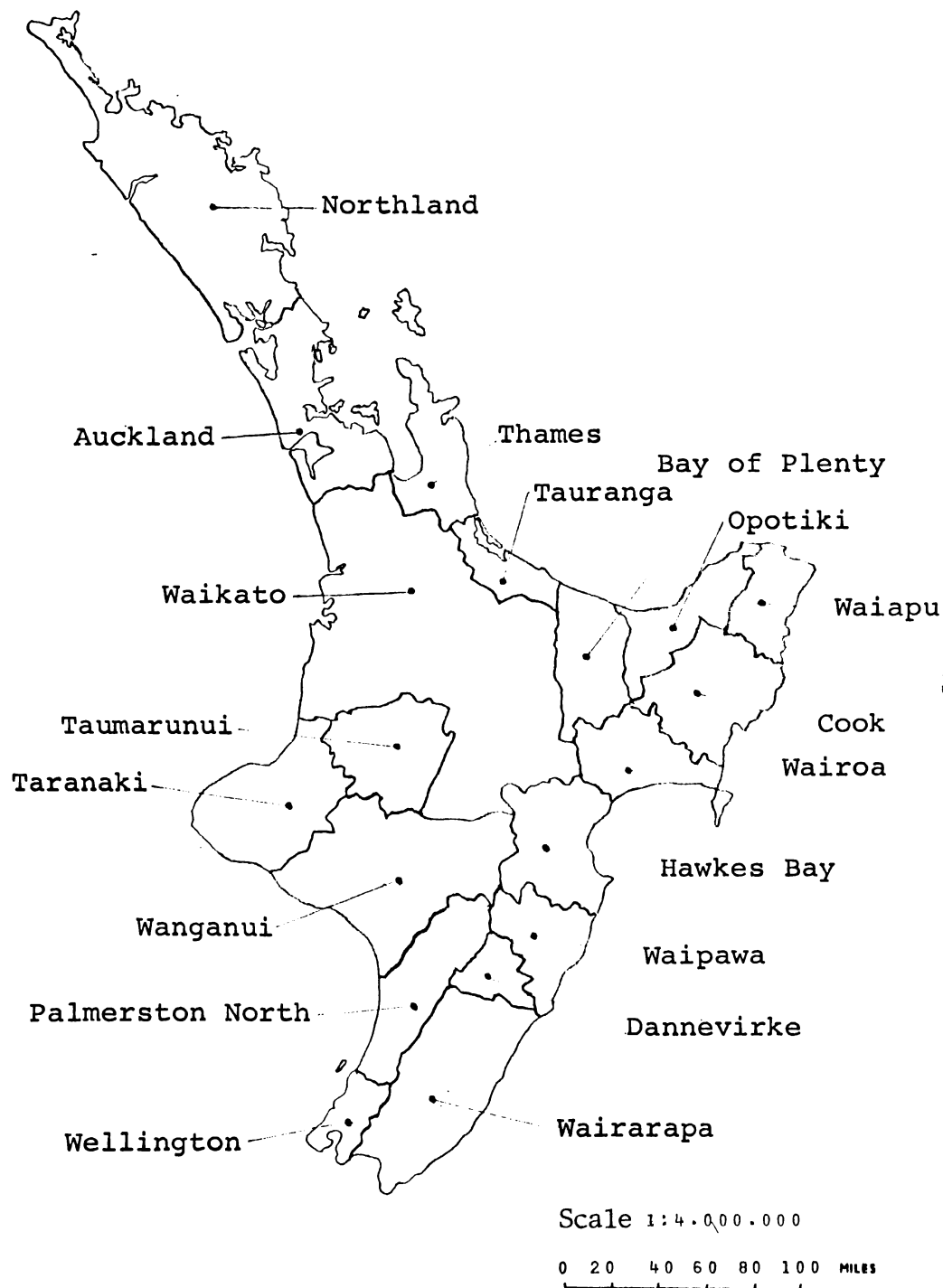
The first and most obvious difference lies in the ownership of the hospitals - America's 'voluntary' and

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1. See Data Appendix Table A-11. For ease of analysis it is assumed that there was no change in the number of Hospital Boards over the 10 year period. In fact, prior to 1968 when a number of Boards were amalgamated, their numbers were greater (see NZ Department of Health Annual Report 1969 pp.50-51). The hospitals included in the study are classed as either General or Special, and a number of Old Peoples Homes are also included. General Hospitals, which treat the 'acute' patients, range in size from less than 10 beds to approximately 800 beds; Special Hospitals include 'Non-Acute', Maternity, and Convalescent hospitals and range in size from less than 10 beds to approximately 400 beds; Old Peoples Homes are anything up to 100 beds in size. The majority of patients treated in New Zealand's public hospitals enter the General Hospitals - 84 per cent of all patients in 1971 - while most of the others are treated in Special Hospitals (15.5 per cent); only a very small proportion (0.5 per cent) are treated in Old Peoples Homes (see NZ Hospital Statistics 1971).



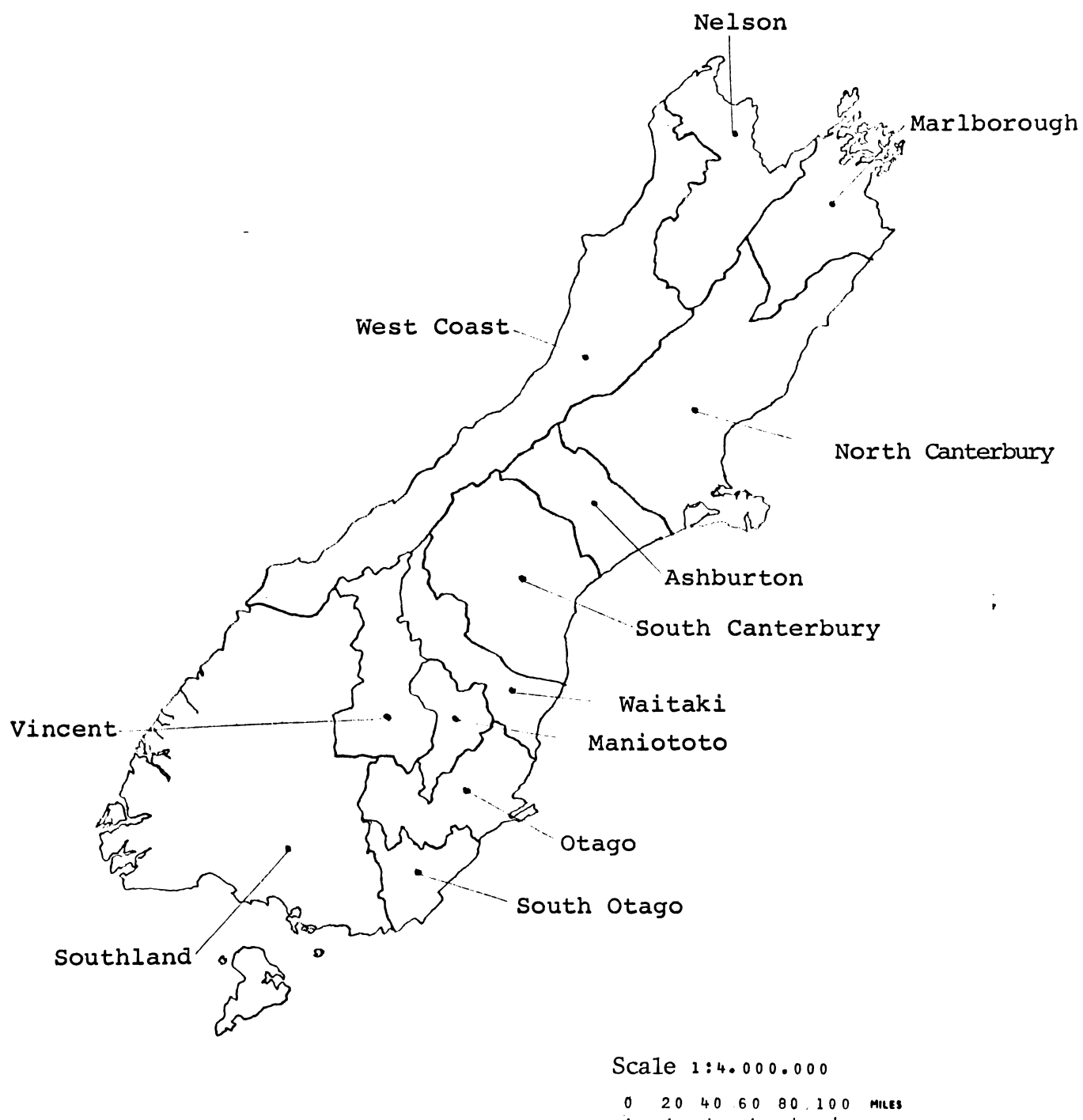
FIGURE 5.1  
Hospital Board Areas, North Island



Source: NZ Department of Health, Hospital Statistics,  
Wellington, (1971).

FIGURE 5.2

Hospital Board Areas, South Island.



Source: NZ Department of Health, Hospital Statistics,  
Wellington, (1971).

'proprietary' hospitals are privately owned and operated while New Zealand's public hospitals are owned and operated by the state. This ownership difference implies alternative behavioural motivations for the hospital administrators of each system - the former striving to make profits or at least to break even subject to ensuring funds for future expansion of facilities and services, and the latter endeavouring to provide services within the budgetary constraints imposed by the Government in its annual maintenance allocations to Hospital Boards. Subject to these financial constraints, however, it seems reasonable to assume that administrators of both systems are endeavouring to maximise the quantity and quality of the services they provide.

A second difference, and one that arises from the difference in ownership, lies in the method of financing the hospitals - America's private hospitals are largely funded either directly by the patient or indirectly by various health insurance companies, whereas New Zealand's hospitals are funded almost entirely from taxation revenue. In contrast to the American system no direct charges are imposed on patients receiving hospital care in New Zealand.

The basic similarity between the two hospital systems lies in the nature of the outputs they each produce, which include inpatient and outpatient care as well as education, research and community services. Hospitals in both systems can therefore appropriately be described as multiproduct institutions.

In view of the public ownership of New Zealand's hospitals and the absence both of a profit motive and of

prices for hospital services, the models developed to describe the process of hospital cost inflation in the American context, particularly those which include price adjustment mechanisms (M. Feldstein 1971c and Salkever 1972), appear to be inappropriate for New Zealand. A more appropriate model for New Zealand conditions, and the one developed here, can best be described as a "general behavioural model" as it seeks to describe the relationship between the level of a hospital's average costs in a given year and a number of exogenous variables which influence that hospitals behaviour.

The model comprises a demand function, a production function and a total cost function from which a quasi reduced-form average cost function is derived. This is then generalised from the specific hospital case to describe the entire hospital system over time.

The demand function for each individual hospital can be stated as:

$$f_d(S_1, S_2, \dots, S_n; D_1, D_2, \dots, D_m) = 0 \quad (5.1)$$

where the  $S_{di}$  ( $i=1,2,\dots,n$ ) are the various services demanded from that hospital, such as inpatient care, outpatient services, teaching or research, and the  $D_j$  ( $j=1,2,\dots,m$ ) are the various factors which determine the level of demand for those services, such as the size and nature of the population being served. Thus the demand for a particular service,  $S_{di}$  offered by a given hospital can be represented as

$$S_{di} = g_d(D_1, D_2, \dots, D_m) \quad (5.2)$$

Not all the demand factors included in equation (5.1) are necessarily included in equation (5.2), since demand for service  $S_{di}$  may depend on a subset of those factors rather than all of them. This specification differs from the conventional demand function of economic theory particularly with the exclusion of price as a primary determinant of quantity demanded. The function also reflects the peculiar nature of the demand for hospital care compared with that for consumer goods. Apart from the usual demand parameters such as income and taste (which in the medical context includes those factors that affect the health levels and health 'attitudes' of the population), a person's decision to seek hospital care is also affected by the preferences of his doctor, and by the availability of suitable facilities, particularly beds. The hospital demand function represented in equation (5.1), therefore, is determined by the decisions of several persons and by factors external to them, in contrast to the more usual demand function which can be derived from the preferences of a single individual.

The production function for each individual hospital can be stated as:

$$f_q(S_1, S_2, \dots, S_n; Q_1, Q_2, \dots, Q_k) = 0 \quad (5.3)$$

where the  $S_{qi}$  ( $i=1,2,\dots,n$ ) are the various services (outputs) provided (produced) by that hospital, and the  $Q_y$  ( $y=1,2,\dots,k$ ) are the quantities of the labour and non-labour inputs used by the hospital in its 'production process'. Thus the production function for one particular product or service, provided by a given hospital can be represented as follows:

$$S_{qi} = h_q(Q_1, Q_2, \dots, Q_k) \quad (5.4)$$

As with the demand equation (5.2), not all the quantity parameters of equation (5.3) are necessarily included in this equation since the production of product  $S_{qi}$  may only require a subset of those inputs rather than all of them.

Each hospital's total cost function can be represented as:

$$TC_i = \sum_{y=1}^k Q_y W_y \quad (5.5)$$

where the  $Q_y$  are the quantities of labour and non-labour inputs used by the hospital, as already defined above, and the  $W_y$  are the costs of those inputs either in the form of wages and salaries or input prices.

It is now possible to describe the behaviour of each hospital's average costs in terms of the combined effect of the demand, production and cost factors defined above. Accordingly, the average cost function for a particular output or service provided by a given hospital,  $x$ , can be stated as follows:

$$AC_x = f_c(D_{mx}, Q_{kx}, W_{kx}) \quad (5.6)$$

This equation shows that the average cost of providing a given hospital service is determined by the demand for that service ( $D_m$ ) by the quantity ( $Q_k$ ) of the inputs required to produce that service, and by the cost ( $W_k$ ) of those inputs.

Equation (5.6) can now be aggregated and generalised to represent the average cost function of a particular hospital board,  $b$ , in year  $t$ :

$$AC_{bt} = f_c(D_{mbt}, Q_{kbt}, W_{kbt}) \quad (5.7)$$

Although this general behavioural model is an appropriate one for the New Zealand Hospital System, a number of its features require some comment. As defined here the model does not permit one to make a priori predictions about the effect on average costs of changes in a particular parameter without incorporating additional assumptions into the model. However, it does seem reasonable to expect that increases in demand, production, and input costs will have positive effects on cost levels, and that the direction of the effects of a particular parameter in equations (5.1) to (5.5) will be the same when it is included in equation (5.7). There is also the problem of aggregation involved in moving from the individual hospital cost function to that for the hospital board. Although it is assumed that the cost functions in the two instances have identical components and are of the same form, an element of bias will be introduced into the model if this is not the case. The same problem will occur if there are any changes in the structure of the cost function over time, which are not accounted for in the model. Finally, despite being included in the model, a number of the variables are either immeasurable or can only be represented in the analysis by proxy variables. This is particularly the case with some of the quantity and input cost variables in the model.

### 5.3 The Variables

Before discussing the variables in detail a summary

list of all variables included in the analysis and their definitions is given.<sup>1</sup> To avoid unnecessary repetition in these definitions, each variable is defined on a hospital board basis and for a full year.

Three dependent average cost variables are included in the analysis which differ according to the particular output measure used:

- (i) CASE  $\frac{\text{total maintenance costs}}{\text{total number of inpatients treated}}$
- (ii) PDAY  $\frac{\text{total maintenance costs}}{\text{total number of inpatient days of care}}$
- (iii) PADJ  $\frac{\text{total maintenance costs}}{\text{the sum of the number of inpatient days and the number of outpatient visits}}$

Three groups of independent variables are included in the analysis - demand, production and input cost. These are defined as follows:

a. Demand Variables

- (i) INCO per capita income level
- (ii) DIAGMIX the proportion of inpatients with selected diagnoses
- (iii) POPBED  $\frac{\text{hospital board population}}{\text{total number of available beds}}$
- (iv) POPDENS  $\frac{\text{hospital board population}}{\text{geographical area of board}}$
- (v) GPPPOP  $\frac{\text{total number of general practitioners}}{\text{hospital board population}} \times 10,000$
- (vi) BEDS The number of available public hospital beds

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1. The numerical values of these variables, for each hospital Board and year, are given in Data Appendix Tables A-1 to A-24.



- (vii) ALOS  $\frac{\text{total number of inpatient days}}{\text{total number of inpatients}}$   
i.e. the average length of (inpatient) stay
- (viii) OCCR  $\frac{\text{Average number of occupied beds}}{\text{total available beds}} \times 100$   
i.e. the bed occupancy rate
- (ix) INPS  $\frac{\text{total inpatient days}}{\text{the sum of inpatient days and outpatient visits}} \times 100$

#### b. Production Variables

- (i) STAFFBED  $\frac{\text{Full time equivalent hospital staff numbers}}{\text{Average number of occupied beds}}$
- (ii) TREAT  $\frac{\text{Full time equivalent treatment staff numbers}}{\text{Full time equivalent staff numbers}} \times 100$
- (iii) TECHN A dummy variable taking the value 0 in 1962, 1 in 1963, up to 9 in 1971.

#### c. Input Cost Variables

- (i) EARNs Average annual earnings of hospital staff
- (ii) CPI Consumer Price Index (All groups)

#### 5.3.1 The Dependent Variables

Three alternative measures of output are employed as the bases upon which the dependent variables CASE, PDAY and PADJ are derived. They are the number of inpatients treated, the number of inpatient days of care provided, and the sum of the number of inpatient days and outpatient visits. This last output measure is included to account for the growth in the relative importance of outpatient services in the provision of hospital care. Its associated dependent variable, PADJ, represents a statistical

improvement on the other two variables as the factors in the numerator - total hospital maintenance costs - are more closely related to the factors in the denominator - total 'adjusted' patient days.<sup>1</sup> The other two measures relate total costs to inpatient measures thereby ignoring the role of outpatient departments in providing hospital care. Unfortunately, data limitations prevent the analysis of CASE and PDAY using only those maintenance costs that relate solely to the treatment of inpatients.

### 5.3.2 The Demand Variables

Demand for hospital care in New Zealand, as evidenced in Chapter Three, has increased substantially in recent years as a result of changes in various economic and non-economic factors.

Although economic factors are unlikely to have any direct effect on the demand for hospital care in a system in which hospital services are provided free of charge, the evidence presented in Chapter Two above suggests that the demand for all medical care tends to rise with increasing affluence. In order to capture this effect INCO<sup>2</sup> is included as an economic demand variable in the analysis, and is expected to be positively related to the level of demand for hospital care.

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1. Criticism of CASE and PDAY measures based on total hospital costs has been voiced by Somers A.R. (1969), Johnson E.A. (1971) and Shuman et al. (1972), among others.
  2. The average annual earnings of adult employees in all New Zealand industries. Derived from NZ Department of Statistics Prices, Wages and Labour Statistics for the years 1962-71. An alternative measure of rising income or affluence which could have been used is GNP per capita.

Three groups of non-economic demand variables are included - diagnostic, demographic and institutional. A measure of changing diagnostic mix, DIAGMIX, is derived on the basis of results obtained in Chapter Three where it was shown that although there had been an increase in the number of patients treated in New Zealand hospitals, there had also been a change in the diagnostic mix of those cases - certain broad disease groupings had increased as a proportion of all cases treated, groups which, on average, had longer lengths of stay than the remaining disease groups. Most of the increased pressure on the demand for hospital care, therefore, is associated with the proportionate increase in six broad disease categories - allergic diseases, mental and personality disorders, diseases of the nervous and sense organs, diseases of the circulatory system, congenital malformations, and accidents. By calculating the proportion of patients in each hospital board area suffering from those six diagnoses, a measure of changing diagnostic mix is obtained. This variable, DIAGMIX, is assumed to have a positive impact on demand, reflecting the general trend towards a higher proportion of those diagnoses that require, on average, more hospital days per case.

POPBED, the first of the demographic demand variables, measures the number of persons served by each hospital board. The variable provides an indication of the potential demand for hospital care in a given Hospital Board, despite a certain amount of inter-Board movement of patients, particularly from those Hospital Boards which do not provide certain specialist services but rely on the

major boards for their provision.<sup>1</sup> The extent of this interchange, however, does not represent a significant proportion of the patient load. For example, an analysis of the origin of patients admitted to hospitals in the Waikato Hospital Board in 1971 revealed that approximately 90 per cent of the patients admitted come from within the Waikato Hospital Board district.<sup>2</sup> Since the Waikato Board is included amongst those providing certain regional and national specialties and is therefore likely to derive more patients than average from outside its own area, it seems

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1. New Zealand's Hospital Boards can be divided into four groups according to the scope of the services they provide. Group A Boards (Auckland, Otago, N.Canterbury, Wellington, Northland, Waikato, Palmerston North and Southland) provide a full range of services for their own population as well as certain 'national and regional specialties'. Group B Boards (Tauranga, Wairapapa, Cook, West Coast, Hawkes Bay, Wanganui, Taranaki, Nelson and S.Canterbury) provide a full general service to their own population except for national and some other 'esoteric' specialties for which they depend on Group A Boards' assistance. Group C Boards (Thames, Waipawa, Bay of Plenty, S.Otago, Taumarunui, Waitaki, Ashburton, Dannevirke, Marlborough, and Wairoa) provide general hospital facilities but rely on neighbouring Boards for many specialist services. The final Group D (Vincent, Maniototo, Waiapu, and Opotiki) provide only 'Cottage Hospital' facilities and depend on other Boards for all specialist services. Group A Boards, therefore, are likely to derive a higher proportion of their patients from outside their districts than the other Board groupings.
2. This analysis was based on unpublished data provided by the National Health Statistics Centre, Wellington. Details of the town of origin of every fifth patient admitted to hospitals within the Waikato Hospital Board in 1971 were made available.

reasonable to conclude that, in general, only a small proportion of a Hospital Board's patients are likely to originate from outside its own district. An increase in population per hospital bed, POPBED, is assumed to have a positive impact on the level of the demand for hospital services.

The density of population in each hospital board, POPDENS, is included as a demographic variable to indicate the effect of travel distance on the demand for hospital care. The relationship between POPDENS and demand is assumed to be a negative one - increases in population density result in a fall in demand for hospital care. Patients from low density areas are more likely to demand inpatient care than outpatient or ambulatory care in view of the greater distances and hence costs involved in the repeat visits associated with the latter. Doctors may also tend to favour hospitalisation for patients in rural areas rather than repeated visits to their homes - the travel time and expense involved in treating a number of patients may be considerable for a doctor in a low density area.

A measure of the availability of general practitioners, GPPPOP, is included as the third demographic variable although the direction of influence of this variable on the level of the demand for hospital care is a matter for some speculation.<sup>1</sup> On the one hand one might argue that

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1. The influence of physician availability on the demand for hospital care has been discussed recently by Salkever (1972), Feldstein M. (1971c, 1974a), Anderson (1973), and Davis (1974). Anderson, for example, finds that inpatient hospital care is substituted for ambulatory care normally provided by physicians in areas where the physician to population ratio is low.

the more GP's there are per head of population the greater the availability of ambulatory care implying a reduction in the demand for hospital care. On the other hand, since one of the roles of the general practitioner is that of 'gatekeeper' to the hospital, a greater supply of GP's relative to the population may in fact increase the demand for hospital care. In view of the uncertainty relating to the influence of this variable on demand, no prior hypothesis is made.

Although it has already been shown that other demographic variables, such as the age, sex and racial composition of the population, are likely to affect the demand for hospital care, variables which account for possible changes in these factors cannot be included in this study due to lack of sufficiently detailed information. However, insofar as changes in age, sex and race over time affect the types of illnesses treated in hospitals, their impact on demand will be accounted for by the diagnostic mix variable already defined and included in the analysis.

Four variables are included to represent the effect of institutional factors on the demand for hospital care. The first of these, BEDS, is a measure of the availability of hospital beds for persons in each hospital board area. An increase in the supply of beds implies an increase in the demand for hospital services.<sup>1</sup> The length of stay variable also gives an indication of the demand for hospital care, as it is a principle determinant of the total number of

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1. See Chapter 2 for a discussion of the effect of hospital bed availability on the level of demand for hospital care.

patient days provided by a hospital (the number of patients x average length of stay = total patient days). Length of stay is determined by a number of factors both patient determined (diagnosis, age, race and so on) and hospital determined (state of medical technology, skill of the medical staff, hospital policy and so on). The relationship between ALOS and demand is assumed to be a positive one. The overall trend in recent years has been for a reduction in the average length of stay of patients which has tended to offset the rise in the number of inpatients and has thereby controlled to some extent the rise in the number of inpatient days.

The bed occupancy rate, OCCR, gives an indication of the capacity limitation of each hospital board and also of the intensity and nature of the demand for hospital services. The relationship between OCCR and demand, however, is not immediately apparent, largely because of the influence of length of stay and throughput on hospital occupancy rates. In general high occupancy hospitals tend to be those with a low throughput and to contain a large proportion of long stay patients, whereas the low occupancy hospitals tend to have a faster throughput and to contain mostly short stay acute patients. On the assumption that faster throughput indicates a higher level of demand and a lower occupancy rate, a negative relationship between OCCR and demand is expected.

The final institutional demand variable, INPS, is included to reflect the rapid growth in the utilisation of outpatient hospital facilities. This implies a shift in demand from the more intensive and costly inpatient services

to the less intensive and costly outpatient services. A reduction in INPS therefore implies a downward or dampening pressure on hospital demand and costs, that is, a positive relationship.

### 5.3.3 The Production Variables.

Measurement of the production variables poses some problems particularly with regard to the non-labour inputs for which no suitable data are available. It is possible, however, to measure the quantity of labour inputs, which is represented here by the variable STAFFBED. An important aspect of the changing quantity of inputs being used by hospitals is their effectiveness, which, over a period of years, is likely to increase as a result of changes in the skills of the personnel and in the technology and practice of medicine. Two 'quality' variables, both of them proxies, are included to capture these effects. The first, TREAT, measures the skill mix of the staff employed by each Hospital Board, while the second, TECHN, is intended to represent the medical and technological advances that have taken place during the period under study. This latter variable is in Dummy form, taking the value 0 in 1962, 1 in 1963, and so on up to 9 in 1971.

### 5.3.4 The Input Cost Variables

Two final variables, EARNs and CPI, are included in the analysis to capture the effect of changes in wages and prices on the level of total hospital board costs. EARNs,



the average annual earnings of the staff of each hospital board, is derived by dividing total salary payments to hospital staff by staff numbers in each board area. CPI, the consumer price index for all commodities, is included as a proxy measure for the price of non-labour hospital inputs in the absence both of a Hospital Price Index and of a regional Wholesale Price Index. An increase in either variable can be expected to lead to a rise in the level of hospital board total costs, assuming there is no compensating reduction in the quantity of labour and non-labour inputs utilised.

#### 5.4 The Functional Forms and Estimation Method

The hypothesis that the costs of running New Zealand's public hospitals have risen as a result of changes in a number of demand, production and input cost variables is tested using multiple regression estimating techniques (Ordinary Least Squares) on pooled cross-section and time-series data for the ten year period 1962 to 1971. Equation 5.7 is estimated in both linear and log-linear functional forms.<sup>1</sup> In its linear form, and denoting the explanatory variables as  $X_{it}$ , equation (5.7) can be expressed as:

$$AC_{it} = \beta_0 + \beta_1 X_{it,1} + \beta_2 X_{it,2} + \dots + \beta_k X_{it,k} + \varepsilon_{it} \quad (5.8)$$

- 
1. There is no a priori reason to prefer one form to the other, although of the econometric studies of hospital cost inflation undertaken to date only one has tested both forms (Davis 1973b and 1974), the remainder preferring the non-linear specification. Davis' results were substantially the same for both forms.

where AC denotes average cost per case, per patient day or per adjusted patient day; the X's are the explanatory demand, quantity, quality and cost variables; the  $\beta$ 's are the unknown regression coefficients and  $\epsilon$  is a disturbance term. Subscript i ( $i = 1, 2, \dots, N$ ) refers to the particular Hospital Board, subscript t ( $t = 1, 2, \dots, T$ ) to the particular year and there are k explanatory variables and regression coefficients. In matrix notation equation (5.8) can be written as:

$$AC = X\beta + \epsilon \quad (5.9)$$

where

$$AC = \begin{bmatrix} AC_{11} \\ AC_{12} \\ \vdots \\ AC_{1T} \\ AC_{21} \\ AC_{22} \\ \vdots \\ AC_{NT} \end{bmatrix}, \quad X = \begin{bmatrix} X_0 X_{11,1} & X_{11,2} & \dots & X_{11,k} \\ X_0 X_{12,1} & X_{12,2} & & X_{12,k} \\ \vdots & \vdots & & \vdots \\ X_0 X_{1T,1} & X_{1T,2} & \dots & X_{1T,k} \\ X_0 X_{21,1} & X_{21,2} & \dots & X_{21,k} \\ X_0 X_{22,1} & X_{22,2} & \dots & X_{22,k} \\ \vdots & \vdots & & \vdots \\ X_0 X_{NT,1} & X_{NT,2} & \dots & X_{NT,k} \end{bmatrix}, \quad \epsilon = \begin{bmatrix} \epsilon_{11} \\ \epsilon_{12} \\ \vdots \\ \epsilon_{1T} \\ \epsilon_{21} \\ \epsilon_{22} \\ \vdots \\ \epsilon_{NT} \end{bmatrix}$$

$$\text{and } \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \beta_k \end{bmatrix}$$

Matrix X in the above specification is of the order 310 by 18 since there are observations on N=31 hospital boards over a period of T=10 years, and there are k=18 explanatory variables defined - the additional variable,  $X_0$  is assumed always to be unity which has the effect of making  $\beta_0$  the constant.

In its non-linear multiplicative form equation (5.7) can be expressed as:

$$AC_{it} = \beta_0^* X_{it,1}^{\beta_1^*} X_{it,2}^{\beta_2^*} \dots X_{it,k}^{\beta_k^*} \epsilon_{it}^* \quad (5.10)$$

where the variables AC and X are as defined above, and the regression coefficients and disturbance term are now expressed as  $\beta^*$  and  $\epsilon^*$  respectively in order to distinguish them from their linear equivalents. A double logarithmic transformation of all the variables (except the dummy time variable, TECHN) in equation (5.10) yields an equation that is linear in the logs of the variables, thus permitting the application of Ordinary Least Squares to obtain estimates of the  $\beta^*$  coefficients. Equation (5.10) can therefore be written as:

$$\log AC_{it} = \log \beta_0^* + \beta_1^* \log X_{it,1} + \beta_2^* \log X_{it,2} + \dots + \beta_k^* \log X_{it,k} + \log \epsilon_{it}^* \quad (5.11)$$

which, in matrix notation, reads:

$$\log AC = (\log X) \beta^* + \epsilon^* \quad (5.12)$$

The standard assumptions for ordinary least squares are assumed to apply for equations (5.9) and (5.12).<sup>1</sup> However, the application of ordinary least squares to pooled cross-section and time-series data may be inappropriate if any of these assumptions are violated. Cross-section data, for example, are often characterised by heteroskedasticity, while time-series data often produce autocorrelated disturbances. Existence of either or both conditions would lead to inefficient, though unbiased, estimates of the unknown  $\beta$  coefficients, and to biased results for significance tests and confidence intervals. Several transformation techniques using Generalised Least Squares estimates have been employed in a number of studies (e.g. Nerlove, 1971, Balestra and Nerlove, 1966, and Blair and Kraft, 1974) in an effort to overcome some of the estimation problems associated with pooled cross-section and time-series data.<sup>2</sup> For the purposes of this study, however, the added accuracy of Generalised Least Squares is not felt to be necessary.

## 5.5 Empirical Results

The results of the estimation process are presented in two stages: tables 5.1 to 5.3 present the results for

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1. These assumptions are clearly stated in Johnston (1972) ch.5.
  2. For an excellent description and discussion of various transformation procedures see Kmenta (1971).

the estimation of linear equation (5.9) while tables 5.4 to 5.6 present those for the estimation of log-linear equation (5.12). Results for both forms are given for each of the three dependent variables CASE, PDAY and PADJ. Detailed discussion of all these results follows some brief comments relating first to the linear and then to the log-linear equations as well as a statistical comparison of the two sets of results.

#### 5.5.1 The Linear Equations

Several equations are estimated for each dependent variable largely because of the close association that was found to exist between some of the independent variables as indicated by their simple correlations.<sup>1</sup> Thus the first equation in each table includes all the explanatory variables listed and discussed above, while the remaining equations omit some of the more closely associated variables. In general the results lend fairly strong support to the model. Overall explanation is high in most equations - the  $\bar{R}^2$  and F values for the PADJ equations tend to be somewhat lower than those for the CASE and PDAY equations; most coefficients enter with the expected signs; and a number of the variables have coefficients with significant t-ratios.

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1. Appendix 5A to this chapter gives a matrix of correlation coefficients for the variables included in this analysis.

TABLE 5.1  
Linear Cost per Case Equations (a)

| Variable        | Equation            |                     |                    |                    |                    |
|-----------------|---------------------|---------------------|--------------------|--------------------|--------------------|
|                 | 1                   | 2                   | 3                  | 4                  | 5                  |
| Constant        | -506.54             | -375.77             | -422.74            | -206.38            | -306.00            |
| INCO            | 0.0006<br>(0.30)    |                     |                    |                    | 0.085<br>(19.20)** |
| DIAGMIX         | 98.11<br>(3.12)*    | 78.33<br>(2.47)*    | 158.97<br>(3.93)** | 125.29<br>(2.90)*  | 174.85<br>(4.48)** |
| POPBED          | -0.131<br>(2.57)*   | -0.097<br>(1.87)    | 0.093<br>(1.38)    | -0.05<br>(0.69)    | -0.106<br>(1.62)   |
| POPDENS         | -0.056<br>(1.98)*   | -0.047<br>(1.62)    | -0.041<br>(1.09)   | -0.029<br>(0.76)   | -0.036<br>(0.98)   |
| GPPPOP          | -0.836<br>(1.27)    | 0.127<br>(0.20)     | 0.904<br>(1.10)    | 2.192<br>(2.54)*   | 0.681<br>(0.84)    |
| BEDS            | 0.004<br>(1.16)     | 0.004<br>(1.33)     | 0.012<br>(2.91)*   | 0.011<br>(2.83)*   | 0.012<br>(3.12)*   |
| ALOS            | 10.872<br>(25.47)** | 10.859<br>(24.50)** | 9.498<br>(17.01)** | 9.67<br>(16.88)**  | 9.451<br>(17.22)** |
| OCCR            | 0.138<br>(0.89)     | -0.013<br>(0.08)    | -0.209<br>(1.04)   | -0.392<br>(1.88)   | -0.129<br>(0.65)   |
| INPS            | 0.137<br>(1.43)     | 0.234<br>(2.40)*    | 0.206<br>(1.65)    | 0.349<br>(2.68)*   | 0.181<br>(1.48)    |
| STAFFBED        | 102.34<br>(20.12)** | 98.06<br>(21.73)**  | 67.81<br>(11.57)** | 66.49<br>(11.04)** | 68.76<br>(11.95)** |
| TREAT           | 0.862<br>(5.61)**   | 0.708<br>(4.55)**   | 0.754<br>(3.77)**  | 0.531<br>(2.54)*   | 0.819<br>(4.19)**  |
| TECHN           | -7.91<br>(4.47)**   |                     |                    | 12.81<br>(17.79)** |                    |
| EARNs           | 0.094<br>(13.80)**  | 0.085<br>(27.48)**  |                    |                    |                    |
| CPI             | 0.111<br>(1.60)     |                     | 0.239<br>(18.62)** |                    |                    |
| R <sup>2</sup>  | 0.938               | 0.931               | 0.887              | 0.882              | 0.891              |
| $\bar{R}^2$ (b) | 0.935               | 0.929               | 0.883              | 0.878              | 0.887              |
| F value (c)     | 319.1**             | 365.6**             | 213.3**            | 202.1**            | 221.6**            |
| S.E.E. (d)      | 13.98               | 14.68               | 18.76              | 19.22              | 18.45              |

(a) t-ratios are given in parentheses with significance levels denoted by \* = 5 % and \*\* = 1%.

(b)  $\bar{R}^2$  is equivalent to  $R^2$  corrected for degrees of freedom.

(c) F is a test statistic for the null hypothesis  $H_0 = \beta_k = (0, 0, \dots, 0)$ .

(d) The standard error of the estimates.

TABLE 5.2

## Linear Cost per Patient Day Equations

| Variable       | Equation           |                    |                    |                    |                    |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                | 1                  | 2                  | 3                  | 4                  | 5                  |
| Constant       | -22.91             | -10.73             | -13.66             | -0.45              | -9.75              |
| INCO           | -0.0007<br>(0.53)  |                    |                    |                    | 0.005<br>(19.18)** |
| DIAGMIX        | 6.75<br>(3.51)**   | 4.99<br>(2.48)**   | 9.84<br>(3.89)**   | 8.53<br>(3.09)*    | 10.81<br>(4.44)**  |
| POPBED         | -0.011<br>(3.60)** | -0.008<br>(2.47)*  | -0.008<br>(1.84)   | -0.006<br>(1.24)   | -0.009<br>(2.09)*  |
| POPDENS        | -0.004<br>(2.26)*  | -0.003<br>(1.61)   | -0.003<br>(1.09)   | -0.002<br>(0.80)   | -0.002<br>(0.98)   |
| GPPOP          | -0.087<br>(2.15)*  | -0.001<br>(0.03)   | 0.048<br>(0.93)    | 0.122<br>(2.21)*   | 0.034<br>(0.68)    |
| BEDS           | 0.0004<br>(2.13)*  | 0.0005<br>(2.40)*  | 0.0009<br>(3.76)** | 0.0009<br>(3.59)** | 0.001<br>(3.99)**  |
| ALOS           | -0.123<br>(4.71)** | -0.127<br>(4.55)** | -0.212<br>(6.07)** | -0.202<br>(5.52)** | -0.214<br>(6.26)** |
| OCCR           | 0.013<br>(1.35)    | -0.0003<br>(-0.03) | -0.013<br>(-0.10)  | -0.023<br>(-1.72)  | -0.008<br>(-0.62)  |
| INPS           | 0.006<br>(1.06)    | 0.015<br>(2.39)*   | 0.013<br>(1.69)    | 0.021<br>(2.53)*   | 0.012<br>(1.52)    |
| STAFFBED       | 6.90<br>(22.17)**  | 6.44<br>(22.55)**  | 4.56<br>(12.45)**  | 4.51<br>(11.70)**  | 4.62<br>(12.86)**  |
| TREAT          | 0.058<br>(6.12)**  | 0.044<br>(4.49)**  | 0.047<br>(3.74)**  | 0.035<br>(2.59)*   | 0.051<br>(4.16)**  |
| TECHN          | -0.693<br>(6.40)** |                    |                    | 0.741<br>(16.91)** |                    |
| EARN\$         | 0.006<br>(15.05)** | 0.005<br>(26.92)** |                    |                    |                    |
| CPI            | 0.012<br>(2.88)*   |                    | 0.015<br>(18.57)** |                    |                    |
| R <sup>2</sup> | 0.941              | 0.930              | 0.889              | 0.878              | 0.893              |
| $\bar{R}^2$    | 0.938              | 0.928              | 0.885              | 0.874              | 0.888              |
| F value        | 338.8**            | 361.1**            | 217.0**            | 194.5**            | 225.7**            |
| S.E.E.         | 0.86               | 0.93               | 1.17               | 1.23               | 1.15               |

TABLE 5.3

Linear Cost per Adjusted Patient Day  
Equations

| Variable       | Equation           |                    |                    |                    |                    |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                | 1                  | 2                  | 3                  | 4                  | 5                  |
| Constant       | -20.80             | -14.14             | -16.02             | -7.39              | -13.52             |
| INCO           | -0.0004<br>(0.38)  |                    |                    |                    | 0.003<br>(15.56)** |
| DIAGMIX        | 6.10<br>(3.60)**   | 5.05<br>(3.01)*    | 8.56<br>(4.33)**   | 7.25<br>(3.46)**   | 9.25<br>(4.81)**   |
| POPBED         | -0.005<br>(1.77)   | -0.003<br>(1.11)   | -0.003<br>(0.93)   | -0.001<br>(0.38)   | -0.004<br>(1.12)   |
| POPDENS        | -0.002<br>(1.26)   | -0.001<br>(0.89)   | -0.001<br>(0.63)   | -0.0007<br>(0.38)  | -0.001<br>(0.54)   |
| GPPOP          | -0.116<br>(3.26)*  | -0.067<br>(2.00)*  | -0.037<br>(0.93)   | 0.014<br>(0.33)    | -0.047<br>(1.17)   |
| BEDS           | -0.0001<br>(0.79)  | -0.0001<br>(0.48)  | 0.0002<br>(1.15)   | 0.0002<br>(1.11)   | 0.0002<br>(1.28)   |
| ALOS           | -0.048<br>(2.08)*  | -0.051<br>(2.17)*  | -0.106<br>(3.90)** | -0.099<br>(3.57)** | -0.108<br>(4.01)** |
| OCCR           | 0.004<br>(0.48)    | -0.003<br>(0.41)   | -0.011<br>(1.12)   | -0.018<br>(1.81)   | -0.008<br>(0.80)   |
| INPS           | 0.106<br>(20.51)** | 0.111<br>(21.57)** | 0.109<br>(17.93)** | 0.115<br>(18.22)** | 0.108<br>(17.97)** |
| STAFFBED       | 4.04<br>(14.79)**  | 3.77<br>(15.82)**  | 2.55<br>(8.92)**   | 2.50<br>(8.56)**   | 2.59<br>(9.16)**   |
| TREAT          | 0.047<br>(5.68)**  | 0.039<br>(4.80)**  | 0.042<br>(4.27)**  | 0.033<br>(3.25)**  | 0.044<br>(4.62)**  |
| TECHN          | -0.379<br>(3.99)** |                    |                    | 0.486<br>(14.63)** |                    |
| EARNs          | 0.004<br>(11.06)** | 0.003<br>(21.08)** |                    |                    |                    |
| CPI            | 0.007<br>(1.76)    |                    | 0.01<br>(15.24)**  |                    |                    |
| R <sup>2</sup> | 0.884              | 0.875              | 0.825              | 0.819              | 0.829              |
| $\bar{R}^2$    | 0.879              | 0.871              | 0.819              | 0.813              | 0.823              |
| F value        | 160.0**            | 190.2**            | 128.1**            | 122.7**            | 130.9**            |
| S.E.E.         | 0.75               | 0.77               | 0.92               | 0.93               | 0.91               |



### 5.5.2 The Log-Linear Equations

In contrast to the linear equations presented in tables 5.1 to 5.3 all the variables (except TECHN, the dummy variable) in the log-linear regressions are entered in logarithmic form. However, since the same close association still exists between the variables in this form, a number of regressions are estimated for each dependent variable to test the effect of omitting some or all of them from the equations. As with the linear equations the results for the log-linear runs lend strong support to the model. The  $\bar{R}^2$  and F values are again high in most equations and most coefficients have signs as expected.

Comparison between the two sets of results, linear and log-linear, is made possible by a transformation procedure first introduced by Cox and Box (1964) and later summarised by Miller and Rao (1971, Chapter 4). Direct comparison of the  $\bar{R}^2$  values or of the residual sum of squares is inappropriate because the dependent variables are different in the two cases. However, by standardising the dependent variable in the linear equations by dividing it by its geometric mean, it becomes possible to determine which of the two functional forms is the more appropriate through a comparison of their residual sum of squares. The functional form which yields the smaller residual sum of squares is chosen as the more appropriate functional form.

Comparison of the two sets of results using this transformation procedure shows that the log-linear functional form appears to be empirically more appropriate than the linear function for the CASE and PDAY equations, but that for

the PADJ equations the linear function is the preferred form. Furthermore, for most equations, the difference between the residual sums of squares in these two functional forms is significant at the 95 per cent level of confidence.<sup>1</sup>

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1. The test statistic used is the d statistic which follows a Chi-squared distribution; see Miller and Rao (1971) p.109.

TABLE 5.4

## Log-Linear Cost per Case Equations

| Variable       | Equations          |                    |                    |                    |                    |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                | 1                  | 2                  | 3                  | 4                  | 5                  |
| Constant       | -12.03             | -3.37              | -5.19              | 2.70               | -3.64              |
| INCO           | -0.012<br>(0.06)   |                    |                    |                    | 0.844<br>(17.15)** |
| DIAGMIX        | 0.273<br>(5.04)**  | 0.245<br>(4.36)**  | 0.454<br>(5.97)**  | 0.370<br>(4.81)**  | 0.465<br>(6.30)**  |
| POPBED         | 0.01<br>(0.37)     | 0.038<br>(1.34)    | 0.060<br>(1.49)    | 0.084<br>(2.12)*   | 0.062<br>(1.57)    |
| POPDENS        | -0.012<br>(2.19)*  | -0.01<br>(1.82)    | -0.012<br>(1.57)   | -0.011<br>(1.39)   | -0.01<br>(1.31)    |
| GPPOP          | -0.007<br>(0.37)   | 0.027<br>(1.50)    | 0.057<br>(2.32)*   | 0.082<br>(3.36)**  | 0.056<br>(2.30)*   |
| BEDS           | -0.014<br>(2.13)*  | -0.012<br>(1.72)   | -0.007<br>(0.79)   | -0.007<br>(0.73)   | -0.009<br>(0.93)   |
| ALOS           | 0.906<br>(25.99)** | 0.895<br>(23.94)** | 0.788<br>(15.76)** | 0.803<br>(16.36)** | 0.792<br>(16.05)** |
| OCCR           | -0.032<br>(0.69)   | -0.095<br>(1.94)   | -0.122<br>(1.82)   | -0.176<br>(2.66)*  | -0.111<br>(1.69)   |
| INPS           | 0.001<br>(0.08)    | 0.014<br>(0.82)    | -0.002<br>(0.09)   | 0.014<br>(0.61)    | -0.005<br>(0.23)   |
| STAFFBED       | 0.735<br>(20.84)** | 0.674<br>(20.84)** | 0.461<br>(10.25)** | 0.449<br>(10.17)** | 0.461<br>(10.40)** |
| TREAT          | 0.258<br>(6.04)**  | 0.202<br>(4.60)**  | 0.160<br>(2.65)*   | 0.114<br>(1.91)    | 0.166<br>(2.80)*   |
| TECHN          | -0.062<br>(6.63)** |                    |                    | 0.055<br>(17.40)** |                    |
| EARNs          | 0.894<br>(16.92)** | 0.725<br>(27.64)** |                    |                    |                    |
| CPI            | 1.074<br>(3.35)**  |                    | 1.158<br>(16.67)** |                    |                    |
| R <sup>2</sup> | 0.943              | 0.933              | 0.877              | 0.882              | 0.880              |
| $\bar{R}^2$    | 0.940              | 0.931              | 0.873              | 0.878              | 0.876              |
| F value        | 348.1**            | 379.5**            | 193.4**            | 202.9**            | 199.6**            |
| S.E.E.         | 0.06               | 0.07               | 0.09               | 0.09               | 0.09               |

TABLE 5.5

## Log-Linear Cost per Patient Day Equations

| Variable       | Equation           |                    |                    |                    |                    |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                | 1                  | 2                  | 3                  | 4                  | 5                  |
| Constant       | -12.00             | -3.40              | -5.22              | 2.67               | -3.67              |
| INCO           | 0.012<br>(0.06)    |                    |                    |                    | 0.845<br>(17.16)** |
| DIAGMIX        | 0.269<br>(4.95)**  | 0.240<br>(4.27)**  | 0.449<br>(5.91)**  | 0.366<br>(4.74)**  | 0.460<br>(6.22)**  |
| POPBED         | 0.010<br>(0.34)    | 0.037<br>(1.30)    | 0.059<br>(1.47)    | 0.083<br>(2.09)*   | 0.061<br>(1.55)    |
| POPDENS        | -0.011<br>(2.09)*  | -0.010<br>(1.74)   | -0.012<br>(1.51)   | -0.010<br>(1.32)   | -0.010<br>(1.25)   |
| GPPOP          | -0.007<br>(0.39)   | 0.027<br>(1.48)    | 0.057<br>(2.30)*   | 0.082<br>(3.33)**  | 0.056<br>(2.29)*   |
| BEDS           | -0.013<br>(2.03)*  | -0.011<br>(1.64)   | -0.007<br>(0.72)   | -0.006<br>(0.67)   | 0.008<br>(0.86)    |
| ALOS           | -0.093<br>(2.67)*  | -0.104<br>(2.78)*  | -0.211<br>(4.21)** | -0.196<br>(3.99)** | -0.207<br>(4.19)** |
| OCCR           | -0.034<br>(0.72)   | -0.097<br>(1.98)*  | -0.124<br>(1.85)   | -0.178<br>(2.68)*  | -0.113<br>(1.72)   |
| INPS           | 0.001<br>(0.07)    | 0.014<br>(0.81)    | -0.002<br>(0.10)   | 0.014<br>(0.60)    | -0.005<br>(0.23)   |
| STAFFBED       | 0.733<br>(20.74)** | 0.673<br>(20.75)** | 0.459<br>(10.19)** | 0.447<br>(10.11)** | 0.459<br>(10.34)** |
| TREAT          | 0.264<br>(6.17)**  | 0.208<br>(4.73)**  | 0.166<br>(2.74)*   | 0.120<br>(2.01)*   | 0.172<br>(2.89)*   |
| TECHN          | -0.062<br>(6.60)** |                    |                    | 0.055<br>(17.38)** |                    |
| EARNs          | 0.894<br>(16.88)** | 0.725<br>(27.61)** |                    |                    |                    |
| CPI            | 1.041<br>(3.23)**  |                    | 0.059<br>(16.66)*  |                    |                    |
| R <sup>2</sup> | 0.940              | 0.930              | 0.871              | 0.876              | 0.874              |
| $\bar{R}^2$    | 0.937              | 0.928              | 0.867              | 0.872              | 0.870              |
| F value        | 329.6**            | 359.1**            | 182.5**            | 191.4**            | 188.7**            |
| S.E.E.         | 0.06               | 0.07               | 0.09               | 0.09               | 0.09               |

Log-Linear Cost per Adjusted Patient Day  
Equations

| Variable       | Equation           |                    |                    |                    |                    |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                | 1                  | 2                  | 3                  | 4                  | 5                  |
| Constant       | -15.92             | -4.86              | -6.60              | 0.41               | -5.23              |
| INCO           | -0.060<br>(0.17)   |                    |                    |                    | 0.748<br>(10.50)** |
| DIAGMIX        | 0.240<br>(2.37)*   | 0.206<br>(2.04)*   | 0.371<br>(3.39)**  | 0.328<br>(2.88)*   | 0.379<br>(3.54)**  |
| POPBED         | 0.004<br>(0.08)    | 0.039<br>(0.77)    | 0.062<br>(1.09)    | 0.075<br>(1.29)    | 0.064<br>(1.13)    |
| POPDENS        | -0.011<br>(1.11)   | -0.009<br>(0.90)   | -0.011<br>(0.96)   | -0.010<br>(0.85)   | -0.009<br>(0.79)   |
| GPPOP          | -0.121<br>(3.60)** | -0.078<br>(2.40)*  | -0.051<br>(1.44)   | -0.032<br>(0.88)   | -0.052<br>(1.48)   |
| BEDS           | -0.041<br>(3.42)** | -0.039<br>(3.15)** | -0.035<br>(2.60)*  | -0.034<br>(2.55)*  | -0.036<br>(2.70)*  |
| ALOS           | 0.053<br>(0.81)    | 0.039<br>(0.58)    | -0.051<br>(0.71)   | -0.043<br>(0.59)   | -0.047<br>(0.66)   |
| OCCR           | 0.001<br>(0.01)    | -0.077<br>(0.88)   | -0.106<br>(1.10)   | -0.144<br>(1.47)   | -0.097<br>(1.01)   |
| INPS           | 0.248<br>(7.97)**  | 0.264<br>(8.35)**  | 0.251<br>(7.30)**  | 0.262<br>(7.52)**  | 0.249<br>(7.29)**  |
| STAFFBED       | 0.521<br>(7.90)**  | 0.445<br>(7.65)**  | 0.257<br>(3.97)**  | 0.252<br>(3.87)**  | 0.257<br>(3.99)**  |
| TREAT          | 0.455<br>(5.68)**  | 0.383<br>(4.87)**  | 0.343<br>(3.94)**  | 0.312<br>(3.53)**  | 0.348<br>(4.03)**  |
| TECHN          | -0.078<br>(4.48)** |                    |                    | 0.047<br>(10.06)** |                    |
| EARN\$         | 0.843<br>(8.52)**  | 0.628<br>(13.34)** |                    |                    |                    |
| CPI            | 1.421<br>(2.36)*   | (10.27)**          | 1.025<br>(10.27)** |                    |                    |
| R <sup>2</sup> | 0.752              | 0.733              | 0.685              | 0.682              | 0.689              |
| $\bar{R}^2$    | 0.741              | 0.724              | 0.675              | 0.672              | 0.679              |
| F value        | 63.8**             | 74.4**             | 58.9**             | 58.0**             | 59.9**             |
| S.E.E.         | 0.12               | 0.12               | 0.13               | 0.13               | 0.13               |

### 5.5.3 Discussion

Before discussing the results for the individual variables it is necessary to mention the probable existence of multicollinearity among the variables.<sup>1</sup> This problem arises when some or all of the explanatory variables in the model are so highly correlated with one another that it becomes very difficult to disentangle their separate influences and obtain a reasonably precise estimate of their relative effects. A high degree of multicollinearity amongst the variables results in highly imprecise estimates of the regression coefficients, which is reflected in the large variances of the least squares estimators.

Evidence of the existence of multicollinearity in the sample is suggested by the instability of a small number of the variables with respect to changing signs and t-values. TECHN for example, has a negative coefficient when included in the same equations as EARNs, CPI, and INCO, and a positive and highly significant coefficient when included in equations without those three variables. INCO, also, tends to have insignificant t-values when included in equations with TECHN, EARNs and CPI, and highly significant t-values when included in equations without those three

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1. Since multicollinearity is a question of degree and not of kind, much debate has focused on identifying the point at which multicollinearity becomes a problem in regression analysis; see, for example, Conlisk (1971), and Newhouse (1971). The question of identifying and accounting for multicollinearity has also received attention in the literature; see, for example, Farrar and Glauber (1967), Haitovsky (1970), Kmenta (1971) and Johnston (1972).

variables. There is, in fact, a high degree of inter-correlation amongst these four variables, which provides a rough 'rule of thumb' indication of the existence of a multicollinearity problem.<sup>1</sup> Although exclusion of the closely correlated variables from some of the equations helps to minimise the possibility of a high degree of multicollinearity amongst the remaining explanatory variables, the coefficients of the included variables are likely to be biased as a result. This is clearly illustrated by the significantly high t-values for INCO which are obtained only after the exclusion of TECHN, EARNs and CPI from the regressions (reported in equation 5 in each table). Since INCO, in these instances, is capturing the effect of the excluded variables, one cannot conclude that rising income levels, alone, have a significantly positive impact on hospital costs levels through their effect on the demand for hospital care.

The estimated coefficients for DIAGMIX, the second of the demand variables, are positive and highly significant in all the equations listed, lending strong support to the hypothesis that changes in diagnostic mix are responsible for some of the rise in average costs over the ten year period. The coefficients of the log-linear equations range in value from approximately 0.2 to 0.5 suggesting quite a substantial impact on the level of average hospital costs as a result of a change in disease patterns.

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1. See Farrar and Glauber (1967) for a discussion of this and other indicators of multicollinearity.

Coefficients for the first of the demographic demand variables, POPBED, are consistently negative in the linear equations and positive in the log-linear equations, although their t-values are rarely significant, and only once at the 1% level in equation 1, table 5.2. Results for POPDENS, in contrast, follow the predicted pattern in all equations and are consistently negative. The coefficients are again rarely significant, however, and then only at the 5% level. It appears, then, that demographic changes, as measured by these two variables, had little impact on the level of hospital costs during the period 1962 to 1971.

The relative abundance of general practitioners as measured by GPPOP appears to exert an upward pressure on cost per case and per patient day, and a downward pressure on cost per adjusted patient day, although the estimated coefficients of GPPOP do not exceed their standard errors in a number of instances. The hypothesis that a greater supply of GP's relative to the population leads to an increase in the demand for (and hence in the costs of) hospital care is therefore confirmed when costs are measured on an inpatient basis. One plausible explanation for the negative relationship between GPPOP and PADJ (the average cost measure that includes both inpatient days and outpatient visits) is that the demand for outpatient care is likely to be higher in those areas where GP's are relatively scarce per head of population. The extent of the influence of GP availability on demand and hospital costs, however, is small - a 10 per cent increase in physician availability increases CASE and PDAY by less than 1 per cent (see equation 3, table 5.4 and equation 3, table 5.5) and



decreases PADJ by approximately 1 per cent (equation 1, table 5.6).

The effect of BEDS, the first of the institutional demand variables, on hospital cost levels appears to be indeterminate as the coefficients are for the most part small and rarely significant and have both positive and negative signs. Exceptions are the linear cost per patient day equations (Table 5.2) in which the coefficients are consistently positive and significant, and the log-linear cost per adjusted patient day equations (Table 5.6) in which the coefficients are consistently negative and significant. The evidence relating bed availability to rising hospital cost levels therefore appears to be rather inconsistent thereby preventing the formulation of any conclusions about the effect of BEDS on hospital costs.

The prediction that length of stay, ALOS, has a positive impact on hospital cost levels is supported by the results, though only in the equations in which CASE is the dependent variable. The estimated coefficients of ALOS shown in Tables 5.1 and 5.4 are all positive and highly significant, and suggest a substantial impact on costs per case: a 10 per cent increase (decrease) in ALOS increases (decreases) costs per case by between 7 and 9 per cent depending on the equation chosen (in Table 5.4). In the remaining equations in which PDAY and PADJ are the dependent variables the estimated coefficients for ALOS are consistently negative and frequently highly significant. This negative relationship may well be the result of the continuing tendency for the length of the patient's stay to fall. A shorter stay, particularly for patients

undergoing operations, 'spreads' surgical costs over a shorter period and therefore tends to increase patient day cost. The remaining medical and 'hotel' costs are likely to remain fairly constant whatever the patients' length of stay. The overall effect of a fall in ALOS, as the results indicate, is therefore to increase PDAY and PADJ, although the extent of the impact does not appear to be as great as the effect of changes in ALOS on CASE noted above.

The coefficients of OCCR, the bed occupancy rate, are consistently negative in all but a few equations, which suggests that the slight overall rise in bed occupancy rates that has occurred over the 10 year period under study has had a dampening effect on the rate of hospital cost increases. The coefficients, however, are small in value and rarely significant, indicating that the impact of changing occupancy rates on hospital costs is probably quite small.

In contrast, the final institutional demand variable, INPS, has had as predicted a marked positive impact on hospital cost levels, particularly in those equations in which the dependent variable is PADJ in Tables 5.3 and 5.6. The results indicate that an increase (decrease) in the proportion of inpatient days to total patient days (inpatient days plus outpatient visits), leads to an increase (decrease) in average costs per adjusted patient day. Or expressed slightly differently, the tendency for proportionately more patients to be treated on an outpatient basis has a dampening effect on the rate of increase in hospital costs. The coefficients in Table 5.6 suggest that

a 10 per cent reduction in the proportion of inpatient days to total patient days decreases average costs per adjusted patient day by approximately 2.5 per cent.

The direction of the influence of the remaining production and input cost variables is consistently positive, as predicted, and the estimated coefficients are highly significant in all but a few equations. The results therefore strongly support the hypothesis that the rise in the quantity and quality of hospital labour inputs (as measured by STAFFBED and TREAT) and the rising cost of both labour and non-labour inputs (as measured by EARNs and CPI) have been largely responsible for the rapid increase in average hospital cost levels during the ten year period under study. The estimated coefficients for CPI, for example, in Tables 5.4 to 5.6 are in many cases greater than unity, while those for EARNs and STAFFBED approach this value in a number of equations. A ten per cent increase in CPI, therefore, implies an equally large increase in average costs, while an equivalent change in EARNs or STAFFBED leads to a 7 to 9 per cent change in average costs. The effect of the remaining dummy variable, TECHN, included to represent technological change in the non-labour inputs over time, is not as clear. The changing signs of this variable's estimated coefficients, as well as the large fluctuations in the standard errors, reflect a multicollinearity problem already noted above. The true direction of the effect of this variable on average costs is therefore difficult to determine, although in those equations in which the presence of multicollinearity is minimised due to the omission of the closely related

variables EARNs, CPI, and INCO the estimated coefficients for TECHN are positive and highly significant. As in the case of INCO noted above, however, exclusion of closely related variables from the equations leads to biased coefficients amongst the remaining variables, so that TECHN, in effect, is capturing the impact of the excluded variables as well as its own impact on hospital cost levels.

#### 5.6 The Relative Cost Effects of the Explanatory Variables

It now remains to assess the relative importance of the various explanatory variables in explaining the overall increase in hospital costs during the period being studied. Two alternative approaches are employed. The first calculates the contribution of each set of factors to changing costs by multiplying the actual percentage change in each variable for the whole of New Zealand during the 10 year period by its estimated coefficient (taken from a representative equation).<sup>1</sup> This gives the predicted change in average costs attributable to each variable and thereby enables the impact of a group of variables on average costs to be estimated. These calculations, which were conducted using coefficients from a number of the log-linear equations in Tables 5.4 to 5.6, consistently indicate that the production and input cost variables account for almost all the predicted increases in average costs, while the demand variables (with the exception of DIAGMIX) appear to account

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1. Similar techniques for attributing cost increases to particular factors have been used by Salkever (1972) and Davis (1974).

for very little of the change in costs. These results should be interpreted cautiously, particularly as they assume that the values obtained for the whole of New Zealand represent those for individual Hospital Boards. Moreover, only the direct effect of changes in variables on average costs are measured, which ignores the possibility of substantial indirect effects. Rising income levels, for example, may lead to increases in the availability of general practitioners, or to a change in disease patterns associated with a more affluent life style. Since only the direct effect of changing incomes on hospital costs is calculated, a possible downward bias is imparted on the inflationary impact of this variable.

The second method of assessing the relative importance of the explanatory variables involves the use of factor analysis.<sup>1</sup> This technique enables one to represent a large proportion of the variance of the original variables by a smaller number of linear combinations of them. Factor analysis therefore not only reduces the dimension of the original set of variables, and assists in the redefinition of their groupings, but also, since the factors obtained are mutually orthogonal,

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1. The technique of factor analysis is described fully by Kendall (1957), and has been used in a number of hospital studies in recent years; see Feldstein M (1967), Evans (1971a), and Lave, Lave and Silverman (1972).

it effectively eliminates the problem of collinearity among the variables in the regression equations. The resulting factors can then be regressed against the three average cost measures and estimates of their relative inflationary impact can be derived. Naturally, it is desirable that the factors obtained by this technique have some plausible interpretation as meaningful variables in their own right, otherwise there would be no point in discarding the original variables in their favour.

Although a few factors may extract a large proportion of the total variance of the original variables, all components are required to reproduce the correlations between the variables exactly. In this study factors are extracted until the characteristic root of the next factor to be drawn would have fallen below unity. The resulting factors are therefore simply those which have characteristic roots greater than unity. By following this criterion, the original 14 explanatory variables are reduced to 4 factors. Table 5.7 shows the proportion of the total variance in the original variables that is explained by these four factors, which together account for 80 per cent of the variance, while individually the marginal change in the amount of variance explained decreases for each factor from 35 per cent (Factor 1) to 9 per cent (Factor 4).

Identification of the factors is performed by examining the correlations between the factors and the original variables given in Table 5.8. The first factor relates positively to the various input cost variables as well as to DIAGMIX, and is probably best labelled an 'input cost'

TABLE 5.7

Proportion of the Variance in the Explanatory  
Variables Explained by each Factor

| Factor<br>Number | Percentage of<br>Total Variance | Cumulative<br>Percentage<br>Total |
|------------------|---------------------------------|-----------------------------------|
|                  | %                               | %                                 |
| 1                | 34.78                           | 34.78                             |
| 2                | 26.12                           | 60.90                             |
| 3                | 10.08                           | 70.98                             |
| 4                | 9.28                            | 80.26                             |

TABLE 5.8

Simple Correlations between the Explanatory Variables  
and the Factors

| Factor | $r \geq 0.5$                                                        | $0.5 > r \geq 0.25$           | $r \leq -0.5$  | $-0.5 < r \leq -0.25$ |
|--------|---------------------------------------------------------------------|-------------------------------|----------------|-----------------------|
| 1      | TECHN 0.98<br>CPI 0.98<br>INCO 0.98<br>EARN 0.94<br>DIAGMIX 0.81    | TREAT 0.32                    |                |                       |
| 2      | BEDS 0.87<br>GPPOP 0.77<br>POPBED 0.76<br>OCCR 0.71<br>POPDENS 0.71 | STAFFBED 0.41<br>DIAGMIX 0.29 |                |                       |
| 3      | TREAT 0.84<br>INPS 0.61                                             |                               | STAFFBED -0.75 |                       |
| 4      |                                                                     | POPBED 0.44<br>STAFFBED 0.30  | ALOS -0.96     | OCCR -0.34            |

factor. The second factor relates positively to a number of demand variables and is therefore most appropriately classified as a 'demand' factor. The third factor is bipolar as it relates positively to TREAT and INPS, and negatively to STAFFBED. It seems appropriate to regard this as an 'input quantity' factor in view of the high correlations between the two labour input variables and the factor. The fourth and final factor is also bipolar relating negatively to the two utilisation variables ALOS and OCCR and positively, though not so strongly, to POPBED and STAFFBED. Factor four appears, therefore, to be an activity or 'utilisation' factor.

The results of regression equations relating the three average cost measures to the four factors are presented in Table 5.9. Three equations are given for each dependent variable, the first of which includes all four factors as explanatory variables, while the remaining two divide the factors between the input or supply factors and the demand and utilisation factors. As might be expected the  $\bar{R}^2$  values for these equations are generally lower in value than those for the regressions on the original variables. The estimated coefficients for the factors, however, are almost without exception highly significant. The input cost and demand factors appear to be positively related to the average cost measures, while input quantity is negatively related in the CASE and PDAY regressions. The utilisation factor is negatively related to CASE and positively related to PDAY and PADJ reflecting the relationship between ALOS and average costs already apparent in the earlier regression results.



TABLE 5.9

Linear Equations Based on Factor Analysed Variables

| Variable       | Equation            |                    |                    |                    |                   |                  |                   |                   |                  |
|----------------|---------------------|--------------------|--------------------|--------------------|-------------------|------------------|-------------------|-------------------|------------------|
|                | 1                   | CASE<br>2          | 3                  | 4                  | PDAY<br>5         | 6                | 7                 | PADJ<br>8         | 9                |
| Constant       | 217.5               | 217.5              | 217.5              | 13.35              | 13.35             | 13.35            | 9.38              | 9.38              | 9.38             |
| Input Cost     | 42.42<br>(33.16)**  | 42.32<br>(22.13)** |                    | 2.74<br>(35.91)**  | 2.74<br>(24.88)** |                  | 1.59<br>(20.60)** | 1.59<br>(19.29)** |                  |
| Demand         | 13.99<br>(10.24)**  |                    | 14.36<br>(4.78)**  | 1.00<br>(12.25)**  |                   | 1.03<br>(5.32)** | -0.23<br>(2.83)*  |                   | -0.25<br>(1.93)  |
| Input Quantity | -11.99<br>(8.69)**  | -12.32<br>(5.98)** |                    | -0.92<br>(11.23)** | -0.97<br>(8.17)** |                  | 0.32<br>(3.82)**  | 0.32<br>(3.63)**  |                  |
| Utilization    | -22.44<br>(16.76)** |                    | -22.18<br>(7.53)** | 1.07<br>(13.46)**  |                   | 1.09<br>(5.77)** | 0.50<br>(6.21)**  |                   | 0.50<br>(4.02)** |
| $R^2$          | 0.836               | 0.632              | 0.204              | 0.853              | 0.691             | 0.169            | 0.614             | 0.556             | 0.060            |
| $\bar{R}^2$    | 0.853               | 0.631              | 0.202              | 0.852              | 0.690             | 0.167            | 0.611             | 0.555             | 0.057            |
| F value        | 389.57**            | 263.48**           | 39.34**            | 442.82**           | 343.84**          | 31.25**          | 121.51**          | 192.34**          | 9.84*            |
| S.E.E.         | 22.35               | 33.41              | 49.13              | 1.33               | 1.92              | 3.16             | 1.35              | 1.44              | 2.09             |

The question of the relative importance of the various factors can be gauged from an examination of the equations in which the input and demand factors are included separately as explanatory variables. It appears that the cost and quantity of the hospital inputs, as measured by the two factors 'input cost' and 'input quantity', explain more of the variation in hospital cost levels than the demand and utilisation factors, judging from the different values for the coefficients of determination in each equation. The  $\bar{R}^2$ 's in equations 2, 5 and 8 are consistently higher than those in equations 3, 6 and 9. This result supports the conclusion already noted above that the increasing cost, quantity and quality of hospital inputs appear to have been the main contributors to rising hospital cost levels in recent years.

## 5.6 Summary and Conclusions

This chapter has been devoted to the presentation and testing of an econometric model of hospital cost inflation in New Zealand. The main purpose of the analysis has been to determine the direction and extent of the influence of a number of variables on the costs of running New Zealand's hospitals.

A number of conclusions have arisen from the analysis, perhaps the most significant of which is the relative importance of the supply related and demand related variables in explaining the rising level of hospital costs. The results suggest that most of the upward pressure on

hospital costs is due to the rising cost, quantity and quality of the labour and non-labour inputs used by the hospitals. Although a number of the demand variables, notably DIAGMIX and ALOS, were shown to have highly significant estimated coefficients in many of the equations, their impact on hospital cost levels appears to be small in comparison to that of the supply variables. A factor analysis of the explanatory variables and the subsequent regression analysis based on the derived factors provided results which tend to support this conclusion. While it is apparent, however, that changes on the supply side are primarily responsible for rising hospital costs in New Zealand, the results also make it clear that all relevant factors, both supply and demand related, need to be included in the analysis for the best explanation of rising average hospital costs. Omission of any of these important sources of cost inflation substantially reduces the explanatory power of the regressions, as well as biasing the estimated coefficients of the remaining variables.

A number of important policy implications can be drawn from these results. Clearly if, as the results suggest, the main impetus for rising hospital costs is related to the supply of the hospitals' inputs, policies for controlling this inflation are best directed at the supply variables. While it may be possible to control the rise in the earnings of hospital staff, however, it may not be as easy to restrict the cost increases which accompany improvements in the skill and quality of the labour and non-labour inputs. Indeed, the diminishing

returns to medical advance in terms of prolonged or saved lives, or in terms of improved health levels, make one wonder whether it is possible to prevent hospital costs from rising, for improvements in health appear to be possible only with a greatly increased expenditure on health and hospital services.

It is also apparent that few savings in costs are possible on the demand side. For although, for example, a continued reduction in the length of stay of patients in hospital imparts a downward pressure on costs per case, this relationship is reversed when the cost per patient day measures are considered - a reduction in length of stay concentrates and intensifies the care that patients receive on a daily basis, thus tending to increase patient day costs. Changes in the occupancy rate do not appear to have any significant effect on the level of hospital costs over time.

One demand related area in which cost savings may be possible arises from the rapid growth in the utilisation of outpatient facilities. The trend, noted in Chapter Three, for the utilisation of outpatient facilities to expand more rapidly than inpatient care, represents the widening health care role of the hospital, as well as a tendency for outpatient and ambulatory care to be substituted for inpatient care. Since the cost of treating patients on an outpatient basis is substantially less than the cost of inpatient care, considerable savings are possible if more patients are treated on an outpatient basis. This is borne out by the results which indicate that the proportionate increase in outpatient visits has imparted a downward

pressure on the rate of increase in average costs per adjusted patient day.

Finally, it remains to provide an overall assessment of the model and method of estimation used in this chapter. Clearly the model has its limitations. In the first place much detail is lost by taking the Hospital Board as the basic data unit. Consideration of a micro-economic model based on data for individual hospitals may alter and possibly improve the explanatory power of the model. Secondly, the presence of problems associated with the estimation of a pooled cross-section time-series regression model, throws some doubt on the stability and efficiency of the estimated coefficients. Thirdly, the inclusion of proxy measures, such as TECHN and TREAT, to explain some of the important variables in the model, and the exclusion of others, such as age, sex and race, due to a lack of suitable data, may have introduced an unexplained element of bias and unreliability into the analysis.

On a more favourable note the inclusion of a variable, based on detailed diagnostic data, which summarises the changing pattern of diseases being treated in hospitals, marks a considerable improvement on the diagnostic mix variables included in previous hospital cost inflation studies. Although the change in diagnostic mix and its impact on hospital cost levels during the period studied are small in comparison to the impact of the rising cost of inputs, the estimated coefficients (which are consistently positive and highly significant) in the regressions indicate the importance of the inclusion of such a variable in studies of hospital cost inflation.

The model also helps to highlight the folly of comparing average hospital costs from year to year without taking into account the many changes that have taken place in the technology and practice of medicine, in the skills of the doctors, nurses and other staff, and in the types of patients that are treated. Even over as short a period as the 10 years examined in this research the nature of a hospital's output has changed dramatically. Any comparisons of hospital costs over time which ignore these improvements are therefore seriously misrepresenting the extent of the rise in hospital costs which has actually taken place.

Attention, to this point, has been devoted to an analysis of hospital costs over time with the main emphasis being on the identification and examination of the various factors that have been responsible for the recent rapid rise in hospital costs. The remaining chapters are taken up with an analysis of the second important aspect of hospital costs: the reasons for cost variations between hospitals at a given point of time, that is, a cross-section analysis of hospital costs.

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## CHAPTER SIX

A Review of the Literature on Hospital Cost Variations:  
(Part a) Differences in Institutional Characteristics and  
Utilisation

## 6.1 Introduction

It was pointed out in the introductory chapter that a complete analysis of hospital costs should include an examination of both inter-temporal and interhospital cost variations. The analysis to this point has been concerned with identifying those factors that have been largely responsible for raising the level of hospital costs in recent years. Attention is now turned to analysing the variations in the costs of running individual hospitals at a given point in time, or in a given year. Interest is therefore diverted from the generic forces which appear to have influenced the growth in the costs of running all hospitals, to the particular factors that determine why it costs more to treat patients in some hospitals than in others.

Three groups of factors have been identified in the literature as contributing towards interhospital cost variations: differences in institutional characteristics, in utilisation and in hospital output. This chapter is devoted to reviewing the evidence relating to the first two groups of factors, while output differences are discussed



in Chapter 7. The review begins with an examination of a number of the methodological issues involved in studying interhospital cost variations, followed by a discussion of several alternative theoretical models of hospital behaviour.

## 6.2 The Econometric Approach to Analysing Hospital Cost Variations

Analysis of variations in the costs of running hospitals involves, essentially, an examination of cost-output relationships. Empirical studies of interhospital cost variations therefore follow quite closely the approach and methodology employed in empirical cost studies that have been undertaken for many different types of firms in recent years.<sup>1</sup> Typically, following specification of a suitable production function relating a "flow of output per unit of time achievable for any given rates of input services per unit of time" (Johnston, 1960, p.4), cost functions are derived which describe the costs of producing different levels of output in both the short and the long run. In addition, the majority of the cost studies have utilised cross-section data, and have employed econometric techniques to estimate the cost-output relationships.

Common to many of these empirical cost studies have been a number of data problems such as the variability of accounting practices behind the published data, the effect of geographical factor price variations, the variability

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1. For two excellent reviews of the more important of these studies see Johnston (1960) and Walters (1963).

of conditions between firms of different size at any given period of time, and estimation problems such as errors of observation, simultaneous equations bias, and the regression fallacy.<sup>1</sup> In addition, the estimation of hospital cost functions involves further methodological difficulties which arise from the peculiar nature of the institution being examined. Hospitals, typically, are multiproduct firms which are rarely motivated by the profit motive. Moreover, while it is possible in most cost studies to define and measure in precise terms the output(s) of a particular firm, the output of the hospital is not so amenable to satisfactory definition and measurement.<sup>2</sup>

Specification of the cost-output relationship for the multiproduct firm requires either a host of independent variables, or a series of cost functions to account for the many products of the firm. The former approach is normally followed because of the lack of suitably detailed data on the costs of producing each individual output. It has been argued that an estimated cost function is not a 'true' representation of the complex cost-output relationship, but is rather an approximation over a limited range (Lave and Lave, 1970). The extent of this range inevitably becomes more difficult to specify the more products the firm is producing. This problem is

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1. For a full description of these problems see Johnston (1960), Chapters 3 and 6.
  2. A discussion of the various approaches to defining and measuring hospital output follows in Chapter 7, and an examination of alternative measures of output for hospitals in New Zealand is undertaken in Chapter 9.

particularly relevant for the hospital, which is producing a large number of products ranging from inpatient and outpatient care to varying quantities of teaching and research activities. One cannot assume, for example, that the hospital 'behaves' in the same way as the traditional firm of economic theory and attempts to meet an exogenously determined level of demand and to produce this level of output at minimum cost. In the first place, it is debatable whether the demand for hospital care is determined entirely outside the hospital - the rate of hospital utilisation may be influenced considerably by hospital management policy towards, say, the scheduling of operating times, or through the regulation of admissions and discharges. In the second place, the absence of the profit motive implies that the hospital is not necessarily striving to minimise its costs of production. Both these considerations lead one to conclude that estimated cost-output relationships for hospitals are unlikely to represent economically determined cost functions. It seems more appropriate, therefore, to follow the lead of one or two researchers and describe estimated cost functions for hospitals as 'behavioural', since they attempt simply to describe the way in which particular hospitals behave in a given period.<sup>1</sup>

### 6.3 Economic Theories of Hospital Behaviour

Absence of the profit motive in most of the hospital

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1. See, for example, Evans (1971a) and Salkever (1972).

industry has led a number of economists to postulate alternative explanations of the behaviour of hospitals. Four such explanations have been proposed - output maximisation, output and quality maximisation, utility maximisation, and physician profits maximisation.<sup>1</sup>

The suggestion that the objective of nonprofit hospitals is to maximise output, subject to certain constraints has been proposed by a number of writers,<sup>2</sup> and can be regarded as a variant of Baumol's hypothesis that business firms attempt to maximise sales subject to earning a minimum acceptable rate of return (Baumol 1959). Long (1964) for example, argues that hospitals desire to maximise the number of patients treated subject to a financial constraint "specified by the sponsoring agency" (ibid, p.212), and a quality constraint which states that care must be the best possible with available equipment and personnel. Klarman (1965) also proposes this objective for the non-profit hospital and includes among the constraints that the size of its deficit should not exceed certain specified limits. Davis (1972a), in

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1. Alternative classifications of the models of hospital behaviour abound in the literature. Davis (1972a), for example, identifies five groups of theories: recovery of costs, output maximisation, output and quality maximisation, utility maximisation, and cash flow maximisation. M. Feldstein (1974a), on the other hand, describes three alternative maximands: quality and quantity of care delivered, the net revenue earned by the hospital, and the income of medical staff. Finally, Jacobs (1974) places the models into two groups: 'organism' models which treat the hospital as an organism or entity and 'exchange' models which regard the hospital as an institution designed to serve the interests of the parties connected with it.

2. See Long (1964), Klarman (1965), Reder (1965) and Rice (1966).

comparing profit-maximising and quantity-maximising hospitals points out that in the short run, for any given bed size a quantity-maximising hospital can be expected to serve a greater number of patients, and in the long run to increase output at a faster rate, than a profit-maximising hospital. Both Davis (ibid) and Rice (1966) also note that both types of hospital will hire factor inputs in such a way as to minimise the cost of providing that level of output.

Although conceptually simple and appealing the quantity-maximisation model ignores the fact that decision-making within the hospital is not restricted to one group as in most other organisations, but is divided between two principle groups - medical and administrative<sup>1</sup> - whose aims and motives are not necessarily the same. An additional criticism is that quality of care is largely ignored, or, at best, included as a constraint in the achievement of output maximisation.

Quality of care is included explicitly in several more recent models of hospital behaviour which postulate maximisation of both quantity and quality of output, subject to a breakeven constraint. This maximand has been applied by M. Feldstein (1967) to analysing the response of hospitals in the U.K. to changes in the government budget constraint, and by Evans (1970) and M. Feldstein (1971c) to predicting the price, input and output behaviour of

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1. Other groups that may influence hospital policy decisions include the hospitals' trustees and the patients themselves. For a discussion of the various types of hospital organisation and authority structure see Perrow (1967).

American hospitals. Despite the inclusion of quality in these studies, the question of a suitable definition of quality has by and large been overlooked. Newhouse (1970) defines quality in terms of certain quality-indicative input criteria such as personnel per patient or the availability of various facilities. Feldstein refers to quality as "a catch-all term to denote the general level of amenities provided to patients as well as additional expenditure on professional staff" (1967, p.159). Both writers therefore define the quality of a hospital's outputs in terms of the quantity and nature of the inputs it provides, the implication being that the larger the number of personnel per patient, and the greater the quantity of sophisticated equipment provided, the higher the quality of hospital care. A more output-oriented definition of quality of care in terms of, say, the probability of successful treatment,<sup>1</sup> has not yet been satisfactorily defined, thus leading researchers to rely on proxy measures based on a number of input criteria.

An additional complication with this model of hospital behaviour concerns the way in which the different decision-makers in the hospital view quality of care. Newhouse assumes that any differences that may exist between the attitudes of trustees, doctors and administrators are overcome through compromise. As Jacobs (1974) points out, however, "quality to doctors and trustees may mean something entirely different, and it is not enough to assume

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1. This has been suggested by Davis (1972a). Further consideration is given to the problem of defining and measuring the quality of hospital care in Chapter 7.

'some final resolution'" (ibid, p.87).

The hypothesis that hospital behaviour is determined by the utility that hospital administrators obtain from the size and nature of the hospital in which they work has been proposed by Reder (1965) and Lee (1971). Reder argues that hospital administrators attempt to maximise their own utility which is a function of the size of the hospital, the extensiveness of modern sophisticated equipment, and the professional prestige of doctors on the staff. In addition Reder postulates that the hospitals ability to attract and retain doctors on its staff is a function of the range of capital equipment available at the hospital. Lee (1974) also proposes a utility maximising model in which the utility function includes "all those variables which affect the well-being of the administrator.....salary, prestige, security, power, professional satisfaction among others" (ibid, p.49). In addition, Lee argues that the utility of hospital administrators is a function of the status of the hospitals in which they serve, which is assumed "to vary with with range of services available and the extent to which expensive and highly specialised equipment and personnel (including M.D.'s) are available" (ibid, p.49). In order to maximise the status of the hospital, and thereby the utility of the administrators, hospitals strive to acquire certain inputs without adequate regard to actual production, with the result that they tend to use more resources than required to produce a given output. As a result, the stocks of certain inputs increase without a corresponding increase in output, resulting in "undue

duplication, over-equipment and overcapacity" (ibid, p.57).

Perhaps the principle shortcoming of the utility maximisation model of hospital behaviour is that it has little to say about the level of a hospital's output as the emphasis is on the quality of the hospital's inputs, both labour and non-labour. No prestige or utility, apparently, is obtained from the level of the hospital's output, even though it is clear that hospital administrators do make decisions about output through policies on admissions, length of stay and capacity utilisation. There is, in other words, more to hospital behaviour than simply the pursuit of prestige and status. A further criticism, of Lee's model in particular, concerns the exclusion of decision-makers other than hospital administrators from the analysis. Doctors, for example, are regarded as inputs into the administrator's utility function thus ignoring the significant role that they may play in determining the introduction of new techniques and methods of treatment into the hospital.

A further model of hospital behaviour has been proposed by Pauly and Redisch (1973) who suggest that the hospital be viewed as a doctor's cooperative or implicit partnership that seeks to maximise the physicians' money income. Again, this theory can be criticised on the grounds that it is too restrictive in outlook. All the actions of the hospital are explained in terms of a single income maximand, despite the fact that doctors are likely to be just as concerned with other important matters such as "the style and character of their work and in their sense of professional accomplishment" (Feldstein, 1974a,



p.394), as well as with questions of the quality and quantity of the hospital's output. Furthermore, by concentrating solely on the behaviour of doctors, the behaviour of other decision-making groups, such as the trustees and administrators of the hospitals, has been omitted thereby effectively reducing the explanatory usefulness of the model.

It appears that the common shortcoming of these four theories of hospital behaviour is their oversimplification of reality through their tendency to omit certain important behavioural or organisational elements of the hospital. A complete "bureaucratic" model of hospital behaviour would require the inclusion of all these groups: trustees, doctors, administrators and patients. Such a model however, is likely to prove unwieldy and to lack the predictive power of the simpler models. The task of explaining the behaviour of such a complex non-profit making, (and in many cases, publicly owned) institution seems, therefore, to be a question of "constructing a model that is rich enough to explain all observed behaviour, while also being simple enough so that the analysis of the model yields new insights into behaviour" (Feldstein, *ibid.* p.395).

Finally, with the exception of M. Feldstein's study of hospitals in England and Wales (1967), all the models reviewed describe the behaviour of non-profit privately owned and operated hospitals in America, which may not be relevant to other health systems. It is unlikely, for example, that the physician income maximisation model is a suitable behavioural description for hospitals that are

publicly owned and financed. A more appropriate model for such hospitals is probably the utility maximisation model - status and prestige remain important motivating forces in the competition for resources for hospitals in both public and private health systems - or by the quantity-quality maximisation model, which explicitly accounts for the budgetary constraint under which publicly owned hospitals are required to function.

#### 6.4 The Effect of Differences in Institutional Characteristics

Institutional characteristics refer to those physical features of the hospital which are likely to affect the structure and level of its costs. The characteristic that has received most attention in the literature is the size of the hospital and consequently the bulk of this section is devoted to reviewing this work. The other characteristic of importance is the location of the hospital which gives rise to questions of the costs involved in travelling to the hospital for medical care.<sup>1</sup>

##### 6.4.1 The Relationship Between Hospital Size and Hospital Cost

The relationship between the cost of producing hospital services and the size (or level of output) of the hospital

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1. Other institutional factors that may be relevant in explaining interhospital cost differences include type of ownership, and the system of financing and organisation of the hospitals. Few studies have examined the role of these factors, however, mainly because the majority of cross-section studies of hospital costs have focused on particular groups or types of hospital. Recent exceptions include Neuhauser and Turcotte (1972) and Fottler and Rock (1974).

can be examined from either a short term or long term point of view.<sup>1</sup> In the short run, during which time the size of the hospital is assumed to be relatively constant, the average cost of hospital care depends on both the extent to which costs are fixed in nature, and the extent to which the hospital facilities are utilised. If, for example, fixed costs are a high proportion of total hospital running costs, average costs will tend to fall as the level of output, or utilisation, increases. The importance of the level of utilisation, the length of patient stay, and other aspects of the hospital's level of activity in relation to its costs are discussed in the next section. This section is devoted to the behaviour of hospital costs in the long run, when the size of the hospital is no longer assumed to be fixed.

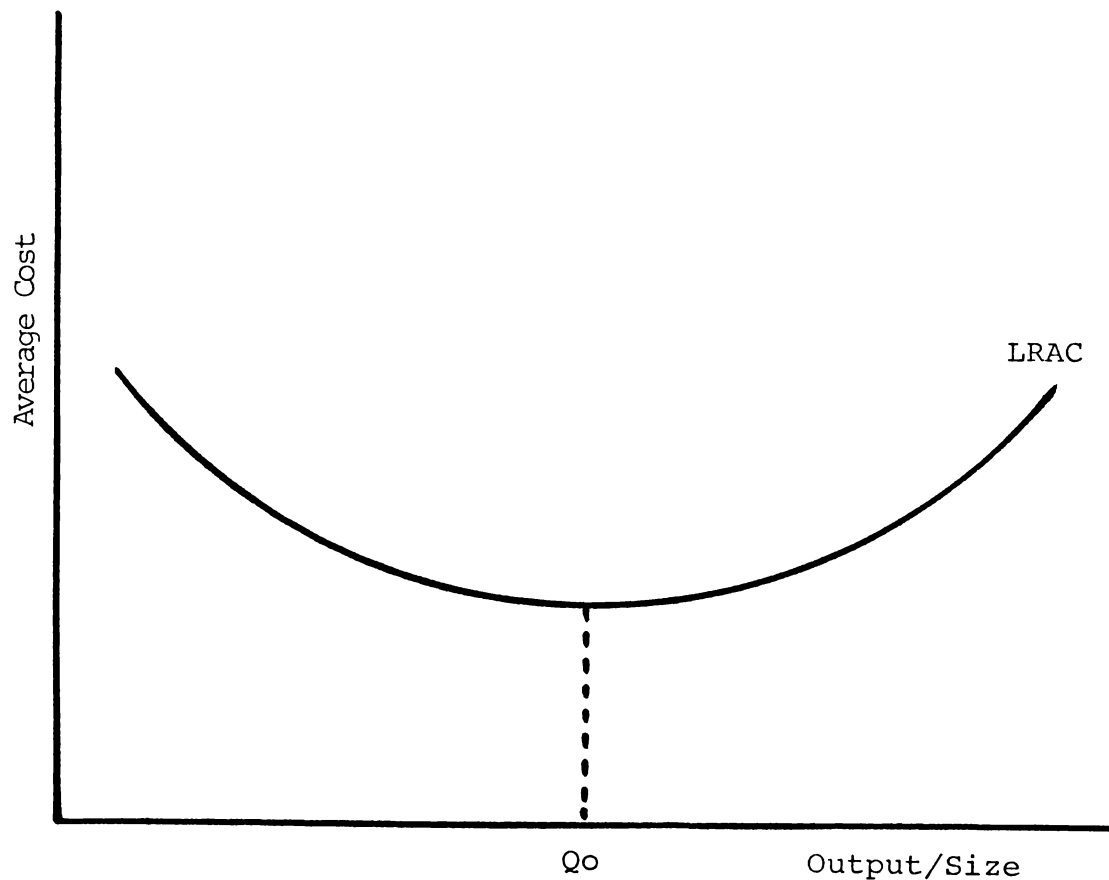
Discussion of hospital costs in the long term raises questions of the existence of economies or diseconomies of scale in the production of hospital services and of the optimal size for hospitals. A hypothetical long-run average cost curve (LRAC) which reflects these relationships is shown in figure 6.1. It is typically U-shaped, with increasing returns to scale over the lower range of output and decreasing returns to scale in the upper range. The firm's optimal scale of operation is defined as that level of output ( $Q_0$ ) which coincides with the minimum point of the LRAC curve, that is, the point at which all the economies of increasing scale have been fully exploited

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1. A number of alternative definitions of hospital size and output have been used in recent studies; these are noted later in this section.

and before the diseconomies of large scale have been incurred.<sup>1</sup>

Fig. 6.1 A Typical Long-Run Average Cost Curve.



Evidence of the existence of economies of scale in a number of other industries,<sup>2</sup> has led several economists to anticipate them in the hospital industry. Technical economies, for example, are likely to exist in hospitals with high levels of output, since they are able to use

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1. It should be noted that while point  $Q_0$  represents the firm's optimal scale of operation, it does not necessarily coincide with the optimal level of output.
  2. These industries include electricity, road passenger transport, coalmining, building societies and life assurance companies. Excellent summaries of these empirical cost studies have been given by Wiles (1956) and Johnston (1960).

indivisible factors of production, such as a coronary care unit, or a pathology laboratory, more fully and efficiently than smaller hospitals. Economies may also result from the division of labour that occurs as hospitals expand, which permits greater task specialisation and thereby increases overall staff dexterity and efficiency.

Diseconomies of scale, on the other hand, may also be expected, particularly in large hospitals producing a wide range and a large quantity of outputs. It is argued that the hospital's LRAC curve will begin to rise at some level of output because of the problems of management and communications associated with a large institution. The large scale work environment may also serve to offset the gains resulting from greater task specialisation in large hospitals. Revans (1962 and 1964) has shown that staff morale tends to be lower and ease of communication tends to be worse in larger English hospitals, resulting in a lower level of staff efficiency in the larger than in the smaller hospitals.

A number of empirical studies of the relationship between hospital size and costs have been undertaken in recent years more especially in America, but also in Britain and Canada. The results, according to one reviewer of the literature, "are as varied as the methods and the models used in the studies" (Hefty 1969, p.275).

On the methodological side, in addition to the wide variety of output measures employed, researchers have used a number of different measures of size. Most<sup>1</sup> define and

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1. These include Long (1964), Ro (1968), M. Feldstein (1967), Stevens (1970), Lave and Lave (1970 and 1972), and Evans (1971 and 1972).

measure size in terms of the number of available beds, although Ro (1968) deflates this quantity to account for beds not in use for extended periods and considers 'bed complement' instead. Others, pointing to the shortcomings of available beds as a measure of size, attempt to find alternatives: Carr and Feldstein (1967) and Berry (1967 and 1970) use 'average daily census' as their measure, while Ingbar and Taylor (1968) use 'patient days' and 'available bed days'. Cohen (1967 and 1970) transforms his weighted measure of output into patient days, using some unstated formula, which he then includes as his measure of scale.

Further confusion arises from the various definitions of the dependent cost variable that are used. Some use total cost,<sup>1</sup> while the majority use average cost per case or per patient day. In many cases, however, the cost measure is inappropriately defined. In the first place, researchers have, for the most part, failed to include depreciation charges in their definition of long-run total costs. Although, in many cases, depreciation data are either unavailable or grossly inadequate, their exclusion from the regression analyses is likely to lead to biased results, particularly if the capital-labour ratio is positively correlated with hospital size. Secondly, many of the studies define an average cost measure which relates the total cost of all hospital activities to a measure of output based only on the number of inpatients or inpatient days. In order to obtain a more representative cost measure an attempt should be made either to reduce the total

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1. These include P. Feldstein (1961), Carr and Feldstein (1967) and Cohen (1967).

cost measure to one which accounts only for the cost of inpatient care,<sup>1</sup> or to expand the measure of output to include some allowance for outpatient care.

Differences in the way in which the cost functions are specified are also likely to produce conflicting results. Berry (1967) and Francisco (1970), for example, specify a linear relation between average cost and size, thereby implicitly assuming either economies or diseconomies of scale throughout the entire range. Some researchers also test the hypothesis that the LRAC curve may in fact be L-shaped by assuming a multiplicative cost function. Neither of these models accords with the traditionally postulated U-shaped LRAC curve, which can best be represented by a polynomial of the second degree.

In view of the many methodologies and definitions employed, as well as the different hospital systems studied, it is hardly surprising to find that empirical analyses of economies of scale in hospitals have produced conflicting results. A summary of these findings (Table 6.1) includes studies that confirm the existence of scale economies, studies that find evidence suggesting scale diseconomies, and also studies that find little evidence of either. One pattern that does emerge, however, is related to the method of output standardisation employed. Those investigators who have used service-mix measures to control for differences in output have, with the exception of Ingbar and Taylor (1968), generally obtained fairly strong evidence of

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1. An adjustment along these lines was undertaken by Evans (1971 and 1972) in his analyses of hospital costs in Ontario and British Columbia.

TABLE 6.1

Economies of Scale in Hospitals : A Summary of Findings<sup>a</sup>

| Investigator and year of publication | Location and Number of Hospitals Studied | Output Standardisation Method used <sup>b</sup>                                 | Principal Findings                                                                                        |
|--------------------------------------|------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| P. Feldstein (1961)                  | Eastern United States, 60 hospitals      | None                                                                            | Economies of scale throughout range                                                                       |
| Carr and P. Feldstein (1967)         | United States, 3147 hospitals            | 5 Service-capability groups                                                     | Economies of scale over a wide range of output. Optimum size 190 beds.                                    |
| Berry (1967 & 1970)                  | United States, 5294 hospitals            | Identical service groups                                                        | Economies of scale throughout range                                                                       |
| Cohen (1967 & 1970)                  | New York, 46 hospitals                   | Weighted Output measure                                                         | U-shaped LRAC curve with optimum range between 540 and 790 beds                                           |
| M. Feldstein (1967)                  | Britain, 177 hospitals                   | Nine Specialty-mix proportions                                                  | Shallow U-shaped LRAC curve with optimum size 310 beds, coefficients not statistically significant        |
| Ingbar & Taylor (1968)               | Massachusetts, 72 hospitals              | Four measures of service availability and quantity                              | Inverted U-shaped LRAC curve with maximum cost at 190 beds                                                |
| Ro (1968)                            | Western Pennsylvania, 68 hospitals       | A number of scope of service variables                                          | Economies of scale throughout size range studied                                                          |
| Francisco (1970)                     | United States, 4710 hospitals            | (i) Identical service groups<br>(ii) Index of available services and facilities | (i) Economies of scale for smaller hospitals, constant returns for larger<br>(ii) Weak economies of scale |
| Fraser (1971)                        | Canada, 1266 hospitals                   | Weighted Output measure                                                         | Economies of scale throughout range                                                                       |
| Lave and Lave (1970)                 | Western Pennsylvania, 74 hospitals       | None - assumed constant output mix within hospitals                             | } Weak economies of scale in both studies, coefficients rarely significant                                |
| Lave, Lave & Silverman (1972)        | Western Pennsylvania, 74 hospitals       | Diagnostic-mix proportions                                                      |                                                                                                           |
| Evans (1971)                         | Ontario, 188 hospitals                   | Diagnostic-mix proportions                                                      | } Very weak diseconomies of scale in both studies though coefficients insignificant                       |
| Evans (1972)                         | British Columbia, 90 hospitals           | Diagnostic-mix proportions and complexity measure                               |                                                                                                           |

<sup>a</sup> Similar summaries though less comprehensive and up to date, have been given by Hefty (1969, p. 278), Spitzer (1970, p. 424) and Berki (1972, p. 115).

<sup>b</sup> A detailed review of these standardisation methods is undertaken in Chapter 7.



economies of scale. Those that have used case-mix measures, on the other hand, have found the relationship between size and cost to be weak and generally insignificant in each of the three hospital systems studied to date: Britain (Feldstein 1967), Canada (Evans 1971), and America (Lave et al. 1972). The explanation for this may be related to the superiority of the latter technique of output standardisation, which has been shown to yield substantially more explanatory power than the service-mix technique. With a large proportion of interhospital cost variation being explained by differences in diagnostic mix, the effects of hospital size on costs becomes less significant.

The question of whether economies of scale exist in the hospital industry is still largely unresolved, judging by the variety of the results obtained in empirical studies to date. Future analysis, by concentrating on improving the measures of cost, size and output employed should help to resolve this problem.

#### 6.4.2 The Effect of Location on Hospital Costs

A hospital's location, whether metropolitan, urban or rural, can be expected to affect the level of costs both directly, as a result of differences in local factor prices, and indirectly, through the incidence of transportation costs, which include the costs of time and transport incurred by patients and doctors travelling to and from the hospital.

The task of determining the level of transport costs is a particularly difficult one which few economists have

tackled.<sup>1</sup> Long and P. Feldstein (1967) derive travel time estimates for patients, visitors, doctors, and hospital personnel from data on the time and distance between home and hospital for obstetric patients in the Chicago region. The value they place on travel time, excluding any allowance for the cost of transport, is between \$1.55 and \$2.80 per hour. In a more recent study, Gruer (1971) estimates and compares the travel costs incurred by consultants travelling to clinics outside base hospitals and by patients travelling to hospital outpatient clinics. Estimates for both groups include the cost of transport as well as the cost of work time lost while travelling and, for patients, while waiting for care. This study, which was undertaken to compare alternative outpatient clinic locations, shows that the cost of consultants travelling to 'peripheral' clinics is invariably less than the costs to the community of outpatients travelling to centralised services. Despite some of the heroic assumptions used in deriving the estimates, such as the assumptions relating to mode of travel, occupation, and income for which information was not collected, Gruer's results indicate that a centralised outpatient service is not necessarily the optimal arrangement when consideration is given to the costs of time and travel associated with it.

Allowance for the effect of hospital location on

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1. Most recent studies relating to hospital location examine the effect of distance from the hospital on its utilisation. See, for example, Morrill and Earickson (1968 and 1970), Shannon et al. (1969), Weiss et al. (1970) and Bashshur et al. (1971).

hospital costs has been made in a few recent empirical studies. Lave et al. (1972), for example, include a dummy variable in their regression equations to distinguish between hospitals located in metropolitan and non-metropolitan areas, and find that average cost per case for the metropolitan hospitals is \$US27.97 (6 percent) more expensive than for their non-metropolitan counterparts. Shuman et al. (1972) define four locational categories in their analysis of hospital costs in Western Pennsylvania: Pittsburgh, metropolitan, urban and rural, which they also represent as dummy variables. Their results indicate that higher costs are associated with the Pittsburgh and metropolitan locations. In the absence of data that would more accurately describe the different cost effects of urban and rural hospitals, the use of dummy variables in these studies provides a useful approximation, and the results obtained support the hypothesis that urban hospitals incur higher costs than rural hospitals.

#### 6.5 The Effect of Differences in Utilisation

Consideration of the relationship between the intensity of hospital and bed utilisation and the level of costs involves an examination of costs in the short run during which time each hospital's capacity is assumed to be fixed. The level of utilisation of a hospital's facilities, which is usually measured in terms of its bed occupancy rate, depends on a variety of factors such as the type of patients treated and their length of stay, as well as the size and nature of the hospital itself. It is generally argued, for

example, that larger hospitals tend to have higher occupancy rates because they offer more comprehensive care and treat more complex longer stay patients than the smaller hospitals. It has also been shown that different levels of utilisation in the same institution are associated with different patient types. Rafferty (1971) examined the pattern of hospital use in two American hospitals over a four year period and found that certain diagnoses, those for which admission might reasonably be considered postponable or discretionary, were more likely to be admitted to hospital at low levels of utilisation than at high levels, while the reverse was true for a second more complex group of diagnoses. Part of the change in costs that accompanies a change in output may, therefore, be attributable to the altered "package of services" produced at different utilisation levels.

A further peculiarity of the hospital industry that complicates the discussion of its utilisation, is that in many instances the existence of an excess capacity, both in terms of vacant beds and excess staff, is regarded as desirable, because of daily and seasonal fluctuations in admissions and patient types. Optimal utilisation, therefore, has often been defined to include an allowance for excess capacity,<sup>1</sup> even though vacant beds add substantially to costs because of the high proportion of fixed costs involved.

It is also relevant to consider the intensity with

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1. Klarman (1965) notes that hospital planners in America for many years set the optimum rate of occupancy at 80 per cent, and that the current consensus revolves around 85 per cent.

which a hospital's beds are utilised, given its occupancy rate. Intensity of use can be measured either by the average length of a patient's stay (ALOS), or by the case flow rate (CFR), the number of patients treated per bed year. Clearly the two measures are closely related for the longer a patient's average stay the slower the case flow rate. More intense utilisation of capacity can be expected to lead to a higher cost per day of care if the reduction in ALOS, or increase in CFR, is the result of a concentration of diagnostic and therapeutic services into a shorter period. If, however, the reduction in ALOS is simply the result of medical progress and improvements and changes in the methods and patterns of care, more intense utilisation may not necessarily imply higher cost per day.

The effect on cost per case of intensity of bed utilisation is more predictable. A higher ALOS (lower CFR) can be expected to increase cost per case as a longer stay usually implies additional day to day expenses which are incurred regardless of the intensity of treatment. Similarly a reduction in ALOS implies a fall in cost per case although the effect may be reduced if the reduction in stay leads to an increase in cost per patient day.

A number of empirical estimates of the relationship between the intensity of hospital and bed utilisation and hospital costs have been made in recent years, generally in the context of a comprehensive study of interhospital cost variations. Several researchers<sup>1</sup> have

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1. These include Ro (1968), Evans (1971a) and Lave, Lave and Silverman (1972).

found a negative relationship between occupancy rate and hospital costs. Lave et al. (1972), for example, estimate that a 1% increase in utilisation leads to a small 0.4 per cent decrease in average cost per case of \$1.96. Others have found that more intense bed utilisation lowers cost per case and raises cost per patient day either through a reduction in ALOS or an increase in CFR.<sup>1</sup> Deeble (1965) who finds this situation exists in Victorian Public General Hospitals in Australia, argues that although reductions in ALOS increase cost per patient day, they are still warranted as they allow an earlier return to home and work which benefits both society and the individual patient.

Several investigators have found that marginal costs (i.e. the cost of treating an additional patient or patient day) tend to represent a fairly high proportion of the level of average costs.<sup>2</sup> Lave and Lave (1970d), for example, find that the marginal cost of an additional case is between 40 and 65 per cent of average cost per case. Evans (1971a) also finds high marginal cost-average cost ratios: marginal cost per treated case is 86% of average cost, and per extra day of care is 76% of average cost in Ontario, Canada. These results are contrary to the generally held belief that "empty beds are costly beds", i.e. that a high proportion of a hospitals running costs

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1. These include Deeble (1965), Feldstein (1967) Evans (1971a), and Lave, Lave and Silverman (1972).
  2. These include Deeble (1965), Ingbar and Taylor (1968), Lave and Lave (1970d), and Evans (1971a).

are fixed in the short run, which has been supported empirically by Brown (1956), P. Feldstein (1961) and M. Feldstein (1967). Some of the apparent contradiction in results may be due to the different time periods used. P. Feldstein, for example, bases his analysis on one monthly data, Lave and Lave on 6 monthly data, and the remainder on annual data. One would expect a higher proportion of the cost of running hospitals to be variable the longer the time period being analysed.

The discussion up to this point has centred on the evidence accumulated to date which describes the effect on hospital costs of differences in certain institutional characteristics and activity levels. Attention is now turned to one of the central conceptual and analytical problems encountered in studies of hospital cost variations, namely the problem of defining and measuring hospital output. A summary of both these review chapters is given at the end of Chapter Seven.

## CHAPTER SEVEN

## A Review of the Literature on Hospital Cost Variations:

## (Part b) Differences in Output

## 7.1 The Problem of Defining Hospital Output

One of the main elements of the cost-output relationship is clearly the output of the business firm or institution being studied. Frequently that output can be easily described and quantified in physical terms as the number of units of a product (shoes, butter, cars,) produced in a given period of time. The definition and measurement of the output of the hospital, however, is not as straightforward and has in consequence proved an awkward problem for those who have attempted to estimate cost functions for hospitals. Indeed, as reviewers of the literature have noted, the picture is somewhat confused. Berki (1972, p.32) for example, concludes that:

the definition of output is not only unclear, diverse, conflicting, tautological and ephemeral, .....(but also) there appears to be no agreement either on a conceptual or merely definitional level ..... on what the appropriate measure of output is, or should be.

Ideally, from the point of view of the hospital cost analyst, the definition of hospital output should not only be conceptually sound, but should also be quantifiable. It seems inappropriate therefore to define the hospital's output as the restoration of health, for apart from the



obvious measurement difficulties, this definition does not take into account the function of a hospital in treating terminal illnesses.<sup>1</sup> Nor can it be defined in terms of the end result of a period of hospital care as this ignores the many other factors that influence health levels, such as the whole range of public health services and the many curative and preventive services available to the public.<sup>2</sup> Similarly, although conceptually one may argue that a hospital's output is best reflected by the satisfactions consumers derive from improved states of health, or even from expected improvements in their health, it is not possible to measure such satisfaction directly.<sup>3</sup>

Faced with this intractable problem of definition, economists have, for the most part, adopted a pragmatic approach and have measured hospital output in terms of the number of patient days, the number of admissions or the number of deaths and discharges recorded at a particular hospital, data for which are readily available for analysis in most countries. Use of such surrogate measures, however, creates problems of its own, the most significant of which arises from the realisation that output measured in these terms is not homogeneous among hospitals treating different types of diseases and offering different ranges of services.

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1. See Lave (1966).

2. See Somers and Somers (1967a).

3. This proposition, mentioned by Berki (1972, p.32) is based on Lancaster's theory of consumer behaviour (1966).

Broadly speaking, two approaches have been used to account for the heterogeneous nature of hospital output: that based on the hospital's "service-mix", and that based on the hospital's "case-mix". This difference in approach has been largely determined by the availability of particular data. In America, for example, detailed diagnostic information for individual hospitals is not generally available,<sup>1</sup> whereas considerable information is available on the types and ranges of services offered. Canada and the U.K., on the other hand, have well documented and detailed information on the diagnostic mix (Canada) and 'specialty' mix<sup>2</sup> (U.K.) of patients treated in hospital. American studies of hospital costs have therefore tended to account for output differences on the basis of services offered, while the Canadian and British studies have based their measures on treated case types.

## 7.2 Output Standardisation for Differences in Service-mix

Two procedures have been used to standardise output for service-mix differences among hospitals. The first controls for the kinds of services the hospital can perform as reflected in the scope and range of its specialised facilities, while the second controls for differences in

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1. Some recent American studies have gained access to detailed diagnostic information usually from a small sample of hospitals in a particular region. See, for example, Lave and Lave (1971), Lave, Lave and Silverman (1972), Rafferty (1972a and 1972b) and Lee and Wallace (1973).
  2. Measures of diagnostic mix are based on the International Classification of Diseases and include over 1000 different disease types, while measures of specialty mix are based on the 30 to 40 different specialities in which patients are treated (general medicine, paediatrics, gynaecology etc).

the number of specific services that are performed for the patient, such as x-ray and laboratory tests.

Several studies have adopted the former approach<sup>1</sup> which assumes that hospitals with identical or very similar facilities produce patient days that are homogeneous in service content. 'Homogenisation' of the hospital's output is achieved by stratifying the hospitals in such a way that each group contains only hospitals with the same or similar service capabilities.<sup>2</sup> Carr and Feldstein (1967) take account of the number of services offered in 3147 U.S. Voluntary short-term general hospitals in two ways. They initially include as independent variables in their regression equation both the number of services offered by each hospital (S), and the product of S and the number of patient days of care. They then group the hospitals into five 'service-capability groups' based on the number of services offered, and analyse each group separately. Similar methods are used by Berry (1967 and 1970) who defines 40 groups of hospitals with identical facilities and services, and Francisco (1970) who defines 25 such groups, while a later study by Edwards et al. (1972) presents four indexes based on the scope of service provided by 5439 U.S. short-term nonfederal general hospitals in 1969 - a general index, an acute care index, an outpatient index and an index for long-term care.

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1. Carr and Feldstein (1967), Berry (1967 and 1970), Francisco (1970), Edwards et al. (1972) and Shuman et al. (1972).
  2. The data for these calculations are reported annually by the American Hospital Association (A.H.A.), which specifies the presence or absence of a range of services provided by American Hospitals.

The main shortcoming of all of these studies arises from their basic assumption, which, as stated by Berry (1967, p.127), reads:

As the range of diagnoses a given hospital is capable of treating is directly related to the spectrum of facilities and services available in that hospital, the availability or non-availability of facilities and services is probably a reasonable approximation of product differentiation in the form of more or less complex scopes of services.

By basing their measures of service capability simply on the presence or absence of certain facilities or services, these authors take no account of differences in the size, complexity or rate of utilisation of the facilities. One cannot, for example, assume that a hospital specialising in obstetrics and gynaecology and having the same physical facilities as a general hospital is producing the same output. In other words the existence of common facilities or services cannot be taken to imply similar case-mix, case complexity, or quality of care.<sup>1</sup> Nor can one assume that the mere existence of a service ensures its full utilisation.

There have been two attempts to overcome some of these inadequacies. The first appears in a study which derives an index measure of the quality of hospital care based on hospital death rates adjusted for case severity

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1. This point has been stressed by Lave and Lave (1970) and is supported by their later empirical work (1971) in which they provide evidence of a low correlation between various case mix measures and measures of service capability. They conclude that service capability cannot meaningfully be employed as a proxy for case mix.

(Roemer et al. 1968). The authors develop a 'Technological Adequacy Index' with which to test the proposition that the presence or absence of certain facilities and services in a hospital may have an influence on its death rate. Thirteen components are identified, based on the A.H.A. survey results, and then weighted according to the "judgement of the authors on the probable relative influence of these inputs on the outcome of patient care" (ibid, p.108). Those components which receive the greatest weighting are the presence of accreditation, approved residency, and an approved cancer program. A Technological Adequacy Score (TAS) is then derived for each of the 33 hospitals being studied; its value depends on the presence of certain facilities and the relative weights attached to them. On the basis of this measure the authors are able to show that the hospitals with higher TAS's have consistently higher crude death rates, which confirms their general hypothesis that larger hospitals with a more sophisticated and advanced technology attract the more complex and severe cases.

While the Roemer study is an advance on previous research in that it attempts to account for differences in the relative technological sophistication of hospital facilities, the measure still suffers from the inadequacies inherent in the AHA reports noted above. Shuman et al. (1972) endeavour to overcome these problems by collecting data more directly suited to their needs from the 100 Western Pennsylvannia hospitals included in their study of hospital costs. By restricting their attention to those services associated with "extraordinary or non-routine

inpatient procedures, rather than basic or routine services" the authors emphasise "the specialised procedures which typically have a significant effect on both direct and indirect costs and which can be used to differentiate hospitals" (ibid, p.2). Twenty services selected for inclusion in the analysis, are weighted using a psychometric scale based on the subjective estimates of a group of hospital administrators, physicians and controllers as to the relative total effect on cost of providing each service. In arriving at their estimate of the total effect on cost, the raters include "not only the direct costs which could be allocated to the service, but also the cost of all other hospital functions that may have been influenced as a result of the specific service" (ibid, p.22). A value for the service variable at each hospital is obtained by summing up the psychometric weights for the services provided at each institution. This value is then used as an indicator of the total effect of non-routine services on hospital cost.

Although the Shuman study marks a considerable improvement over previous attempts to control for output heterogeneity through service capability measures, the service variable defined still ignores the differences that exist in the size, complexity and rate of utilisation of those services in individual hospitals. The value for the service capability of each hospital is based on weights derived from the average for all hospitals, which therefore assumes that the effect of each service on hospital costs is the same in every hospital. This however, need not necessarily be the case.

The second approach to standardising hospital output for service-mix differences controls for differences in the number of specific services actually performed for the patient rather than controlling for the kinds of services the hospital is able to perform on the basis of its available facilities. In the earliest study of this kind Saathoff and Kurtz (1962) devise a weighted measure of output intended to overcome the shortcomings of the 'patient day' statistic and its derivative, cost per patient day. Output is represented by the sum of seven weighted service variables,<sup>1</sup> where the weights are based on "what were considered to be the logical time and cost relationships of these services in total hospital operations" (Ibid, p.14). There is however little discussion of the origin of the weights, and the authors themselves admit that their formula "is obviously arbitrary" (ibid, p.14).

Two later studies by Cohen (1967b and 1970) represent attempts to develop "a more inclusive measure of service output which weights each included service by its estimated average cost in dollars rather than time" (Cohen 1967b, p.359). Cohen defines output as the sum of weighted services as follows:

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1. Adult and paediatric patient days of service, newborn infant days of service, obstetrical service, surgical service, x-ray service, laboratory service, and out-patient service (Saathoff and Kurtz 1962, p.14).

$$S^k = \sum_i W_i Q_i^k$$

where  $S^k$  = service output in kth hospital

$W_i$  = weight of ith service

$Q_i^k$  = quantity of ith service<sup>1</sup> in kth hospital

The  $W_i$  are determined by dividing each service unit's average costs by the average cost of an adult and pediatric patient day. The average cost of each service is determined from data on the direct cost and quantity of services reported by a sample of 23 member hospitals to the United Hospital Fund of New York City. Use of average costs as weights for the service units is based on the argument that "in the revenue-constrained world of the supply of these services, relative average cost is an important determinant ..... of which services are offered and how much of each" (ibid, p.280). Cohen also includes an additional weighting factor in his more recent study (1970) to take account of differences in the quality of care between hospitals. He argues that quality of care is reflected in the degree of accreditation and affiliation of a hospital, and assumes that the average output unit of the affiliated hospital is composed of 10, 20, or 30 per cent "more care", depending on the degree of

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1. 13 'service units' are identified: operations (weighted), deliveries, diagnostic x-rays, laboratory examinations, physical therapy treatments, electrocardiograms, therapeutic x-ray treatments, blood transfusions, newborn days, outpatients visits, electroencephalograms, emergency room treatments, and adult and pediatric days (Cohen 1967b, p.360).



affiliation, than that of the non-affiliated hospital.

Several criticisms have been made of Cohen's studies, particularly in relation to his weighting methods. Berki (1972) questions the validity of using an output measure weighted by average costs with which to estimate total cost functions: "statistically one would expect a high degree of autocorrelation between output weighted by cost and cost itself" (ibid, p.37). Berki finds Cohen's attempt to incorporate quality differentials "ingenious, but somewhat troublesome" (ibid, p.37) as does P. Feldstein (1970), who questions the quality measure used, primarily on the grounds that it is not sufficiently discriminating to account for all quality differences among large hospitals in an urban area. In addition, the measure "may be indicating merely the higher costs per unit of output that are associated with medical school affiliation" (ibid, p.295). Finally, the implicit assumption in studies such as Cohen's which standardise output according to that set of services received by the patient, is that hospitals which provide the same number of services produce similar outputs. Measuring output in terms of the quantity of services given, however, ignores the differences in output that arise because of case-mix differences amongst patients, efficiency differences between hospitals, and the different amounts of research, teaching, and other functions performed by the hospitals.

Several other studies have been conducted which have either used weighted output measures similar to those used by Cohen (Ro 1969 and Fraser 1971) or have attempted to standardise output by including as independent variables a

range of input services which account for both the type and quantity of services offered to the patient (Ingbar and Taylor 1968). Perhaps the most fruitful of the studies using this approach is the work of Kovner (1969) who has developed a detailed weighting scheme for specific services comprising ambulatory care. Kovner weights each of a large number of procedures such as history taking, prior evaluation of records, and so on, on the basis of the professional qualifications of the individual performing the service, the health status of the patient, and the estimated difficulty of the diagnostic or treatment procedure, which he aggregates into an index entitled the "Identifiable Medical Procedure". The multidimensionality of this index, achieved through a combination of a large number of narrowly specified procedures and a variety of weights, represents a substantial improvement over previous output standardisation techniques, which, theoretically, should also be applicable to inpatient care. In common with the other studies, however, Kovner attempts to control for hospital output heterogeneity in terms of inputs. A more direct approach would be to study hospital output from the point of view of the patient rather than the services he receives. A review of research that has adopted this approach now follows.

### 7.3 Output Standardisation for Differences in Case-mix

A number of researchers with access to detailed diagnostic information, have derived measures of hospital case-mix which attempt to standardise output by accounting

for the wide variety of case types treated in hospitals. Although most of these measures have been based on the International Classification of Diseases, Adapted (ICDA) which, in its most detailed form, lists over 1000 disease types, the earliest attempt to standardise hospital output for case mix was based on 'specialty-mix'. In his study of 177 large, acute, non-teaching hospitals in England and Wales in 1960-61, M. Feldstein (1965b and 1967) groups the various specialties into eight mutually exclusive groups,<sup>1</sup> and expresses the number of cases treated in each category as a proportion of all cases. On the assumption that these case-mix proportions summarise the substantial interhospital variation in output, the eight case-mix proportions for each hospital are included as independent variables in a multiple regression analysis of interhospital cost variations. Feldstein's results indicate not only that hospitals treat significantly dissimilar case-mixes, but also that these case-mix differences explain a significant proportion (27.5 per cent) of the variation in ward costs per case among hospitals. He concludes, therefore, that "in studying the factors that influence hospital costs, biased and possibly misleading results may be obtained if case-mix differences are not taken into account" (Feldstein, 1967, p.51).

While going a substantial way towards accounting for interhospital case-mix differences, Feldstein's specialty

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1. General medicine, paediatrics, general surgery, ear nose and throat, traumatic and orthopaedic surgery, other surgery, gynaecology, and obstetrics (Feldstein 1965b, p.98).

categories are still extremely broad, for more than half of his treated cases are included in the rather vague 'general medicine' and 'general surgery' specialties which can scarcely be regarded as homogeneous treatment groupings. The availability of the more detailed ICDA data has led to the development of measures of diagnostic mix that more closely approximate the desired homogeneous output measure, for ideally one is seeking to divide up hospital patients according to the amount and types of resources necessary to treat them, that is into 'isoresource categories' (Lave and Lave 1971, p.17).

The main problem that researchers have encountered when using ICDA data to represent hospital case-mix, is the fineness of detail with which the data are presented. Clearly, it is impractical to use the unadjusted raw data in view of the large number of medical diagnoses and surgical procedures that exist. Several techniques have been used in attempts to group the data into more manageable forms so as to facilitate statistical analyses of the effects of case-mix variations on hospital costs.

In his analysis of 188 acute care hospitals in Ontario in 1967, Evans (1971a) groups the ICDA diagnoses into 41 'roughly homogeneous categories' on the basis of advice from the Ontario Hospital Services Commission. Following division of the total number of inpatients in each hospital according to the proportions falling into each diagnostic category, the resulting matrix of 188 x 41 observations is factor analysed in order to reduce the dimensionality of the matrix to more manageable proportions. The ten factors thus identified are then used as inputs in

a regression analysis to explain inter-hospital variations in average cost per case and per patient day. The results, as Evans himself notes are quite striking: "the factor-analysed proportions .... account for 72.3% of cost per case and 57.4% of cost per day" (Evans 1971b, p.3), indicating the extreme importance of the diagnostic mix of a hospital's patient load in determining its inpatient expense patterns. Two further aspects of hospital case-mix which are not accounted for when diagnoses are grouped in this way are the age and sex of the patients treated and the relative severity or complexity of the diagnoses. Evans accounts for the age-sex composition of the inpatients of Ontario's hospitals in a similar fashion to case-mix. He divides the hospital case load according to the proportions falling into each of 40 age and sex categories which when factor analysed yield factor scores for each hospital. The addition of the age-sex factors in the regression analysis raises the explanatory power of the cost per case equation from 72.3 to 84.2 per cent; no increase is evident in the cost per day equation (Evans, *ibid.* p.3).

Perhaps the most ingenious innovation, however, is introduced by Evans in his later study of hospitals in British Columbia (1971b) in which he attempts to capture the impact of differing case complexity through an information measure defined on the diagnostic mix proportions. On the assumption that "severe and complex cases tend to be handled in a few hospitals with more extensive facilities and more specialised staff, while relatively straightforward cases tend to be distributed more evenly over the hospital

system" (ibid, p.5), Evans uses the degree of concentration of a case type across hospitals as a measure of its severity.<sup>1</sup> Two indexes of relative complexity are derived: the first, CMPXC1, measures the relative complexity of the case load of each of the 90 British Columbian hospitals, while the second, CMPXC2, indicates the relative complexity of each hospital's case load after account has been taken of differences in hospital size.

The validity of the measures is supported through observation of the diagnoses and hospitals which have a high and low complexity values. Diagnoses with the highest values include nephritis and nephrosis, diseases of the eye, poliomyelitis and encephalitis, and malignant neoplasms, while low values are assigned to upper respiratory disease, skin infections and stomach troubles. Hospitals with high complexity ratings are generally the large urban hospitals such as Vancouver General (1731 beds), and Victoria Royal Jubilee (512 beds).

Inclusion of these complexity measures in the regression equations reveals a strong positive relationship, particularly for CMPXC1. Indeed, this variable is found to explain nearly as much of the inter-hospital cost

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1. Evans estimates the degree of concentration of a case type across hospitals with an 'expected information measure', a statistical concept applied widely in Economics by Theil (1967). Following consideration of what is known, a priori, about the hospital system as a whole, Evans then measures the 'expected information gain' from learning more about the characteristics of a particular case type. Further consideration is given to this measure in Chapter 9 when the technique is used to derive complexity values for New Zealand's hospitals.

variations as do the original diagnostic factor scores, which suggests that similar sorts of information are being represented by the two types of variable. Of the two approaches Evans argues that the complexity measures based on information theory are superior as they "enable one to capture the information in the discharge diagnosis matrix directly, and to avoid the arbitrariness of 'a priori' aggregation of diagnoses and factor analysis to reduce excess dimensionality" (ibid, p.38).

One problem with this approach lies with the basic premise that the severe and complex cases tend to be handled in a few hospitals with the specialised facilities to cope with them, with the further implicit assumption that complex cases imply higher average costs. In some instances, particularly if the technique is applied to handling very large numbers of diagnoses,<sup>1</sup> complexity may be confused with rarity. Some diseases, especially of the infectious variety, though rare, are not necessarily complex or costly in terms of the resources utilised in their treatment, while other diseases that are quite common and spread throughout the hospital system may be more complex and costly than the complexity values imply. Furthermore, the possibility of there being a variation in the complexity of cases within a diagnostic classification is ignored. Patients with diabetes, for example, which is assigned a relatively low complexity value of 0.85, may

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1. Evans calculates his complexity indexes on the basis of the 98 item Canadian list of diagnoses, which is itself based on the ICDA taxonomy.

include those with mild diabetes in an early stage as well as those with rapidly progressive diabetes combined with certain renal and cardiac complications.<sup>1</sup> The complexity measure, however, assigns equal weight to all patients within a given diagnostic category. This problem clearly stems from the inadequacies of the basic diagnostic information rather than with the information measure used.

Several researchers in America have also had access to detailed ICDA information and have developed techniques for grouping the data in order to derive manageable and representative measures of hospital case-mix for inclusion in interhospital cost variation analyses. Of particular importance is the work of Lave and Lave (1971) and Lave, Lave and Silverman (1972), who carried out an intensive analysis of the case-mix of 65 Western Pennsylvanian hospitals, using Hospital Utilisation Project data.<sup>2</sup> They develop several measures to account for the variations in hospital case-mix based both on diagnostic information and on data relating to the incidence and distribution of surgical procedures. Their principle measure is based on the distribution of patients among the 17 broad ICDA diagnosis classifications, which include such groupings as infective and parasitic diseases, deliveries and

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1. See Katz et al. (1969) for an informative discussion of the problems encountered in classifying chronic diseases.
  2. Other techniques of deriving summary case-mix measures have been presented by Moore (1970), Hurtado and Greenlick (1971), Rafferty (1972a and 1972b), Lee and Wallace (1972 and 1973), and Fottler and Rock (1974).



complications of pregnancy, and injuries and adverse effects of an external cause. This approach is chosen in preference to a measure based on service data or specialty data as in M. Feldstein (1967) above, as the authors feel that the diagnostic groups approximate more closely the ideal 'isoresource' classification being sought, despite the considerable loss of detail associated with such broad aggregations.

The results arising from an initial regression of the diagnostic proportions and a number of 'characteristic' variables, such as size, occupancy, location and teaching status on average cost per case, are described by the authors as 'unsatisfactory' (Lave et al. 1973, p.170) due largely to the presence of a high degree of multicollinearity in the full cost function specification. In the absence of additional information, which is the classic solution to the collinearity problem, Lave et al. use three alternative procedures to aggregate the 17 diagnostic variables: principal component analysis, clustering with principal components and clustering on estimated marginal costs, each of which reduces the dimensionality of the variables to five groups. Of the three techniques, the latter 'purposive' measure, which combines these diagnostic categories that had similar marginal costs in the preliminary estimates, is shown to be superior to the two 'non-purposive' traditional techniques as it permits the "estimation of a cost function with greater explanatory power and more reasonable parameter estimates" (ibid, p.179).

In addition to this diagnostic measure, Lave et al. develop two measures of disease 'commonality', one based on

the proportion of a hospital's inpatient load being treated for certain 'common' diseases (those that individually accounted for at least 0.5 per cent of all patients), the other based on the proportion of a hospital's non-surgical patients with a 'common' diagnosis. Forty eight conditions out of a possible 1000 are defined as being common by this definition and together they constitute approximately 55 per cent of all discharges and deaths from the Western Pennsylvanian hospitals being studied. In view of the fact that this small subset of diagnoses accounts for such a high proportion of all inpatient cases, Lave et al. hypothesise that hospitals in which a high proportion of common cases are treated will have lower costs per case. Their results, for both commonality measures, support this hypothesis.

Lave et al. finally supplement their measures of hospital case-mix with an index measure of surgical difficulty based on a national index of relative charges for surgical procedures constructed by Blue Shield in 1964. This measure is used by the authors as a surrogate for case-mix complexity on what they regard as "the rather reasonable assumption that a hospital that receives the more complex surgical cases is also likely to receive the more complex medical cases" (Lave and Lave 1971, p.24). The hypothesis that higher costs are associated with hospitals in which a high proportion of the surgery performed is complex (having a surgical difficulty index value greater than 70) is strongly supported by the

results.<sup>1</sup> The authors also found that as the proportion of patients receiving surgery of any kind increases, cost per case rises, although the coefficients are never statistically significant.

To summarise, it is clear that the detailed analysis by Lave et al. of the case-mix of a number of Western Pennsylvanian hospitals has led to the development of a number of conceptually and statistically simple measures which go a long way towards standardising the extremely heterogeneous nature of hospital output.

The question now remains as to the relative merits of the two broad approaches to standardising hospital output - using either service-mix or case-mix measures - bearing in mind that the principal objective of these procedures is to improve the specification and analysis of hospital cost functions. Opinion is almost unanimous among reviewers of the literature (Hefty 1969, Morris 1970, and Berki 1972) and researchers (Berry 1970, Evans 1971b, Lave and Lave 1971, and Rafferty 1972a) that output standardisation by case-mix measures is the superior technique, as it yields substantially more explanatory power than the service mix approach. There is, however, room for the point of view that the two approaches are measuring essentially different aspects of hospital output

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1. This conclusion is supported by an earlier study (Muller 1967) in which it is shown that persons with the more complex types of surgery incur higher charges than other surgical patients for their hospital stay, although this is partly attributable to a longer length of stay. The index of surgical complexity referred to ranges between 0 and 100, the more complex procedures having the higher values.

and therefore adjustment for output heterogeneity is incomplete unless both service-mix and case-mix differences are accounted for. Unfortunately, in the majority of studies to date the availability of particular data has largely determined which procedure has been adopted for the analysis.

#### 7.5 Output Standardisation for Differences in the Quality of Care

While there is little doubt that the quality of care offered by hospitals varies both within and between hospitals, the difficulties of defining and measuring quality differentials and of adjusting hospital output accordingly, have proved considerable and have led to much confusion and uncertainty in the literature. A substantial part of this confusion has resulted from there being essentially two groups - 'practitioners', including doctors and administrators, and economists, - interested in defining measures of quality of care, whose objectives in doing so are far from similar. In general, the practitioners regard quality definition and measurement primarily in terms of setting benchmarks against which existing practice and performance can be evaluated and hopefully improved. The economists on the other hand, are primarily concerned with quality as a factor in product definition and differentiation.<sup>1</sup> Unfortunately, the sorts

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1. This divergence of approach was noted by Somers and Somers (1967a) in the course of a Conference on Health Economics at the Brookings Institution in 1965.

of quality measures derived by practitioners to assess quality of care are for the most part not suitable for use by economists in studies of inter-hospital cost variations, usually because they are too detailed and too specific to be applied to the hospital as a whole. As a result, economists have generally used surrogate measures of quality based on the existence of certain hospital characteristics which it is thought reflect a higher quality of care.

Roemer (1959) in an analysis of post-operative mortality rates for nearly 20 thousand operations performed in Saskatchewan hospitals between 1950 and 1953, concludes that for three out of the five surgical procedures studied - appendectomies, cholecystectomies and prostatectomies - "the evidence seems clear that large hospitals are safer places than small ones" (ibid, p.50). Several researchers have also found that mortality rates for certain specified conditions are considerably lower in teaching than in non-teaching hospitals, both in England and America,<sup>1</sup> while others have shown that 'optimal care', as defined by a committee of experts comprised of doctors and administrators, is more likely to be obtained in teaching hospitals than in voluntary non-teaching hospitals, and even more so than in proprietary hospitals.<sup>2</sup> It has also been shown that, controlling for size and teaching status, hospitals with coronary care units have a

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1. These include Lee et al. (1957), Sparling (1962), Lipworth et al. (1963), and Slee and Amerst (1969).

2. Trussell et al. (1964).

significantly lower mortality rate from acute myocardial infarction (heart attack) than those without.<sup>1</sup> Grier and McClellan (1968) found that the introduction of a coronary care unit to a large community hospital reduced the mortality rate from heart attacks from 32 per cent to 15.5 per cent during its first year of operation.

The available evidence suggests, then, that quality of care varies with the size of the hospital, its teaching status, its type of ownership and the scope of its services. Most of these studies, however, have based their analysis on mortality rate variations which, rather than reflecting differences in quality of care, may simply be the result of differences in the severity and diversity of cases admitted to different types of hospitals. Roemer et al. (1968) have attempted to adjust mortality rates to account for interhospital case severity differentials in order to ensure that "a hospital's total mortality record will properly reflect the overall quality of the care given rather than the gravity of condition of the patients who enter the hospital's doors" (ibid, p.100). By representing case severity by average length of patient stay adjusted for differences in occupancy rates, the authors are able to show that severity adjusted death rates are lower in accredited and voluntary hospitals in Los Angeles County, than in unaccredited and proprietary hospitals, the reverse, in fact, of the pattern suggested by the crude death rates

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1. PAS Reporter (1970).

in those hospitals.<sup>1</sup> Although the measure has some attractive features - it is simple, easy to calculate and data are readily available - subsequent studies have questioned its validity. Lave and Lave (1971), for example, who develop a surgical complexity index based on relative charges for surgical procedures,<sup>2</sup> find little relationship between their direct measure and the 'surrogate' measure of Roemer and his associates. Goss and Reed (1974) also question the validity of the Roemer index following their application of it to 102 short-term hospitals in New York City, particularly as their results are not as clear cut as those of the Roemer study. They argue that the use of occupancy-corrected length of stay to indicate case severity in hospitals is not justified in the New York sample as the association between the two is much lower than that for the Los Angeles hospitals.

Despite the many problems and shortcomings associated with attempts to identify hospital characteristics that reflect a higher quality of care, a number of hospital cost studies have included variables in their equations intended to account for quality differentials. Cohen (1970), for example, includes a dummy variable to distinguish between hospitals affiliated and not affiliated to a medical school.

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1. Roemer et al. studied a sample of 33 hospitals in Los Angeles County, in 1964, ranging in size from less than 100 beds to more than 500. The apparent contradiction between Roemer's results (for crude death rates) and those mentioned in the previous paragraph probably stem from the fact that Roemer is concerned with all deaths, while the others deal with deaths from certain selected diseases.

2. This measure has already been discussed above.

Fraser (1971) includes dummy variables in his analysis of Canadian hospital costs to indicate the existence of health care education and training programmes for both doctors and nurses which, he argues, "usually result in the provision of both a larger quantity and quality of health goods and services to a patient with a given complaint than would be provided in other hospitals" (ibid, p.39). Lave et al. (1972) also represent the teaching status of a hospital with dummy variables, though not specifically to account for a quality differential, but rather in recognition of the fact that teaching hospitals tend to incur higher costs than non-teaching hospitals. The results of all three studies support the general hypothesis that higher quality care is associated with higher average costs.

An alternative approach to measuring the quality of hospital services has recently been proposed by M. Feldstein (1974c), who computes quality indexes for both labour and non-labour hospital inputs in America by states, deflated respectively by indexes of wage rates and of capital goods prices. Quality improvement is assumed to have occurred if changes in average cost per case exceed the rise in the cost of inputs. Feldstein's results indicate not only considerable interstate differences in quality, but also substantial quality improvement over time. His approach, however, has been criticised mainly on the grounds that one cannot in practice assume that the quality of a hospital's output is necessarily related very closely to



the quantity of its inputs.<sup>1</sup>

A direct measure of quality ideally can only be defined in terms of the final outcome of health activities. Davis, (1972a) for example, suggests that quality be defined in terms of the probability of successful treatment, in which case higher quality care is that which results in a higher probability of successful treatment than does low quality care. The difficulties of defining output in terms of final outcomes, however, have led most researchers to either ignore quality differentials, or to account for them by using various rather unsatisfactory input criteria. It appears, then, that Rice's comment that "the measurement of quality may well be one of the most difficult problems with which we must contend in the economic analysis of hospitals" (Rice 1966, p.87) is an appropriate reflection on the current state of the art of quality assessment.

## 7.5 Summary

A summary of the factors found to be responsible for interhospital cost variations as reviewed in Chapters Six and seven, is given in Table 7.1. As well as listing the variables and their estimated relationships with the level of hospital costs, the table also records the measurement techniques employed, the presence of any

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1. This criticism was made by A.J. Culyer in a discussion which followed the presentation of the paper at a recent Health Economics Conference held in Tokyo by the International Economic Association; see Perlman (ed.) 1974 p.420.

unresolved problems, and the more important empirical studies relating to each variable. The variables are grouped under the three headings used in the two review chapters - differences in output, in institutional characteristics, and in utilisation. The table illustrates the considerable interest that has been shown in recent years in the whole question of hospital cost variations. It also shows that although significant advances have been made in the techniques and methods employed, particularly in relation to the standardisation of hospital output to control for service and case-mix differences, there remain a number of unresolved problems such as the measurement of interhospital differences in the quality of care, and a number of areas in which substantial improvements in methodology and measurement have still to be made.

Judging by the quantity of the literature on the subject, the main concern in the study of interhospital cost variations appears to be with the definition and measurement of output differences among hospitals. Although it is generally agreed that differences in hospital output, whether as a result of differences in service-mix, case-mix, case complexity, quality of care, or the age and sex of the patients, are likely to have a considerable influence on the level of a hospital's average costs, there appears to be little agreement on how best to account for these differences when analysing interhospital cost variations. Indeed, in many studies the particular measurement technique adopted is often dictated by the availability of suitable data, whether it be detailed diagnostic information or information on the age and sex of each patient treated.

TABLE 7.1

## A SUMMARY OF THE FACTORS FOUND TO BE RESPONSIBLE FOR INTERHOSPITAL COST VARIATIONS

| Variable                     | Measurement                                                                                                                                   | Findings                                                                                                                  | Problems Encountered                                                                                                                         | Empirical Studies                                                                                                                   |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <b>A. Output Differences</b> |                                                                                                                                               |                                                                                                                           |                                                                                                                                              |                                                                                                                                     |
| 1. Service Mix               | (i) Analysis restricted to hospitals with identical facilities or 'service capabilities'                                                      | Lower average costs associated with hospitals with greater service capability                                             | Few studies account for differences in the size, complexity, or rate of utilisation of the facilities                                        | Carr and Feldstein (1967), Berry (1967 & 1970), Roemer et al. (1968), Francisco (1970), Edwards et al. (1972), Shuman et al. (1972) |
|                              | (ii) Output controlled for differences in the number of specific services performed for the patient, typically with a weighted output measure | Lower average costs associated with higher (weighted) output hospitals                                                    | Weighting procedures generally unsatisfactory                                                                                                | Saathoff and Kurtz (1962), Cohen (1967b and 1970), Roemer (1969), Fraser (1971), Ingbar and Taylor (1968), and Kovner (1969)        |
| 2. Case Mix                  | (i) Measures of Diagnostic mix based on ICDA lists or specialty groupings, factor analysed to reduce dimensionality                           | A substantial proportion of cost variation between hospitals is explained by differences in the types of patients treated | Broad aggregate groupings of diagnoses obscure much detail, and ignore possible differences in severity of cases within diagnostic groupings | Feldstein (1967), Evans (1971a), Lave, Lave and Silverman (1972), Lee and Wallace (1973)                                            |
|                              | (ii) A summary measure of the more 'common' diagnoses treated                                                                                 | Hospitals treating high proportion of common cases have lower average costs                                               | No account taken of variations in case severity within diagnostic groupings                                                                  | Lave, Lave and Silverman (1972)                                                                                                     |
| 3. Case Complexity           | (i) 'Information' measure defined on basis of ICDA diagnostic proportions                                                                     | Explains a high proportion of interhospital cost variation                                                                | May be measuring rarity of diagnosis; does not allow for variations in complexity within diagnostic classifications                          | Evans (1971b) and Evans and Walker (1972)                                                                                           |
|                              | (ii) Index measure of surgical complexity based on relative charges for surgical procedures                                                   | Hospitals performing a high proportion of complex surgery have higher average costs                                       | Weighting with relative charges may not accurately reflect relative complexities                                                             | Lave and Lave (1971), and Lave and Silverman (1972)                                                                                 |
| 4. Quality of Output         | Usually measured with dummy variables to denote existence of certain facilities or functions which are thought to reflect higher quality      | Accredited and Teaching hospitals have higher than average unit cost                                                      | Quality of care should ideally be measured in terms of outcomes, not inputs - i.e. general problems of definition and measurement            | Roemer et al. (1968), Cohen (1970), Fraser (1971), Lave, Lave and Silverman (1972), and Feldstein (1974c)                           |

TABLE 7.1 cont'd

| Variable                            | Measurement                                                                            | Findings                                                                                                                              | Problems Encountered                                                                                                                             | Empirical Studies                                                                                                                                                                                                                                     |
|-------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5. Age and Sex of Inpatients        | Certain specified age-sex groups expressed as proportions                              | Differences in the age and sex of patients explain a small proportion of the variations in hospital costs                             | Age-sex groupings too broad and need to be related to diagnostic information                                                                     | Evans (1971a), Evans and Walker (1972), and Lave, Lave and Silverman (1972)                                                                                                                                                                           |
| <b>B. Institutional Differences</b> |                                                                                        |                                                                                                                                       |                                                                                                                                                  |                                                                                                                                                                                                                                                       |
| 1. Size of Hospital                 | Measured variously as available beds, occupied beds, bed 'complement', or patient days | A variety of results giving evidence of both economies and diseconomies of scale. Results vary according to methods and data employed | Basic problems of methodology and data limitations, especially with respect to the alternative methods of output standardisation used            | P. Feldstein (1961), Carr & P. Feldstein (1967), Berry (1967 and 1970), Cohen (1967 & 1970), Feldstein M. (1967), Ingbar & Taylor (1968), Ro (1968), Francisco (1970), Fraser (1971), Lave and Lave (1970), Lave et al. (1972), Evans (1971 and 1972) |
| 2. Location of Hospital             | Measured by dummy variables to distinguish between, say, urban and rural locations     | Hospitals located in urban or metropolitan regions incur higher than average unit costs                                               | Data limitations : detailed data on transportation costs would more accurately represent the effect of location (and distance) on hospital costs | Long and P. Feldstein (1967), Gruer (1971), Fraser (1971), Lave et al. (1972), Shuman et al. (1972)                                                                                                                                                   |
| <b>C. Utilisation Differences</b>   |                                                                                        |                                                                                                                                       |                                                                                                                                                  |                                                                                                                                                                                                                                                       |
| 1. Occupancy Rate                   | Measured as a percentage : occupied beds as a proportion of available beds             | A rise in the occupancy rate tends to lower average costs                                                                             | Different types of patients (by diagnosis) appear to be treated at different levels of utilisation                                               | Klarman (1965), Ro (1968), Evans (1971a), Rafferty (1971), and Lave et al (1972)                                                                                                                                                                      |
| 2. Length of Stay                   | Total inpatient days divided by total inpatients                                       | Longer length of stay is associated with higher cost per case and lower cost per patient day                                          | Intensity of utilisation is not necessarily reflected in variations in length of stay                                                            | Deeble (1965), Feldstein (1967) Evans (1971a), and Lave et al. (1972)                                                                                                                                                                                 |
| 3. Case Flow Rate                   | The number of inpatients per bed year                                                  | A slower case flow rate is associated with higher cost per case and lower cost per patient day                                        | Intensity of utilisation is not necessarily reflected in variations in case flow rate                                                            | Feldstein (1967, Evans (1971a), and Lave et al. (1972)                                                                                                                                                                                                |

One conclusion that does arise from this literature review is that although output standardisation based on case-mix differences appears to be a better method than that based on service-mix differences among hospitals, adjustment for output heterogeneity is incomplete unless both service-mix and case-mix differences are accounted for.

Other conclusions that have arisen in this review, and which are summarised in Table 7.1, relate to the institutional and utilisation differences among hospitals. Empirical evidence on the relationship between a hospital's size and its cost structure is varied and for the most part inconclusive, largely as a result of differences in the type of hospitals studied and in the analytical methods used.

Finally, the effect of the intensity of hospital and bed utilisation on the level of hospital costs has been the subject of considerable research effort in recent years. Empirical evidence accumulated to date suggests a negative relationship between a hospital's occupancy rate and its average costs, and a positive relationship between length of stay and cost per case. The evidence, however, is not so clear on the proportion of a hospital's running costs that are fixed in the short run, although some of the disparity in results may be due to the different analytical methods employed.

## CHAPTER EIGHT

An Econometric Analysis of Hospital Cost Variations in  
New Zealand

## 8.1 Introduction

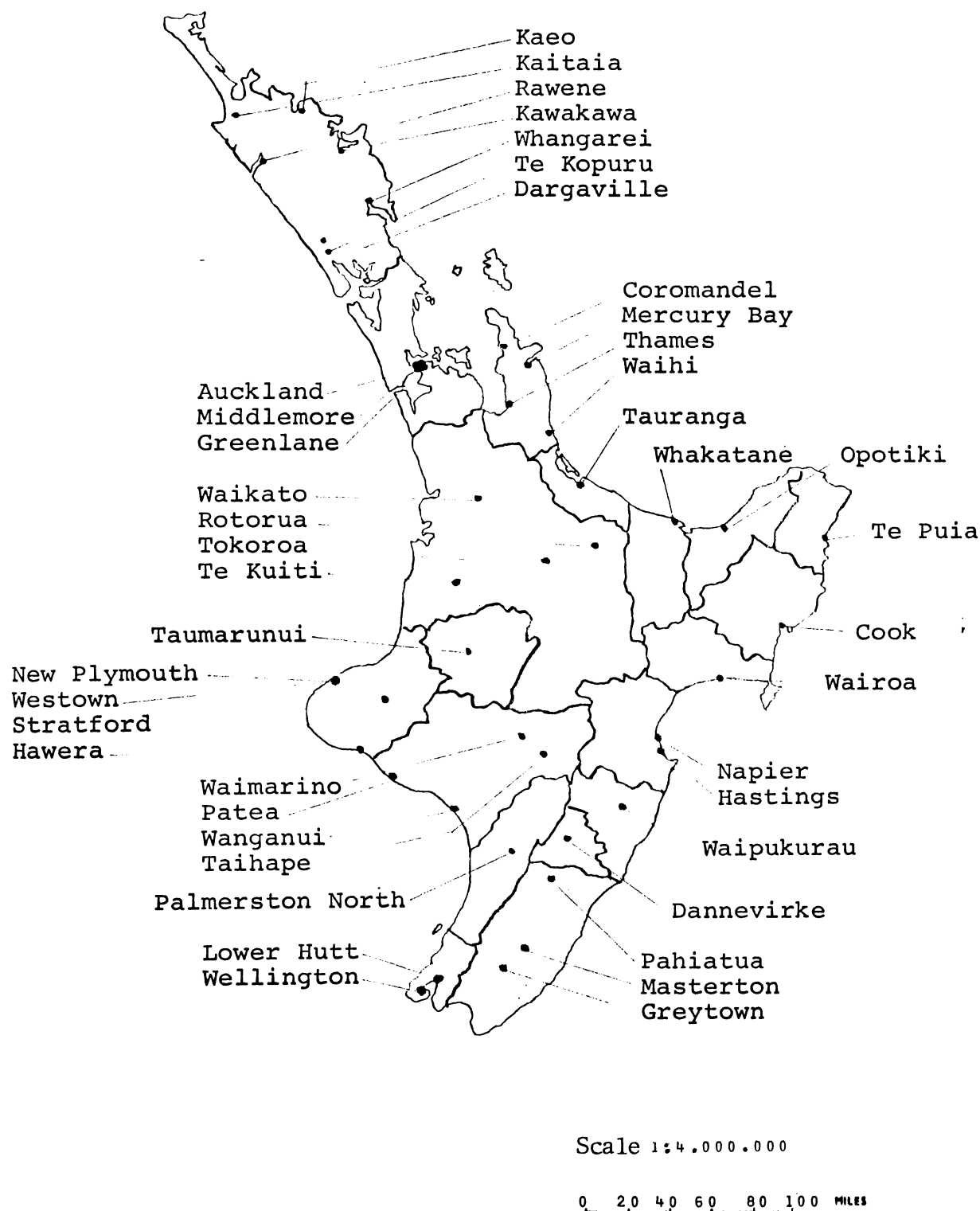
This chapter is devoted to an analysis of cost variations among New Zealand's public hospitals. Although the primary objective is the identification of those factors that determine why it costs more to treat patients in some hospitals than in others, several subsidiary issues are also examined. Access to diagnostic information, for example, permits an analysis of interhospital case-mix variations. Because of the apparent importance of such variations in explaining cost variations, considerable attention is paid to the problem of developing a suitable means of incorporating the information in hospital cost functions. The question of returns to scale in New Zealand's hospital industry is also examined.

The analysis is restricted to consideration of public general hospitals which are spread throughout the country's two islands (Figures 8.1 and 8.1) and range in size from 6 to 925 beds.<sup>1</sup> Analysis of the other categories of public hospital - 'special',<sup>2</sup> maternity and old people's homes - is

- 
1. These are 1971 figures. Comparable figures for 1969 are from 6 to 953 beds.
  2. Special hospitals are non-acute and include geriatric hospitals, homes for cripples, homes for children, and convalescent homes. A small number of geriatric and maternity cases are treated in the general hospitals included in the analysis.

FIGURE 8.1

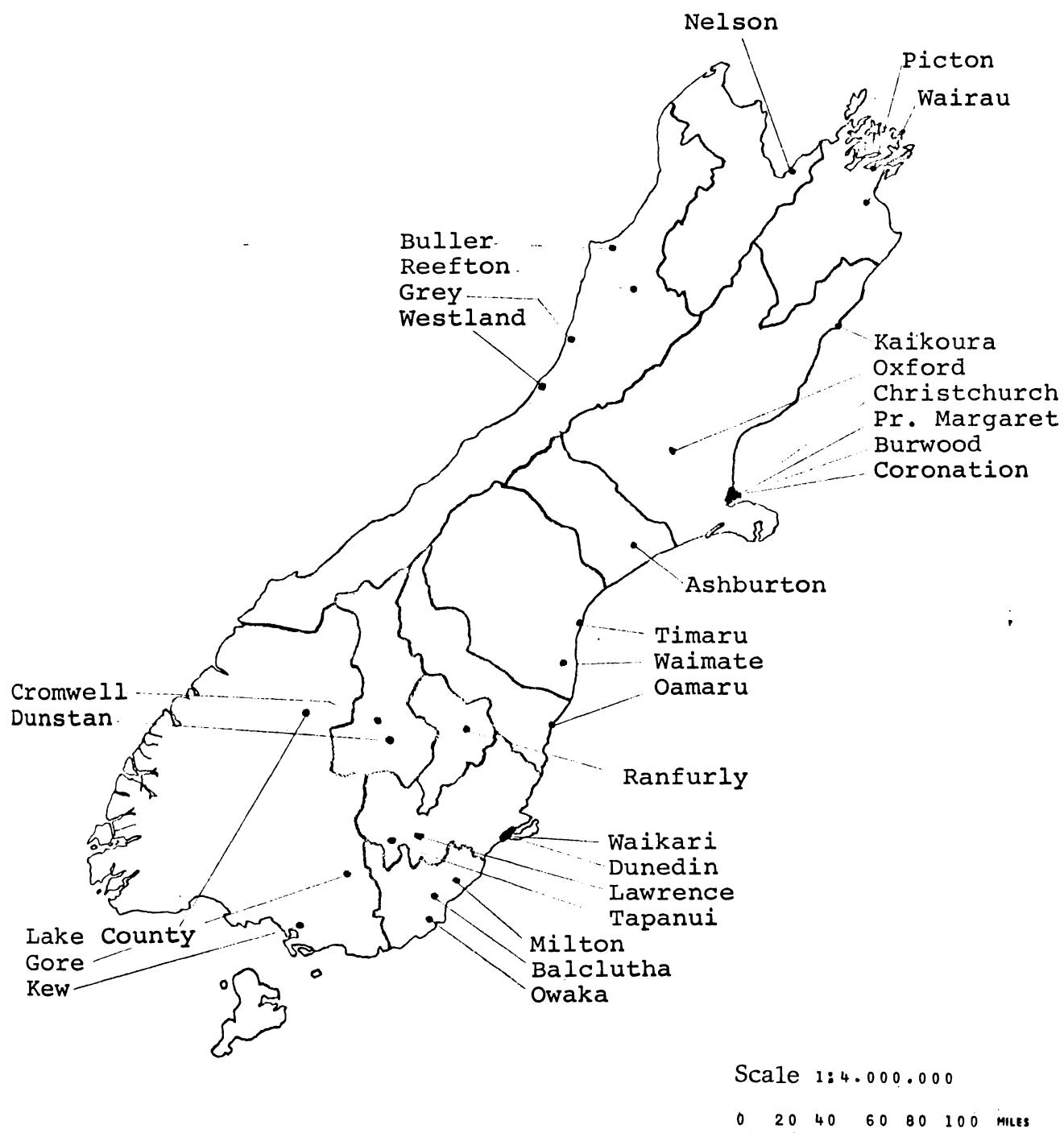
Public General Hospitals, North Island, 1971.



Source: NZ Department of Health, Hospital Statistics, Wellington (1971).

FIGURE 8.2

Public General Hospitals, South Island, 1971.



Source: NZ Department of Health, Hospital Statistics,  
Wellington, (1971).



not undertaken, primarily because their functions differ markedly from those of the general hospitals, but also because much of the data, particularly the diagnostic data, required in the analysis relates only to the general hospitals. Attention, therefore, is focused on the public general hospitals in two recent years, 1969 and 1971, during which time their number increased from 72 to 73 with the expansion of Tokoroa maternity hospital to a general hospital.

The chapter begins with a description of the cost function that is to be estimated, and the data and variables that are included in the analysis; then the empirical results are presented and discussed.

## 8.2 The Model and Variables

Although the administration, staffing, and physical appearance of New Zealand's public hospitals differ from their overseas counterparts,<sup>1</sup> their basic economic characteristics - they are all multiproduct, non-profit firms - are similar to the hospitals examined in the bulk of the recent literature. As noted in Chapter 6, specification of the cost-output relationship for the multiproduct firm requires either a host of independent variables or a series of cost functions to account for the many products of the hospital. The former approach is adopted here and a cost

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1. See the British Medical Association's report: Health Services Financing (1970) which includes appendices on the organisation and financing of health services in 15 different countries, including New Zealand (Ward, 1970, Appendix M).

function is specified which relates the average cost (AC) of running hospital  $i$  in year  $t$  to three groups of explanatory variables - patient (P), institutional (S), and utilisation (U):

$$AC_{it} = f(P_{it}, S_{it}, U_{it}) \quad (8.1)$$

Before discussing these variables in detail a summary list of all the variables included in the analysis and their definitions is given.<sup>1</sup> To avoid unnecessary repetition in these definitions, each variable is defined for an individual hospital and for a full year.

Two dependent average cost variables are included in the analysis which differ according to the output measure employed:

- |            |                                                                                                  |
|------------|--------------------------------------------------------------------------------------------------|
| (i) INCASE | $\frac{\text{total inpatient maintenance costs}}{\text{total number of discharges and deaths}}$  |
| (ii) INDAY | $\frac{\text{total inpatient maintenance costs}}{\text{total number of inpatient days of care}}$ |

The three groups of independent variables - patient, institutional and utilisation - are defined in turn as follows:

#### a. Patient Variables

- |               |                                                                                                                                         |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| (i) D1 to D18 | $\frac{\text{The number of inpatients in each of 18 broad diagnostic groups}}{\text{Total number of discharges and deaths}} \times 100$ |
| (ii) AGE14    | $\frac{\text{The number of inpatients 14 years of age and under}}{\text{Total number of discharges and deaths}} \times 100$             |
| (iii) AGE65   | $\frac{\text{The number of inpatients 65 years of age and over}}{\text{Total number of discharges and deaths}} \times 100$              |

---

1. The numerical values of these variables, for each hospital and year, are given in Data Appendix Tables A-25 (1969) and A-26 (1971).

## b. Institutional Variables

|            |                                                                                                                           |
|------------|---------------------------------------------------------------------------------------------------------------------------|
| (i) BEDS   | The number of available public hospital beds                                                                              |
| (ii) BEDSQ | The number of available beds, squared<br>(quadratic variable)                                                             |
| (iii) LOCN | A dummy variable: 1 if urban location<br>0 if rural location                                                              |
| (iv) TMED  | A dummy variable: 1 if medical students<br>0 otherwise                                                                    |
| (v) TNURS  | A dummy variable: 1 if nursing students<br>0 otherwise                                                                    |
| (vi) OPS   | $\frac{\text{The number of inpatients undergoing an operation}}{\text{Total number of discharges and deaths}} \times 100$ |
| (vii) OUTP | $\frac{\text{Expenditure on outpatient services}}{\text{Total hospital maintenance expenditure}} \times 100$              |

## c. Utilisation Variables

|           |                                                                                                                                                     |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| (i) ALOS  | $\frac{\text{Total number of inpatient days of care}}{\text{Total number of discharges and deaths}}$<br>i.e. the average length of (inpatient) stay |
| (ii) OCCR | $\frac{\text{Average number of occupied beds}}{\text{Total number of available beds}} \times 100$<br>i.e. the bed occupancy rate                    |
| (iii) CFR | $\frac{\text{Total number of discharges and deaths}}{\text{Number of available beds}}$<br>i.e. the case flow rate                                   |

## 8.2.1 The Dependent Variables

The two measures of output used to derive the dependent variables INCASE and INDAY are based on the number of deaths and discharges recorded from New Zealand's public hospitals. This measure has been used in preference to the total number of inpatients treated largely because the diagnostic

information, used later to derive the case-mix measures, relates only to discharges and deaths.<sup>1</sup>

Three broad categories of inpatient are included as discharges and deaths - general, maternity and 'non-hospital'. General patients, by far the largest of the three groups, numbered 223,850 in 1969 and 231,998 in 1971;<sup>2</sup> maternity cases numbered 16,744 (1969) and 19,508 (1971);<sup>3</sup> and non-hospital patients numbered 538 (1969) and 477 (1971).<sup>4</sup> The number of patient days associated with these three categories of inpatient, that is with all discharges and deaths, totalled 3,358,191 in 1969 and 3,371,532 in 1971.<sup>5</sup>

- 
1. Discharges and deaths as a measure of total inpatients will differ from that total by the extent of the number of inpatients in hospital at the beginning and end of a given year.
  2. This information was obtained from unpublished data, Department of Health, Wellington, (for 1969 and 1971).
  3. These figures are derived by summing the number of 'complicated' and 'uncomplicated' deliveries, numbers for which were obtained from unpublished information on maternity cases treated in NZ hospitals, Dept. of Health, Wellington (1969 and 1971).
  4. The non-hospital category of patient is, on the face of it, a misnomer, since it refers not, as one might expect, to patients treated outside the hospital, but to those who simply require custodial or 'hotel' care without any form of treatment. The figures given here for non-hospital cases were derived by summing the 'supplementary' diseases included amongst (and subtracted from) the general patients already defined, and the non-hospital patients listed as having been treated in the sample hospitals, numbers for which were obtained from Dept. of Health Hospital Statistics of New Zealand Wellington (1969 and 1971) table 10. Supplementary cases include such things as routine investigations and examinations, post-partum mothercraft instruction, and the accommodation of healthy persons accompanying a sick relative in hospital; see the International Classification of Diseases Eighth revision, W.H.O., Geneva (1965).
  5. The number of inpatient days for each group were General: 3,167,743 (1969) and 3,141,016 (1971); Maternity: 148,761 (1969) and 183,539 (1971); and Non-Hospital: 41,687 (1969) and 46,977 (1971).

The measure of cost used to calculate both dependent variables is the total cost of inpatient activity in each hospital. These costs, referred to in the Hospital Statistics as 'Institutional Maintenance Payments', include the labour and non-labour costs of treatment, administration, and accommodation, but exclude the cost of providing outpatient services.<sup>1</sup> Interest, depreciation and other capital costs are also excluded as no data exists which accurately reflect the utilisation of capital services in New Zealand public hospitals. The exclusion of capital costs from total costs is unfortunate particularly with regard to the measurement of scale effects. Since rates of depreciation and other capital costs are likely to vary from hospital to hospital, their exclusion means that interhospital cost comparisons will lose some of their accuracy, thus introducing an element of bias into the results.<sup>2</sup>

The two measures of average cost, INCASE and INDAY, are derived by dividing total inpatient costs, for each hospital, by the two output measures: discharges and deaths and inpatient days. The values obtained for these variables (Table 8.1) vary widely amongst the hospitals chosen: INCASE

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1. The total cost of inpatient activity for each of New Zealand's public hospitals is given in Department of Health Hospital Statistics of New Zealand, Wellington, (1969 and 1971), Table 13.

2. For a recent American study which does include capital costs see Kushner (1969).

TABLE 8.1

Variations in Average Cost per Inpatient (INCASE)  
and Average Cost per Inpatient day (INDAY)  
in 1969 and 1971

| Measure                            | INCASE                  |                         | INDAY               |                     |
|------------------------------------|-------------------------|-------------------------|---------------------|---------------------|
|                                    | 1969<br>(N=72)          | 1971<br>(N=73)          | 1969<br>(N=72)      | 1971<br>(N=73)      |
| Range                              | \$161.90 -<br>\$1522.00 | \$192.60 -<br>\$4059.40 | \$6.30 -<br>\$56.80 | \$4.70 -<br>\$41.90 |
| Mean (a)                           | \$252.80                | \$319.50                | \$18.20             | \$23.90             |
| Standard<br>Deviation              | \$195.30                | \$489.30                | \$6.40              | \$6.70              |
| Coefficient<br>of<br>Variation (b) | 65.1%                   | 117.0%                  | 36.0%               | 28.9%               |

(a) A weighted mean:  $\bar{X} = \sum X_{it} C_{it} / \sum C_{it}$  where  $X_{it}$  is the average cost of an inpatient or inpatient day, and  $C_{it}$  is the number of inpatients or inpatient days (both in hospital  $i$  and year  $t$ ).

(b) Standard deviation/Mean (as percentage).

ranges from \$161.90 (\$192.60) to \$1522.00 (\$4059.40) in 1969 (1971), while INDAY ranges from \$6.30 (\$4.70) to \$56.80 (\$41.90) in 1969 (1971). The skewed distribution, particularly of the INCASE figures, is reflected in the standard deviations which in 1971 (s.d. = \$489.3) exceeded the mean INCASE value of \$319.50. Much of this skewness is due to the unusually high INCASE values of Coronation

hospital: \$1522.00 in 1969 and \$4059 in 1971. A close examination of the nature of this hospital's activity suggests that it should be excluded from the sample as it is not a general hospital.<sup>1</sup> The majority of the patients treated are elderly (68.4%) and are suffering from long term illnesses such as tuberculosis, cerebrovascular disease, bronchitis and pneumonia. Each patient stayed an average of 144 (284) days in 1969 (1971) causing a very slow case flow rate of 1.7 (0.8) patients per bed in each year. Exclusion of Coronation hospital reduces the upper limit of INCASE values to \$1101.20 in 1969 and \$1900.8 in 1971, and slightly alters the mean INCASE and INDAY values in both years.<sup>2</sup>

A further interesting feature of the figures in Table 8.1 is that the lowest INDAY value is less in 1971 (\$4.70) than in 1969 (\$6.30). Both values are for Owaka hospital, and the fall in cost between the two years is probably due to the substantial increase in 'non-hospital' patients treated, from 14 in 1969 to 47 in 1971, which caused a rise in patient stay from 46 days to 82 days. A similar pattern is evident at the top of the range as the

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1. This conclusion was confirmed through personal communication with the Health Department, Wellington.
  2. The mean values for the reduced sample are INCASE \$251.43 (1969) and \$317.79 (1971); and INDAY \$18.22 (1969) and \$23.97 (1971).

highest INDAY value is less in 1971 (\$41.90) than in 1969 (\$56.80). This again is caused by changes in the nature of the patients treated in the hospitals concerned: Te Kopuru in 1969 and Lawrence in 1971.

### 8.2.2 The Patient Variables

The first group of variables that are thought to be responsible for the substantial interhospital cost variations found above, are the patient variables; these refer to two of the distinguishing characteristics of patients treated in hospitals - their case-mix and their age composition.

#### (i) Case-mix

Detailed diagnostic information is available from which to construct suitable measures of hospital case-mix.<sup>1</sup> This information includes data on the numbers and days stay of the discharges, deaths, transfers, operations and readmissions for each of the 3-digit I.C.D. disease categories, and for each hospital. The problem of aggregating these data so as to accurately represent each hospital's case-mix in a form suitable for inclusion in a regression equation, has been the subject of much debate in the literature, as reviewed in the previous chapter. A number of the aggregation methods used elsewhere are examined and compared

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1. Unpublished diagnostic summary sheets were obtained for each hospital in 1969 and 1971 from the Health Department, Wellington. The 3-digit I.C.D. disease categories number from 001 to 999 with an additional 89 'supplementary' diagnoses. See the International Classification of Diseases, 8th Revision, W.H.O., Geneva, (1965).



in the next chapter. In the present chapter the procedure adopted is based on the 18 principle diagnostic categories into which the 3 digit diagnoses are grouped in the International Classification of Diseases. By expressing the number of inpatients in each disease group as a proportion of the total inpatients treated, summary statistics are derived which describe each hospital's case-mix and hence its output. The variation between hospitals can then be calculated.

It is interesting to examine the distribution of patients amongst the 18 diagnostic categories in 1969 and 1971 (Table 8.2). It appears that those disease groups that form a large proportion of total inpatients, such as accidents, poisonings and violence, and diseases of the circulatory and respiratory systems, have low coefficients of variation. In contrast, diseases groups that form a small proportion of total inpatients, such as diseases of early infancy and congenital malformations, have high coefficients of variation. In other words, the larger the disease group as a proportion of each hospital's patient load the smaller the interhospital variation in that disease group. This pattern is consistent in both 1969 and 1971. It is also apparent when comparison is made between the two years, that the proportions and coefficients of variation generally remain relatively stable, implying little change in case-mix over a short period of time. Again, any marked changes in the coefficients between the two years tend to be associated with the proportionately smaller disease groups such as diseases of the blood, and diseases of early infancy, although this is not always the case as is

TABLE 8.2  
Inpatient Numbers and Proportions by Major Disease Groups  
in 1969 and 1971 (1)

| Disease Group                                 | 1969 (N=71)           |                            |                          | 1971 (N=72)           |                            |                          |
|-----------------------------------------------|-----------------------|----------------------------|--------------------------|-----------------------|----------------------------|--------------------------|
|                                               | Deaths and Discharges | As a Percentage of Total % | Coefficient of Variation | Deaths and Discharges | As a Percentage of Total % | Coefficient of Variation |
| 1. Infective and Parasitic                    | 7410                  | 3.1                        | 87.9                     | 7667                  | 3.0                        | 91.2                     |
| 2. Neoplasms                                  | 5626                  | 6.5                        | 65.1                     | 16834                 | 6.7                        | 62.2                     |
| 3. Allergic                                   | 4208                  | 1.7                        | 58.8                     | 4358                  | 1.7                        | 52.9                     |
| 4. Blood                                      | 1760                  | 0.7                        | 83.3                     | 1564                  | 0.6                        | 60.0                     |
| 5. Mental and Personality                     | 5927                  | 2.5                        | 83.3                     | 6123                  | 2.4                        | 70.8                     |
| 6. Nervous and Sense Organs                   | 11592                 | 4.8                        | 78.8                     | 11898                 | 4.7                        | 121.1                    |
| 7. Circulatory System                         | 26422                 | 11.0                       | 41.7                     | 28069                 | 11.1                       | 49.6                     |
| 8. Respiratory System                         | 28302                 | 11.7                       | 42.4                     | 27098                 | 10.8                       | 47.6                     |
| 9. Digestive System                           | 22853                 | 9.5                        | 48.2                     | 23344                 | 9.3                        | 51.8                     |
| 10. Genito-urinary system                     | 15833                 | 6.6                        | 48.2                     | 16375                 | 6.5                        | 53.6                     |
| 11. Deliveries and Complications of Pregnancy | 22730                 | 9.4                        | 93.0                     | 25774                 | 10.2                       | 96.5                     |
| 12. Skin and Cellular Tissues                 | 5490                  | 2.3                        | 59.1                     | 5625                  | 2.2                        | 69.6                     |
| 13. Bones                                     | 9416                  | 3.9                        | 83.3                     | 10157                 | 4.0                        | 89.2                     |
| 14. Congenital Malformations                  | 5391                  | 2.2                        | 100.0                    | 6075                  | 2.4                        | 100.0                    |
| 15. Early Infancy                             | 1001                  | 0.4                        | 300.0                    | 1070                  | 0.4                        | 250.0                    |
| 16. Symptoms and Senility                     | 12650                 | 5.2                        | 68.9                     | 13622                 | 5.4                        | 65.1                     |
| 17. Accidents, Poisonings and Violence        | 41109                 | 17.1                       | 36.2                     | 43232                 | 17.2                       | 39.5                     |
| 18. Supplementary                             | 3380                  | 1.4                        | 233.3                    | 3098                  | 1.2                        | 84.6                     |
| Totals                                        | 241,100               | 100.0                      | -                        | 251,983               | 99.8                       | -                        |

1. Components may not add to totals owing to rounding.

shown by the large fluctuation in the coefficients for diseases of the nervous and sense organs which comprised 4.8 (4.7) per cent of all inpatients in 1969 (1971).

There are a number of problems associated with the disease classification system used as a basis for the case-mix variables which warrant consideration. In the first place, although a diagnosis is defined as "the clinical condition selected as the most specific diagnosis possible consistent with the treatment given.... and taking into account all the information available at the time of discharge",<sup>1</sup> it is not always possible to state at a given time whether an individual has a particular disease or not. In addition, patients classified as suffering from a particular disease may vary widely in the degree of severity and in the pattern of complications associated with each case. The example of diabetes is often given to illustrate this point: one patient may have mild diabetes in an early stage while another had rapidly progressive diabetes; one may have renal or cardiac complications while another has additional conditions such as a stroke or a fracture of the hip.<sup>2</sup>

Apart from these definitional problems, there is also the possibility of incorrect recording of diagnoses either through an error of judgement on the part of the physician in charge, or because of a delay between the patient's discharge and the completion of the discharge summary sheet, which as a result is often filled out by someone not

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1. Report on the Hospital In-patient Enquiry for the Year 1970 HMSO, London, (1972).

2. See, for example, Katz et al. (1969).

directly associated with that particular patient.<sup>1</sup>

Further problems arise with transfers from and readmissions to New Zealand's public hospitals. At present the transfer of a patient from one hospital to another is only recorded as such if the transfer was between hospitals in different hospital board areas; movement of patients within board areas are not recorded as transfers but as new admissions.<sup>2</sup> The procedure adopted here for calculating the number of deaths and discharges for each hospital, is to deduct the number of transfers recorded so as to avoid double counting of the same patient in different hospitals, and to include readmissions and regard them as essentially separate cases being treated for a different episode of illness.

(ii) Age Composition

Three broad age groupings are defined which express the numbers of inpatients in each group - 0 to 14, 15 to 64 and 65 years and over - as a proportion of the total number

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1. Personal Communication, Department of Health, Wellington.
2. Personal communication from Department of Health, Wellington. Although individual hospital boards are required to record their 'internal' transfers, nationally they are treated as new admissions.

of inpatients treated in each hospital. These groupings are aggregations of more detailed age-sex data made available by the Department of Health.<sup>1</sup> Unfortunately this information is limited to the latter of the two years being studied, so it is assumed that the age proportions for the earlier year are the same. This assumption is unlikely to cause undue bias in the results in view of the earlier finding that the age composition of hospital patients tends to change only gradually over time.<sup>2</sup>

In order to avoid the possibility of obtaining a singular matrix in the regression calculations it is necessary to exclude one of the age groups from the analysis. As the main objective of this part of the study is to determine what factors are responsible for interhospital cost variations, it was decided to exclude the second group on the assumption that it would be unlikely to explain as much of the cost variation as the younger and older age groups. The two age variables included in the analysis, therefore, are AGE14 and AGE65. The younger (older) group comprise nearly 26 (18) per cent of the total number of inpatients treated. With a standard deviation of 17.5 compared with 9.9, and a coefficient of variation of 71.1 as against 41.3, there is more interhospital variation in the proportions of elderly inpatients than of younger patients.<sup>3</sup>

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1. Inpatients in this more detailed breakdown are grouped into 38 different age-sex groupings.
  2. See Table 3.5 in Chapter 3.
  3. This can clearly be seen in Data Appendix Tables A-25 and A-26 which give the proportions of patients in the two age groups by individual hospital; the percentages vary between zero and 40.9 for the younger group and between 3 and 96.6 for the older group.

### 8.2.3 The Institutional Variables

The explanatory variables selected for inclusion in the second group are designated 'institutional' since they relate to the various physical and functional characteristics of the hospitals being studied such as their size and location, and their various surgical teaching and outpatient functions.

#### (i) Size

Hospital size is measured by the number of available beds provided in each hospital. This variable, BEDS, has values ranging between 6 (Mercury Bay hospital) and 953 (Wellington hospital) in 1969 with an average of 181 beds overall, and between 6 and 925 in 1971 for the same two hospitals, with an average of 185 beds.

#### (ii) Location

The next institutional variable that is thought to explain some of the interhospital variation in costs is LOCN, the location of the hospital represented here by a dummy variable. An urban area in New Zealand is defined for census purposes as any large center of population of 20,000 persons or more, and typically comprises a city or large town plus neighbouring boroughs, town districts and parts of counties regarded as suburban and belonging to that centre of population.<sup>1</sup> According to this definition 25 of the general hospitals included in this study were located in urban areas in both 1969 and 1971, the remainder being in

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1. Department of Statistics NZ Census of Population and Dwellings Wellington (1972) Vol.1.

rural areas.

(iii) Surgery

The proportion of a hospital's inpatient population who have undergone an operation, OPS, is included as a measure of the extent of the surgical component of each hospital's activities. In the hospitals performing operations, which numbered 65 (64) in 1969 (1971), approximately 36 per cent of the inpatients underwent surgery in both years. This proportion, however, varies considerably among hospitals being as high as 48 per cent in 1969 (Burwood hospital) and 55 per cent in 1971 (Greytown hospital).

(iv) Teaching

Two measures of teaching status are included in the analysis, again as dummy variables, to indicate the presence or absence of a teaching programme in the hospital. The first variable, TMED, denotes the presence of a training programme for doctors offered in hospitals associated with the two medical schools in Dunedin and Auckland and with the clinical schools in Christchurch and Wellington. The second variable, TNURS, denotes the presence in a hospital of a nursing school offering a three year general nursing course; 30 hospitals offered such a programme in both 1969 and 1971.

(v) Outpatients

The extent of a hospital's financial commitment to outpatient care is measured by OUP, a hospital's outpatient costs expressed as a proportion of its total costs - that is, the sum of both its inpatient and outpatient costs.

Of the hospitals with outpatient facilities which numbered 64 (67) in 1969 (1971), the cost of providing outpatient care amounted to a fraction under 10 per cent of the total cost in both years. Again, there is considerable inter-hospital variation in this variable with maximum values of 21 per cent in both 1969 and 1971 at Auckland hospital.

#### 8.2.4 The Utilisation Variables

The third group of explanatory variables is termed 'utilisation' and reflects the intensity of hospital and bed utilisation.

##### (i) Occupancy

The intensity of a hospital's utilisation is measured by OCCR, the bed occupancy rate. For 1969 approximately 79 per cent of all available beds were occupied while for 1971 the rate was slightly lower at 77 per cent. In general it appears that the larger hospitals tend to have higher bed occupancy rates than the smaller ones, although there are exceptions such as the 6 bed Mercury Bay hospital whose bed occupancy rates were well above average at 90 (99) per cent. Higher than average occupancy rates such as this are generally due to the presence of a high proportion of geriatric patients who tend to stay in hospital longer than average. Higher occupancy rates are therefore often associated with a less intense use of hospital beds.

##### (ii) Length of Stay and Case Flow

Intensity of bed utilisation is measured by ALOS, average length of stay, and CFR, case flow rate, two variables



which are closely related. Clearly, the longer (shorter) the patient's length of stay the smaller (larger) the case flow rate or number of inpatients treated per bed per year. On average patients stayed 13.9 (13.4) days for a CFR of 18.5 (18.7) in 1969 (1971). The variation between hospitals is again considerable: ALOS ranged from 7.4 (6.4) to 144.2 (284.0) and CFR from 1.7 (0.8) to 27.6 (29.9) in 1969 (1971).

### 8.3 The Functional Form

The hypothesis that the interhospital cost variations of New Zealand's public hospitals can be explained by differences in their patient and institutional characteristics, and in their utilisation, is tested using ordinary least squares regression techniques on cross-section data for 71 (72) public hospitals in 1969 (1971). The cost function previously defined in equation (8.1) is estimated in both linear and log-linear form. In its linear form this equation can be stated as:

$$AC_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + \varepsilon_i \quad (8.2)$$

where AC denotes the dependent cost variable INCASE or INDAY, the X's denote the explanatory patient, institutional and utilisation variables, the  $\beta$ 's denote the unknown regression coefficients and  $\varepsilon$  is a stochastic disturbance term.

Subscript  $i$  ( $i=1,2,\dots,n$ ) refers to observations on a particular hospital, and there are  $k$  explanatory variables and regression coefficients included in the model. Linear cost functions of this form are estimated for both 1969 and 1971.

In its log-linear multiplicative form equation (8.1) can be expressed as:

$$AC_i = \beta_0^* X_{i1}^{\beta_1^*} X_{i2}^{\beta_2^*} \dots X_{ik}^{\beta_k^*} \epsilon_i^* \quad (8.3)$$

where the variables AC and X are as defined above, and the regression coefficients and disturbance term are now expressed as  $\beta^*$  and  $\epsilon^*$  respectively in order to distinguish them from their linear equivalents. A double logarithmic transformation of all variables, except dummy variables, in equation (8.3) yields an equation that is linear in the logs of the variables, thus permitting the application of ordinary least squares to obtain estimates of the  $\beta^*$  coefficients. Equation (8.3) can therefore be written as:

$$\log AC_i = \log \beta_0^* + \beta_1^* \log X_{i1} + \beta_2^* \log X_{i2} + \dots + \beta_k^* \log X_{ik} + \log \epsilon_i^* \quad (8.4)$$

As with the equations defined in Chapter 5, the standard assumptions for ordinary least squares are assumed to apply for equations (8.2) and (8.4).

#### 8.4 Empirical Hypotheses

The expected relationships between the 18 case-mix variables and average costs are difficult to predict largely because of the absence of any knowledge of the costs of treating inpatients in each diagnostic category. Because of this difficulty no a priori hypotheses are made about these relationships. The expected cost influence of the other two patient variables, AGE14 and AGE65 however, can be pointed to. It is known, for example, that elderly patients tend to have longer than average lengths of stay

and are therefore likely to cost relatively more on an INCASE basis. On the other hand they tend to require less intensive care and to consume fewer resources per day, and hence are likely to cost relatively less on an INDAY basis. The relationship between the younger age group and average cost is not so easily predicted - it is not possible to say whether hospitals having a higher than average proportion of young inpatients are likely to experience higher or lower than average unit costs. It seems plausible to predict, however, that the effect on average costs of variations in the younger age group is unlikely to be as great as that of the older group, if only because of the nature of the diseases from which the latter group suffer.

Of the institutional variables, considerable interest is focused on the direction and magnitude of the cost-size relationship. Preliminary examination of this relationship reveals some interesting facts. This examination was undertaken by grouping the hospitals into four size classes<sup>1</sup> according to the number of their available beds, and by then calculating the average cost for each size group in 1969 and 1971. The cost and size figures thus derived (Table 8.3 and Figure 8.3) indicate a more consistent pattern between the two years for the inpatient day results than for the inpatient figures. Costs per inpatient day rise slightly as size increases while costs per inpatient tend to fall initially, with size class 2 having the lowest costs in both years, and rise when bed numbers exceed 200

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1. These size groupings are based on those used by the Department of Health which defines the groups according to occupied rather than available bed numbers. See Hospital Statistics of New Zealand, Wellington 1969 and 1971, Table 10.

(size class 1). The inpatient cost figures indicate the possibility of there being a U-shaped size-cost relationship, with higher costs being associated with the smaller and larger hospitals and lower costs with the medium-sized hospitals. This possibility is clearly shown, particularly with the 1971 inpatient cost curve, in Figure 8.3. In order to test this hypothesis, a quadratic size variable, the number of available beds squared, BEDSQ, is included in the linear regression equations so as to pick up any curvilinear relationship that may exist between size and cost.<sup>1</sup> It is interesting to note, from Table 8.3, that average costs per inpatient for all hospitals rose by 26 per cent while average costs per inpatient day rose by 32 per cent over the two year period, a difference that can largely be explained by the reduction in average length of stay during that time. The largest increases for the individual size groups were 34 per cent for inpatient costs (size group 4) and 35 per cent for inpatient day costs (size group 3).

Previous studies of hospital cost variations that have included location among the explanatory variables have generally argued that hospitals located in urban or metropolitan areas experience higher average costs than their rural counterparts largely because of the higher local factor prices, especially for labour and land, that the urban hospitals are obliged to pay. In the New Zealand context, which is characterised by considerable inter-regional uniformity of wage rates and standardisation of prices, hospital location is unlikely to be as important a

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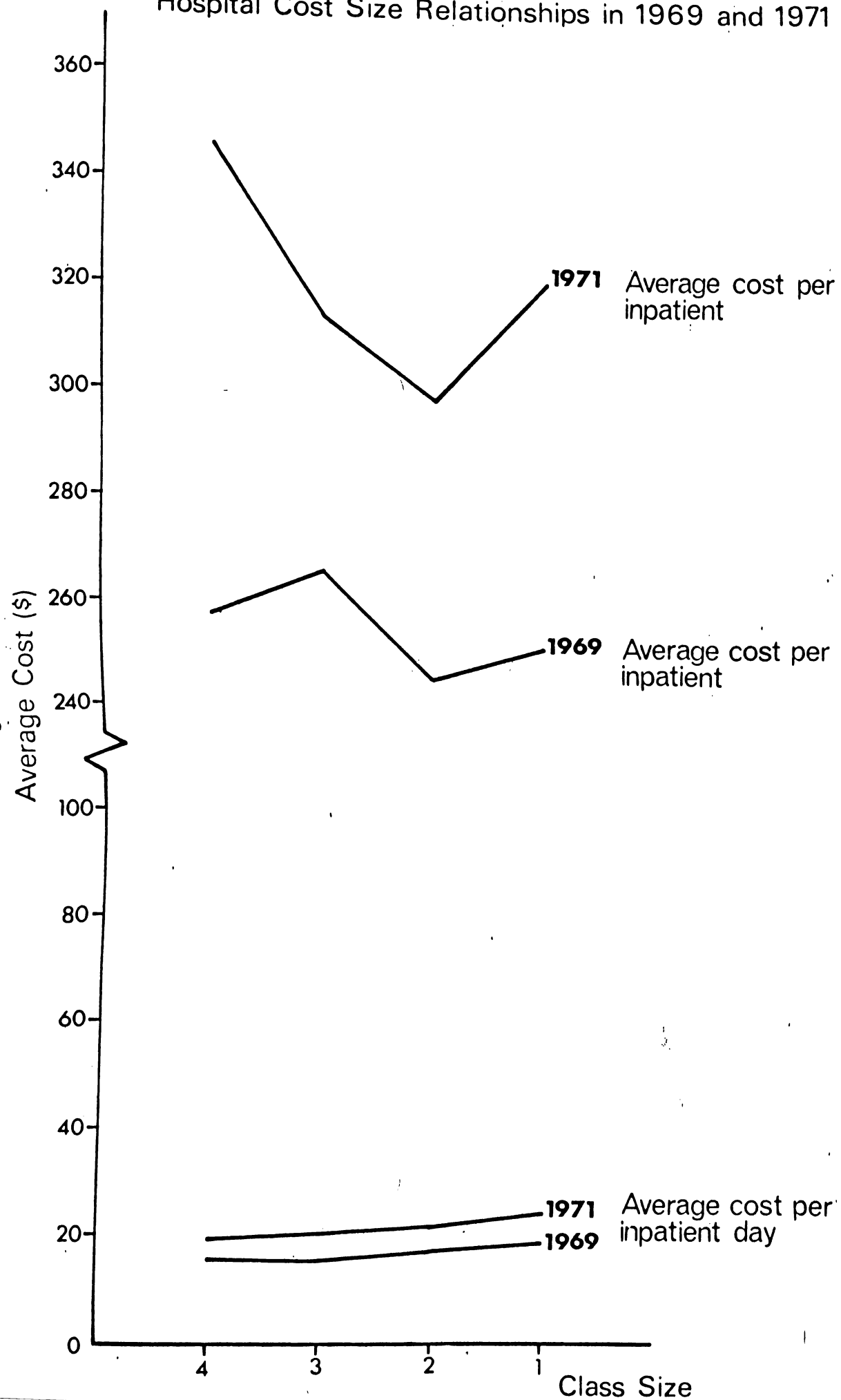
1. This variable is not included in the log-linear regressions to avoid the possibility of obtaining a singular matrix. This would occur because of the perfect correlation that exists between  $\log(\text{BEDS})$  and  $\log(\text{BEDSQ})$ .

TABLE 8.3  
Average Hospital Costs by Size Groupings in 1969 and 1971

| Hospital<br>Size<br>Class | 1969                      |                             |                                            |                                                   | 1971                      |                             |                                            |                                                   |
|---------------------------|---------------------------|-----------------------------|--------------------------------------------|---------------------------------------------------|---------------------------|-----------------------------|--------------------------------------------|---------------------------------------------------|
|                           | Number<br>of<br>Hospitals | Average<br>Hospital<br>Size | Average<br>Cost per<br>Inpatient (a)<br>\$ | Average<br>Cost per<br>Inpatient<br>Day (a)<br>\$ | Number<br>of<br>Hospitals | Average<br>Hospital<br>Size | Average<br>Cost per<br>Inpatient (a)<br>\$ | Average<br>Cost per<br>Inpatient<br>Day (a)<br>\$ |
| 1. 200 +                  | 24                        | 391                         | 251.20                                     | 18.70                                             | 25                        | 393                         | 320.40                                     | 24.70                                             |
| 2. 100 -<br>199           | 14                        | 141                         | 244.90                                     | 17.50                                             | 15                        | 137                         | 298.50                                     | 22.10                                             |
| 3. 50-99                  | 14                        | 74                          | 266.00                                     | 15.50                                             | 13                        | 73                          | 314.00                                     | 20.90                                             |
| 4. 0-49                   | 19                        | 27                          | 257.80                                     | 15.80                                             | 19                        | 28                          | 346.20                                     | 19.70                                             |
| All<br>Hospitals          | 71                        | 182                         | 251.40                                     | 18.20                                             | 72                        | 186                         | 317.80                                     | 24.00                                             |

(a) These are weighted averages:  $\bar{X} = \sum X_{it} C_{it} / \sum C_{it}$  where  $X_{it}$  is the average cost of an inpatient or inpatient day and  $C_{it}$  is the number of inpatients or inpatient days (in hospital i and year t). The averages are calculated separately for each hospital size group and are rounded to the nearest 100.

FIGURE 8.3  
Hospital Cost Size Relationships in 1969 and 1971



factor. However, in order to establish the extent of its influence hospital location, measured by the dummy variable LOCN, is included in the analysis, and is expected to relate positively to the two measures of average cost.

Teaching of doctors or nurses is expected to add to the cost of running a hospital, the former teaching function to a greater extent than the latter; a positive relationship between average cost and the two teaching variables TMED and TNURS is therefore predicted. Positive relationships are also expected between average costs and OPS and OUTP, as the higher cost hospitals are likely to be those performing proportionately more operations and spending proportionately more on outpatient care. As the cost of outpatient services is not included in the dependent variables the effect of OUTP on INCASE and INDAY is assumed to be an indirect one.

Expected relationships between average cost and the remaining utilisation variables require some discussion because of the interrelationships that exist between the three variables. Average length of stay (ALOS) and case flow rate (CFR), which are both included as measures of the intensity of bed use, are closely and negatively related. In view of their close association these two variables are not included together in the same regressions so as to avoid possible collinearity problems. Since longer lengths of stay are likely to be associated with higher inpatient costs, ALOS is included in the INCASE equations, and a positive relationship between the two variables is expected. Likewise faster case flow rates implies a more intense use of beds and hospital facilities and hence a higher inpatient

day cost. CFR is therefore included in the INDAY equations and a positive relationship is expected.

Previous research into the nature of the relationship between OCCR and costs has suggested a negative influence - higher occupancy rates are frequently associated with lower average costs. But the data being used for the present analysis show that the highest occupancy rates occur in hospitals with the longest lengths of stay which itself implies higher costs per inpatient and lower costs per inpatient day. If however we assume other things to remain the same and base our expectations on previous research findings, the relationship between OCCR and average costs can be expected to be negative.<sup>1</sup>

## 8.5 The Empirical Results

The results of the estimation process are presented in the following two tables: Table 8.4 shows the coefficients of the linear equations for both years and for the two dependent variables INCASE and INDAY while Table 8.5 shows the coefficients for the corresponding log-linear equations.

It is apparent, judging by the small number of significant coefficients in most equations combined with reasonably high  $\bar{R}^2$  values, that multicollinearity is probably affecting the results. This suspicion is reinforced by an examination of the simple correlations amongst the variables (shown in the Appendices to this chapter) which reveal that

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1. This relationship will be affected by the omission of capital costs from the two dependent cost variables: their exclusion results in the cost of unutilised bed capacity being underestimated.



TABLE 8.4  
Linear Cost Functions for New Zealand Public Hospitals  
In 1969 and 1971<sup>(a)</sup>

| Variable                            | INCASE                           |                   | INDAY             |                   |
|-------------------------------------|----------------------------------|-------------------|-------------------|-------------------|
|                                     | 1969<br>1                        | 1971<br>2         | 1969<br>3         | 1971<br>4         |
| Constant                            | -282.19                          | -685.09           | -15.13            | 22.91             |
| D1 Infective and parasitic          | 9.89<br>(1.43)                   | -9.58<br>(0.66)   | 0.59<br>(1.40)    | 0.38<br>(0.51)    |
| D2 Neoplasms                        | 5.25<br>(0.67)                   | 4.76<br>(0.41)    | 0.12<br>(0.22)    | 0.95<br>(1.58)    |
| D3 Allergic Diseases                | -7.30<br>(0.42)                  | 35.14<br>(1.62)   | -0.35<br>(0.29)   | 2.21<br>(1.97)    |
| D4 Diseases of Blood                | -23.65<br>(0.83)                 | -6.03<br>(0.09)   | -1.17<br>(0.57)   | -4.50<br>(1.25)   |
| D5 Mental and Personality Disorders | 4.52<br>(0.56)                   | -3.08<br>(0.26)   | 0.05<br>(0.10)    | -0.46<br>(0.75)   |
| D6 Nervous and Sense organs         | -5.08<br>(0.84)                  | 26.39<br>(3.89)** | -0.43<br>(1.08)   | 0.53<br>(1.51)    |
| D7 Circulatory System diseases      | 3.92<br>(0.88)                   | 7.98<br>(0.90)    | 0.29<br>(1.07)    | -0.47<br>(1.04)   |
| D8 Respiratory System diseases      | 1.07<br>(0.24)                   | 8.13<br>(1.20)    | 0.28<br>(1.08)    | 0.54<br>(1.59)    |
| D9 Digestive System diseases        | -4.12<br>(0.63)                  | 10.63<br>(1.50)   | -0.14<br>(0.35)   | 0.27<br>(0.73)    |
| D10 Genito-urinary system diseases  | 4.03<br>(0.61)                   | 33.85<br>(2.68)*  | 0.40<br>(0.95)    | 0.68<br>(1.03)    |
| D11 Complications of pregnancy      | 3.78<br>(0.82)                   | 5.51<br>(0.93)    | 0.31<br>(1.24)    | 0.16<br>(0.53)    |
| D12 Skin and Cellular tissue        | 1.51<br>(0.13)                   | 8.49<br>(0.54)    | 0.02<br>(0.03)    | -0.02<br>(0.02)   |
| D13 Diseases of bones               | 7.49<br>(1.36)                   | 14.76<br>(1.85)   | 0.46<br>(1.28)    | 0.01<br>(0.03)    |
| D14 Congenital Malformations        | -5.02<br>(0.32)                  | 45.43<br>(1.43)   | -0.64<br>(0.63)   | 0.07<br>(0.04)    |
| D15 Diseases of early infancy       | -0.81<br>(0.05)                  | 26.79<br>(0.80)   | -0.72<br>(0.62)   | 1.73<br>(1.00)    |
| D16 Symptoms and Senility           | -13.68<br>(2.35)*                | -15.69<br>(2.25)* | -0.71<br>(1.73)   | -0.38<br>(1.00)   |
| D17 Accidents, poisonings, violence | 2.97<br>(0.81)                   | 12.70<br>(1.83)   | 0.17<br>(0.77)    | 0.38<br>(1.06)    |
| D18 Supplementary classifications   | Excluded Variable <sup>(b)</sup> |                   |                   |                   |
| AGE.14                              | 3.80<br>(1.21)                   | -0.49<br>(0.10)   | 0.31<br>(1.35)    | -0.45<br>(1.80)   |
| AGE 65                              | 6.29<br>(2.87)**                 | 4.61<br>(1.44)    | 0.34<br>(2.43)*   | -0.10<br>(0.56)   |
| BEDS                                | -0.09<br>(0.25)                  | -0.27<br>(0.41)   | -0.02<br>(0.03)   | -0.05<br>(1.67)   |
| BEDSQ                               | 0.00003<br>(0.10)                | 0.0003<br>(0.49)  | 0.00001<br>(0.50) | 0.00004<br>(1.33) |
| LOCN                                | -31.49<br>(0.65)                 | -85.15<br>(0.98)  | 2.15<br>(0.64)    | -2.30<br>(0.50)   |
| TMED                                | 30.94<br>(0.52)                  | 73.48<br>(0.90)   | 5.25<br>(1.27)    | 9.04<br>(2.11)*   |
| TNURS                               | 26.27<br>(0.67)                  | 44.95<br>(0.67)   | 3.32<br>(1.26)    | 5.27<br>(1.49)    |
| OPS                                 | 0.49<br>(0.27)                   | -6.43<br>(1.94)   | 0.01<br>(0.08)    | -0.09<br>(0.54)   |
| OUTP                                | 7.81<br>(2.15)*                  | -6.95<br>(0.91)   | 0.68<br>(2.62)*   | 0.01<br>(0.02)    |
| OCCR                                | 1.06<br>(0.91)                   | 1.10<br>(0.64)    | -0.05<br>(0.69)   | -0.10<br>(1.02)   |
| ALOS                                | 5.57<br>(2.84)**                 | 9.77<br>(4.98)**  | —                 | —                 |
| CFR                                 | —                                | —                 | 0.42<br>(2.00)*   | 0.28<br>(1.04)    |
| R <sup>2</sup>                      | 0.849                            | 0.860             | 0.692             | 0.549             |
| $\bar{R}^2$                         | 0.748                            | 0.768             | 0.487             | 0.255             |
| F value                             | 8.44**                           | 9.41**            | 3.37**            | 1.87*             |
| S.E.E.                              | 65.51                            | 111.31            | 4.56              | 5.78              |

(a) t values in parentheses.

(b) This variable is excluded to avoid the possibility of obtaining a singular matrix in the regressions.

\* significant at the 5 per cent level

TABLE 8.5

Log-Linear Cost Functions for New Zealand Public Hospitals  
in 1969 and 1971<sup>(a)</sup>

| Variable                            | INCASE            |                   | INDAY                   |                   |
|-------------------------------------|-------------------|-------------------|-------------------------|-------------------|
|                                     | 1969<br>1         | 1971<br>2         | 1969<br>3               | 1971<br>4         |
| Constant                            | 1.74              | 1.78              | 0.84                    | 2.16              |
| D1 Infective and parasitic          | -0.004<br>(0.40)  | 0.004<br>(0.44)   | -0.008<br>(0.94)        | -0.01<br>(1.07)   |
| D2 Neoplasms                        | -0.002<br>(0.20)  | 0.005<br>(0.36)   | 0.003<br>(0.27)         | 0.04<br>(2.17)*   |
| D3 Allergic diseases                | -0.01<br>(0.33)   | 0.03<br>(1.33)    | -0.04<br>(1.64)         | -0.002<br>(0.06)  |
| D4 Diseases of blood                | -0.02<br>(0.50)   | -0.05<br>(0.78)   | -0.005<br>(0.14)        | -0.17<br>(2.13)*  |
| D5 Mental and personality disorders | -0.01<br>(0.80)   | -0.007<br>(0.78)  | -0.02<br>(2.38)*        | -0.02<br>(1.25)   |
| D6 Nervous and sense organs         | -0.01<br>(0.90)   | 0.01<br>(2.00)*   | -0.03<br>(4.14)**       | -0.005<br>(0.52)  |
| D7 Circulatory system diseases      | -0.002<br>(0.91)  | -0.002<br>(0.50)  | -0.009<br>(2.02)*       | -0.005<br>(1.11)  |
| D8 Respiratory System diseases      | -0.006<br>(1.00)  | 0.002<br>(0.67)   | 0.004<br>(0.95)         | 0.002<br>(0.53)   |
| D9 Digestive System diseases        | -0.02<br>(3.17)** | 0.002<br>(0.40)   | -0.03<br>(5.20)**       | -0.01<br>(1.47)   |
| D10 Genito-urinary system diseases  | -0.003<br>(0.30)  | 0.01<br>(1.25)    | 0.005<br>(0.63)         | 0.0009<br>(0.09)  |
| D11 Complications of pregnancy      | -0.004<br>(2.00)* | 0.002<br>(0.94)   | -0.005<br>(5.00)**      | -0.004<br>(1.99)  |
| D12 Skin and cellular tissue        | -0.01<br>(0.71)   | -0.01<br>(1.08)   | -0.009<br>(0.75)        | -0.02<br>(1.18)   |
| D13 Diseases of bones               | -0.004<br>(0.57)  | 0.005<br>(1.25)   | -0.01<br>(2.60)         | -0.008<br>(1.26)  |
| D14 Congenital malformations        | -0.003<br>(0.12)  | 0.005<br>(0.02)   | -0.03<br>(1.24)         | -0.03<br>(1.20)   |
| D15 Diseases of early infancy       | -0.02<br>(0.48)   | 0.02<br>(0.80)    | -0.06<br>(2.43)*        | 0.03<br>(0.84)    |
| D16 Symptoms and senility           | -0.02<br>(2.29)*  | -0.01<br>(4.67)** | -0.03<br>(5.20)**       | -0.02<br>(7.93)** |
| D17 Accidents, poisonings, violence | -0.005<br>(1.25)  | 0.003<br>(1.18)   | 0.003<br>(0.90)         | 0.005<br>(1.28)   |
| D18 Supplementary classifications   | Excluded          |                   | Variable <sup>(b)</sup> |                   |
| AGE 14                              | 0.01<br>(0.48)    | 0.05<br>(0.56)    | -0.07<br>(0.58)         | -0.01<br>(0.09)   |
| AGE 65                              | 0.15<br>(0.94)    | 0.18<br>(1.50)    | 0.21<br>(1.50)          | -0.12<br>(0.71)   |
| BEDS                                | -0.01<br>(0.15)   | -0.05<br>(0.71)   | -0.11<br>(1.83)         | -0.14<br>(1.56)   |
| BEDSQ                               | -                 | -                 | -                       | -                 |
| LOCN                                | -0.09<br>(1.29)   | -0.07<br>(1.27)   | -0.02<br>(0.22)         | -0.13<br>(1.86)   |
| TMED                                | 0.04<br>(0.44)    | 0.13<br>(2.17)*   | 0.04<br>(1.33)          | 0.12<br>(1.50)    |
| TNURS                               | 0.01<br>(0.15)    | 0.04<br>(0.73)    | 0.04<br>(0.05)          | 0.05<br>(0.71)    |
| OPS                                 | -0.04<br>(0.50)   | -0.03<br>(0.43)   | -0.23<br>(7.67)**       | -0.18<br>(4.50)** |
| OUTP                                | 0.01<br>(0.11)    | -0.06<br>(0.70)   | 0.22<br>(5.50)**        | 0.22<br>(1.57)    |
| OCCR                                | 0.46<br>(2.42)*   | -0.03<br>(0.13)   | 0.59<br>(3.69)**        | 0.04<br>(0.12)    |
| ALOS                                | 0.30<br>(1.15)    | 0.43<br>(3.91)**  | -                       | -                 |
| CFR                                 | -                 | -                 | 0.23<br>(2.30)          | 0.05<br>(0.28)    |
| R <sup>2</sup>                      | 0.778             | 0.814             | 0.802                   | 0.622             |
| $\bar{R}^2$                         | 0.578             | 0.657             | 0.625                   | 0.302             |
| F value                             | 3.89**            | 5.18**            | 4.51**                  | 1.95*             |
| S.E.E.                              | 0.09              | 0.10              | 0.08                    | 0.12              |

(a) t values in parentheses.

(b) This variable is excluded to avoid the possibility of obtaining a singular matrix in the regressions.

\* significant at the 5 per cent level.

a number of the explanatory variables, apart from the case-mix variables, are highly intercorrelated in both years, particularly with BEDS.

Initial examination of the results also indicates that many of the estimated coefficients either have signs that are contrary to those hypothesised, such as OCCR and LOCN, or have unstable signs over time, such as AGE14 and OPS.

Comparison between the linear and log-linear results, using the same transformation procedure employed in § 5.5.2, Chapter 5, again show that the log-linear form is the more appropriate of the two functional forms, in this case for all the equations estimated. Furthermore, the differences between the residual sums of squares for each pair of equations are always highly significant at the 99 per cent confidence level. This conclusion, although not apparent when comparing  $\bar{R}^2$  values, is borne out by the improved t statistics particularly in the log-linear INDAY regression (equations 3 and 4, Table 8.5).

Examination of the coefficients for the individual variables provides confirmation for a number of the hypothesised relationships. As expected there is a positive relationship between ALOS and INCASE, and the coefficients are significant in all but one of the equations in which the variable is entered. From the coefficients for ALOS in the linear INCASE equations (Table 8.4) it is apparent that the marginal cost of an extra day of care was \$5.57 in 1969 and \$9.77 in 1971. The ALOS coefficients in the log-linear INCASE equations (Table 8.5) suggest that a 10 per cent increase (decrease) in ALOS raised (reduced) INCASE by

3 per cent in 1969 and by 4.3 per cent in 1971. The positive relationship expected between CFR and INDAY is also confirmed in the results, and in two instances the coefficients are significant at the 5 per cent level.

The coefficients of the two teaching variables, TMED and TNURS, both enter with the expected positive signs, and their magnitudes suggest that the presence of a teaching programme for either doctors, or nurses, or both, adds a considerable premium to the costs of treatment. The coefficients, however, are rarely significant and fluctuate considerably in magnitude from equation to equation.

The signs and significance levels of the coefficients of AGE65 support the hypothesis, in all but two equations, that hospitals treating a higher proportion of elderly patients tend to have higher inpatient costs and lower inpatient day costs. This variable is quite closely correlated with ALOS (positive) and CFR (negative), so that these results are consistent with and add further support to the important influence of bed utilisation on average hospital costs.

The coefficients of the long run scale variables, BEDS and BEDSQ, have consistent signs which suggest economies of scale throughout a large proportion of the hospital size range in both years and for both dependent variables. As the coefficients of BEDS are always negative while those for BEDSQ are always positive the hypothesis of a U-shaped average cost function is confirmed. None of the estimated coefficients, however, have significant t-values.

By excluding all other explanatory variables from the

analysis a closer examination of the cost-size relationship is made possible. Estimation of linear regressions which include BEDS and BEDSQ as the sole explanatory variables gives rise to the following four estimated equations:

(i) INCASE 1969

$$Y = 325.39 - 0.369 \text{ BEDS} + 0.00035 \text{ BEDSQ}$$

(1.71)                      (1.25)

$$R^2 = 0.050, \bar{R}^2 = 0.023, F = 1.81, \text{S.E.E.} = 129.13$$

(ii) INCASE 1971

$$Y = 453.01 - 0.769 \text{ BEDS} + 0.00008 \text{ BEDSQ}$$

(2.00\*)                      (1.60)

$$R^2 = 0.061, \bar{R}^2 = 0.034, F = 2.23*, \text{S.E.E.} = 227.33$$

(iii) INDAY 1969

$$Y = 17.44 + 0.0028 \text{ BEDS} - 0.00000 \text{ BEDSQ}$$

(0.26)                      ( - )

$$R^2 = 0.005, \bar{R}^2 = -0.024, F = 0.16, \text{S.E.E.} = 6.44$$

(iv) INDAY 1971

$$Y = 23.15 - 0.0032 \text{ BEDS} + 0.00001 \text{ BEDSQ}$$

(0.28)                      (1.00)

$$R^2 = 0.024, \bar{R}^2 = -0.004, F = 0.86, \text{S.E.E.} = 6.71$$

The scatter diagrams for these four cost-size relationships and their respective estimated cost curves (figures 8.4 to 8.7) show that in all but one case, INDAY 1969 (figure 8.6), the curves are U-shaped. Average costs reach their minimum at approximately 500 beds in the two INCASE regressions, and at 160 beds in the 1971 INDAY regression. The remaining INDAY equation displays slight diseconomies of scale throughout the entire hospital size range. Comparison of

FIGURE 8.4

The Relationship Between Hospital Size and INCASE in 1969

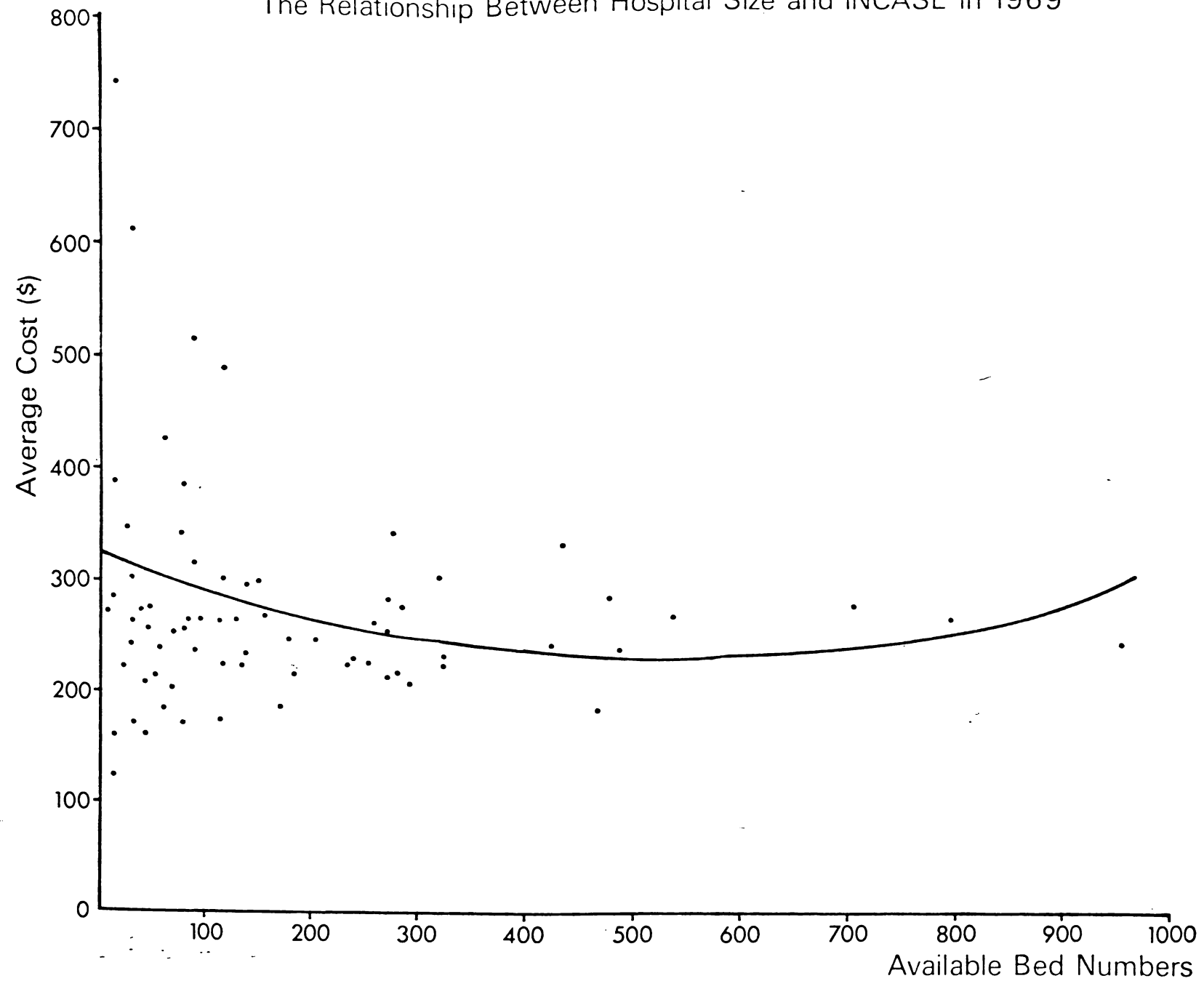


FIGURE 8.5

The Relationship Between Hospital Size and INCASE in 1971

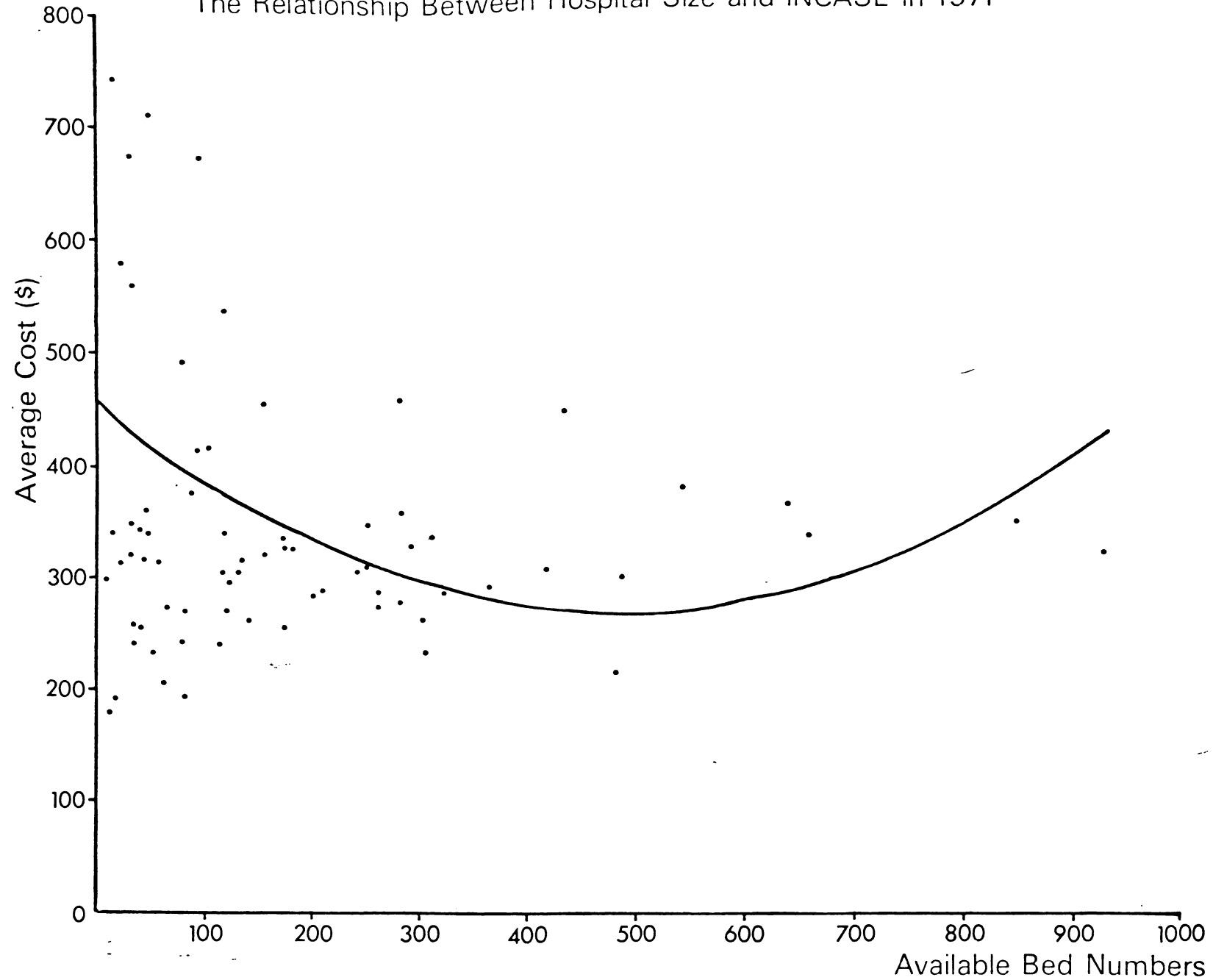


FIGURE 8.6  
The Relationship Between Hospital Size and INDAY in 1969

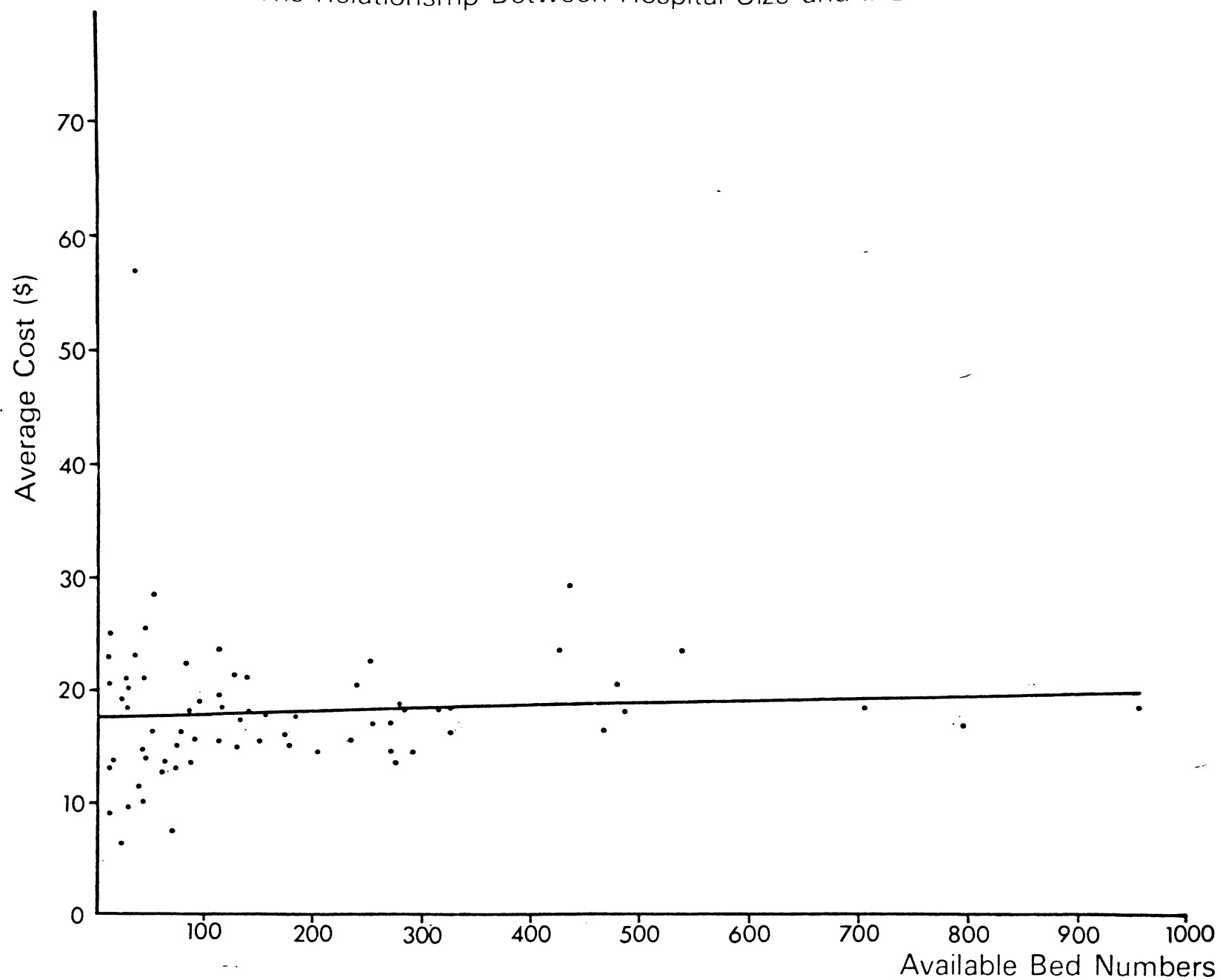
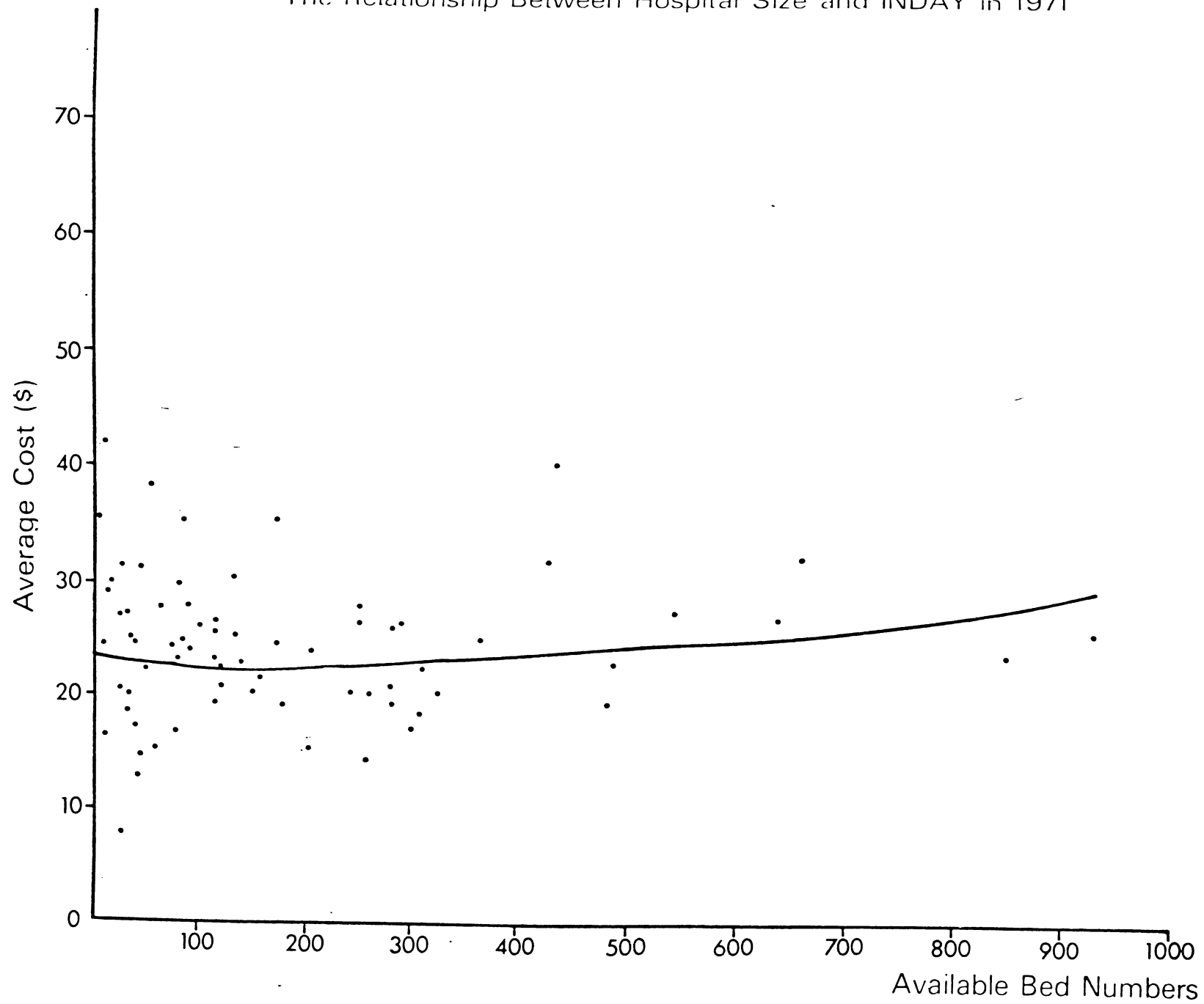




FIGURE 8.7  
The Relationship Between Hospital Size and INDAY in 1971



the scatter diagrams for INCASE and INDAY reveals a wider variation about the estimated cost curves in 1971 than in 1969. This is reflected in the deeper U-shape of the 1971 INCASE curve and in the slight U-shape of the 1971 INDAY curve.

Needless to say exclusion of the other explanatory variables from the above regressions is likely to have seriously biased the results obtained. It is also worth noting the very low  $R^2$  values and the poor t-values for the coefficients only one of which reaches a 5 per cent significance level. Nevertheless, these results do not conflict with those of the larger regressions all of which suggest the existence of economies of scale for a large proportion of the hospital size range.

Returning now to the remaining variables in the original regressions the estimated coefficients of the case-mix variable vary considerably both between individual diagnoses and over time. Since these coefficients represent the differences in average costs between each individual disease group and the excluded supplementary disease group, the coefficients reflect the relative cost of providing care in the various disease categories, rather than the actual cost.

Comparison between the coefficients for the case-mix variables over the two years however, reveals some considerable changes in value, particularly in the linear equations, which one would not have expected judging by the relatively stable case-mix patterns indicated in Table 8.2. The linear INCASE coefficients for D17, accidents, poisonings and violence, for example, changed from 2.97 in 1969 to 12.70

in 1971, despite the fact that as a proportion of all diseases this group remained virtually constant over the two years (17.1 and 17.2) and had low coefficients of variation. Other diagnoses to display a similar pattern include D3, allergic diseases, D6, diseases of nervous and sense organs, D10, allergic diseases of the genito-urinary system, and D14, congenital malformations. The reasons for this instability in the values of the coefficients over time is not clear, although it can be surmised that the large number of case-mix variables relative to the number of other explanatory variables, and the likelihood of multicollinearity among the variables, are both contributory factors. Alternative measures of case-mix are developed and tested in Chapter Nine which endeavour to overcome these problems and improve the measurement of hospital case-mix.

The hypothesis that average costs tend to be higher in hospitals which spend a relatively large proportion of their total expenditure on outpatient services, as measured by OUTP, is supported in the majority of the equations reported, in three of which the coefficients are significant. The relationship between OPS and average cost, however, is not as expected, as the coefficients are negative in all but two of the equations, and significantly so in the two non-linear INDAY equations (Table 8.5). This suggests, rather implausibly, that hospitals which perform a proportionately large number of operations tend to have lower average costs than the mean, whether INCASE or INDAY.

The coefficients for OCCR, the third of the utilisation variables, are negative as hypothesised in only three of

the eight equations listed. Moreover those coefficients that are significant (in equations 1 and 3, Table 8.5) both have positive signs. It appears, then, that higher occupancy rates are associated with higher levels of average cost. This may be due, as noted earlier, to the fact that the highest occupancy rates, for those hospitals included in this analysis, occur in the relatively small hospitals which are characterised by longer than average lengths of stay and higher than average inpatient costs.

Results for the final two explanatory variables, AGE14 and LOCN, are generally poor. The coefficients for AGE14 vary both in sign and magnitude while those for LOCN, contrary to expectations, are almost all negative. None of the coefficients for either variable is significant. In view of the close association between AGE14 and AGE65, the poor performance of AGE14, and the apparent irrelevance of LOCN to New Zealand conditions a further set of regressions are run omitting AGE14 and LOCN and including AGE65 as the sole age-related variable. Results for these additional equations are presented in Tables 8.6 (linear) and 8.7 (log-linear).

As might be expected when the number of explanatory variables in the regressions is reduced the  $R^2$  values are, almost without exception, lower in value in these equations than in their equivalents in tables 8.4 and 8.5. However, it is also noticeable, when comparing the two sets of results, that there is a general improvement in the  $t$  statistics, particularly of those coefficients that were already significant in the earlier results. The coefficients of ALOS, for example, all have  $t$ -statistics of higher value

TABLE 8.6  
 Linear Cost Functions With Omitted Variables  
 for 1969 and 1971<sup>(a)</sup>

| Variable                            | INCASE            |                   | INDAY                   |                   |
|-------------------------------------|-------------------|-------------------|-------------------------|-------------------|
|                                     | 1969<br>1         | 1971<br>2         | 1969<br>3               | 1971<br>4         |
| Constant                            | -262.71           | -797.50           | -11.97                  | 4.24              |
| D1 Infective and parasitic          | 10.17<br>(1.47)   | -7.49<br>(0.55)   | 0.60<br>(1.43)          | -0.01<br>(0.02)   |
| D2 Neoplasms                        | 4.18<br>(0.53)    | 2.71<br>(0.24)    | 0.13<br>(0.24)          | 0.78<br>(1.32)    |
| D3 Allergic diseases                | -2.58<br>(0.15)   | 36.90<br>(1.74)   | -0.27<br>(0.23)         | 1.94<br>(1.73)    |
| D4 Diseases of blood                | -9.16<br>(0.34)   | 5.93<br>(0.09)    | -0.28<br>(0.15)         | -3.81<br>(1.07)   |
| D5 Mental and personality disorders | 5.76<br>(0.74)    | -5.79<br>(0.51)   | -0.29<br>(0.59)         | -0.59<br>(0.98)   |
| D6 Nervous and sense organs         | -3.67<br>(0.64)   | 27.28<br>(4.13)** | -0.21<br>(0.58)         | 0.44<br>(1.26)    |
| D7 Circulatory system diseases      | 2.75<br>(0.63)    | 9.42<br>(1.18)    | 0.22<br>(0.85)          | -0.15<br>(0.36)   |
| D8 Respiratory system diseases      | 2.81<br>(0.66)    | 9.67<br>(1.50)    | 0.38<br>(1.52)          | 0.47<br>(1.42)    |
| D9 Digestive system diseases        | -4.93<br>(0.76)   | 11.18<br>(1.60)   | -0.22<br>(0.55)         | 0.33<br>(0.91)    |
| D10 Genito-Urinary system diseases  | 3.21<br>(0.49)    | 37.03<br>(3.12)** | 0.32<br>(0.76)          | 0.87<br>(1.39)    |
| D11 Complications of pregnancy      | 4.99<br>(1.09)    | 6.41<br>(1.11)    | 0.39<br>(1.63)          | 0.17<br>(0.57)    |
| B12 Skin and cellular tissue        | 11.15<br>(1.17)   | 8.84<br>(0.59)    | 0.65<br>(0.97)          | -0.38<br>(0.48)   |
| D13 Diseases of bones               | 4.87<br>(0.95)    | 14.74<br>(1.98)   | 0.27<br>(0.82)          | 0.30<br>(0.75)    |
| D14 Congenital malformations        | -2.83<br>(0.18)   | 47.64<br>(1.52)   | -0.29<br>(0.28)         | -0.13<br>(0.08)   |
| D15 Diseases of early infancy       | -0.19<br>(0.01)   | 20.37<br>(0.64)   | -0.23<br>(0.21)         | 1.03<br>(0.61)    |
| D16 Symptoms and senility           | -11.59<br>(2.05)* | -14.68<br>(2.17)* | -0.55<br>(1.41)         | -0.31<br>(0.84)   |
| D17 Accidents, poisonings, violence | 3.39<br>(0.93)    | 14.43<br>(2.21)*  | 0.18<br>(0.82)          | 0.50<br>(1.43)    |
| D18 Supplementary classifications   | Excluded          |                   | Variable <sup>(b)</sup> |                   |
| AGE 65                              | 4.44<br>(2.74)**  | 5.15<br>(1.96)    | 0.19<br>(2.11)*         | 0.08<br>(0.62)    |
| BEDS                                | -0.28<br>(1.06)   | -0.66<br>(1.25)   | -0.01<br>(0.72)         | -0.05<br>(1.82)   |
| BEDSQ                               | 0.0002<br>(0.71)  | 0.0006<br>(1.24)  | 0.00001<br>(0.50)       | 0.00005<br>(1.67) |
| TMED                                | 12.38<br>(0.21)   | 82.98<br>(1.05)   | 3.74<br>(0.94)          | 10.03<br>(2.35)*  |
| TNURS                               | 16.13<br>(0.44)   | 57.12<br>(0.88)   | 2.03<br>(0.82)          | 5.72<br>(1.63)    |
| OPS                                 | 1.19<br>(0.66)    | -5.88<br>(1.83)   | 0.03<br>(0.27)          | -0.13<br>(0.76)   |
| OUTP                                | 9.19<br>(2.67)*   | -7.55<br>(1.01)   | 0.69<br>(2.85)**        | -0.06<br>(0.15)   |
| OCCR                                | 1.47<br>(1.40)    | 0.81<br>(0.48)    | -0.001<br>(0.02)        | -0.12<br>(1.17)   |
| ALOS                                | 6.15<br>(3.20)**  | 9.83<br>(5.09)**  | -                       | -                 |
| CFR                                 | -                 | -                 | 0.36<br>(1.82)          | 0.37<br>(1.42)    |
| R <sup>2</sup>                      | 0.841             | 0.856             | 0.677                   | 0.514             |
| $\bar{R}^2$                         | 0.746             | 0.773             | 0.486                   | 0.233             |
| F value                             | 8.93**            | 10.32**           | 3.55**                  | 1.83*             |
| S.E.E.                              | 65.77             | 110.08            | 4.56                    | 5.86              |

(a) t values in parentheses.

(b) This variable is excluded to avoid the possibility of obtaining a singular matrix in the regressions.

\* significant at the 5 per cent level.

\*\* significant at the 1 per cent level.

TABLE 8.7  
Log-Linear Cost Functions with Omitted Variables  
for 1969 and 1971<sup>(a)</sup>

| Variable                            | INCASE            |                    | INDAY                   |                    |
|-------------------------------------|-------------------|--------------------|-------------------------|--------------------|
|                                     | 1969<br>1         | 1971<br>2          | 1969<br>3               | 1971<br>4          |
| Constant                            | 1.83              | 2.31               | 0.67                    | 2.88               |
| D1 Infective and parasitic          | -0.002<br>(0.22)  | 0.005<br>(0.50)    | 0.003<br>(0.33)         | -0.02<br>(1.36)    |
| D2 Neoplasms                        | -0.005<br>(0.45)  | -0.003<br>(0.20)   | -0.0004<br>(0.04)       | 0.02<br>(1.50)     |
| D3 Allergic Diseases                | -0.01<br>(0.42)   | 0.04<br>(1.50)     | -0.03<br>(1.42)         | 0.004<br>(0.13)    |
| D4 Diseases of Blood                | -0.01<br>(0.33)   | -0.03<br>(0.45)    | -0.002<br>(0.06)        | -0.14<br>(1.75)    |
| D5 Mental and Personality disorders | -0.01<br>(2.00)*  | -0.01<br>(1.50)    | -0.02<br>(2.37)*        | -0.03<br>(2.52)*   |
| D6 Nervous and sense organs         | -0.01<br>(1.71)   | 0.01<br>(1.83)     | -0.02<br>(3.28)**       | -0.006<br>(0.61)   |
| D7 Circulatory system diseases      | -0.003<br>(0.60)  | -0.007<br>(1.75)   | -0.006<br>(1.20)        | -0.009<br>(1.67)   |
| D8 Respiratory system diseases      | -0.007<br>(1.75)  | -0.001<br>(0.38)   | -0.005<br>(0.14)        | -0.002<br>(0.61)   |
| D9 Digestive system diseases        | -0.02<br>(3.33)** | 0.002<br>(0.36)    | -0.02<br>(4.29)**       | -0.01<br>(1.50)    |
| D10 Genito-urinary system diseases  | -0.003<br>(0.33)  | 0.01<br>(1.09)     | 0.003<br>(0.34)         | 0.003<br>(0.25)    |
| D11 Complications of pregnancy      | -0.005<br>(2.45)* | -0.002<br>(0.67)   | -0.004<br>(2.50)*       | -0.009<br>(3.31)** |
| D12 Skin and Cellular tissue        | -0.01<br>(0.86)   | -0.01<br>(1.04)    | -0.02<br>(1.38)         | -0.02<br>(1.29)    |
| D13 Diseases of bones               | -0.007<br>(1.23)  | 0.001<br>(0.23)    | -0.01<br>(2.15)*        | -0.01<br>(1.86)    |
| D14 Congenital malformations        | -0.004<br>(0.17)  | -0.007<br>(0.30)   | -0.002<br>(0.10)        | -0.03<br>(1.18)    |
| D15 Diseases of early infancy       | -0.022<br>(0.96)  | 0.01<br>(0.45)     | -0.03<br>(1.52)         | 0.01<br>(0.32)     |
| D16 Symptoms and senility           | -0.02<br>(3.17)** | -0.02<br>(23.18)** | -0.03<br>(5.20)**       | -0.03<br>(32.95)** |
| D17 Accidents, poisonings, violence | -0.005<br>(1.50)  | 0.0004<br>(0.19)   | 0.0003<br>(0.10)        | 0.0001<br>(0.03)   |
| D18 Supplementary classifications   |                   | Excluded           | Variable <sup>(b)</sup> |                    |
| AGE 65                              | 0.16<br>(0.99)    | 0.17<br>(1.42)     | 0.24<br>(1.60)          | -0.12<br>(0.65)    |
| BEDS                                | -0.02<br>(0.22)   | -0.08<br>(1.14)    | -0.05<br>(0.85)         | -0.18<br>(2.03)*   |
| BEDSQ                               | -                 | -                  | -                       | -                  |
| TMED                                | 0.04<br>(0.43)    | 0.14<br>(2.19)*    | 0.05<br>(0.52)          | 0.13<br>(1.52)     |
| TNURS                               | 0.01<br>(0.20)    | 0.05<br>(0.89)     | 0.03<br>(0.70)          | 0.06<br>(0.78)     |
| OPS                                 | -0.06<br>(1.20)   | 0.002<br>(0.08)    | -0.20<br>(8.82)**       | -0.20<br>(3.18)**  |
| OUTP                                | 0.02<br>(0.34)    | -0.11<br>(1.43)    | 0.19<br>(4.45)**        | 0.15<br>(1.10)     |
| OCCR                                | 0.46<br>(2.59)*   | -0.11<br>(0.46)    | 0.48<br>(2.85)**        | -0.11<br>(0.31)    |
| ALOS                                | 0.35<br>(1.88)    | 0.44<br>(4.07)**   | -                       | -                  |
| CFR                                 | -                 | -                  | 0.30<br>(2.87)**        | 0.08<br>(0.42)     |
| R <sup>2</sup>                      | 0.763             | 0.808              | 0.756                   | 0.584              |
| $\bar{R}^2$                         | 0.577             | 0.667              | 0.565                   | 0.277              |
| F value                             | 4.12**            | 5.72**             | 3.97**                  | 1.91*              |
| S.E.E.                              | 0.09              | 0.09               | 0.09                    | 0.12               |

(a) t values in parentheses.

(b) This variable is excluded to avoid the possibility of obtaining a singular matrix in the regressions.

\* significant at the 5 per cent level.

\*\* significant at the 1 per cent level.

in these revised regressions. There is also a slight improvement in the F statistics reported, suggesting a small improvement in the 'goodness of fit' of these regressions.

In general these results are similar to those reported earlier - the coefficients resemble closely their counterparts in the earlier tables both in the direction of their signs and in their magnitude, and once again the log-linear form appears to be significantly the more appropriate of the two forms.

Perhaps the main problem with both these sets of results is the presence of what appears to be a considerable degree of multicollinearity amongst the explanatory variables which if reduced should assist in improving the precision and reliability of the results obtained. One possible method of reducing the risk of multicollinearity is to reduce the number of parameters to be estimated. This, however, is not an advisable course to adopt as exclusion of variables originally included in the model for theoretical reasons could well bias the estimates obtained in the regressions. A more appropriate solution is to combine some of the variables, particularly the patient variables which considerably outnumber the other variables while only representing one facet of the cost function. Accordingly, a number of alternative methods of aggregating the diagnostic information are presented and tested in Chapter 9 in an attempt to improve the precision of the regression estimates obtained.

## 8.6 Summary

This chapter has examined the cost structure of a number of New Zealand's public hospitals in two recent years. A cost function was defined relating two alternative measures of average costs to three groups of explanatory variables: namely the type of patient treated and the institutional and utilisation characteristics of the hospitals. A number of the problems of definition and measurement arising from the nature of the data available were discussed and for the most part resolved satisfactorily.

Results for the regressions, in which parameters for each of the 30 variables were estimated, exhibited strong evidence of multicollinearity and a few of the coefficients had signs contrary to prior expectations. There also appeared to be some instability in the estimated cost functions between the two years, particularly in the coefficients of the case-mix variables. Nevertheless the results reported lend support to the hypothesis that economies of scale exist in New Zealand's hospital industry, and also confirm the importance of length of stay and teaching in explaining interhospital cost variations. It was also apparent, consistently, that the log-linear functional form is more appropriate than the linear form for explaining interhospital cost variations in New Zealand.

In view of the apparent high degree of multicollinearity present in the data, it was argued that further consolidation of the case-mix variables included in the regression equations might serve to improve the precision of the regression parameters. This is certainly desirable since



one of the aims of this research is to represent the structure of hospital costs in New Zealand as accurately as possible with regard to the signs and magnitudes of the estimated parameters. Chapter Nine, therefore, is devoted to the examination and testing of a number of alternative methods of aggregating the diagnostic information so as to represent the diagnostic mix of New Zealand's public hospitals as closely and as succinctly as possible.

# APPENDIX 8A

A simple Correlation Coefficient Matrix for the Cost Variation  
Variables in 1969

|        | INCASE | INDAY | ALOS  | OCCR  | CFR   | OPS   | OUTP  | BEDS  | BEDSQ | LOCN | TMED  | TNURS | AGE14 | AGE65 |
|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|
| INCASE |        | 0.18  | 0.84  | 0.20  | -0.53 | -0.36 | -0.17 | -0.13 | -0.09 | 0.05 | -0.02 | -0.22 | -0.57 | 0.71  |
| INDAY  |        |       | -0.35 | -0.09 | 0.24  | -0.09 | 0.17  | 0.07  | 0.07  | 0.07 | 0.12  | 0.10  | -0.13 | 0.18  |
| ALOS   |        |       |       | 0.24  | -0.61 | -0.31 | -0.21 | -0.16 | -0.12 | 0.01 | -0.06 | -0.25 | -0.48 | 0.60  |
| OCCR   |        |       |       |       | 0.31  | 0.49  | 0.41  | 0.48  | 0.33  | 0.52 | 0.08  | 0.50  | 0.02  | -0.04 |
| CFR    |        |       |       |       |       | 0.58  | 0.63  | 0.55  | 0.40  | 0.47 | 0.15  | 0.64  | 0.35  | -0.55 |
| OPS    |        |       |       |       |       |       | 0.50  | 0.52  | 0.32  | 0.39 | 0.11  | 0.56  | 0.38  | -0.62 |
| OUTP   |        |       |       |       |       |       |       | 0.72  | 0.59  | 0.55 | 0.23  | 0.64  | 0.20  | -0.35 |
| BEDS   |        |       |       |       |       |       |       |       | 0.93  | 0.76 | 0.14  | 0.69  | 0.08  | -0.27 |
| BEDSQ  |        |       |       |       |       |       |       |       |       | 0.56 | 0.06  | 0.49  | 0.04  | -0.17 |
| LOCN   |        |       |       |       |       |       |       |       |       |      | 0.23  | 0.63  | -0.10 | -0.10 |
| TMED   |        |       |       |       |       |       |       |       |       |      |       | -0.03 | -0.04 | -0.04 |
| TNURS  |        |       |       |       |       |       |       |       |       |      |       |       | 0.07  | -0.30 |
| AGE14  |        |       |       |       |       |       |       |       |       |      |       |       |       | -0.82 |
| AGE65  |        |       |       |       |       |       |       |       |       |      |       |       |       |       |

# APPENDIX 8B

A Simple Correlation Coefficient Matrix for the Cost Variation  
Variables in 1971

|        | INCASE | INDAY | ALOS  | OCCR  | CFR   | OPS   | OUTP  | BEDS  | BEDSQ | LOCN  | TMED  | TNURS | AGE14 | AGE65 |
|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| INCASE |        | -0.03 | 0.95  | 0.20  | -0.51 | -0.31 | -0.27 | -0.10 | -0.08 | 0.08  | -0.05 | -0.20 | -0.49 | 0.58  |
| INDAY  |        |       | -0.22 | -0.06 | 0.22  | 0.23  | 0.02  | -0.03 | 0.03  | -0.08 | 0.14  | -0.06 | 0.08  | -0.12 |
| ALOS   |        |       |       | 0.15  | -0.49 | -0.32 | -0.26 | -0.09 | -0.08 | 0.11  | -0.08 | -0.18 | -0.44 | 0.52  |
| OCCR   |        |       |       |       | 0.39  | 0.33  | 0.31  | 0.50  | 0.38  | 0.58  | 0.26  | 0.49  | -0.21 | 0.08  |
| CFR    |        |       |       |       |       | 0.62  | 0.65  | 0.51  | 0.37  | 0.41  | 0.37  | 0.60  | 0.41  | -0.63 |
| OPS    |        |       |       |       |       |       | 0.46  | 0.46  | 0.29  | 0.32  | 0.20  | 0.48  | 0.39  | -0.60 |
| OUTP   |        |       |       |       |       |       |       | 0.74  | 0.65  | 0.52  | 0.54  | 0.63  | 0.33  | -0.44 |
| BEDS   |        |       |       |       |       |       |       |       | 0.93  | 0.76  | 0.46  | 0.71  | 0.09  | -0.26 |
| BEDSQ  |        |       |       |       |       |       |       |       |       | 0.58  | 0.35  | 0.50  | 0.06  | -0.17 |
| LOCN   |        |       |       |       |       |       |       |       |       |       | 0.45  | 0.63  | -0.10 | -0.09 |
| TMED   |        |       |       |       |       |       |       |       |       |       |       | 0.30  | -0.09 | -0.07 |
| TNURS  |        |       |       |       |       |       |       |       |       |       |       |       | 0.06  | -0.28 |
| AGE14  |        |       |       |       |       |       |       |       |       |       |       |       |       | -0.82 |
| AGE65  |        |       |       |       |       |       |       |       |       |       |       |       |       |       |

# APPENDIX 8C

A Simple Correlation Coefficient Matrix for Case-mix Proportions in 1969

|                   | Infective | Neoplasms | Allergic | Blood | Mental | Nervous | Circulatory | Respiratory | Digestive | Urinary | Pregnancy | Skin  | Bones | Malformations | Infancy | Senility | Accidents | Supplementary |
|-------------------|-----------|-----------|----------|-------|--------|---------|-------------|-------------|-----------|---------|-----------|-------|-------|---------------|---------|----------|-----------|---------------|
|                   | 1         | 2         | 3        | 4     | 5      | 6       | 7           | 8           | 9         | 10      | 11        | 12    | 13    | 14            | 15      | 16       | 17        | 18            |
| 1. Infective      |           | -0.17     | -0.08    | 0.01  | 0.06   | 0.03    | -0.00       | 0.00        | -0.14     | -0.03   | -0.37     | 0.15  | -0.19 | -0.11         | 0.02    | 0.30     | -0.19     | 0.55          |
| 2. Neoplasms      |           |           | 0.26     | 0.37  | 0.06   | 0.35    | 0.27        | -0.16       | 0.34      | 0.26    | -0.41     | -0.07 | 0.05  | 0.70          | 0.07    | -0.07    | -0.07     | -0.15         |
| 3. Allergic       |           |           |          | 0.18  | 0.40   | 0.08    | 0.39        | 0.30        | -0.17     | 0.14    | -0.28     | -0.00 | -0.22 | -0.05         | 0.07    | -0.01    | -0.01     | -0.20         |
| 4. Blood          |           |           |          |       | 0.11   | 0.10    | -0.06       | 0.18        | 0.54      | 0.60    | -0.39     | 0.18  | -0.12 | 0.26          | -0.02   | -0.25    | 0.15      | -0.24         |
| 5. Mental         |           |           |          |       |        | -0.11   | -0.06       | 0.20        | 0.01      | 0.11    | -0.22     | 0.06  | -0.07 | 0.03          | 0.06    | -0.08    | -0.03     | -0.04         |
| 6. Nervous        |           |           |          |       |        |         | -0.03       | -0.15       | -0.01     | 0.19    | -0.26     | 0.09  | -0.02 | 0.27          | 0.14    | -0.05    | 0.11      | -0.11         |
| 7. Circulatory    |           |           |          |       |        |         |             | -0.00       | -0.06     | -0.06   | -0.22     | -0.35 | -0.31 | -0.10         | -0.09   | 0.18     | -0.31     | 0.09          |
| 8. Respiratory    |           |           |          |       |        |         |             |             | 0.29      | 0.23    | -0.40     | 0.41  | -0.28 | -0.11         | -0.01   | -0.12    | 0.08      | -0.23         |
| 9. Digestive      |           |           |          |       |        |         |             |             |           | 0.52    | -0.48     | 0.15  | -0.14 | 0.26          | -0.02   | -0.23    | 0.17      | -0.19         |
| 10. Urinary       |           |           |          |       |        |         |             |             |           |         | -0.44     | 0.26  | -0.14 | 0.08          | 0.14    | -0.19    | 0.14      | -0.30         |
| 11. Pregnancy     |           |           |          |       |        |         |             |             |           |         |           | -0.24 | 0.03  | -0.31         | -0.10   | -0.05    | -0.29     | -0.09         |
| 12. Skin          |           |           |          |       |        |         |             |             |           |         |           |       | -0.05 | 0.09          | 0.10    | -0.20    | 0.26      | -0.24         |
| 13. Bones         |           |           |          |       |        |         |             |             |           |         |           |       |       | 0.28          | -0.06   | -0.19    | 0.45      | -0.11         |
| 14. Malformations |           |           |          |       |        |         |             |             |           |         |           |       |       |               | 0.13    | -0.25    | 0.18      | -0.14         |
| 15. Infancy       |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         | -0.06    | 0.09      | -0.05         |
| 16. Senility      |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          | -0.27     | 0.07          |
| 17. Accidents     |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          |           | -0.42         |
| 18. Supplementary |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          |           |               |

APPENDIX 8D

A Simple Correlation Coefficient Matrix for Case-mix Proportions in 1971

|                   | Infective | Neoplasms | Allergic | Blood | Mental | Nervous | Circulatory | Respiratory | Digestive | Urinary | Pregnancy | Skin  | Bones | Malformations | Infancy | Senility | Accidents | Supplementary |
|-------------------|-----------|-----------|----------|-------|--------|---------|-------------|-------------|-----------|---------|-----------|-------|-------|---------------|---------|----------|-----------|---------------|
|                   | 1         | 2         | 3        | 4     | 5      | 6       | 7           | 8           | 9         | 10      | 11        | 12    | 13    | 14            | 15      | 16       | 17        | 18            |
| 1. Infective      |           | -0.19     | 0.09     | 0.06  | 0.35   | -0.06   | 0.34        | 0.13        | -0.17     | 0.01    | -0.31     | 0.25  | 0.02  | -0.14         | -0.08   | -0.01    | -0.13     | 0.03          |
| 2. Neoplasms      |           |           | 0.22     | 0.33  | 0.04   | 0.26    | 0.18        | -0.22       | 0.30      | 0.16    | -0.37     | -0.07 | -0.01 | 0.72          | 0.20    | -0.23    | 0.07      | -0.22         |
| 3. Allergic       |           |           |          | 0.19  | 0.28   | 0.15    | 0.34        | 0.18        | 0.06      | -0.02   | -0.31     | -0.08 | -0.21 | -0.06         | 0.05    | 0.21     | -0.16     | -0.18         |
| 4. Blood          |           |           |          |       | 0.06   | -0.14   | -0.09       | 0.07        | 0.46      | 0.59    | -0.37     | 0.35  | -0.09 | 0.29          | -0.01   | -0.16    | 0.09      | -0.08         |
| 5. Mental         |           |           |          |       |        | -0.13   | 0.16        | 0.25        | -0.04     | 0.03    | -0.28     | 0.04  | -0.05 | -0.04         | 0.10    | 0.03     | -0.08     | -0.13         |
| 6. Nervous        |           |           |          |       |        |         | 0.31        | -0.22       | -0.15     | -0.19   | -0.20     | -0.13 | -0.15 | 0.03          | 0.06    | 0.16     | -0.18     | -0.11         |
| 7. Circulatory    |           |           |          |       |        |         |             | -0.02       | -0.04     | -0.28   | -0.24     | -0.33 | -0.28 | -0.14         | -0.11   | 0.01     | -0.46     | -0.11         |
| 8. Respiratory    |           |           |          |       |        |         |             |             | 0.20      | 0.12    | -0.37     | 0.24  | -0.30 | -0.14         | -0.06   | 0.04     | -0.05     | -0.02         |
| 9. Digestive      |           |           |          |       |        |         |             |             |           | 0.51    | -0.45     | 0.16  | -0.17 | 0.24          | -0.01   | -0.14    | 0.07      | 0.07          |
| 10. Urinary       |           |           |          |       |        |         |             |             |           |         | -0.34     | 0.39  | -0.07 | 0.10          | 0.16    | -0.08    | 0.14      | -0.10         |
| 11. Pregnancy     |           |           |          |       |        |         |             |             |           |         |           | -0.29 | 0.06  | -0.31         | -0.06   | -0.15    | -0.27     | -0.09         |
| 12. Skin          |           |           |          |       |        |         |             |             |           |         |           |       | -0.02 | 0.06          | -0.10   | -0.09    | 0.35      | -0.06         |
| 13. Bones         |           |           |          |       |        |         |             |             |           |         |           |       |       | 0.27          | -0.03   | -0.31    | 0.44      | -0.17         |
| 14. Malformations |           |           |          |       |        |         |             |             |           |         |           |       |       |               | 0.19    | -0.38    | 0.34      | -0.16         |
| 15. Infancy       |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         | 0.06     | 0.02      | -0.09         |
| 16. Senility      |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          | -0.12     | 0.38          |
| 17. Accidents     |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          |           | -0.22         |
| 18. Supplementary |           |           |          |       |        |         |             |             |           |         |           |       |       |               |         |          |           |               |

## CHAPTER NINE

## An Examination of Alternative Output Measures for New Zealand Hospitals

## 9.1 Introduction

This chapter presents a number of alternative measures of hospital case-mix with a view not only to improving the regression estimates obtained in Chapter 8, but also to finding a measure of case-mix of smaller dimensions and yet of greater predictive value than those already employed.

Three measures are derived. The first is a consolidation, by means of factor analysis, of the 18 diagnostic categories already presented in Chapter 8; the second is based on the extent to which each hospital's caseload consists of 'common' diagnoses; and the third is a measure of the complexity of a hospital's case-mix. As these measures are based on those employed in several recent American and Canadian studies some attention is devoted to assessing their relevance and suitability to the New Zealand hospital system.

Each measure is included as an additional explanatory variable in the regression equations in order to ascertain the extent and direction of its influence on average hospital costs. Consideration is also given to the possibility that all three measures, taken together, might give a more complete picture of hospital output, since each measure represents a different aspect of hospital case-mix.

## 9.2 Derivation of Alternative Case-mix Measures

### 9.2.1 Factor Analysed Measures

Factor analysis, as already demonstrated in Chapter 5, is a technique for reducing the dimension of a set of variables. Its application to the 18 case-mix variables previously derived serves to reduce them to seven factors in both 1969 and 1971, each of which can be identified through an examination of the correlations between the factors and the original variables (Tables 9.1 and 9.2).

The first factor relates closely to three disease groups in both years: digestive, blood and genito-urinary diseases. The relationship, rather surprisingly, is positive in 1969 and negative in 1971, a finding that recurs with a number of the other factors in these tables.<sup>1</sup> The disease groups which comprise the second factor - accidents, diseases of the skin, and of the bones, seem to be a more logical combination than those included in the first factor, with the highest correlation being for the accidents in both years. The highest correlations for the third factor in both years are for neoplasms and congenital malformations, although as with the previous factor, the signs differ between the two years. The final four factors, which do not display the intertemporal similarities of the initial factors, account for the remainder of the disease groups in various combinations.

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1. Although the signs differ over time, similar groups of diagnoses are found for each factor in the two years.

TABLE 9.1

Simple Correlations between the Case-mix Proportions\*  
and the Factors in 1969

| FACTOR | $r \geq 0.5$                        | $0.5 > r \geq 0.25$                 | $r \leq -0.5$            | $-0.5 < r \leq -0.25$    |
|--------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|
| F1     | DIGV 0.85<br>BLOD 0.76<br>GENI 0.76 | RESP 0.47<br>SKIN 0.37<br>NEOP 0.34 | PREG -0.58               | BONE -0.33               |
| F2     |                                     | SUPL 0.36<br>PREG 0.36<br>CIRC 0.35 | AXID -0.84<br>BONE -0.63 | SKIN -0.42               |
| F3     | NEOP 0.82<br>MALF 0.77              | BONE 0.38<br>NERV 0.33              |                          | RESP -0.49<br>SKIN -0.35 |
| F4     | INFV 0.90<br>SUPL 0.76              |                                     |                          | PREG -0.45               |
| F5     | MENT 0.81<br>ALER 0.77              | RESP 0.43                           |                          | PREG -0.30               |
| F6     |                                     |                                     | INFY -0.74<br>NERV -0.64 | SKIN -0.34               |
| F7     | CIRC 0.71<br>SENL 0.62              | ALER 0.42                           |                          | PREG -0.35<br>BONE -0.29 |

\* The abbreviated case-mix groups listed in these two tables are defined as follows:

|                                 |                                           |
|---------------------------------|-------------------------------------------|
| INFV - Infective and parasitic  | GENI - Genito-urinary system              |
| NEOP - Neoplasms                | PREG - Deliveries and complications       |
| ALER - Allergic                 | SKIN - Skin and Cellular tissues          |
| BLOD - Blood                    | BONE - Bones                              |
| MENT - Mental and Personality   | MALF - Congenital Malformations           |
| NERV - Nervous and Sense Organs | INFY - Early Infancy                      |
| CIRC - Circulatory system       | SENL - Symptoms and Senility              |
| RESP - Respiratory System       | AXID - Accidents, Poisonings and Violence |
| DIGV - Digestive System         | SUPL - Supplementary                      |



TABLE 9.2

Simple Correlations between the Case-mix Proportions  
and the Factors in 1971

| FACTOR | $r \geq 0.5$                        | $0.5 > r \geq 0.25$                 | $r \leq -0.5$                          | $-0.5 < r \leq -0.25$                                |
|--------|-------------------------------------|-------------------------------------|----------------------------------------|------------------------------------------------------|
| F1     | PREG 0.50                           | BONE 0.34                           | DIGV -0.81<br>BLOD -0.77<br>GENI -0.76 | SKIN -0.43<br>RESP -0.37<br>NEOP -0.33<br>MALF -0.25 |
| F2     | AXID 0.85<br>SKIN 0.60<br>BONE 0.50 |                                     | CIRC -0.63                             |                                                      |
| F3     | RESP 0.50                           | SENL 0.42                           | MALF -0.81<br>NEOP -0.75               | BONE -0.44                                           |
| F4     | INFV 0.80<br>MENT 0.74              | CIRC 0.39<br>RESP 0.35<br>ALER 0.31 | PREG -0.53                             |                                                      |
| F5     |                                     |                                     | SUPL -0.92<br>SENL -0.58               |                                                      |
| F6     | INFY 0.82                           | MENT 0.34<br>SENL 0.27              |                                        | INFV -0.30<br>SKIN -0.26                             |
| F7     |                                     | PREG 0.47<br>BONE 0.33              | NERV -0.79<br>ALER -0.53               | SENL -0.44<br>CIRC -0.40<br>NEOP -0.33               |

Factor five relates positively to mental and personality disorders and allergic diseases in 1969, and negatively to supplementary diseases and senility in 1971. Factor six has its highest correlations in both years with diseases of early infancy although the factor also relates negatively to diseases of the nervous and sense organs in 1969. The final factor relates positively to circulatory system diseases and senility in 1969 and negatively to diseases of nervous and sense organs and allergic diseases in 1971.

The proportion of the total variance in the original variables explained by these seven factors amounts to approximately 74 per cent in both years (Table 9.3) while the marginal change for each factor falls from 20 per cent for factor 1 (18 per cent in 1971) to 6 per cent for factor 7. The similarity between the numbers of factors derived and the proportion of the variance explained by each factor in the two years indicates that little change has taken place in the case-mix of New Zealand's general hospitals over this short period.

Although in this context factor analysis is a particularly efficient means of reducing the dimensionality of the case-mix variables, it is questionable whether the seven factors obtained have any plausible interpretation as meaningful variables in their own right. It can be argued that since the original 18 diagnostic groups represent the broadest disease categories possible, any further amalgamation serves no useful purpose but rather

TABLE 9.3

Proportion of the Variance in the Case-Mix Proportions  
Explained by each Factor in 1969 and 1971

| Factor | Percentage of Total<br>Variance |       | Cumulative Percentage<br>Total |       |
|--------|---------------------------------|-------|--------------------------------|-------|
|        | 1969                            | 1971  | 1969                           | 1971  |
|        | %                               | %     | %                              | %     |
| F1     | 20.27                           | 18.23 | 20.27                          | 18.23 |
| F2     | 13.28                           | 14.58 | 33.55                          | 32.81 |
| F3     | 11.21                           | 12.30 | 44.76                          | 45.11 |
| F4     | 9.34                            | 9.20  | 54.10                          | 54.31 |
| F5     | 7.74                            | 7.05  | 61.84                          | 61.36 |
| F6     | 6.44                            | 6.52  | 68.28                          | 67.88 |
| F7     | 5.86                            | 5.67  | 74.14                          | 73.55 |

tends to confuse. An alternative interpretation, however, and the one adhered to here, is to view each factor as combining those diseases groups which tend to be associated together within the hospital context. Thus, for example, hospitals which cater for accidents, poisonings and violence also tend to treat diseases of the bones and diseases of the skin and cellular tissue (factor 2). Likewise hospitals which treat cancer patients

(neoplasms) also tend to treat congenital malformations (factor 3).<sup>1</sup>

### 9.2.2 Common Diagnoses

The second approach to measuring hospital case-mix involves the identification of what can be termed 'common diagnoses', that is those diseases which occur more frequently than others and which, taken together, comprise a significant part of a hospital's case-mix. A common diagnosis is defined as one which accounts for at least one per cent of all patients treated in New Zealand's public general hospitals in 1969 and 1971.<sup>2</sup> The diagnostic list on which the measure is based is the ICD List 'A' consisting of 151 diagnostic groups which are defined in full later in the chapter (Table 9.6).

The 31 disease groups (21% of the total) defined as 'common' according to this definition accounted for 73 per cent of all inpatients in both 1969 and 1971 (Table 9.4).

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1. An examination of the raw diagnostic data for individual hospitals indicates that these associations tend to exist in practice, and this was borne out in personal discussions with several doctors and physicians.
  2. Lave and Lave (1971), who earlier developed a similar measure, used a cut off point of 0.5 per cent. They based their calculations on the 3-digit ICD code which consists of nearly 1000 diseases compared with the 151 disease groups used in this study.

TABLE 9.4

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## Common Diagnoses by Disease Group in 1969 and 1971

| ICD List<br>A Code<br>No. | Disease Group                                      | Proportion<br>of patients<br>1969<br>% | Proportion<br>of patients<br>1971<br>% |
|---------------------------|----------------------------------------------------|----------------------------------------|----------------------------------------|
| 118                       | Delivery without complications                     | 6.944                                  | 7.751                                  |
| 137                       | Symptoms & other ill-defined conditions            | 4.874                                  | 5.082                                  |
| 111                       | Other diseases of genito-urinary system            | 4.706                                  | 4.596                                  |
| 140                       | Fracture of limbs                                  | 3.758                                  | 3.810                                  |
| 83                        | Ischaemic heart disease                            | 3.255                                  | 3.442                                  |
| 143                       | Intracranial injury                                | 3.438                                  | 3.433                                  |
| 94                        | Hypertrophy of tonsils and adenoids                | 4.075                                  | 3.228                                  |
| 145                       | Laceration and open wound                          | 2.408                                  | 2.539                                  |
| 93                        | Bronchitis, emphysema and asthma                   | 2.080                                  | 2.445                                  |
| 79                        | Other diseases of nervous system & sense<br>organs | 2.518                                  | 2.432                                  |
| 101                       | Intestinal obstruction and hernia                  | 2.506                                  | 2.329                                  |
| 100                       | Appendicitis                                       | 2.323                                  | 2.268                                  |
| 125                       | Other diseases of muskuloskeletal system           | 2.076                                  | 2.155                                  |
| 92                        | Other pneumonia                                    | 2.134                                  | 1.988                                  |
| 88                        | Other diseases of circulatory system               | 2.049                                  | 1.970                                  |
| 85                        | Cerebrovascular Disease                            | 1.831                                  | 1.902                                  |
| 130                       | All other congenital anomalies                     | 1.745                                  | 1.831                                  |
| 104                       | Other diseases of digestive system                 | 1.807                                  | 1.748                                  |
| 149                       | Adverse effects of chemical substances             | 1.918                                  | 1.733                                  |
| 89                        | Acute respiratory infections                       | 1.738                                  | 1.705                                  |
| 58                        | Malignant neoplasm, unspecified sites              | 1.551                                  | 1.610                                  |
| 70                        | Neuroses, personality disorders                    | 1.458                                  | 1.480                                  |
| 61                        | Benign neoplasms                                   | 1.488                                  | 1.447                                  |
| 84                        | Other forms of heart disease                       | 1.427                                  | 1.419                                  |
| 103                       | Cholelithiasis and cholecystitis                   | 1.330                                  | 1.380                                  |
| 119                       | Infections of skin and subcutaneous tissue         | 1.301                                  | 1.326                                  |
| 96                        | Other idseases of respiratory system               | 1.512                                  | 1.276                                  |
| 121                       | Arthritis and Spondylitis                          | 1.108                                  | 1.233                                  |
| 115                       | Other and unspecified abortion                     | 1.294                                  | 1.227                                  |
| 146                       | Superficial injury, contusion and crushing         | 1.046                                  | 1.117                                  |
| 151                       | Supplementary and 'non-hospital'                   | 1.246                                  | 1.109                                  |
|                           | Cumulative Percentage total                        | 72.944                                 | 73.011                                 |

Source: derived from diagnostic information received from the National Health Statistics Centre, Wellington.

The most common diagnosis, or perhaps more aptly, the most common cause of hospitalisation in both years was "delivery without complication" which accounted for 6.9 (7.8) per cent of all inpatients in 1969 (1971). There was little change over the period in the proportion that each diagnosis represented of the total number of inpatients treated, providing further evidence that hospital case-mix appears to remain relatively stable over a short period.

Using these 31 common diagnoses as a basis the proportion of each hospital's case-mix that is 'common' can be derived (Table 9.5). There is considerable case-mix variation among hospitals, as these diagnoses constitute as few as 48 per cent (50 per cent) of all deaths and discharges in Owaka hospital and as many as 96 per cent (97 per cent) in Te Kopuru hospital in 1969 (1971). On the other hand the case-mix stability already noted when examining the hospital system as a whole also exists at the individual hospital level, for the proportions of common diagnoses vary little between the two years for most hospitals. Exceptions included Rotorua, whose proportion of common diagnoses changed from 72.8 to 63.1 per cent, Burwood from 72.3 to 63.6 per cent, Coronation from 56.7 to 65.8 per cent, Milton from 79.0 to 90.5 per cent and Oxford from 54.2 to 73.1 per cent.

### 9.2.3 Complexity Measures

The final means of accounting for case-mix variations among hospitals is achieved through the measurement of the complexity of each hospital's case-mix. The method followed

## Common Diagnoses by Public Hospitals in 1969 and 1971

| Hospital     | Proportion of Patients<br>with<br>Common Diagnoses |           | Hospital              | Proportion of Patients<br>with<br>Common Diagnoses |           |
|--------------|----------------------------------------------------|-----------|-----------------------|----------------------------------------------------|-----------|
|              | 1969<br>%                                          | 1971<br>% |                       | 1969<br>%                                          | 1971<br>% |
| Wellington   | 71.4                                               | 69.4      | Te Kuiti              | 77.7                                               | 77.0      |
| Waikato      | 72.4                                               | 72.2      | Waipukurau            | 76.7                                               | 78.9      |
| Middlemore   | 73.2                                               | 75.5      | Kaitaia               | 74.9                                               | 72.1      |
| Auckland     | 62.9                                               | 64.6      | Balclutha             | 77.4                                               | 79.7      |
| Palmerston   | 72.3                                               | 75.2      | Gore                  | 77.6                                               | 75.7      |
| Green Lane   | 64.8                                               | 66.2      | Tokoroa               | -                                                  | 81.1      |
| Lower Hutt   | 80.1                                               | 78.7      | Greytown              | 76.4                                               | 72.9      |
| Christchurch | 71.0                                               | 71.1      | Stratford             | 80.8                                               | 74.0      |
| Dunedin      | 78.4                                               | 77.0      | Dargaville            | 79.3                                               | 75.8      |
| Tauranga     | 74.3                                               | 74.9      | Westland              | 78.9                                               | 76.6      |
| Rotorua      | 72.8                                               | 63.1      | Waimate               | 73.2                                               | 74.2      |
| Whangarei    | 72.6                                               | 73.9      | Buller                | 76.5                                               | 74.9      |
| Hastings Mem | 80.6                                               | 80.2      | Kawakawa              | 75.8                                               | 79.3      |
| Nelson       | 73.5                                               | 75.2      | Patea                 | 69.2                                               | 76.2      |
| Kew          | 69.2                                               | 66.6      | Waihi                 | 83.7                                               | 84.8      |
| Napier       | 68.5                                               | 67.6      | Opotiki               | 75.4                                               | 74.3      |
| Pr Margaret  | 70.3                                               | 69.5      | Reefton               | 71.4                                               | 65.6      |
| Wanganui     | 76.5                                               | 76.2      | Rawene                | 61.7                                               | 65.8      |
| Timaru       | 74.4                                               | 74.9      | Taihape               | 72.1                                               | 70.4      |
| Burwood      | 72.3                                               | 63.6      | Te Puia               | 66.6                                               | 69.8      |
| New Plymouth | 71.1                                               | 72.1      | Te Kopuru             | 95.7                                               | 97.4      |
| Cook         | 75.6                                               | 73.6      | Owaka                 | 47.8                                               | 49.5      |
| Wakari       | 66.2                                               | 66.4      | Pahiatua              | 74.4                                               | 73.7      |
| Thames       | 78.0                                               | 76.9      | Cromwell              | 72.6                                               | 76.3      |
| Masterton    | 78.9                                               | 77.2      | Dunstan               | 77.1                                               | 80.7      |
| Wairau       | 75.2                                               | 73.1      | Ranfurly              | 78.7                                               | 78.5      |
| Whakatane    | 76.5                                               | 78.7      | Milton                | 79.0                                               | 90.5      |
| Oamaru       | 73.7                                               | 79.0      | Kaeo                  | 79.7                                               | 75.3      |
| Dannevirke   | 80.5                                               | 79.3      | Oxford                | 54.2                                               | 73.1      |
| Taumarunui   | 72.9                                               | 74.3      | Kaikoura              | 82.2                                               | 83.5      |
| Ashburton    | 77.4                                               | 76.8      | Waimarino             | 71.9                                               | 79.3      |
| Hawera       | 78.6                                               | 77.9      | Coromandel            | 71.6                                               | 71.8      |
| Grey         | 76.5                                               | 75.9      | Tapanui               | 84.9                                               | 79.7      |
| Westown      | 86.9                                               | 86.2      | Lake County           | 69.3                                               | 71.8      |
| Wairoa       | 72.0                                               | 73.6      | Mercury Bay           | 76.8                                               | 83.0      |
|              |                                                    |           | Lawrence              | 74.6                                               | 76.4      |
|              |                                                    |           | Picton                | 80.8                                               | 84.1      |
|              |                                                    |           | Range                 | 47.8-95.7                                          | 49.5-97.4 |
|              |                                                    |           | Unweighted<br>average | 74.2                                               | 74.9      |
|              |                                                    |           | Standard<br>deviation | 7.0                                                | 6.7       |

Source: Table 9.4 and information received from the National Health Statistics Centre, Wellington.

is similar to that employed by Evans and Walker (1972) who derived their complexity measures by using an 'expected information measure' previously used by Theil (1967) in a number of economic contexts. Their basic assumption, and the one employed in this study, is that complex cases tend to be treated in relatively few hospitals equipped with sophisticated and extensive facilities while the more straightforward cases tend to be distributed more evenly throughout the hospital system. Thus, for example, it may only be possible to treat cases of a particular complexity in one hospital in New Zealand, while other more straightforward or common cases can be treated in any one of the country's hospitals.

Information theory provides a convenient means of measuring the extent of the concentration of a particular case type in the hospital system, since it is based on a comparison between a priori assumptions about the distribution of cases types throughout the hospital system, and the "information gain" obtained from learning about the actual distribution of those case types.

The two a priori assumptions employed in this study are:

- a. that no prior knowledge of the hospital system is available except that it consists of  $N$  hospitals of unknown size, location, case-mix and so on. In these circumstances it can only be surmised that each case type is evenly distributed throughout the hospital system, that is, that  $1/N$  of the cases of each type are treated in each hospital.
- b. that prior knowledge of the hospital system is



limited to information on the size of each hospital as measured by the total number of cases each hospital treats. In this case it can be assumed that if a hospital treats say 2 per cent of all hospital patients, it also treats 2 per cent of all cancer patients, accident victims or maternity cases.

Clearly the actual distribution of case types throughout New Zealand's public general hospitals will differ from either of these two hypothetical distributions. Information theory permits the measurement of the extent of the difference between the hypothetical and the actual. Indeed, the theory has as its basic tenet that "the more unlikely the event before the message on its realisation, the larger the information content of this message" (Theil 1967 p.3). In other words, while little is learnt from ascertaining that an event regarded as almost certain has taken place, the 'information gain' derived from the occurrence of a very unlikely event is much greater.

Two measures of diagnostic complexity,  $\bar{H}_j^1$  and  $\bar{H}_j^2$ , are derived on the basis of the two assumptions given above.<sup>1</sup> Evans and Walker employed a 98 item Canadian List of diagnoses as the basis for their complexity measures for hospital patients in British Columbia. In this study, in view of the fact that no directly comparable list of diagnoses exists for the New Zealand context, it was decided that the ICD list A comprising 150 diagnostic groups

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1. A detailed description of the derivation of these complexity measures is given in Appendix 9A to this Chapter.

would be a suitable alternative.<sup>1</sup> In fact, the use of a different diagnostic list to that used by Evans and Walker fulfils the useful function of testing the applicability of information theory to a larger number of diagnoses; for, as the authors point out, it would be worth knowing if the information measure loses reliability at some point (ibid p.417). In addition, the derivation of complexity values for two different years serves as a test of the stability of the complexity indices for each case type and, following suitable calculations, for each hospital.

Complexity values for each of the 151 diagnostic categories are listed for both 1969 and 1971 in Table 9.6. According to the basic assumptions and the nature of the information measures, the higher the value the more concentrated the diagnosis in the hospital system and, hence, the more complex the diagnosis. Among the most 'complex' diseases in both years, and for both measures, are 22, acute poliomyelitis, 14, leprosy, 42, ancylostomiasis, 91, viral pneumonia, 132, conditions of placenta and chord, and 134, anoxic and hypoxic conditions. In contrast, the diagnostic groups with the lowest complexity scores include 84, other forms of heart disease, 93, bronchitis, emphysema and asthma, 136, senility, and 146, superficial injury contusion and crushing.

Several features of this table are worth noting. In the first place the ranges in the complexity values are

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1. An additional diagnostic category, A151 'supplementary', has been defined, and appended to the original list, and includes the supplementary classifications of the 3 digit ICD list as well as the patients classed as 'non-hospital' in New Zealand's hospital statistics.

TABLE 9.6  
Complexity Values for 150 Causes of Hospitalisation in 1969 and 1971

| ICD List A Code No. | Disease Group                               | $\bar{H}_j^1$ |       | $\bar{H}_j^2$ |        | ICD List A Code No. | Disease Group                               | $\bar{H}_j^1$ |       | $\bar{H}_j^2$ |        |
|---------------------|---------------------------------------------|---------------|-------|---------------|--------|---------------------|---------------------------------------------|---------------|-------|---------------|--------|
|                     |                                             | 1969          | 1971  | 1969          | 1971   |                     |                                             | 1969          | 1971  | 1969          | 1971   |
| 1                   | Cholera                                     | - *           | - *   | - *           | * -    | 42                  | Ancylostomiasis                             | 3.773         | 5.072 | 8.895         | 12.872 |
| 2                   | Typhoid fever                               | 3.142         | 3.542 | 7.725         | 10.385 | 43                  | Other helminthiasis                         | 2.522         | 1.629 | 5.296         | 4.095  |
| 3                   | Paratyphoid fever                           | 1.665         | 1.863 | 3.016         | 3.925  | 44                  | All other infective and parasitic           | 0.953         | 0.878 | 1.606         | 1.629  |
| 4                   | Bacillary dysentery                         | 2.547         | 1.842 | 4.800         | 3.693  | 45                  | Malignant neoplasm of buccalcavity          | 1.914         | 1.557 | 2.446         | 1.627  |
| 5                   | Enteritis and other diarrhoeal diseases     | 0.897         | 0.897 | 0.982         | 0.936  | 46                  | Malignant neoplasm of oesophagus            | 1.632         | 1.661 | 2.731         | 2.503  |
| 6                   | Tuberculosis of respiratory system          | 1.527         | 1.571 | 2.681         | 2.829  | 47                  | Malignant neoplasm of stomach               | 1.087         | 1.105 | 0.834         | 0.580  |
| 7                   | Tuberculosis of meninges and CNS            | 3.036         | 3.395 | 7.630         | 8.612  | 48                  | Malignant neoplasm of intestine             | 1.093         | 1.051 | 0.908         | 0.565  |
| 8                   | Tuberculosis of intestines etc.             | 2.292         | 2.678 | 4.888         | 11.736 | 49                  | Malignant neoplasm of rectum                | 1.174         | 1.149 | 1.145         | 0.727  |
| 9                   | Tuberculosis of bones and joints            | 2.144         | 2.198 | 5.094         | 4.255  | 50                  | Malignant neoplasm of larynx                | 1.971         | 2.010 | 2.893         | 2.606  |
| 10                  | Other tuberculosis                          | 1.325         | 1.497 | 1.504         | 2.025  | 51                  | Malignant neoplasm of trachea, lung         | 1.577         | 1.399 | 2.021         | 1.724  |
| 11                  | Plague                                      | -             | -     | -             | -      | 52                  | Malignant neoplasm of bone                  | 2.009         | 2.048 | 2.985         | 3.593  |
| 12                  | Anthrax                                     | -             | -     | -             | -      | 53                  | Malignant neoplasm of skin                  | 1.326         | 1.347 | 1.644         | 1.695  |
| 13                  | Brucellosis                                 | 3.035         | 2.064 | 7.540         | 6.293  | 54                  | Malignant neoplasm of breast                | 1.231         | 1.161 | 0.714         | 0.773  |
| 14                  | Leprosy                                     | 4.587         | 4.837 | 11.055        | 11.407 | 55                  | Malignant neoplasm of cervix uteri          | 1.354         | 1.459 | 1.507         | 2.291  |
| 15                  | Diphtheria                                  | 3.227         | -     | 8.231         | -      | 56                  | Other malignant neoplasm of uterus          | 1.368         | 1.516 | 2.015         | 2.298  |
| 16                  | Whooping cough                              | 1.801         | 1.862 | 4.248         | 3.277  | 57                  | Malignant neoplasm of prostate              | 1.304         | 1.057 | 1.186         | 1.027  |
| 17                  | Streptococcal sore throat and scarlet fever | 1.827         | 1.629 | 5.407         | 4.209  | 58                  | Other malignant neoplasms                   | 1.226         | 1.227 | 0.719         | 0.713  |
| 18                  | Erysipelas                                  | 1.462         | 1.572 | 5.419         | 5.169  | 59                  | Leukaemia                                   | 1.651         | 1.869 | 1.832         | 2.392  |
| 19                  | Meningococcal infection                     | 1.864         | 2.078 | 2.989         | 3.692  | 60                  | Other neoplasms of lymphatic tissue         | 1.469         | 1.534 | 1.333         | 1.420  |
| 20                  | Tetanus                                     | 2.618         | 4.025 | 5.900         | 8.649  | 61                  | Benign neoplasms                            | 0.881         | 0.908 | 0.251         | 0.310  |
| 21                  | Other bacterial diseases                    | 1.657         | 1.359 | 1.920         | 1.355  | 62                  | Non toxic goitre                            | 1.283         | 1.229 | 1.078         | 0.863  |
| 22                  | Acute poliomyelitis                         | 5.071         | 5.072 | 18.197        | 17.665 | 63                  | Thyrotoxicosis with or without goitre       | 1.156         | 1.283 | 1.288         | 1.424  |
| 23                  | Late effects of acute poliomyelitis         | 2.376         | 2.044 | 9.591         | 7.040  | 64                  | Diabetes mellitus                           | 0.728         | 0.752 | 0.488         | 0.357  |
| 24                  | Smallpox                                    | -             | -     | -             | -      | 65                  | Avitaminoses & other nutritional deficiency | 0.822         | 0.927 | 1.368         | 1.325  |
| 25                  | Measles                                     | 1.205         | 2.024 | -             | 3.852  | 66                  | Other endocrine & metabolic diseases        | 1.223         | 1.332 | 1.010         | 1.257  |
| 26                  | Yellow fever                                | -             | 5.072 | -             | 15.228 | 67                  | Anaemias                                    | 0.992         | 1.007 | 0.669         | 0.565  |
| 27                  | Viral encephalitis                          | 1.906         | 1.992 | 3.706         | 4.205  | 68                  | Other diseases of blood                     | 1.179         | 1.113 | 1.100         | 0.782  |
| 28                  | Infectious hepatitis                        | 1.189         | 0.883 | 1.760         | 1.334  | 69                  | Psychoses                                   | 1.227         | 1.172 | 2.031         | 1.844  |
| 29                  | Other viral diseases                        | 0.880         | 0.872 | 0.612         | 0.499  | 70                  | Neuroses                                    | 1.010         | 0.971 | 1.176         | 1.011  |
| 30                  | Typhus and other rickettsioses              | -             | -     | -             | -      | 71                  | Mental retardation                          | 1.601         | 1.559 | 3.186         | 3.064  |
| 31                  | Malaria                                     | 1.684         | 1.891 | 3.556         | 4.670  | 72                  | Meningitis                                  | 1.478         | 1.563 | 1.894         | 1.990  |
| 32                  | Trypanosomiasis                             | 5.071         | -     | 16.465        | -      | 73                  | Multiple sclerosis                          | 1.247         | 1.371 | 2.479         | 3.282  |
| 33                  | Relapsing fever                             | -             | -     | -             | -      | 74                  | Epilepsy                                    | 1.066         | 1.046 | 0.592         | 0.569  |
| 34                  | Congenital syphilis                         | -             | 3.773 | -             | 9.195  | 75                  | Inflammatory diseases of the eye            | 1.585         | 1.676 | 2.063         | 2.213  |
| 35                  | Early syphilis                              | 3.227         | 3.497 | 7.474         | 8.577  | 76                  | Cataract                                    | 2.032         | 2.168 | 2.904         | 3.424  |
| 36                  | Syphilis of CNS                             | 3.005         | 3.542 | 6.240         | 7.858  | 77                  | Glaucoma                                    | 2.088         | 2.124 | 3.371         | 3.042  |
| 37                  | Other Syphilis                              | 3.620         | 2.597 | 10.786        | 4.427  | 78                  | Otitis media and mastoiditis                | 1.241         | 1.273 | 1.526         | 1.502  |
| 38                  | Gonococcal infections                       | 1.789         | 1.725 | 2.997         | 3.402  | 79                  | Other diseases of nervous system            | 1.310         | 1.250 | 0.923         | 0.859  |
| 39                  | Schistosomiasis                             | -             | -     | -             | -      | 80                  | Active rheumatic fever                      | 0.821         | 0.838 | 1.472         | 1.137  |
| 40                  | Hydatidosis                                 | 1.957         | 1.612 | 2.892         | 3.135  | 81                  | Chronic rheumatic heart disease             | 2.166         | 1.757 | 4.004         | 2.608  |
| 41                  | Filarial infection                          | 4.252         | 3.497 | 9.130         | 9.672  | 82                  | Hypertensive disease                        | 0.754         | 0.769 | 0.566         | 0.711  |

TABLE 9.6 (Cont)

| ICD<br>List A<br>Code No. | Disease Group                                  | $\bar{H}_j^1$ |       | $\bar{H}_j^2$ |       | ICD<br>List A<br>Code No. | Disease Group                              | $\bar{H}_j^1$ |             | $\bar{H}_j^2$ |              |
|---------------------------|------------------------------------------------|---------------|-------|---------------|-------|---------------------------|--------------------------------------------|---------------|-------------|---------------|--------------|
|                           |                                                | 1969          | 1971  | 1969          | 1971  |                           |                                            | 1969          | 1971        | 1969          | 1971         |
| 83                        | Ischaemic heart disease                        | 0.951         | 0.947 | 0.371         | 0.488 | 124                       | Ankylosis & muscular deformities           | 1.042         | 1.066       | 1.403         | 1.385        |
| 84                        | Other forms of heart disease                   | 0.677         | 0.761 | 0.616         | 0.787 | 125                       | Other diseases of muskuloskeletal system   | 0.891         | 0.883       | 0.699         | 0.551        |
| 85                        | Cerebro vascular disease                       | 0.795         | 0.760 | 0.338         | 0.403 | 126                       | Spina bifida                               | 2.075         | 2.074       | 2.804         | 2.515        |
| 86                        | Diseases of arteries, arterioles & capillaries | 1.591         | 1.650 | 2.048         | 2.277 | 127                       | Congenital anomalies of the heart          | 3.023         | 2.918       | 6.553         | 6.211        |
| 87                        | Venous thrombosis and embolism                 | 1.057         | 0.977 | 0.720         | 0.689 | 128                       | Other congenital anomalies of circulation  | 2.615         | 2.775       | 5.199         | 5.829        |
| 88                        | Other diseases of circulatory system           | 0.753         | 0.693 | 0.377         | 0.510 | 129                       | Cleft palate and cleft lip                 | 3.427         | 3.548       | 8.596         | 9.609        |
| 89                        | Acute respiratory infections                   | 0.770         | 0.757 | 0.937         | 0.987 | 130                       | All other congenital anomalies             | 1.157         | 1.182       | 0.624         | 0.611        |
| 90                        | Influenza                                      | 0.687         | 0.877 | 3.961         | 5.785 | 131                       | Birth injury and difficult labour          | 2.619         | 2.459       | 4.529         | 4.554        |
| 91                        | Viral pneumonia                                | 1.430         | 1.733 | 6.542         | 5.528 | 132                       | Conditions of placenta and chord           | 3.005         | 4.253       | 7.750         | 11.489       |
| 92                        | Other pneumonia                                | 0.710         | 0.829 | 0.764         | 0.636 | 133                       | Haemolytic disease of newborn              | 2.676         | 2.654       | 5.114         | 5.517        |
| 93                        | Bronchitis, emphysema and asthma               | 0.691         | 0.687 | 0.387         | 0.387 | 134                       | Anoxic & Hypoxic conditions                | 3.028         | 2.916       | 7.572         | 6.918        |
| 94                        | Hypertrophy of tonsils and adenoids            | 0.872         | 0.814 | 1.182         | 1.232 | 135                       | Other causes of perinatal morbidity        | 2.536         | 2.274       | 5.401         | 4.454        |
| 95                        | Empyema and abscess of lung                    | 1.723         | 1.855 | 2.814         | 2.763 | 136                       | Senility, no psychosis                     | 0.726         | 0.731       | 3.597         | 3.768        |
| 96                        | Other diseases of respiratory system           | 1.185         | 1.174 | 0.813         | 0.813 | 137                       | Symptoms & other ill-defined conditions    | 0.803         | 0.793       | 0.177         | 0.207        |
| 97                        | Diseases of teeth & supporting structures      | 0.948         | 0.939 | 3.655         | 3.512 | 138                       | Fracture of skull                          | 1.247         | 1.295       | 0.892         | 1.050        |
| 98                        | Peptic ulcer                                   | 0.959         | 1.008 | 0.325         | 0.339 | 139                       | Fracture of spine and trunk                | 0.980         | 1.000       | 0.798         | 0.836        |
| 99                        | Gastritis and duodenitis                       | 0.956         | 0.878 | 2.201         | 1.760 | 140                       | Fracture of limbs                          | 0.992         | 0.955       | 1.142         | 0.982        |
| 100                       | Appendicitis                                   | 0.874         | 0.899 | 0.333         | 0.297 | 141                       | Dislocation without fracture               | 0.826         | 0.799       | 1.497         | 1.257        |
| 101                       | Intestinal obstruction and hernia              | 0.854         | 0.814 | 0.151         | 0.179 | 142                       | Sprains and strains of joints & muscles    | 0.873         | 0.900       | 1.363         | 1.132        |
| 102                       | Cirrhosis of liver                             | 1.430         | 1.517 | 1.241         | 1.366 | 143                       | Intracranial injury                        | 1.046         | 1.054       | 0.486         | 0.439        |
| 103                       | Cholelithiasis and cholecystitis               | 0.853         | 0.897 | 0.313         | 0.356 | 144                       | Internal injury of chest, abdomen & pelvis | 1.091         | 1.091       | 0.762         | 0.573        |
| 104                       | Other diseases of digestive system             | 0.914         | 0.890 | 0.209         | 0.210 | 145                       | Laceration and open wound                  | 0.708         | 0.791       | 0.549         | 0.647        |
| 105                       | Acute nephritis                                | 1.469         | 1.618 | 2.262         | 2.278 | 146                       | Superficial injury, contusion, crushing    | 0.594         | 0.614       | 0.580         | 0.559        |
| 106                       | Other nephritis and nephrosis                  | 1.982         | 1.929 | 2.690         | 2.238 | 147                       | Foreign body entering through orifice      | 1.066         | 1.123       | 0.842         | 0.805        |
| 107                       | Infections of kidney                           | 0.823         | 0.728 | 1.085         | 1.081 | 148                       | Burn                                       | 0.973         | 0.980       | 1.277         | 1.546        |
| 108                       | Calculus of urinary system                     | 1.214         | 1.484 | 1.058         | 1.353 | 149                       | Adverse effects of chemical substances     | 1.087         | 1.027       | 0.589         | 0.483        |
| 109                       | Hyperplasia of prostate                        | 1.488         | 1.362 | 1.658         | 1.371 | 150                       | All other & unspecified effects            | 0.975         | 0.890       | 0.481         | 0.391        |
| 110                       | Diseases of breast                             | 1.037         | 0.862 | 0.445         | 0.462 | 151                       | Supplementary categories                   | 0.949         | 0.849       | 0.860         | 1.266        |
| 111                       | Other diseases of genito-urinary system        | 0.814         | 0.796 | 0.411         | 0.508 |                           |                                            |               |             |               |              |
| 112                       | Toxaemias of pregnancy and puerperium          | 1.481         | 1.640 | 2.591         | 3.231 |                           | Range                                      | 0.594-5.071   | 0.614-5.072 | 0.151-18.197  | 0.179-17.665 |
| 113                       | Haemorrhage of pregnancy and childbirth        | 0.920         | 0.971 | 1.757         | 1.864 |                           |                                            |               |             |               |              |
| 114                       | Abortion induced for legal indications         | 2.061         | 2.197 | 4.202         | 4.432 |                           |                                            |               |             |               |              |
| 115                       | Other and unspecified abortion                 | 1.061         | 1.020 | 1.501         | 1.597 |                           |                                            |               |             |               |              |
| 116                       | Sepsis of childbirth and the puerperium        | 1.411         | 1.450 | 2.452         | 3.149 |                           |                                            |               |             |               |              |
| 117                       | Other complications of pregnancy               | 1.343         | 1.379 | 2.172         | 1.957 |                           |                                            |               |             |               |              |
| 118                       | Delivery, no complications                     | 0.973         | 1.057 | 2.101         | 2.077 |                           |                                            |               |             |               |              |
| 119                       | Infections of skin & subcutaneous tissue       | 0.776         | 0.750 | 0.405         | 0.469 |                           |                                            |               |             |               |              |
| 120                       | Other diseases of skin & subcutaneous tissue   | 0.807         | 0.850 | 0.524         | 0.650 |                           |                                            |               |             |               |              |
| 121                       | Arthritis & spondylitis                        | 1.069         | 0.984 | 0.993         | 0.867 |                           |                                            |               |             |               |              |
| 122                       | Non-articular rheumatism                       | 0.817         | 0.788 | 1.302         | 1.590 |                           |                                            |               |             |               |              |
| 123                       | Osteomyelitis and periostitis                  | 1.385         | 1.168 | 1.982         | 1.311 |                           |                                            |               |             |               |              |

Source: The complexity values are based on diagnostic information for New Zealand's public general hospitals obtained from the National Health Statistics Centre, Wellington.  
 \*Diagnoses for which no complexity values are given are those for which no patients were treated in the year in question.

considerably greater for the second measure,  $\bar{H}_j^2$ , than for the first,  $\bar{H}_j^1$ . In 1971 the values for  $\bar{H}_j^1$  ranged from 0.614 (146, superficial injury) to 5.072 (22, acute poliomyelitis) while the values for  $\bar{H}_j^2$  ranged from 0.179 (101, intestinal obstruction and hernia) to 17.665 (22, acute poliomyelitis).

The explanation for this difference lies in the two a priori assumptions on which the measures are based and their relationship to the structure of the  $q_{ij}$ ,<sup>1</sup> that is, to the actual distribution of case types throughout the hospital system. Since the first measure,  $H_j^1$  includes information about the size distribution of hospitals as well as the concentration of cases, its value will be large even if cases of type  $j$  are distributed across hospitals in exactly the same way as total cases. However, although the  $q_{ij}$  will vary greatly for a given  $j$ , because the hospitals are of very different sizes, this systematic upward bias is general across all  $j$  and is removed in going from  $H_j^1$  to  $\bar{H}_j^1$ . In contrast, the second measure,  $H_j^2$ , is sensitive to deviations in the  $q_{ij}$  away from  $P_i$  in either direction which means not only that case types that are more or less concentrated than average will have high complexity values, but also that the range in those values will be greater than for the  $\bar{H}_j^1$ .

A further feature of the table is the similarity in the values for the  $\bar{H}_j^1$  and  $\bar{H}_j^2$  in the two years given. This is evident both when examining values for individual diagnoses and when comparing the ranges in their overall values which differ little between 1969 and 1971. This similarity suggests that the relative complexity indices for

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1. Refer to Appendix 9A for definitions of these terms.

each diagnosis are stable over a period of a few years. It also supports the conclusion reached earlier that hospital case-mix is relatively stable over time.

Perhaps the most important question that needs to be asked about these results is whether or not the complexity values have any meaning or validity from a medical point of view: are those diagnoses with high complexity values actually the case types that would be expected to have high values?<sup>1</sup> Close examination of the results leads to the conclusion that although in some instances expectations and eventualities are in accordance - for example, the various congenital abnormalities (disease numbers 126-129), and to a lesser extent the various cancers (disease numbers 45 to 61) have higher than average values, as expected, - in other instances the results tend to contradict those expected. This is the case particularly with the infective and parasitic diseases (numbers 1 to 44) which generally have complexity values considerably higher than average, and considerably higher than expected. The most obvious explanation for this is that the high values for these diseases are an indication of their rarity rather than their complexity. There was, for example, only one reported case of acute poliomyelitis (disease 22) in 1969 in addition to one case of trypanosomiasis (32), six cases of diphtheria (15) and seven cases of leprosy (14). A similar explanation can be given for the unexpectedly high values for the various causes of perinatal morbidity

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1. Assistance with the interpretation of these results was obtained from a number of medical practitioners and is gratefully acknowledged.

and mortality (diseases 131-135), although in this instance they probably result from the exclusion from the study of Maternity Hospitals where such conditions would normally be treated.

One means of overcoming the 'rarity effect' associated with the 150 ICD list is to reduce the number of diagnostic groups included in the analysis. A convenient alternative is the ICD list of 50 causes of hospitalisation which, among other aggregations, reduces the 44 infective and parasitic diseases of the ICD list A to two groups:

(a) infective and parasitic diseases other than tuberculosis and (b) tuberculosis. By employing the same assumptions and methods as before, two further case-mix complexity measures,  $\bar{H}_j^3$  and  $\bar{H}_j^4$ , can be derived based on 50 rather than 150 diagnostic groups.<sup>1</sup>

Values for these two measures, given in Table 9.7, suggest that the most complex diseases in both years and for both measures include perinatal morbidity and mortality (42), diseases of the eye (11), tuberculosis (2) and diseases of the arteries, arterioles and capillaries (18) while the least complex diseases include hypertensive heart disease (16), bronchitis, emphysema and asthma (22), hernia of the abdominal cavity (28) and diseases of the intestine and peritoneum (29).

Similar patterns to those which emerged from the previous table reappear with this smaller group of diagnoses. There is a contrast in range between the two measures  $\bar{H}_j^3$

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1. These two additional measures are defined in Appendix 9A to this Chapter.

TABLE 9.7  
Complexity values for 50 Causes of Hospitalisation in 1969 and 1971

| ICD<br>Code<br>No. | Disease Group                            | $\bar{H}_j^3$ |       | $\bar{H}_j^4$ |       | ICD<br>Code<br>No. | Disease Group                               | $\bar{H}_j^3$   |                 | $\bar{H}_j^4$   |                 |
|--------------------|------------------------------------------|---------------|-------|---------------|-------|--------------------|---------------------------------------------|-----------------|-----------------|-----------------|-----------------|
|                    |                                          | 1969          | 1971  | 1969          | 1971  |                    |                                             | 1969            | 1971            | 1969            | 1971            |
| 1                  | Infective and parasitic                  | 0.933         | 0.906 | 0.835         | 0.713 | 26                 | Oesophagus, stomach & duodenum              | 1.036           | 1.017           | 0.528           | 0.420           |
| 2                  | Tuberculosis                             | 1.457         | 1.457 | 2.552         | 2.492 | 27                 | Appendicitis                                | 0.924           | 0.949           | 0.421           | 0.374           |
| 3                  | Malignant Neoplasms                      | 1.218         | 1.194 | 0.644         | 0.603 | 28                 | Hernia of abdominal cavity                  | 0.898           | 0.851           | 0.233           | 0.269           |
| 4                  | Benign Neoplasms                         | 0.931         | 0.958 | 0.317         | 0.389 | 29                 | Other intestine and peritoneum              | 0.928           | 0.904           | 0.240           | 0.245           |
| 5                  | Thyroid gland                            | 1.167         | 1.248 | 0.935         | 1.056 | 30                 | Liver, gall bladder & pancreas              | 0.933           | 0.976           | 0.343           | 0.375           |
| 6                  | Diabetes Mellitus                        | 0.769         | 0.793 | 0.617         | 0.449 | 31                 | Urinary system                              | 1.084           | 1.156           | 0.796           | 0.885           |
| 7                  | Other endocrine, nutritional & metabolic | 1.081         | 1.193 | 1.026         | 1.149 | 32                 | Male genital organs                         | 1.122           | 1.088           | 0.915           | 0.837           |
| 8                  | Blood and blood forming organs           | 1.088         | 1.067 | 0.808         | 0.583 | 33                 | Breast, ovary, fallopian tube & parametrium | 1.039           | 0.921           | 0.435           | 0.387           |
| 9                  | Psychoses                                | 1.297         | 1.237 | 2.569         | 2.317 | 34                 | Uterus & other female genital organs        | 1.022           | 0.971           | 1.587           | 1.740           |
| 10                 | Other mental disorders                   | 1.051         | 1.022 | 1.399         | 1.246 | 35                 | Delivery and complications of pregnancy     | 0.913           | 1.003           | 1.954           | 1.979           |
| 11                 | Eye                                      | 1.945         | 1.978 | 2.938         | 3.031 | 36                 | Abortion                                    | 1.136           | 1.124           | 1.891           | 2.046           |
| 12                 | Ear and Mastoid process                  | 1.457         | 1.467 | 1.852         | 1.978 | 37                 | Skin and subcutaneous tissue                | 0.784           | 0.772           | 0.346           | 0.393           |
| 13                 | Other nervous system                     | 0.948         | 0.939 | 0.510         | 0.559 | 38                 | Arthritis and rheumatism                    | 1.057           | 0.977           | 1.076           | 0.948           |
| 14                 | Rheumatic fever and heart disease        | 1.416         | 1.172 | 2.377         | 1.345 | 39                 | Osteomyelitis and other bone and joint      | 1.037           | 0.999           | 1.184           | 0.842           |
| 15                 | Ischaemic heart disease                  | 1.009         | 0.999 | 0.474         | 0.612 | 40                 | Other muskuloskeletal                       | 0.924           | 0.939           | 0.882           | 0.946           |
| 16                 | Hypertensive heart disease               | 0.701         | 0.753 | 0.592         | 0.718 | 41                 | Congenital anomalies                        | 1.305           | 1.331           | 0.829           | 0.848           |
| 17                 | Cerebrovascular disease                  | 0.840         | 0.802 | 0.427         | 0.506 | 42                 | Perinatal morbidity and mortality           | 2.604           | 2.450           | 6.342           | 5.740           |
| 18                 | Arteries, arterioles and capillaries     | 1.681         | 1.741 | 2.589         | 2.860 | 43                 | Symptoms and illdefined conditions          | 0.778           | 0.776           | 0.239           | 0.267           |
| 19                 | Veins & lymphatics                       | 0.810         | 0.743 | 0.375         | 0.505 | 44                 | Fractures                                   | 1.017           | 1.018           | 0.992           | 0.949           |
| 20                 | Acute respiratory infections, influenza  | 0.736         | 0.765 | 1.197         | 1.309 | 45                 | Intracranial injury                         | 1.105           | 1.113           | 0.615           | 0.552           |
| 21                 | Pneumonia                                | 0.740         | 0.870 | 0.973         | 0.797 | 46                 | Laceration and open wound                   | 0.748           | 0.835           | 0.694           | 0.813           |
| 22                 | Bronchitis, emphysema and asthma         | 0.730         | 0.725 | 0.490         | 0.485 | 47                 | Burns                                       | 1.028           | 1.034           | 1.615           | 1.941           |
| 23                 | Hypertrophy of tonsils and adenoids      | 0.921         | 0.859 | 1.494         | 1.548 | 48                 | Toxic or adverse effects                    | 1.148           | 1.084           | 0.744           | 0.607           |
| 24                 | Other respiratory system                 | 1.251         | 1.240 | 1.018         | 1.006 | 49                 | Other injuries and adverse effects          | 0.738           | 0.751           | 0.313           | 0.313           |
| 25                 | Oral cavity, salivary glands & jaws      | 0.868         | 0.886 | 3.231         | 3.118 | 50                 | Special admissions, supplementary           | 1.002           | 0.896           | 1.088           | 1.590           |
|                    |                                          |               |       |               |       |                    | Range                                       | 0.701-<br>2.604 | 0.725-<br>2.450 | 0.233-<br>6.342 | 0.245-<br>5.740 |



and  $\bar{H}_j^4$  though not of the same extent as that between  $\bar{H}_j^1$  and  $\bar{H}_j^2$ . In 1971 the values for  $\bar{H}_j^3$  ranged from 0.725 (22, bronchitis, emphysema and asthma) to 2.450 (42, perinatal morbidity and mortality) while the values for  $\bar{H}_j^4$  ranged from 0.245 (29, other diseases of the intestine and peritoneum) to 5.740 (42, perinatal morbidity and mortality). This reduction in range is the direct result of grouping the diagnoses into larger categories and so eliminating the rarity effect. A further congruence between the two groups of values is their intertemporal similarity both for the individual diagnoses and for their ranges.

Although examination of this second set of complexity values confirms that disease rarity no longer appears to be biasing the measure as it clearly did with the first set, some of the values obtained still seem intuitively to be either too high or too low. Hypertensive heart disease (16) and cerebrovascular disease (17) for example seem to be undervalued while special admissions (50) and psychoses (9) may be overvalued. The unexpectedly high values for perinatal morbidity and mortality again reflect the effect of the exclusion of maternity hospitals from the analysis, and are therefore probably an indication of rarity rather than complexity. There is little to question about the remainder of these complexity values. Indeed they appear on the face of it to be more meaningful and intuitively reasonable than the initial set based on the larger group of diagnoses. Prior expectations are confirmed in a number of ways. Malignant neoplasms (3), for example, are shown as being more complex than benign neoplasms (4). The various

respiratory diseases (20-24) are generally low in value while such groups as diseases of the eye (11) and ear (12), rheumatic fever and heart disease (14) and burns (47) score relatively high.

Four hospital complexity measures,<sup>1</sup> CMX1, CMX2, CMX3 and CMX4 are derived on the basis of the four case-mix complexity measures already discussed. Values for each measure by individual hospitals are given in Table 9.8 for both 1969 and 1971. Several features of this table are worth noting. In the first place, comparisons between the four measures support in general the conclusions already reached with regard to the case-mix complexity measures - their values are similar over time and their ranges vary according to the assumptions on which they are based and to the number of diagnoses used in deriving the measure.

It is interesting to note that the ranges in the hospital complexity values are much narrower than those for the individual diagnoses from which they are derived. This is to be expected as there is a tendency for the more complex of a hospital's cases to be balanced by the less complex, thus imparting a centralising effect on the values obtained. It is also worth comparing these figures for the New Zealand situation with those for the British Columbian hospitals studied by Evans (1971b). The equivalent values for CMX1 (or CMX3), which Evans based on a 98 item diagnostic list for 90 active treatment hospitals in 1967, ranged between 0.73 and 1.28. Although the range for New Zealand is not as wide (CMX1 ranged from 0.85 to 1.14 in 1969) some encouragement can be taken from the broad similarity in the results obtained.

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1. These four measures are defined in Appendix 9A to this Chapter.

TABLE 9.8

## Complexity Measures for Public Hospitals in 1969 and 1971

| Hospital     | CMX1 <sup>a</sup> |       | CMX2 <sup>a</sup> |       | CMX3 <sup>b</sup> |       | CMX4 <sup>b</sup> |       |
|--------------|-------------------|-------|-------------------|-------|-------------------|-------|-------------------|-------|
|              | 1969              | 1971  | 1969              | 1971  | 1969              | 1971  | 1969              | 1971  |
| Wellington   | 1.047             | 1.059 | 1.039             | 1.074 | 1.040             | 1.047 | 1.068             | 1.085 |
| Waikato      | 1.009             | 1.015 | 0.973             | 0.997 | 1.007             | 1.011 | 0.988             | 0.997 |
| Middlemore   | 1.020             | 1.023 | 1.139             | 1.123 | 0.992             | 0.998 | 1.004             | 0.999 |
| Auckland     | 1.080             | 1.067 | 0.973             | 0.950 | 1.053             | 1.033 | 0.924             | 0.872 |
| Palmerston   | 1.010             | 1.007 | 0.966             | 0.976 | 1.018             | 1.018 | 1.002             | 1.022 |
| Green Lane   | 1.136             | 1.098 | 1.186             | 1.127 | 1.056             | 1.039 | 0.961             | 0.943 |
| Lower Hutt   | 0.960             | 0.978 | 0.986             | 1.033 | 0.965             | 0.971 | 1.012             | 1.014 |
| Christchurch | 1.032             | 1.018 | 0.816             | 0.791 | 1.048             | 1.038 | 0.855             | 0.832 |
| Dunedin      | 1.012             | 1.025 | 0.968             | 1.059 | 1.031             | 1.035 | 1.066             | 1.148 |
| Tauranga     | 0.977             | 0.992 | 0.958             | 0.997 | 0.987             | 1.004 | 0.968             | 1.033 |
| Rotorua      | 1.036             | 1.027 | 1.156             | 1.138 | 1.048             | 1.040 | 1.219             | 1.215 |
| Whangarei    | 0.999             | 1.002 | 1.047             | 1.017 | 1.003             | 1.008 | 1.052             | 1.037 |
| Hastings Mem | 0.958             | 0.961 | 1.003             | 0.996 | 0.974             | 0.973 | 1.023             | 1.062 |
| Nelson       | 0.985             | 0.995 | 0.978             | 1.027 | 0.979             | 1.002 | 0.988             | 1.069 |
| Kew          | 1.015             | 1.009 | 0.985             | 1.004 | 1.022             | 1.012 | 1.072             | 1.081 |
| Napier       | 1.044             | 1.042 | 1.011             | 1.024 | 1.090             | 1.088 | 1.112             | 1.130 |
| Pr Margaret  | 1.010             | 1.000 | 0.803             | 0.773 | 1.018             | 1.001 | 0.861             | 0.755 |
| Wanganui     | 0.988             | 0.977 | 1.045             | 0.964 | 0.986             | 0.990 | 1.039             | 0.997 |
| Timaru       | 0.988             | 0.974 | 1.043             | 1.022 | 1.001             | 0.994 | 1.082             | 1.076 |
| Burwood      | 1.016             | 1.060 | 1.226             | 1.239 | 0.973             | 0.996 | 1.086             | 1.004 |
| New Plymouth | 0.994             | 0.989 | 0.855             | 0.882 | 1.017             | 1.014 | 0.942             | 0.957 |
| Cook         | 0.957             | 0.970 | 0.982             | 1.020 | 0.964             | 0.973 | 0.981             | 0.012 |
| Wakari       | 1.021             | 1.011 | 0.921             | 0.926 | 1.019             | 0.995 | 0.903             | 0.864 |
| Thames       | 0.930             | 0.925 | 0.888             | 0.857 | 0.947             | 0.939 | 0.921             | 0.869 |
| Masterton    | 0.956             | 0.953 | 0.919             | 0.916 | 0.975             | 0.976 | 0.983             | 0.992 |
| Wairau       | 0.943             | 0.940 | 0.832             | 0.817 | 0.958             | 0.963 | 0.854             | 0.874 |
| Whakatane    | 0.926             | 0.926 | 0.976             | 0.949 | 0.928             | 0.942 | 0.975             | 0.993 |
| Oamaru       | 0.943             | 0.935 | 1.046             | 0.996 | 0.946             | 0.946 | 1.027             | 1.038 |
| Dannevirke   | 0.926             | 0.946 | 0.979             | 1.049 | 0.946             | 0.952 | 0.992             | 1.004 |
| Taumarunui   | 0.918             | 0.921 | 0.873             | 0.952 | 0.933             | 0.932 | 0.872             | 0.962 |
| Ashburton    | 0.910             | 0.927 | 1.095             | 1.037 | 0.912             | 0.936 | 1.075             | 1.050 |
| Hawera       | 0.924             | 0.931 | 0.860             | 0.924 | 0.927             | 0.935 | 0.866             | 0.933 |
| Grey         | 0.947             | 0.935 | 0.862             | 0.851 | 0.959             | 0.954 | 0.898             | 0.925 |
| Westown      | 0.975             | 1.015 | 1.582             | 1.583 | 0.948             | 0.990 | 1.451             | 1.428 |
| Wairoa       | 0.921             | 0.932 | 1.098             | 1.085 | 0.915             | 0.932 | 0.994             | 0.992 |
| Te Kuiti     | 0.910             | 0.924 | 0.996             | 0.944 | 0.925             | 0.934 | 1.004             | 0.944 |
| Waipukurau   | 0.924             | 0.902 | 0.825             | 0.843 | 0.936             | 0.926 | 0.855             | 0.892 |
| Kaitaia      | 0.907             | 0.932 | 1.088             | 1.055 | 0.920             | 0.933 | 1.065             | 1.010 |
| Balclutha    | 0.923             | 0.906 | 0.929             | 0.892 | 0.943             | 0.941 | 1.002             | 0.984 |
| Gore         | 0.911             | 0.942 | 1.024             | 1.086 | 0.924             | 0.954 | 1.023             | 1.091 |
| Tokoroa      | -                 | 0.930 | -                 | 1.010 | -                 | 0.948 | -                 | 1.070 |
| Greytown     | 0.902             | 0.855 | 1.379             | 1.301 | 0.909             | 0.883 | 1.359             | 1.322 |
| Stratford    | 0.932             | 0.919 | 0.993             | 0.837 | 0.947             | 0.932 | 1.056             | 0.874 |
| Dargaville   | 0.909             | 0.908 | 0.771             | 0.810 | 0.936             | 0.939 | 0.819             | 0.861 |
| Westland     | 0.951             | 0.962 | 1.064             | 1.101 | 0.949             | 0.965 | 0.989             | 1.015 |
| Waimate      | 0.925             | 0.917 | 1.144             | 1.155 | 0.933             | 0.922 | 1.078             | 1.109 |
| Buller       | 0.903             | 0.893 | 0.779             | 0.826 | 0.921             | 0.927 | 0.815             | 0.875 |

TABLE 9.8 (Cont)

| Hospital                    | CMX1 <sup>a</sup> |                 | CMX2 <sup>a</sup> |                 | CMX3 <sup>b</sup> |                 | CMX4 <sup>b</sup> |                 |
|-----------------------------|-------------------|-----------------|-------------------|-----------------|-------------------|-----------------|-------------------|-----------------|
|                             | 1969              | 1971            | 1969              | 1971            | 1969              | 1971            | 1969              | 1971            |
| Kawakawa                    | 0.922             | 0.901           | 0.925             | 0.875           | 0.937             | 0.924           | 0.941             | 0.958           |
| Patea                       | 0.890             | 0.876           | 1.026             | 0.929           | 0.904             | 0.905           | 0.978             | 0.984           |
| Waihi                       | 0.934             | 0.926           | 1.188             | 1.062           | 0.933             | 0.930           | 1.090             | 0.993           |
| Opotiki                     | 0.925             | 0.920           | 1.021             | 0.965           | 0.944             | 0.935           | 1.058             | 0.986           |
| Reefton                     | 0.930             | 0.894           | 1.161             | 0.988           | 0.934             | 0.919           | 0.997             | 0.875           |
| Rawene                      | 0.931             | 0.919           | 1.145             | 1.040           | 0.941             | 0.927           | 1.043             | 0.953           |
| Taihape                     | 0.879             | 0.905           | 1.011             | 0.997           | 0.904             | 0.909           | 0.983             | 0.985           |
| Te Puia                     | 0.935             | 0.954           | 1.179             | 1.152           | 0.954             | 0.948           | 1.174             | 1.064           |
| Te Kopuru                   | 0.955             | 1.067           | 1.961             | 1.981           | 0.910             | 1.015           | 1.772             | 1.906           |
| Owaka                       | 1.087             | 0.999           | 3.087             | 2.527           | 0.872             | 0.914           | 0.750             | 0.903           |
| Pahiatua                    | 0.909             | 0.917           | 1.184             | 1.277           | 0.925             | 0.924           | 1.169             | 1.239           |
| Cromwell                    | 0.960             | 0.981           | 1.280             | 1.173           | 0.922             | 0.922           | 1.021             | 0.936           |
| Dunstan                     | 0.937             | 0.937           | 1.109             | 1.113           | 0.944             | 0.939           | 1.113             | 1.105           |
| Ranfurly                    | 0.902             | 0.918           | 0.974             | 1.003           | 0.922             | 0.939           | 1.014             | 1.049           |
| Milton                      | 0.916             | 1.015           | 1.698             | 1.697           | 0.899             | 0.993           | 1.220             | 1.523           |
| Kaeo                        | 0.886             | 0.890           | 0.980             | 0.933           | 0.910             | 0.912           | 1.003             | 0.977           |
| Oxford                      | 0.875             | 1.039           | 1.342             | 1.138           | 0.891             | 0.954           | 0.652             | 0.698           |
| Kaikoura                    | 0.908             | 0.915           | 1.163             | 1.053           | 0.925             | 0.935           | 1.095             | 1.069           |
| Waimarino                   | 0.896             | 0.908           | 1.135             | 0.999           | 0.905             | 0.923           | 1.102             | 1.004           |
| Coromandel                  | 0.853             | 0.868           | 1.143             | 1.471           | 0.867             | 0.864           | 0.928             | 0.965           |
| Tapanui                     | 0.871             | 0.918           | 1.057             | 1.237           | 0.879             | 0.915           | 1.046             | 1.026           |
| Lake County                 | 0.907             | 0.910           | 1.129             | 0.909           | 0.925             | 0.942           | 1.002             | 0.883           |
| Mercury Bay                 | 0.907             | 0.925           | 1.243             | 1.039           | 0.907             | 0.915           | 0.990             | 0.977           |
| Lawrence                    | 0.927             | 0.897           | 1.225             | 1.279           | 0.933             | 0.924           | 1.125             | 1.036           |
| Picton                      | 0.914             | 0.973           | 1.650             | 1.596           | 0.885             | 0.931           | 1.355             | 1.200           |
| Range                       | 0.853-<br>1.136   | 0.855-<br>1.098 | 0.771-<br>3.087   | 0.773-<br>2.527 | 0.867-<br>1.090   | 0.864-<br>1.088 | 0.652<br>1.772    | 0.698-<br>1.906 |
| Average                     | 0.954             | 0.959           | 1.104             | 1.078           | 0.956             | 0.961           | 1.029             | 1.024           |
| Standard<br>Deviation       | 0.059             | 0.055           | 0.318             | 0.270           | 0.052             | 0.044           | 0.158             | 0.167           |
| Coefficient of<br>Variation | 6.2               | 5.7             | 28.8              | 25.0            | 5.4               | 4.6             | 15.4              | 16.3            |

a. based on 150 (ICD) diagnostic groups

b. based on 50 (ICD) diagnostic groups

Closer examination of the hospital complexity measures reported in Table 9.8 reveals some interesting features. Hospitals which treated the most complex and the least complex case loads in the two years are as follows:

|      |      | <u>Most Complex</u> | <u>Least Complex</u> |
|------|------|---------------------|----------------------|
| CMX1 | 1969 | Green Lane          | Coromandel           |
|      | 1971 | Green Lane          | Greytown             |
| CMX2 | 1969 | Owaka               | Dargaville           |
|      | 1971 | Owaka               | Princess Margaret    |
| CMX3 | 1969 | Coronation          | Coromandel           |
|      | 1971 | Napier              | Coromandel           |
| CMX4 | 1969 | Te Kopuru           | Owaka                |
|      | 1971 | Te Kopuru           | Oxford               |

It is apparent that although there is some consistency over time in the values for particular complexity measures at the extremes of their ranges, there seems to be no consistency between the various measures - each measure indicates a different and at times two different hospitals as being the most or the least complex.

A somewhat clearer picture of the relationships between the various hospital complexity measures can be obtained by examining their correlation coefficients (Table 9.9). The strongest (positive) relationship is between CMX1 and CMX3, the two hospital complexity measures based on the first assumption of no prior knowledge of the hospital system. Less strong, though again positive, is the relationship between CMX2 and CMX4. The remaining inter-relationships between the complexity measures are small in

TABLE 9.9

Correlation Coefficients for the Hospital Complexity and  
Commonality Measures in 1969 and 1971

|      |      | BEDS | CMX1  | CMX2   | CMX3   | CMX4   | COMM   |
|------|------|------|-------|--------|--------|--------|--------|
| BEDS | 1969 |      | 0.660 | -0.244 | 0.707  | -0.108 | -0.142 |
|      | 1971 |      | 0.638 | -0.207 | 0.725  | -0.083 | -0.285 |
| CMX1 | 1969 |      |       | 0.183  | 0.835  | 0.027  | -0.438 |
|      | 1971 |      |       | 0.254  | 0.876  | 0.221  | -0.216 |
| CMX2 | 1969 |      |       |        | -0.306 | 0.361  | -0.241 |
|      | 1971 |      |       |        | -0.067 | 0.574  | -0.000 |
| CMX3 | 1969 |      |       |        |        | 0.002  | -0.270 |
|      | 1971 |      |       |        |        | 0.196  | -0.172 |
| CMX4 | 1969 |      |       |        |        |        | -0.452 |
|      | 1971 |      |       |        |        |        | -0.490 |
| COMM | 1969 |      |       |        |        |        |        |
|      | 1971 |      |       |        |        |        |        |

value with the only negative coefficients occurring between CMX2 and CMX3.

The addition of BEDS and COMM into this correlation matrix further clarifies the picture and shows clearly the existence of a strong positive relationship between BEDS and CMX1 and 3. This suggests that the larger the hospital the more complex its case load is likely to be. The correlations between BEDS and the other two complexity measures, CMX2 and 4, are small, reflecting the assumption on which they are based which controls for hospital size. The negative relationship between BEDS and COMM is intuitively plausible as it suggests that the larger

hospitals tend to treat a lower proportion of 'common' diagnoses than the smaller hospitals; the relationship between the two variables is not a strong one, however. The negative relationship between COMM and all four hospital complexity measures is also consistent with expectations since it indicates that the more complex a hospital's case load, the lower the proportion of patients who are suffering from 'common' diseases. Finally, it is worth noting the intertemporal consistency of the correlation coefficients in this table both in the magnitude of the coefficients and in their signs. This adds further support to the earlier finding that complexity of case-mix, as measured here, changes little over time.

### 9.3 Empirical Results

Before presenting the results of the estimation process a description of the hypothesised relationships between these three additional case-mix measures and hospital costs is required. Prediction of the relationship between the factor-analysed case-mix variables and cost is complex. It is perhaps more straightforward to predict those factors which are likely to be relatively the more costly - these include factors 2 and 3 in both 1969 and 1971.

Prediction of the relationship between COMM - the proportion of common diagnoses - and cost is more simple. It is hypothesised that hospitals treating a low proportion of common cases will have higher costs than hospitals treating a high proportion of such cases. It is also

hypothesised that the former group of hospitals, those with a lower proportion of common cases, will tend to be the larger hospitals with facilities to treat the more complex, severe and unusual cases.

Finally, a positive relationship between case complexity and hospital costs is hypothesised - hospitals which have a more complex caseload can be expected to have higher costs.

In order to test these hypotheses, the three sets of case-mix measures are included, both individually and in combination, as explanatory variables in the INCASE and INDAY regression equations. Results presented in the text are restricted to the log-linear equations, largely in recognition of the superiority of this form over the linear form displayed in Chapter 8, but also for ease of presentation.<sup>1</sup> Results are presented, initially, for 1971, and in the following section for 1969.

#### 9.3.1 Log-Linear Results for 1971

Results for the separate inclusion of each of the case-mix measures are given in the first six equations of Tables 9.10 (INCASE) and 9.11 (INDAY). The role of the factor analysed case-mix variables in explaining inter-hospital cost variation (equation 1 in each table) appears to be small judging by the size of their coefficients. In general, one can infer that the factors with positive

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1. The linear results for both years are presented in a series of tables in Appendix 9B to this Chapter.



TABLE 9.10  
Log-Linear INCASE Equations 1971

| Variables      | Equations        |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |
|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                | 1                | 2                | 3                | 4                | 5                | 6                | 7                | 8                | 9                | 10               | 11               |
| Constant       | 1.77             | 0.99             | 1.81             | 1.56             | 1.86             | 1.57             | 5.04             | 5.13             | 3.36             | 3.71             | 1.56             |
| DFAC 1         | 0.0006<br>(0.02) |                  |                  |                  |                  |                  | 0.07<br>(1.52)   | 0.07<br>(1.33)   | 0.02<br>(0.51)   | 0.03<br>(0.76)   |                  |
| DFAC 2         | 0.02<br>(1.14)   |                  |                  |                  |                  |                  | 0.003<br>(0.13)  | 0.008<br>(0.31)  | 0.03<br>(1.31)   | 0.02<br>(0.88)   |                  |
| DFAC 3         | -0.02<br>(0.92)  |                  |                  |                  |                  |                  | -0.03<br>(0.97)  | 0.003<br>(0.10)  | -0.01<br>(0.37)  | -0.003<br>(0.11) |                  |
| DFAC 4         | -0.02<br>(0.88)  |                  |                  |                  |                  |                  | -0.08<br>(2.05)* | -0.06<br>(1.75)  | -0.03<br>(1.10)  | -0.04<br>(1.26)  |                  |
| DFAC 5         | 0.05<br>(2.58)*  |                  |                  |                  |                  |                  | 0.09<br>(3.44)** | 0.06<br>(2.90)** | 0.06<br>(2.74)** | 0.07<br>(3.00)** |                  |
| DFAC 6         | 0.009<br>(0.46)  |                  |                  |                  |                  |                  | 0.005<br>(0.25)  | -0.01<br>(0.59)  | 0.002<br>(0.01)  | -0.001<br>(0.07) |                  |
| DFAC 7         | -0.01<br>(0.71)  |                  |                  |                  |                  |                  | 0.01<br>(0.45)   | 0.04<br>(1.18)   | 0.007<br>(0.31)  | 0.03<br>(0.61)   |                  |
| COMM           |                  | 0.32<br>(0.82)   |                  |                  |                  |                  | -1.96<br>(2.13)* | -1.95<br>(1.88)  | -0.94<br>(1.32)  | -1.15<br>(1.42)  |                  |
| CMX1           |                  |                  | 1.28<br>(1.56)   |                  |                  |                  | 3.00<br>(1.66)   |                  |                  |                  |                  |
| CMX2           |                  |                  |                  | -0.08<br>(0.35)  |                  |                  |                  | 0.57<br>(1.31)   |                  |                  |                  |
| CMX3           |                  |                  |                  |                  | 2.09<br>(1.93)   |                  |                  |                  | 0.20<br>(0.12)   |                  |                  |
| CMX4           |                  |                  |                  |                  |                  | 0.08<br>(0.37)   |                  |                  |                  | 0.30<br>(0.55)   |                  |
| AGE 65         | 0.13<br>(1.13)   | 0.21<br>(2.23)*  | 0.16<br>(1.64)   | 0.24<br>(2.46)*  | 0.16<br>(1.63)   | 0.22<br>(2.34)*  | 0.17<br>(1.49)   | 0.22<br>(1.76)   | 0.16<br>(1.36)   | 0.18<br>(1.47)   | 0.23<br>(2.49)*  |
| BEDS           | -0.10<br>(1.64)  | -0.04<br>(0.78)  | -0.09<br>(1.53)  | -0.05<br>(0.94)  | -0.11<br>(1.83)  | -0.05<br>(1.00)  | -0.07<br>(1.07)  | -0.13<br>(2.03)* | -0.12<br>(1.72)  | -0.12<br>(1.81)  | -0.05<br>(0.98)  |
| TMED           | 0.10<br>(1.70)   | 0.10<br>(1.89)   | 0.07<br>(1.30)   | 0.09<br>(1.75)   | 0.08<br>(1.55)   | 0.10<br>(1.80)   | 0.12<br>(2.16)*  | 0.09<br>(1.61)   | 0.10<br>(1.74)   | 0.09<br>(1.59)   | 0.09<br>(1.77)   |
| TNURS          | 0.01<br>(0.23)   | -0.01<br>(0.20)  | -0.01<br>(0.27)  | -0.01<br>(0.20)  | -0.02<br>(0.33)  | -0.009<br>(0.18) | 0.01<br>(0.26)   | 0.003<br>(0.06)  | 0.02<br>(0.35)   | 0.01<br>(0.25)   | -0.01<br>(0.20)  |
| OPS            | 0.06<br>(1.05)   | 0.08<br>(1.93)   | 0.10<br>(2.40)*  | 0.09<br>(2.26)*  | 0.10<br>(2.54)*  | 0.10<br>(2.37)*  | 0.13<br>(1.91)   | 0.15<br>(2.07)*  | 0.11<br>(1.59)   | 0.13<br>(1.69)   | 0.10<br>(2.39)*  |
| OUTP           | 0.007<br>(0.15)  | -0.005<br>(0.12) | -0.003<br>(0.07) | -0.01<br>(0.26)  | -0.01<br>(0.33)  | -0.004<br>(0.10) | 0.04<br>(0.92)   | 0.02<br>(0.41)   | 0.01<br>(0.27)   | 0.02<br>(0.38)   | -0.007<br>(0.18) |
| ALOS           | 0.62<br>(5.52)** | 0.49<br>(5.24)** | 0.47<br>(5.27)** | 0.48<br>(5.15)** | 0.50<br>(5.52)** | 0.48<br>(5.18)** | 0.60<br>(5.51)** | 0.57<br>(4.95)** | 0.61<br>(5.39)** | 0.60<br>(5.25)** | 0.47<br>(5.21)** |
| OCCR           | -0.02<br>(0.10)  | 0.03<br>(0.18)   | 0.01<br>(0.06)   | 0.04<br>(0.20)   | 0.004<br>(0.02)  | 0.04<br>(0.23)   | 0.05<br>(0.26)   | 0.07<br>(0.34)   | 0.03<br>(0.18)   | 0.04<br>(0.18)   | 0.04<br>(0.22)   |
| CFR            |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| R <sup>2</sup> | 0.759            | 0.677            | 0.688            | 0.674            | 0.696            | 0.674            | 0.783            | 0.778            | 0.769            | 0.771            | 0.673            |
| R <sup>2</sup> | 0.677            | 0.619            | 0.632            | 0.615            | 0.641            | 0.615            | 0.695            | 0.688            | 0.676            | 0.678            | 0.622            |
| F value        | 9.26**           | 11.66**          | 12.26**          | 11.47**          | 12.69**          | 11.47**          | 8.92**           | 8.66**           | 8.23**           | 8.30**           | 13.11**          |
| S.E.E.         | 0.09             | 0.10             | 0.10             | 0.10             | 0.10             | 0.10             | 0.09             | 0.09             | 0.09             | 0.09             | 0.10             |

TABLE 9.11  
Log-Linear INDAY Equations 1971

| Variables      | Equations         |                 |                  |                  |                   |                  |                  |                  |                  |                   |                  |
|----------------|-------------------|-----------------|------------------|------------------|-------------------|------------------|------------------|------------------|------------------|-------------------|------------------|
|                | 1                 | 2               | 3                | 4                | 5                 | 6                | 7                | 8                | 9                | 10                | 11               |
| Constant       | 2.04              | 0.55            | 1.89             | 1.63             | 2.03              | 1.66             | 5.69             | 4.27             | 3.76             | 3.90              | 1.64             |
| DFAC 1         | -0.04<br>(1.12)   |                 |                  |                  |                   |                  | 0.04<br>(0.83)   | -0.005<br>(0.10) | -0.02<br>(0.41)  | -0.01<br>(0.28)   |                  |
| DFAC 2         | 0.04<br>(1.88)    |                 |                  |                  |                   |                  | 0.02<br>(0.68)   | 0.04<br>(1.43)   | 0.04<br>(1.72)   | 0.04<br>(1.65)    |                  |
| DFAC 3         | -0.02<br>(0.79)   |                 |                  |                  |                   |                  | -0.03<br>(0.95)  | -0.003<br>(0.08) | -0.01<br>(0.39)  | -0.003<br>(0.08)  |                  |
| DFAC 4         | -0.03<br>(1.21)   |                 |                  |                  |                   |                  | -0.10<br>(2.37)* | -0.05<br>(1.44)  | -0.05<br>(1.56)  | -0.05<br>(1.41)   |                  |
| DFAC 5         | 0.08<br>(4.72)**  |                 |                  |                  |                   |                  | 0.13<br>(4.92)** | 0.10<br>(4.55)** | 0.10<br>(4.33)** | 0.10<br>(4.43)**  |                  |
| DFAC 6         | 0.04<br>(2.05)*   |                 |                  |                  |                   |                  | 0.04<br>(1.82)   | 0.03<br>(1.25)   | 0.04<br>(1.54)   | 0.03<br>(1.48)    |                  |
| DFAC 7         | -0.009<br>(0.47)  |                 |                  |                  |                   |                  | 0.01<br>(0.58)   | 0.02<br>(0.58)   | 0.01<br>(0.40)   | 0.02<br>(0.52)    |                  |
| COMM           |                   | 0.61<br>(1.29)  |                  |                  |                   |                  | -2.18<br>(2.16)* | -1.30<br>(1.14)  | -1.02<br>(1.30)  | -1.10<br>(1.24)   |                  |
| CMX1           |                   |                 | 1.37<br>(1.33)   |                  |                   |                  | 3.62<br>(1.82)   |                  |                  |                   |                  |
| CMX2           |                   |                 |                  | -0.20<br>(0.70)  |                   |                  |                  | 0.20<br>(0.42)   |                  |                   |                  |
| CMX3           |                   |                 |                  |                  | 2.69<br>(2.01)*   |                  |                  |                  | 0.83<br>(0.47)   |                   |                  |
| CMX4           |                   |                 |                  |                  |                   | 0.18<br>(0.61)   |                  |                  |                  | 0.21<br>(0.35)    |                  |
| AGE 65         | -0.03<br>(0.22)   | 0.03<br>(0.25)  | -0.005<br>(0.04) | 0.09<br>(0.69)   | -0.03<br>(0.22)   | 0.04<br>(0.35)   | 0.01<br>(0.08)   | 0.02<br>(0.14)   | 0.009<br>(0.01)  | 0.01<br>(0.08)    | 0.06<br>(0.52)   |
| BEDS           | -0.18<br>(2.77)** | -0.12<br>(1.88) | -0.18<br>(2.63)* | -0.14<br>(2.21)* | -0.21<br>(3.03)** | -0.15<br>(2.33)* | -0.15<br>(2.03)* | -0.21<br>(3.03)* | -0.19<br>(2.59)* | -0.20<br>(2.94)** | -0.14<br>(2.27)* |
| TMED           | 0.16<br>(2.60)*   | 0.15<br>(2.31)* | 0.11<br>(1.66)   | 0.13<br>(2.05)*  | 0.12<br>(1.87)    | 0.15<br>(2.19)*  | 0.19<br>(3.15)** | 0.16<br>(2.63)*  | 0.17<br>(2.66)** | 0.16<br>(2.56)*   | 0.14<br>(2.09)*  |
| TNURS          | 0.07<br>(1.42)    | 0.05<br>(0.80)  | 0.05<br>(0.75)   | 0.05<br>(0.80)   | 0.04<br>(0.69)    | 0.05<br>(0.87)   | 0.08<br>(1.52)   | 0.08<br>(1.45)   | 0.08<br>(1.58)   | 0.08<br>(1.52)    | 0.05<br>(0.84)   |
| OPS            | 0.05<br>(0.78)    | 0.10<br>(1.93)  | 0.13<br>(2.60)*  | 0.12<br>(2.35)*  | 0.13<br>(2.65)*   | 0.13<br>(2.53)*  | 0.12<br>(1.65)   | 0.11<br>(1.41)   | 0.10<br>(1.27)   | 0.11<br>(1.33)    | 0.13<br>(2.64)*  |
| OUTP           | 0.05<br>(0.94)    | 0.05<br>(0.88)  | 0.04<br>(0.85)   | 0.03<br>(0.57)   | 0.03<br>(0.65)    | 0.05<br>(0.85)   | 0.09<br>(1.69)   | 0.05<br>(1.02)   | 0.06<br>(1.09)   | 0.06<br>(1.04)    | 0.04<br>(0.77)   |
| OCCR           | -0.17<br>(0.85)   | -0.26<br>(1.10) | -0.30<br>(1.27)  | -0.26<br>(1.11)  | -0.29<br>(1.27)   | -0.25<br>(1.05)  | -0.11<br>(0.56)  | -0.12<br>(0.58)  | -0.13<br>(0.61)  | -0.13<br>(0.60)   | -0.26<br>(1.11)  |
| CFR            | -0.10<br>(0.81)   | 0.12<br>(0.89)  | 0.15<br>(1.14)   | 0.13<br>(1.00)   | 0.12<br>(0.91)    | 0.13<br>(0.96)   | -0.10<br>(0.77)  | -0.09<br>(0.74)  | -0.10<br>(0.78)  | -0.10<br>(0.78)   | 0.14<br>(1.06)   |
| R <sup>2</sup> | 0.626             | 0.367           | 0.369            | 0.353            | 0.395             | 0.351            | 0.665            | 0.640            | 0.640            | 0.640             | 0.346            |
| $\bar{R}^2$    | 0.498             | 0.254           | 0.255            | 0.236            | 0.286             | 0.234            | 0.529            | 0.495            | 0.495            | 0.494             | 0.244            |
| F value        | 4.91**            | 3.23**          | 3.24**           | 3.03**           | 3.63**            | 3.01**           | 4.91**           | 4.40**           | 4.40**           | 4.39**            | 3.38**           |
| S.E.E.         | 0.10              | 0.12            | 0.12             | 0.13             | 0.12              | 0.13             | 0.10             | 0.10             | 0.10             | 0.10              | 0.12             |

coefficients are relatively more costly disease combinations and the factors with negative coefficients the relatively less costly. On this basis DFAC5, the factor combining supplementary cases and senility, has the largest positive (and significant) coefficients, while DFAC2 and 3, the factors hypothesised to be among the more costly, have less of an impact on costs than expected.

The signs of the coefficients of the second case-mix measures, COMM, (equation 2 in each table) are both positive. This suggests, contrary to expectations, that hospitals which treat a higher proportion of common diagnoses tend to have higher average costs. Furthermore, the size of these coefficients indicates that the impact of this variable on costs is considerable. It is interesting to note, however, that when COMM is included in the regressions with the other case-mix measures (equations 7 to 10) its coefficients are consistently negative as hypothesised. This implies that the true direction of impact of COMM cannot be found by including the variable as the sole case-mix measure. It also supports the supposition that hospital case-mix is a complex factor which can only be represented comprehensively by a set of variables each of which describes an essentially different aspect of each hospital's caseload.

Results for the four hospital complexity measures (equations 3 to 6 in both tables) generally support prior expectations, for in all but one case (CMX2) the coefficients are positive. The two measures based on the assumption of no prior knowledge of the hospital system, CMX1 and CMX3, appear to perform the better of the four

measures, and the size of their coefficients suggests that they explain a substantial amount of the interhospital variation in costs.

Inclusion of all three measures of hospital case-mix in the same regressions (equations 7 to 10) not surprisingly raises the  $\bar{R}^2$  values in all the equations. Equation 7 appears to provide the best fit judging by the size of its  $\bar{R}^2$  values which stand at 0.695 (INCASE) and 0.529 (INDAY). The relationships between the case-mix measures and cost are also largely as expected, particularly with COMM and the CMX variables whose coefficients, though rarely significant, are considerably larger than those for the remaining explanatory variables especially in equation 7 .

The final equation in each table contains no case-mix measures, and is included for comparative purposes to test whether the inclusion of case-mix variables in the other equations makes a significant contribution to the total explanatory power of the regressions. Application of an F test<sup>1</sup> to the various  $\bar{R}^2$  values reveals that they are significantly higher in value in equations 7 to 10 in both INCASE and INDAY equations as well as in INDAY equation 1. No significant increase in explanatory power was found in the equations in which COMM or the CMX measures were included as the sole case-mix variable (equations 2 to 6). These findings further emphasise the importance of

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1. This test statistic is employed to test the null hypothesis that there is no difference between the  $\bar{R}^2$  values in equations containing case-mix measures and those excluding them (see Kmenta 1971, p.370).

representing hospital case-mix by a variety of variables, rather than by individual measures.

Results for the remaining patient, institutional and utilisation variables are similar to those reported in the previous Chapter (Table 8.7), although the coefficients in these later results appear to be more stable both in the direction of their signs and in their magnitudes. Positive relationships are found, in equations 7 to 10, between average cost (both INCASE and INDAY) and AGE65, TMED, TNURS, OPS and OOTP, while the coefficients of BEDS are consistently negative (and significant) as expected. ALOS again appears to have a strong positive and significant influence on INCASE while CFR is negatively related to INDAY. The coefficients of OCCR are shown to be consistently positive with INCASE and yet negative as hypothesised with INDAY.

### 9.3.2 Log-Linear Results for 1969

The results for the estimation of log-linear regressions using 1969 data are presented in Tables 9.12 and 9.13. As with the 1971 results the case-mix measures are included separately and in combination in the equations reported.

The factor analysed case-mix measures again appear to have little influence on average costs, the largest positive coefficients in both tables being for DFAC6 which combines diseases of early infancy and diseases of the nervous and sense organs. Most coefficients for these variables have negative signs, the largest negative relationships being for

TABLE 9.12  
Log-Linear INCASE Equations 1969

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| Variables      | Equations         |                  |                  |                  |                  |                  |                   |                  |                   |                   |                  |
|----------------|-------------------|------------------|------------------|------------------|------------------|------------------|-------------------|------------------|-------------------|-------------------|------------------|
|                | 1                 | 2                | 3                | 4                | 5                | 6                | 7                 | 8                | 9                 | 10                | 11               |
| Constant       | 1.28              | -0.51            | 0.98             | 1.09             | 1.01             | 1.11             | 1.77              | 0.94             | 1.75              | 1.70              | 1.04             |
| DFAC 1         | -0.09<br>(3.92)** |                  |                  |                  |                  |                  | -0.10<br>(3.52)** | -0.08<br>(2.50)* | -0.09<br>(3.76)** | -0.09<br>(3.62)** |                  |
| DFAC 2         | 0.01<br>(0.50)    |                  |                  |                  |                  |                  | 0.01<br>(0.57)    | 0.001<br>(0.04)  | 0.01<br>(0.55)    | 0.01<br>(0.41)    |                  |
| DFAC 3         | -0.02<br>(0.82)   |                  |                  |                  |                  |                  | -0.02<br>(0.69)   | -0.01<br>(0.31)  | -0.02<br>(0.69)   | -0.02<br>(0.83)   |                  |
| DFAC 4         | -0.04<br>(1.73)   |                  |                  |                  |                  |                  | -0.05<br>(1.41)   | -0.04<br>(0.98)  | -0.05<br>(1.45)   | -0.05<br>(1.18)   |                  |
| DFAC 5         | 0.007<br>(0.46)   |                  |                  |                  |                  |                  | 0.004<br>(0.25)   | 0.02<br>(0.53)   | 0.005<br>(0.32)   | 0.006<br>(0.35)   |                  |
| DFAC 6         | 0.004<br>(0.24)   |                  |                  |                  |                  |                  | 0.007<br>(0.35)   | 0.001<br>(0.04)  | 0.007<br>(0.29)   | 0.007<br>(0.38)   |                  |
| DFAC 7         | -0.02<br>(1.21)   |                  |                  |                  |                  |                  | -0.03<br>(1.21)   | -0.02<br>(0.56)  | -0.03<br>(1.22)   | -0.03<br>(0.87)   |                  |
| COMM           |                   | 0.80<br>(2.43)*  |                  |                  |                  |                  | -0.25<br>(0.39)   | -0.23<br>(0.19)  | -0.24<br>(0.42)   | -0.22<br>(0.37)   |                  |
| CMX1           |                   |                  | -0.34<br>(0.40)  |                  |                  |                  | 0.06<br>(0.05)    |                  |                   |                   |                  |
| CMX2           |                   |                  |                  | 0.12<br>(0.51)   |                  |                  |                   | 0.27<br>(0.43)   |                   |                   |                  |
| CMX3           |                   |                  |                  |                  | -0.21<br>(0.18)  |                  |                   |                  | 0.06<br>(0.05)    |                   |                  |
| CMX4           |                   |                  |                  |                  |                  | 0.62<br>(2.56)*  |                   |                  |                   | 0.05<br>(0.13)    |                  |
| AGE 65         | 0.17<br>(1.31)    | 0.29<br>(3.01)** | 0.32<br>(2.88)** | 0.29<br>(2.75)** | 0.31<br>(2.91)** | 0.27<br>(2.84)** | 0.16<br>(1.04)    | 0.17<br>(1.15)   | 0.16<br>(1.07)    | 0.16<br>(1.05)    | 0.30<br>(2.97)** |
| BEDS           | 0.02<br>(0.40)    | 0.02<br>(0.42)   | 0.04<br>(0.65)   | 0.03<br>(0.52)   | 0.03<br>(0.53)   | 0.002<br>(0.04)  | 0.02<br>(0.33)    | 0.01<br>(0.18)   | 0.01<br>(0.35)    | 0.02<br>(0.34)    | 0.03<br>(0.52)   |
| TMED           | 0.02<br>(0.24)    | 0.02<br>(0.25)   | 0.01<br>(0.14)   | 0.01<br>(0.13)   | 0.01<br>(0.13)   | 0.02<br>(0.24)   | 0.02<br>(0.27)    | 0.01<br>(0.15)   | 0.02<br>(0.27)    | 0.02<br>(0.27)    | 0.008<br>(0.10)  |
| TNURS          | -0.03<br>(0.70)   | -0.04<br>(0.80)  | -0.04<br>(0.89)  | -0.04<br>(0.87)  | -0.04<br>(0.88)  | -0.03<br>(0.58)  | -0.03<br>(0.61)   | -0.02<br>(0.59)  | -0.02<br>(0.60)   | -0.03<br>(0.61)   | -0.04<br>(0.91)  |
| OPS            | 0.12<br>(2.23)*   | -0.01<br>(0.31)  | -0.01<br>(0.27)  | -0.004<br>(0.08) | -0.02<br>(0.31)  | 0.02<br>(0.32)   | 0.12<br>(1.94)    | 0.15<br>(1.71)   | 0.12<br>(2.08)*   | 0.13<br>(2.05)*   | -0.02<br>(0.31)  |
| OUTP           | 0.04<br>(0.81)    | 0.05<br>(0.96)   | 0.02<br>(0.40)   | 0.02<br>(0.42)   | 0.02<br>(0.43)   | 0.05<br>(1.15)   | 0.04<br>(0.79)    | 0.04<br>(0.73)   | 0.04<br>(0.88)    | 0.04<br>(0.88)    | 0.02<br>(0.42)   |
| ALOS           | 0.31<br>(2.14)*   | 0.43<br>(3.30)** | 0.32<br>(2.44)*  | 0.30<br>(2.17)*  | 0.32<br>(2.39)*  | 0.41<br>(3.26)** | 0.33<br>(1.77)    | 0.27<br>(1.33)   | 0.33<br>(2.02)*   | 0.33<br>(2.06)*   | 0.32<br>(2.52)*  |
| OCCR           | 0.17<br>(1.07)    | 0.28<br>(1.59)   | 0.31<br>(1.67)   | 0.30<br>(1.59)   | 0.32<br>(1.68)   | 0.22<br>(1.24)   | 0.16<br>(0.96)    | 0.14<br>(0.80)   | 0.16<br>(0.99)    | 0.16<br>(0.99)    | 0.31<br>(1.69)   |
| CFR            |                   |                  |                  |                  |                  |                  |                   |                  |                   |                   |                  |
| R <sup>2</sup> | 0.779             | 0.643            | 0.601            | 0.602            | 0.600            | 0.648            | 0.780             | 0.781            | 0.780             | 0.780             | 0.600            |
| $\bar{R}^2$    | 0.700             | 0.577            | 0.526            | 0.527            | 0.525            | 0.582            | 0.687             | 0.688            | 0.687             | 0.687             | 0.534            |
| F value        | 9.88**            | 9.63**           | 8.03**           | 8.06**           | 7.99**           | 9.80**           | 8.35**            | 8.40**           | 8.35**            | 8.36**            | 9.17**           |
| S.E.E.         | 0.08              | 0.09             | 0.10             | 0.10             | 0.10             | 0.09             | 0.08              | 0.08             | 0.08              | 0.08              | 0.10             |

TABLE 9.13  
Log-Linear INDAY Equations 1969

| Variables      | Equations         |                  |                  |                  |                  |                  |                   |                   |                   |                   |                  |
|----------------|-------------------|------------------|------------------|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|------------------|
|                | 1                 | 2                | 3                | 4                | 5                | 6                | 7                 | 8                 | 9                 | 10                | 11               |
| Constant       | 0.71              | -1.62            | 0.50             | 0.50             | 0.54             | 0.81             | 1.34              | 5.24              | 2.53              | 2.71              | 0.54             |
| DFAC 1         | -0.05<br>(1.96)   |                  |                  |                  |                  |                  | -0.04<br>(1.67)   | -0.10<br>(3.03)** | -0.06<br>(2.32)*  | -0.06<br>(2.32)*  |                  |
| DFAC 2         | -0.01<br>(0.57)   |                  |                  |                  |                  |                  | -0.02<br>(1.05)   | 0.03<br>(1.07)    | -0.007<br>(0.33)  | -0.002<br>(0.08)  |                  |
| DFAC 3         | -0.04<br>(1.74)   |                  |                  |                  |                  |                  | -0.07<br>(2.96)** | -0.07<br>(2.88)** | -0.06<br>(2.21)*  | -0.05<br>(2.04)*  |                  |
| DFAC 4         | -0.09<br>(4.05)** |                  |                  |                  |                  |                  | -0.12<br>(4.14)** | -0.13<br>(4.47)** | -0.12<br>(3.81)** | -0.13<br>(3.69)** |                  |
| DFAC 5         | 0.005<br>(0.33)   |                  |                  |                  |                  |                  | 0.01<br>(0.73)    | -0.04<br>(1.69)   | -0.004<br>(0.27)  | -0.005<br>(0.29)  |                  |
| DFAC 6         | 0.002<br>(0.11)   |                  |                  |                  |                  |                  | 0.03<br>(1.35)    | 0.03<br>(1.55)    | 0.03<br>(1.30)    | 0.01<br>(0.79)    |                  |
| DFAC 7         | -0.06<br>(2.80)** |                  |                  |                  |                  |                  | -0.06<br>(2.71)** | -0.11<br>(3.86)** | -0.08<br>(2.80)** | -0.09<br>(2.90)** |                  |
| COMM           |                   | 1.18<br>(3.47)** |                  |                  |                  |                  | -0.19<br>(0.30)   | -2.38<br>(2.58)*  | -0.86<br>(1.49)   | -0.97<br>(1.65)   |                  |
| CMX1           |                   |                  | -0.21<br>(0.22)  |                  |                  |                  | 2.55<br>(2.30)*   |                   |                   |                   |                  |
| CMX2           |                   |                  |                  | -0.14<br>(0.55)  |                  |                  |                   | 0.96<br>(1.98)    |                   |                   |                  |
| CMX3           |                   |                  |                  |                  | -0.02<br>(0.02)  |                  |                   |                   | 1.29<br>(0.94)    |                   |                  |
| CMX4           |                   |                  |                  |                  |                  | 0.88<br>(3.35)** |                   |                   |                   | 0.18<br>(0.42)    |                  |
| AGE 65         | 0.14<br>(1.00)    | 0.17<br>(1.80)   | 0.16<br>(1.38)   | 0.17<br>(1.52)   | 0.15<br>(1.38)   | 0.13<br>(1.40)   | 0.04<br>(0.28)    | 0.06<br>(0.41)    | 0.07<br>(0.46)    | 0.05<br>(0.36)    | 0.15<br>(1.43)   |
| BEDS           | 0.005<br>(0.09)   | 0.01<br>(0.22)   | 0.02<br>(0.31)   | 0.01<br>(0.25)   | 0.01<br>(0.21)   | -0.01<br>(0.25)  | -0.05<br>(0.91)   | 0.04<br>(0.65)    | -0.01<br>(0.18)   | 0.004<br>(0.07)   | 0.01<br>(0.25)   |
| TMED           | 0.06<br>(0.72)    | 0.02<br>(0.20)   | 0.004<br>(0.04)  | -0.002<br>(0.02) | 0.002<br>(0.02)  | 0.02<br>(0.21)   | 0.07<br>(0.97)    | 0.09<br>(1.13)    | 0.07<br>(0.87)    | 0.07<br>(0.86)    | 0.002<br>(0.02)  |
| TNURS          | -0.006<br>(0.14)  | -0.04<br>(0.80)  | -0.05<br>(0.91)  | -0.05<br>(0.96)  | -0.05<br>(0.91)  | -0.02<br>(0.44)  | 0.001<br>(0.02)   | -0.008<br>(0.19)  | 0.002<br>(0.05)   | 0.006<br>(0.14)   | -0.05<br>(0.93)  |
| OPS            | 0.003<br>(0.06)   | -0.11<br>(2.31)* | -0.14<br>(2.57)* | -0.15<br>(2.66)* | -0.14<br>(2.59)* | -0.07<br>(1.37)  | -0.01<br>(0.22)   | -0.06<br>(0.93)   | 0.005<br>(0.01)   | 0.003<br>(0.06)   | -0.14<br>(2.64)* |
| OUTP           | 0.21<br>(4.73)**  | 0.18<br>(3.89)** | 0.16<br>(3.10)** | 0.15<br>(3.02)** | 0.16<br>(3.12)** | 0.19<br>(4.20)** | 0.23<br>(5.50)**  | 0.21<br>(4.81)**  | 0.22<br>(4.95)**  | 0.22<br>(4.80)**  | 0.16<br>(3.18)** |
| OCCR           | 0.04<br>(0.24)    | 0.13<br>(0.71)   | 0.15<br>(0.71)   | 0.17<br>(0.81)   | 0.15<br>(0.70)   | 0.04<br>(0.19)   | 0.13<br>(0.79)    | 0.15<br>(0.84)    | 0.04<br>(0.24)    | 0.03<br>(0.16)    | 0.15<br>(0.72)   |
| CFR            | 0.11<br>(0.90)    | 0.19<br>(1.61)   | 0.28<br>(2.16)*  | 0.26<br>(2.03)*  | 0.28<br>(2.08)*  | 0.17<br>(1.39)   | -0.009<br>(0.08)  | 0.008<br>(0.07)   | 0.04<br>(0.32)    | 0.06<br>(0.51)    | 0.27<br>(2.18)*  |
| R <sup>2</sup> | 0.702             | 0.519            | 0.397            | 0.400            | 0.397            | 0.511            | 0.752             | 0.745             | 0.726             | 0.721             | 0.397            |
| $\bar{R}^2$    | 0.596             | 0.428            | 0.284            | 0.288            | 0.284            | 0.420            | 0.647             | 0.637             | 0.610             | 0.603             | 0.298            |
| F value        | 6.61**            | 5.75**           | 3.52**           | 3.56**           | 3.51**           | 5.58**           | 7.15**            | 6.87**            | 6.24**            | 6.09**            | 4.03**           |
| S.E.E.         | 0.09              | 0.10             | 0.11             | 0.11             | 0.11             | 0.10             | 0.08              | 0.08              | 0.08              | 0.08              | 0.11             |

DFAC1 in the INCASE equations and for DFAC4 in the INDAY equations.

The coefficients of COMM are again positive (and on this occasion significant) when this variable is included alone, and negative when included in combination with the other case-mix measures. The size of COMM's coefficients in equations 7 to 10, particularly in the INDAY results, again demonstrates the importance of this variable in explaining interhospital cost variations.

A similar pattern to that found in the 1971 results occurs in 1969 with the hospital complexity measures. Their signs are consistently negative when included in the regressions with the other case-mix measures (equations 7 to 10), but display mixed signs in the other equations (2 to 6).

Statistical comparison between the  $\bar{R}^2$  values obtained in equation 11 (in Tables 9.12 and 9.13) and the remaining equations in which the case-mix measures are included again shows the importance of including all 3 sets of case-mix measures in the regressions. The  $\bar{R}^2$  values are significantly larger in equations 7 to 10, and also in equations 1, 2 and 6 for both the INCASE and INDAY results - these are the equations in which the DFAC measures, COMM and CMX4 are included separately in the regressions.

The coefficients for the remaining explanatory variables display less consistency of sign than in the 1971 results, particularly with regard to BEDS, TNURS, and OPS with the INDAY equations. In addition, several of the variables have signs that are contrary to those expected. This is the case with BEDS, whose signs are mainly positive,



TNURS, mainly negative, OCCR, consistently positive and CFR, consistently positive in the INDAY equations. It is also interesting to note the positive and highly significant coefficients for OUP in the INDAY equations, which lend strong support to the hypothesis that average costs per inpatient day are higher in those hospitals which spend proportionately more on outpatient services.

#### 9.4 Summary and Conclusions

The main purpose of this Chapter has been to develop and test alternative measures of hospital case-mix to those employed in Chapter 8 with a view to improving the precision, stability and predictive validity of the regression coefficients. A number of conclusions can be drawn from the analysis presented in this chapter. It is clear that hospital case-mix is an important factor in explaining interhospital cost variations in New Zealand. A significant improvement in the explanatory power of the regressions was evident, particularly in those equations which included all three case-mix measures.

It is also apparent that hospital case-mix in New Zealand cannot be represented satisfactorily by any single measure, but requires a number of variables to describe fully its multifaceted characteristics. This result contrasts with Evan's Canadian study (1971b) in which he found that the hospital complexity measures explained as much of the interhospital cost variation as a set of 11 diagnostic factor scores.

In terms of their performance in the regressions there

is little to choose between the three case-mix measures. The factor-analysed measures, while difficult to interpret as meaningful variables in their own right, nevertheless appear to play an important part in the regressions. The case commonality measure, a more simple and straightforward variable, also appears to be a relevant cause of interhospital cost variation as the lower cost hospitals seem to be those with the higher proportions of common cases. Complexity of hospital case-mix is also an important factor in explaining interhospital cost differences. Indeed, this analysis lends strong support to Evans' information theory approach (Evans 1971b), for it not only provides results that are similar to those found in the Canadian study, but also shows that the complexity measures are relatively stable over time and can be based on alternative diagnostic breakdowns. It is clear, however, that to extend the diagnostic basis of the measures much beyond the 150 ICD list used here would introduce increasing numbers of 'rare' rather than complex diseases into the analysis which would conflict with the basic assumption of the measure.

Apart from complexity of hospital case-mix, a number of other variables play a part in explaining the interhospital variations in average costs. Higher cost hospitals appear to be those that treat a high proportion of elderly patients, that are involved in teaching either medical or nursing students, that perform proportionately more operations and spend proportionately more on outpatient care than average, and that have longer lengths of stay (INCASE), shorter case flow rates (INDAY) and higher occupancy rates. In

addition the results consistently suggest the presence of economies of scale, as average costs tend to fall as hospital size increases throughout most of the hospital size range.

## APPENDIX 9A

## Information Theory and the Derivation of Diagnostic and Hospital Complexity Measures

The 'information gain' from learning that an event took place is defined as:

$$\ln \frac{1}{p_i} \quad (9.1)$$

where  $p_i$  is the a priori probability of its occurrence.

'Expected information', defined as the sum across all events of the information which would be contained in the message that a particular event occurred, weighted by its prior probability of occurrence, is as follows:

$$\sum_i p_i \ln \frac{1}{p_i} \quad (9.2)$$

If it is now supposed that, rather than the event actually occurring, its probability of occurrence has changed to  $q_i$ , the information gain from learning that event  $i$  took place would be:

$$\ln \frac{1}{p_i} - \ln \frac{1}{q_i} = \ln \frac{q_i}{p_i} \quad (9.3)$$

However, since the expectation of this occurrence is now  $q_i$ , the expected information gain from the revised occurrence is now:

$$\sum_i q_i \ln \frac{q_i}{p_i} \quad (9.4)$$

In the hospital context information theory can be used to measure the expected information gain from learning that a patient with a particular diagnosis was treated in a

particular hospital. It can also be stated that the expected information gain obtained from ascertaining the actual distribution of a particular case type will be greater the more concentrated is that case type in the hospital system. Thus, assuming that concentration is associated with complexity, the expected information gain for a specific case type is a measure of its complexity.

Two expected information measures can now be defined for hospital case-mix proportions based on the two a priori assumptions (given above in the text):

$$H_j^1 = \sum_i q_{ij} \ln(q_{ij}/1/N) \quad (9.5)$$

and

$$H_j^2 = \sum_i q_{ij} \ln(q_{ij}/P_i) \quad (9.6)$$

where  $p_{ij} = c_{ij}/C_i$  - the proportion of each hospitals case load falling into the  $j$ th diagnostic category, where  $c_{ij}$  refers to the total cases of type  $j$  treated in hospital  $i$ , and  $C_i$  to the total cases of all types treated in hospital  $i$ .

$q_{ij} = c_{ij}/C_j$  - the proportion of cases of type  $j$  going to the  $i$ th hospital, where  $C_j$  refers to the total cases of type  $j$  treated in all  $N$  hospitals.

and  $P_i = C_i/C$  - the total number of cases treated in hospital  $i$  ( $C_i$ ) as a proportion of all cases treated in all  $N$  hospitals ( $C$ ).

In order to obtain measures of the relative complexity of cases of type  $j$  across all hospitals these two measures are now expressed in standardised form as:

$$\bar{H}_j^1 = H_j^1 / \sum_j H_j^1 Q_j \quad (9.7)$$

and

$$\bar{H}_j^2 = H_j^2 / \sum_j H_j^2 Q_j \quad (9.8)$$

where

$$Q_j = C_j / C \quad - \quad \text{the total number of cases of type } j \text{ as a proportion of all cases treated in all } N \text{ hospitals.}$$

These two measures are calculated, in this study, on the basis of the 150 I.C.D. list of diagnoses. Two further case-mix complexity measures are derived on the basis of the 50 I.C.D. list of diagnoses and are defined as:

$$\bar{H}_j^3 = H_j^3 / \sum_j H_j^3 Q_j \quad (9.9)$$

and

$$\bar{H}_j^4 = H_j^4 / \sum_j H_j^4 Q_j \quad (9.10)$$

Four measures of hospital complexity are now derived on the basis of these case-mix complexity measures:

$$CMX1 = \sum_j \bar{H}_j^1 p_{ij} \quad (9.11)$$

$$CMX2 = \sum_j \bar{H}_j^2 p_{ij} \quad (9.12)$$

$$CMX3 = \sum_j \bar{H}_j^3 p_{ij} \quad (9.13)$$

$$CMX4 = \sum_j \bar{H}_j^4 p_{ij} \quad (9.14)$$

These four measures reflect the relative complexity of each hospital's case-mix - that is, they measure the extent to which a hospital's case-mix is composed of more or less complex case types. As can be seen, the measures

are derived from the various diagnostic complexity measures  $\bar{H}_j^1$  to  $\bar{H}_j^4$  and are simply the proportion of the hospital's case load falling into a given diagnostic category ( $p_{ij}$ ) weighted by the complexity of the category and summed for all diagnoses.

Appendix 9B  
(a) Linear INCASE equations 1969

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| Variables      | Equations         |                    |                    |                    |                    |                    |                    |                   |                   |                   |                    |
|----------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|--------------------|
|                | 1                 | 2                  | 3                  | 4                  | 5                  | 6                  | 7                  | 8                 | 9                 | 10                | 11                 |
| Constant       | -44.53            | -2.76              | 294.78             | 66.77              | -5.27              | -5.24              | 320.70             | 55.63             | -45.11            | -46.05            | -6.56              |
| DFAC 1         | -24.61<br>(0.76)  |                    |                    |                    |                    |                    | -29.83<br>(0.88)   | -37.60<br>(1.10)  | -24.55<br>(0.73)  | -23.55<br>(0.70)  |                    |
| DFAC 2         | -38.16<br>(1.24)  |                    |                    |                    |                    |                    | -25.47<br>(0.77)   | -22.44<br>(0.70)  | -38.33<br>(1.22)  | -37.46<br>(1.20)  |                    |
| DFAC 3         | -0.10<br>(0.15)   |                    |                    |                    |                    |                    | -0.07<br>(0.09)    | 0.06<br>(0.09)    | 0.35<br>(0.38)    | 0.40<br>(0.43)    |                    |
| DFAC 4         | -3.47<br>(0.11)   |                    |                    |                    |                    |                    | 8.23<br>(0.24)     | 18.66<br>(0.54)   | 0.04<br>(0.001)   | 0.73<br>(0.02)    |                    |
| DFAC 5         | -0.07<br>(0.20)   |                    |                    |                    |                    |                    | -0.13<br>(0.34)    | -0.09<br>(0.25)   | -0.06<br>(0.17)   | -0.06<br>(0.17)   |                    |
| DFAC 6         | -24.84<br>(0.95)  |                    |                    |                    |                    |                    | -28.66<br>(1.08)   | -30.65<br>(1.16)  | -22.07<br>(0.81)  | -21.68<br>(0.80)  |                    |
| DFAC 7         | -0.09<br>(0.11)   |                    |                    |                    |                    |                    | 0.11<br>(0.11)     | 0.02<br>(0.02)    | -0.13<br>(0.12)   | 0.07<br>(0.07)    |                    |
| COMM           |                   | -0.02<br>(0.42)    |                    |                    |                    |                    | -0.03<br>(0.47)    | -0.02<br>(0.28)   | 0.01<br>(0.10)    | 0.02<br>(0.25)    |                    |
| CMX1           |                   |                    | -347.16<br>(1.18)  |                    |                    |                    | -405.91<br>(1.17)  |                   |                   |                   |                    |
| CMX2           |                   |                    |                    | -71.78<br>(1.49)   |                    |                    |                    | -92.62<br>(1.63)  |                   |                   |                    |
| CMX3           |                   |                    |                    |                    | -0.59<br>(0.70)    |                    |                    |                   | -0.94<br>(0.62)   |                   |                    |
| CMX4           |                   |                    |                    |                    |                    | -0.11<br>(0.84)    |                    |                   |                   | -0.18<br>(0.74)   |                    |
| AGE 65         | 6.26<br>(6.14)**  | 5.72<br>(6.24)**   | 6.08<br>(6.39)**   | 6.47<br>(6.31)**   | 5.75<br>(6.30)**   | 5.75<br>(6.31)**   | 6.60<br>(6.20)**   | 7.24<br>(6.16)**  | 6.32<br>(6.10)**  | 6.32<br>(6.11)**  | 5.75<br>(6.31)**   |
| BEDS           | -0.10<br>(0.35)   | 0.07<br>(0.28)     | 0.23<br>(0.78)     | 0.11<br>(0.41)     | 0.09<br>(0.36)     | 0.10<br>(0.39)     | 0.13<br>(0.37)     | -0.04<br>(0.14)   | -0.09<br>(0.31)   | -0.08<br>(0.28)   | 0.06<br>(0.23)     |
| BEDSQ          | 0.00007<br>(0.04) | -0.00007<br>(0.27) | -0.00002<br>(0.67) | -0.00008<br>(0.32) | -0.00009<br>(0.35) | -0.00001<br>(0.39) | -0.00001<br>(0.34) | 0.00003<br>(0.11) | 0.00006<br>(0.21) | 0.00005<br>(0.17) | -0.00006<br>(0.24) |
| TMED           | -15.15<br>(0.23)  | -4.17<br>(0.06)    | -8.83<br>(0.14)    | -16.42<br>(0.26)   | -14.21<br>(0.22)   | -10.15<br>(0.16)   | -7.90<br>(0.10)    | -20.01<br>(0.29)  | -19.42<br>(0.27)  | -16.20<br>(0.23)  | -9.88<br>(0.16)    |
| TNURS          | -38.04<br>(1.01)  | -47.67<br>(1.31)   | -51.28<br>(1.42)   | -52.01<br>(1.45)   | -48.48<br>(1.32)   | -49.27<br>(1.36)   | -47.23<br>(1.22)   | -47.36<br>(1.24)  | -40.01<br>(1.03)  | -41.17<br>(1.06)  | -46.45<br>(1.29)   |
| OPS            | 1.25<br>(0.98)    | 0.61<br>(0.54)     | 0.66<br>(0.59)     | 0.48<br>(0.43)     | 0.61<br>(0.55)     | 0.60<br>(0.53)     | 1.40<br>(1.08)     | 1.37<br>(1.08)    | 1.29<br>(0.99)    | 1.25<br>(0.97)    | 0.62<br>(0.55)     |
| OUTP           | 2.63<br>(0.72)    | 1.42<br>(0.41)     | 2.06<br>(0.59)     | 0.95<br>(0.28)     | 1.46<br>(0.42)     | 1.45<br>(0.42)     | 3.13<br>(0.84)     | 1.70<br>(0.46)    | 2.87<br>(0.76)    | 2.82<br>(0.75)    | 1.38<br>(0.40)     |
| ALOS           | 0.87<br>(0.69)    | 1.24<br>(1.03)     | 1.28<br>(1.07)     | 1.66<br>(1.36)     | 1.25<br>(1.04)     | 1.29<br>(1.15)     | 0.85<br>(0.67)     | 1.28<br>(1.01)    | 0.88<br>(0.69)    | 0.95<br>(0.74)    | 1.24<br>(1.04)     |
| OCCR           | 2.06<br>(1.92)    | 1.65<br>(1.63)     | 1.61<br>(1.61)     | 1.43<br>(1.42)     | 1.62<br>(1.60)     | 1.61<br>(1.60)     | 1.91<br>(1.75)     | 1.73<br>(1.59)    | 2.01<br>(1.84)    | 2.00<br>(1.83)    | 1.67<br>(1.67)     |
| CFR            | —                 | —                  | —                  | —                  | —                  | —                  | —                  | —                 | —                 | —                 | —                  |
| R <sup>2</sup> | 0.683             | 0.662              | 0.668              | 0.673              | 0.663              | 0.664              | 0.692              | 0.699             | 0.686             | 0.687             | 0.661              |
| R <sup>2</sup> | 0.596             | 0.612              | 0.619              | 0.625              | 0.613              | 0.614              | 0.593              | 0.602             | 0.585             | 0.587             | 0.617              |
| F value        | 7.28**            | 11.73**            | 12.08**            | 12.33**            | 11.82**            | 11.88**            | 6.49**             | 6.71**            | 6.31**            | 6.34**            | 13.19**            |
| S.E.E.         | 83.70             | 82.07              | 81.26              | 80.71              | 81.86              | 81.71              | 84.12              | 83.11             | 84.90             | 84.77             | 81.51              |



Appendix 9B  
(b) Linear INCASE Equations 1971

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| Variables        | Equations           |                    |                   |                     |                  |                  |                    |                     |                     |                     |                  |
|------------------|---------------------|--------------------|-------------------|---------------------|------------------|------------------|--------------------|---------------------|---------------------|---------------------|------------------|
|                  | 1                   | 2                  | 3                 | 4                   | 5                | 6                | 7                  | 8                   | 9                   | 10                  | 11               |
| Constant         | -135.50             | -77.43             | -1109.39          | 499.01              | -75.76           | -77.87           | -1165.73           | 411.43              | -136.25             | -130.80             | -88.58           |
| DEAC 1           | 26.75<br>(0.51)     |                    |                   |                     |                  |                  | 21.88<br>(0.41)    | 35.00<br>(0.77)     | 28.51<br>(0.53)     | 27.03<br>(0.50)     |                  |
| DEAC 2           | 1.08<br>(0.58)      |                    |                   |                     |                  |                  | 0.31<br>(0.16)     | 0.67<br>(0.41)      | 1.10<br>(0.58)      | 1.14<br>(0.60)      |                  |
| DEAC 3           | 1.37<br>(1.01)      |                    |                   |                     |                  |                  | 1.49<br>(1.09)     | 1.05<br>(0.88)      | 1.27<br>(0.91)      | 1.37<br>(0.97)      |                  |
| DEAC 4           | 0.03<br>(0.07)      |                    |                   |                     |                  |                  | 0.15<br>(0.29)     | -0.19<br>(0.42)     | 0.05<br>(0.10)      | 0.01<br>(0.03)      |                  |
| DEAC 5           | 0.78<br>(0.85)      |                    |                   |                     |                  |                  | 0.90<br>(0.98)     | 0.65<br>(0.82)      | 0.86<br>(0.91)      | 0.76<br>(0.81)      |                  |
| DEAC 6           | -160.30<br>(2.77)** |                    |                   |                     |                  |                  | -145.88<br>(2.50)* | -128.09<br>(2.53)*  | -160.10<br>(2.72)** | -161.64<br>(2.71)** |                  |
| DEAC 7           | 0.47<br>(0.45)      |                    |                   |                     |                  |                  | 0.77<br>(0.68)     | -0.33<br>(0.34)     | 0.67<br>(0.57)      | 0.46<br>(0.38)      |                  |
| COMM             |                     | -0.0009<br>(0.084) |                   |                     |                  |                  | -0.0001<br>(0.12)  | -0.002<br>(0.20)    | 0.009<br>(0.41)     | 0.0007<br>(0.04)    |                  |
| CMX1             |                     |                    | 1200.82<br>(1.65) |                     |                  |                  | 1204.37<br>(1.52)  |                     |                     |                     |                  |
| CMX2             |                     |                    |                   | -522.84<br>(4.98)** |                  |                  |                    | -490.93<br>(4.53)** |                     |                     |                  |
| CMX3             |                     |                    |                   |                     | -0.17<br>(0.19)  |                  |                    |                     | -1.13<br>(0.55)     |                     |                  |
| CMX4             |                     |                    |                   |                     |                  | -0.08<br>(0.07)  |                    |                     |                     | -0.35<br>(0.18)     |                  |
| AGE65            | 4.57<br>(2.26)*     | 5.15<br>(2.53)*    | 2.73<br>(1.10)    | 10.44<br>(5.19)*    | 5.13<br>(2.52)*  | 5.11<br>(2.34)*  | 2.22<br>(0.88)     | 9.75<br>(4.64)**    | 4.46<br>(2.16)*     | 4.35<br>(1.88)      | 5.29<br>(2.65)*  |
| BEDS             | 0.02<br>(0.03)      | -0.37<br>(0.67)    | -1.02<br>(1.51)   | 0.11<br>(0.22)      | -0.38<br>(0.68)  | -0.37<br>(0.67)  | -0.62<br>(0.81)    | 0.47<br>(0.82)      | -0.02<br>(0.03)     | 0.01<br>(0.02)      | -0.003<br>(0.02) |
| BEDSQ            | 0.00006<br>(0.10)   | 0.00004<br>(0.70)  | 0.0008<br>(1.38)  | 0.0001<br>(0.30)    | 0.0004<br>(0.70) | 0.0004<br>(0.70) | 0.0005<br>(0.77)   | 0.0002<br>(0.39)    | 0.0001<br>(0.16)    | 0.00005<br>(0.08)   | 0.0004<br>(0.70) |
| TMED             | 17.23<br>(0.19)     | 50.78<br>(0.58)    | 41.19<br>(0.48)   | 12.76<br>(0.17)     | 52.85<br>(0.60)  | 49.99<br>(0.57)  | 15.03<br>(0.17)    | -27.30<br>(0.34)    | 33.47<br>(0.35)     | 14.63<br>(0.15)     | 25.55<br>(0.52)  |
| TNIRS            | -23.13<br>(0.28)    | -29.71<br>(0.39)   | -1.13<br>(0.02)   | -74.84<br>(1.15)    | -29.87<br>(0.39) | -29.68<br>(0.39) | 2.61<br>(0.03)     | -86.00<br>(1.18)    | -17.48<br>(0.21)    | -24.39<br>(0.29)    | -61.70<br>(1.03) |
| ONS              | -1.36<br>(0.59)     | 0.61<br>(0.30)     | 0.76<br>(0.38)    | 0.44<br>(0.25)      | 0.58<br>(0.29)   | 0.58<br>(0.27)   | -0.99<br>(0.42)    | -0.81<br>(0.40)     | -1.43<br>(0.60)     | -1.59<br>(0.61)     | 0.12<br>(0.06)   |
| OUTP             | 0.42<br>(0.05)      | 0.45<br>(0.05)     | -0.46<br>(0.06)   | -4.35<br>(0.62)     | 0.40<br>(0.05)   | 0.51<br>(0.06)   | -1.69<br>(0.19)    | -1.94<br>(0.25)     | -0.64<br>(0.07)     | 1.11<br>(0.11)      | 1.12<br>(0.14)   |
| ALOS             | 5.93<br>(2.89)**    | 6.40<br>(3.09)**   | 6.62<br>(3.29)**  | 8.83<br>(4.91)**    | 6.39<br>(3.10)** | 6.46<br>(3.01)** | 6.14<br>(2.97)**   | 8.39<br>(4.47)**    | 5.95<br>(2.82)**    | 6.12<br>(2.50)*     | 6.33<br>(3.13)** |
| OCGR             | 4.20<br>(2.07)*     | 3.42<br>(1.69)     | 3.57<br>(1.80)    | 0.57<br>(0.32)      | 3.43<br>(1.70)   | 3.42<br>(1.69)   | 4.27<br>(2.09)*    | 1.23<br>(0.65)      | 4.37<br>(2.09)*     | 4.26<br>(2.04)*     | 3.31<br>(1.66)   |
| CER              | —                   | —                  | —                 | —                   | —                | —                | —                  | —                   | —                   | —                   | —                |
| R <sup>2</sup>   | 0.638               | 0.574              | 0.592             | 0.697               | 0.574            | 0.574            | 0.653              | 0.739               | 0.640               | 0.638               | 0.570            |
| ̂ R <sup>2</sup> | 0.541               | 0.512              | 0.533             | 0.653               | 0.512            | 0.512            | 0.544              | 0.657               | 0.527               | 0.524               | 0.515            |
| F value          | 6.05**              | 8.21**             | 8.84**            | 14.01**             | 8.21**           | 8.21**           | 5.53**             | 8.32**              | 5.23**              | 5.19**              | 10.45**          |
| S.E.E.           | 158.18              | 162.90             | 159.41            | 137.38              | 162.86           | 162.90           | 157.72             | 136.82              | 160.66              | 161.06              | 160.93           |

Appendix 9B  
(c) Linear INDAY Equations 1969

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| Variables      | Equations        |                   |                    |                   |                   |                  |                  |                  |                  |                  |                  |
|----------------|------------------|-------------------|--------------------|-------------------|-------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                | 1                | 2                 | 3                  | 4                 | 5                 | 6                | 7                | 8                | 9                | 10               | 11               |
| Constant       | 9.67             | 11.95             | 29.11              | 15.92             | 11.83             | 11.78            | 28.02            | 14.48            | 9.39             | 9.00             | 11.84            |
| DFAC 1         | -0.34<br>(0.14)  |                   |                    |                   |                   |                  | -0.58<br>(0.23)  | -0.80<br>(0.31)  | -0.37<br>(0.15)  | -0.36<br>(0.14)  |                  |
| DFAC 2         | -1.92<br>(0.85)  |                   |                    |                   |                   |                  | -1.32<br>(0.54)  | -1.23<br>(0.51)  | -1.95<br>(0.85)  | -1.83<br>(0.80)  |                  |
| DFAC 3         | -0.001<br>(0.02) |                   |                    |                   |                   |                  | 0.005<br>(0.09)  | 0.01<br>(0.18)   | 0.04<br>(0.52)   | 0.05<br>(0.79)   |                  |
| DFAC 4         | 0.17<br>(0.07)   |                   |                    |                   |                   |                  | 0.77<br>(0.31)   | 1.18<br>(0.45)   | 0.45<br>(0.19)   | 0.63<br>(0.26)   |                  |
| DFAC 5         | 0.02<br>(0.56)   |                   |                    |                   |                   |                  | 0.01<br>(0.48)   | 0.01<br>(0.52)   | 0.02<br>(0.59)   | 0.02<br>(0.59)   |                  |
| DFAC 6         | 0.13<br>(0.07)   |                   |                    |                   |                   |                  | -0.09<br>(0.05)  | -0.22<br>(0.11)  | 0.35<br>(0.18)   | 0.49<br>(0.25)   |                  |
| DFAC 7         | 0.02<br>(0.36)   |                   |                    |                   |                   |                  | 0.04<br>(0.53)   | 0.03<br>(0.43)   | 0.02<br>(0.27)   | 0.02<br>(0.28)   |                  |
| QYM            |                  | -0.0009<br>(0.28) |                    |                   |                   |                  | -0.002<br>(0.48) | -0.001<br>(0.32) | 0.0005<br>(0.09) | 0.003<br>(0.48)  |                  |
| QMX1           |                  |                   | -20.06<br>(0.94)   |                   |                   |                  | -20.50<br>(0.79) |                  |                  |                  |                  |
| QMX2           |                  |                   |                    | -3.79<br>(1.09)   |                   |                  |                  | -4.05<br>(0.96)  |                  |                  |                  |
| QMX3           |                  |                   |                    |                   | -0.04<br>(0.67)   |                  |                  |                  | -0.08<br>(0.69)  |                  |                  |
| QMX4           |                  |                   |                    |                   |                   | -0.009<br>(0.93) |                  |                  |                  | -0.02<br>(1.17)  |                  |
| AGE65          | 0.21<br>(3.09)** | 0.19<br>(3.08)**  | 0.21<br>(3.23)**   | 0.23<br>(3.23)**  | 0.19<br>(3.15)**  | 0.19<br>(3.15)** | 0.23<br>(3.14)** | 0.26<br>(3.06)** | 0.22<br>(3.09)** | 0.22<br>(3.20)** | 0.19<br>(3.10)** |
| BEDS           | -0.008<br>(0.38) | -0.002<br>(0.11)  | 0.007<br>(0.33)    | -0.0003<br>(0.02) | -0.0003<br>(0.02) | 0.0008<br>(0.04) | 0.004<br>(0.15)  | -0.005<br>(0.22) | -0.007<br>(0.33) | -0.006<br>(0.28) | -0.003<br>(0.14) |
| BEDSQ          | 0.00<br>(0.00)   | 0.00<br>(0.00)    | -0.00001<br>(0.50) | 0.00<br>(0.00)    | 0.00<br>(0.00)    | 0.00<br>(0.00)   | 0.00<br>(0.00)   | 0.00<br>(0.00)   | 0.00<br>(0.00)   | 0.00<br>(0.00)   | 0.00<br>(0.00)   |
| TMED           | 2.17<br>(0.45)   | 2.33<br>(0.50)    | 2.11<br>(0.46)     | 1.73<br>(0.38)    | 1.76<br>(0.38)    | 2.02<br>(0.44)   | 2.81<br>(0.55)   | 2.18<br>(0.42)   | 1.84<br>(0.35)   | 1.82<br>(0.35)   | 2.07<br>(0.45)   |
| TNTRS          | -0.21<br>(0.08)  | -0.37<br>(0.14)   | -0.61<br>(0.23)    | -0.56<br>(0.21)   | -0.46<br>(0.17)   | 0.57<br>(0.21)   | -0.79<br>(0.27)  | -0.67<br>(0.23)  | -0.43<br>(0.15)  | -0.60<br>(0.21)  | -0.30<br>(0.11)  |
| QYS            | 0.03<br>(0.28)   | 0.002<br>(0.03)   | 0.005<br>(0.06)    | -0.004<br>(0.05)  | 0.002<br>(0.03)   | 0.001<br>(0.01)  | 0.03<br>(0.34)   | 0.03<br>(0.33)   | 0.03<br>(0.31)   | 0.03<br>(0.29)   | 0.003<br>(0.03)  |
| OUTP           | 0.33<br>(1.21)   | 0.28<br>(1.09)    | 0.32<br>(1.22)     | -0.26<br>(1.04)   | 0.28<br>(1.11)    | 0.28<br>(1.10)   | 0.36<br>(1.28)   | 0.30<br>(1.06)   | 0.35<br>(1.25)   | -0.35<br>(1.25)  | 0.28<br>(1.10)   |
| ALOS           | —                | —                 | —                  | —                 | —                 | —                | —                | —                | —                | —                | —                |
| OCCR           | -0.10<br>(1.44)  | -0.11<br>(1.69)   | -0.11<br>(1.72)    | -0.11<br>(1.74)   | -0.11<br>(1.72)   | -0.11<br>(1.74)  | -0.11<br>(1.53)  | -0.11<br>(1.54)  | -0.11<br>(1.44)  | -0.11<br>(1.45)  | -0.11<br>(1.68)  |
| CFR            | 0.57<br>(2.62)*  | 0.55<br>(2.74)**  | 0.56<br>(2.79)**   | 0.51<br>(2.50)*   | 0.55<br>(2.76)**  | 0.56<br>(2.79)** | 0.59<br>(2.66)** | 0.54<br>(2.38)*  | 0.59<br>(2.63)*  | 0.59<br>(2.65)*  | 0.55<br>(2.74)** |
| R <sup>2</sup> | 0.279            | 0.263             | 0.273              | 0.277             | 0.268             | 0.273            | 0.289            | 0.293            | 0.287            | 0.299            | 0.263            |
| R <sup>2</sup> | 0.082            | 0.154             | 0.165              | 0.170             | 0.160             | 0.165            | 0.061            | 0.066            | 0.058            | 0.074            | 0.168            |
| F value        | 1.30             | 2.15*             | 2.26*              | 2.30*             | 2.20*             | 2.25*            | 1.18             | 1.20             | 1.16             | 1.23             | 2.41*            |
| S.E.E.         | 6.15             | 5.90              | 5.86               | 5.84              | 5.88              | 5.86             | 6.22             | 6.21             | 6.23             | 6.18             | 5.85             |

Appendix 9B  
(d) Linear INDAY Equations 1971

311.

| Variables      | Equations        |                    |                   |                   |                    |                    |                   |                   |                   |                   |                    |
|----------------|------------------|--------------------|-------------------|-------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                | 1                | 2                  | 3                 | 4                 | 5                  | 6                  | 7                 | 8                 | 9                 | 10                | 11                 |
| Constant       | 23.80            | 26.03              | 7.92              | 35.96             | 26.09              | 27.24              | 5.55              | 33.05             | 23.58             | 25.06             | 26.29              |
| DEAC 1         | 0.54<br>(0.26)   |                    |                   |                   |                    |                    | 0.43<br>(0.20)    | 0.77<br>(0.37)    | 0.52<br>(0.24)    | 0.62<br>(0.30)    |                    |
| DEAC 2         | 0.06<br>(0.84)   |                    |                   |                   |                    |                    | 0.04<br>(0.55)    | 0.05<br>(0.67)    | 0.06<br>(0.77)    | 0.06<br>(0.88)    |                    |
| DEAC 3         | 0.03<br>(0.53)   |                    |                   |                   |                    |                    | 0.03<br>(0.61)    | 0.03<br>(0.47)    | 0.03<br>(0.56)    | 0.03<br>(0.58)    |                    |
| DEAC 4         | -0.02<br>(0.95)  |                    |                   |                   |                    |                    | -0.02<br>(0.85)   | -0.02<br>(1.05)   | -0.02<br>(0.90)   | -0.02<br>(1.15)   |                    |
| DEAC 5         | 0.08<br>(2.22)*  |                    |                   |                   |                    |                    | 0.08<br>(2.22)*   | 0.08<br>(2.08)*   | 0.08<br>(2.14)*   | 0.07<br>(1.95)    |                    |
| DEAC 6         | -1.06<br>(0.44)  |                    |                   |                   |                    |                    | -0.78<br>(0.32)   | -0.67<br>(0.28)   | -1.07<br>(0.44)   | -1.43<br>(0.60)   |                    |
| DEAC 7         | -0.03<br>(0.76)  |                    |                   |                   |                    |                    | -0.04<br>(0.78)   | -0.05<br>(1.16)   | -0.04<br>(0.85)   | -0.06<br>(1.28)   |                    |
| CONM           |                  | 0.0001<br>(0.35)   |                   |                   |                    |                    | 0.0002<br>(0.43)  | 0.0002<br>(0.49)  | 0.0002<br>(0.17)  | 0.0008<br>(1.32)  |                    |
| CON1           |                  |                    | 21.58<br>(0.74)   |                   |                    |                    | 21.20<br>(0.66)   |                   |                   |                   |                    |
| CON2           |                  |                    |                   | -8.87<br>(1.94)   |                    |                    |                   | -8.47<br>(1.81)   |                   |                   |                    |
| CON3           |                  |                    |                   |                   | 0.01<br>(0.36)     |                    |                   |                   | 0.004<br>(0.04)   |                   |                    |
| CON4           |                  |                    |                   |                   |                    | -0.04<br>(0.83)    |                   |                   |                   | -0.10<br>(1.50)   |                    |
| AGE65          | -0.06<br>(0.84)  | -0.06<br>(0.79)    | -0.11<br>(1.09)   | 0.05<br>(0.57)    | -0.06<br>(0.79)    | -0.08<br>(1.01)    | -0.10<br>(1.02)   | -0.05<br>(0.52)   | -0.06<br>(0.78)   | -0.10<br>(1.21)   | -0.06<br>(0.82)    |
| REHS           | -0.04<br>(1.44)  | -0.03<br>(1.56)    | -0.05<br>(1.74)   | -0.03<br>(1.18)   | -0.03<br>(1.55)    | -0.04<br>(1.64)    | -0.05<br>(1.45)   | -0.03<br>(0.96)   | -0.03<br>(1.31)   | -0.03<br>(1.19)   | -0.03<br>(1.59)    |
| REHSQ          | 0.0003<br>(1.50) | 0.00004<br>(2.00)* | 0.00004<br>(0.50) | 0.00003<br>(1.50) | 0.00004<br>(2.00)* | 0.00004<br>(2.00)* | 0.00004<br>(1.33) | 0.00003<br>(1.50) | 0.00003<br>(1.50) | 0.00003<br>(1.50) | 0.00004<br>(2.00)* |
| TMED           | 7.41<br>(2.04)*  | 8.13<br>(2.33)*    | 8.06<br>(2.32)*   | 7.33<br>(2.15)*   | 8.02<br>(2.28)*    | 8.00<br>(2.31)*    | 7.17<br>(1.93)    | 6.27<br>(1.72)    | 7.16<br>(1.86)    | 6.02<br>(1.61)    | 8.19<br>(2.37)*    |
| TMURS          | 2.80<br>(0.84)   | 3.00<br>(0.97)     | 3.47<br>(1.10)    | 1.81<br>(0.59)    | 2.98<br>(0.97)     | 2.69<br>(0.87)     | 3.22<br>(0.93)    | 1.39<br>(0.41)    | 2.72<br>(0.80)    | 2.19<br>(0.65)    | 2.91<br>(0.95)     |
| OPS            | -0.08<br>(0.89)  | -0.07<br>(0.83)    | -0.07<br>(0.86)   | -0.07<br>(0.87)   | -0.07<br>(0.83)    | -0.09<br>(1.12)    | -0.07<br>(0.70)   | -0.06<br>(0.66)   | -0.07<br>(0.79)   | -0.12<br>(1.27)   | -0.07<br>(0.87)    |
| OUTP           | 0.25<br>(0.68)   | 0.01<br>(0.04)     | 0.02<br>(0.06)    | -0.07<br>(0.21)   | 0.03<br>(0.08)     | 0.11<br>(0.31)     | 0.22<br>(0.58)    | 0.20<br>(0.54)    | 0.25<br>(0.65)    | 0.46<br>(1.16)    | 0.03<br>(0.08)     |
| ALOS           | —                | —                  | —                 | —                 | —                  | —                  | —                 | —                 | —                 | —                 | —                  |
| OCCR           | -0.004<br>(0.04) | -0.02<br>(0.28)    | -0.02<br>(0.22)   | -0.07<br>(0.84)   | -0.02<br>(0.29)    | -0.01<br>(0.17)    | -0.002<br>(0.02)  | -0.05<br>(0.59)   | -0.006<br>(0.06)  | 0.02<br>(0.24)    | -0.03<br>(0.29)    |
| CFR            | 0.27<br>(1.09)   | 0.25<br>(1.06)     | 0.24<br>(1.04)    | 0.27<br>(1.23)    | 0.24<br>(1.06)     | 0.23<br>(0.99)     | 0.23<br>(0.91)    | 0.24<br>(1.00)    | 0.25<br>(0.99)    | 0.13<br>(0.50)    | 0.26<br>(1.13)     |
| R <sup>2</sup> | 0.326            | 0.218              | 0.224             | 0.262             | 0.218              | 0.226              | 0.333             | 0.367             | 0.328             | 0.355             | 0.217              |
| R <sup>2</sup> | 0.145            | 0.105              | 0.111             | 0.155             | 0.105              | 0.114              | 0.123             | 0.168             | 0.231             | 0.152             | 0.118              |
| F value        | 1.66             | 1.70               | 1.76              | 2.17*             | 1.70               | 1.78               | 1.47              | 1.71              | 1.44              | 1.62              | 1.91*              |
| S.E.E.         | 6.25             | 6.39               | 6.37              | 6.21              | 6.39               | 6.36               | 6.33              | 6.17              | 6.35              | 6.23              | 6.34               |

## CHAPTER 10

## Summary and Policy Implications

The main objective of this thesis has been to identify the factors chiefly responsible for the interhospital and intertemporal variations in the costs of running New Zealand's public general hospitals. Achievement of this objective has at the same time permitted an assessment to be made of the relevance of the various theoretical models and empirical techniques that have been employed in recent studies of hospital costs in other countries. In this the final chapter, the main findings as well as the policy and research implications of each of the two main aspects of this study are covered in turn.

## 10.1 Hospital Cost Inflation

## 10.1.1 Summary of Findings

It has become apparent, both from the literature reviewed in Chapter 2 and from the description in Chapter 3, of New Zealand's own experience in the 1960's, that a multiplicity of factors, demand and supply-related, is responsible for the rapid increase in the cost of hospital care experienced in recent years. Rising demand for hospital care stimulated not so much by economic factors such as price and income, but rather by non-economic factors such as changing disease patterns, changing demographic

characteristics, changing attitudes and rising bed numbers, appears to have been partly responsible for these cost increases in New Zealand. Much of the upward pressure on costs, though, has come from the substantial rises in the costs of both labour and non-labour hospital inputs, as well as from increases in the quantity and quality of those inputs.

More rigorous testing of the relative importance of these two sets of variables through the use of an econometric model of hospital cost inflation (Chapter 5) has clearly shown that rising hospital costs are largely due to changes on the supply side, particularly to the rising cost of the inputs used by hospitals. Demand variables, too, were shown to have had an important, though less substantial impact on hospital cost levels. Of particular significance were the variables included to measure the changing length of stay and diagnostic mix of patients in hospital during the 10 year period being studied. Indeed, the inclusion of the latter of these two measures marks a considerable improvement over the diagnostic mix variables employed in other hospital cost inflation studies published to date.

The particular model of hospital cost inflation used in this study is also somewhat of a departure from those reviewed in Chapter 4, largely because it relates to a hospital system which is publicly owned, financed and operated in contrast to the privately owned hospitals studied in America. The general behavioural model developed, apart from indicating the relative importance of the various factors contributing to hospital cost increases, has served

to highlight the rapidity with which the nature of hospital inputs and outputs has been changing in recent years particularly when one considers the many changes that have taken place in the technology and practice of medicine, in the skills of the hospital personnel, and in the types of patients treated, both by age and diagnosis. Intertemporal hospital cost comparisons which fail to account for these rapid changes in the nature of hospital output are likely to misrepresent the true extent of the cost changes.

#### 10.1.2 Implications for Policy and Further Research

A number of policy implications arise from this research. On the cost inflation side the realisation that much of the increase in hospital costs is due to inflationary forces specific to the hospital sector - such as changing diagnostic mix, and improvements in the skills of hospital personnel and in the quality and sophistication of hospital technology - suggests that policies to combat inflation in the hospital sector need to be directed at those particular causative factors. Policies aimed at stemming inflation in the wider economy are therefore likely to be inappropriate and ineffective if applied to the hospital sector.

Since the greater part of the rise in hospital costs appears to have been due to the rising cost of labour and non-labour hospital inputs, the main focus for anti-inflationary policies is best located in those areas. While it may be possible to control the rise in the cost of labour inputs, however, and this has effectively been accomplished in the most recent allocations to Hospital Boards as they

were divided, for the first time, into labour and non-labour grants, it is not so easy, and indeed may not be desirable, to restrict the cost increases which accompany improvements in the skill and quality of the labour and non-labour inputs. One possible way of controlling costs on the non-labour side, particularly with regard to the purchasing of sophisticated new diagnostic or therapeutic equipment, such as C.A.T. scanners, is for more rigorous evaluation to be undertaken aimed at assessing both the expected costs and the anticipated benefits of introducing such devices.

In addition, more emphasis could and should be placed on assessing the comparative costs and benefits of alternative hospital expenditure programmes. The results indicate, for example, that substantial savings can be obtained by substituting outpatient and extra-hospital services for inpatient care. Current hospital board policy in some areas of New Zealand is aimed at expanding these particular services and is to be encouraged as much as possible. For, apart from the cost savings involved, the benefits of such a policy are considerable both in terms of the large numbers of persons able to receive such care, and because many patients are kept out of hospital beds and in their home environment where they are often better off.

The introduction of the hospital price index in 1972 was a significant step in helping to keep track of rising prices and a useful means of determining the non-labour component in the annual allocations to Hospital Boards. The importance of regularly reviewing the mix of items included in the index, however, is underlined when it is realised just how rapidly the hospital production process - both inputs and

outputs - has been changing in recent years. Even in the short time since the introduction of the hospital price index, there are likely to have been considerable changes in the technology and practice of medicine, in the skills of the hospital personnel and in the types of patients treated, all of which are reflected in the types of drugs, materials and supplies used in the provision of hospital care. Regular updating of the basic components of this index is therefore essential if the measure is to retain its reliability and validity.

Perhaps the most important area for further research suggested by the cost inflation section of this study arises from the realisation that resources for hospital services are becoming more and more limited while demand for those services and their costs are continuing to escalate. This situation calls for a greater emphasis to be placed on the evaluation of alternative expenditure programmes and underlines the need for more and better planning of all hospital and health services. Future research, therefore, should be aimed at assessing the costs and benefits of particular hospital programmes with a view to ensuring the most efficient and effective utilisation of the scarce resources available for hospital care in New Zealand.

## 10.2 Hospital Cost Variations

### 10.2.1 Summary of Findings

Similar factors to those identified in the studies reviewed in Chapters 6 and 7 were found to be responsible for variations in New Zealand's hospital costs at a given point



in time. Of particular importance in explaining the cost differences were the types of patient treated, both by age and diagnosis, the length of time the patient stayed in hospital, and the teaching status of the hospital - those hospitals engaged in training doctors and/or nurses tended to have up to 30 per cent higher average costs than their non-teaching counterparts.

Largely in view of the emphasis placed on them in the literature, considerable attention was devoted to two particular areas of concern, namely to establishing whether economies of scale exist in New Zealand's hospital industry, and to developing and testing a number of measures of hospital output. The empirical results presented in both Chapters 8 and 9 consistently indicated the presence of economies of scale, though only on rare occasions were the estimated coefficients significant. The lower cost hospitals tended to be those in what might be termed the middle to upper size range (300-600 beds) while the higher cost hospitals were either relatively small or very large.

Four alternative measures of hospital output or case-mix were developed based on similar measures already employed in various American and Canadian studies. All four measures were shown to be important in explaining interhospital cost variations although the explanatory power of the first of these, the 18 diagnostic proportions, was weakened by the considerable degree of multicollinearity present in the regressions. It also became apparent that the complicated nature of hospital case-mix could only be represented satisfactorily by the inclusion of all three of the case-mix variables developed in Chapter 9, namely the factor analysed

case-mix proportions, the case commonality measure, and the complexity of each hospital's case-mix.

Close attention was paid to the performance of the last of these four case-mix measures in view of its strong showing in Evan's recent Canadian research. The complexity measures developed in this study extended and refined those of Evans by measuring them over time and by basing them on two alternative sets of diagnoses. The results lend further support to this unique method of measuring case-mix complexity through the use of information theory, as they showed the measures to be relatively stable over time both in magnitude and explanatory power. It was argued, however, that the extension of the diagnostic base to more than the 150 diagnoses employed, would tend to introduce increasing numbers of rarer rather than complex diseases into the analysis, thus reducing the measure's validity.

One interesting aspect of the results both for the cost inflation and cost variation parts of this research, is the comparative performance of the linear and log-linear regressions. In nearly all instances in which comparisons were made the log-linear functional form was found to be significantly more appropriate than the linear form for explaining interhospital and intertemporal cost variations in New Zealand. This result is all the more interesting when it is realised that most overseas studies employed only the linear form in the cost inflation research. It is only by testing and comparing alternative functional forms that their relative performance can be assessed.

#### 10.2.2 Implications for Policy and Further Research

A number of policy implications also arise from the

cross-sectional analysis of hospital cost variations. If, as the results indicate, average costs vary among hospitals because of the age and diagnostic mix of the patients treated, the hospital's size, its teaching status and its intensity of bed utilisation, it seems appropriate to suggest a system of allocating finance to Hospital Boards which accounts for these differences. Currently none of these factors receives consideration when the annual maintenance allocations to Hospital Boards are calculated, for they are determined largely on the basis of expenditure in the previous year adjusted to account for such things as the additional cost of wage and salary increases anticipated during the year, the operating costs of new buildings brought into commission, and an allowance for growth based on increases in the numbers of patients treated. One disadvantage of this system of allocating funds to Hospital Boards is that it has tended to perpetuate the marked interboard inequalities in the distribution of both beds and finance which existed when the basis of the present scheme was introduced. Any revised allocation system should therefore endeavour to ensure that a more equitable distribution of resources is achieved over a period of years.

One means of achieving this objective would be to base the allocations on the size of the population served by each hospital board corrected to account for the factors that differentiate the hospitals between regions. These factors, according to the results presented in this study, include the type of population served by each region as reflected in the age, case-mix and case complexity of the patients treated; the number, size and teaching status of the hospitals

in each region; and the intensity of bed and hospital utilisation of the hospitals in each region. Once having developed such a population-based allocation formula gradual movement over a number of years towards the desired objective of an equitable distribution of resources would ensure the avoidance of too drastic an adjustment from the current pattern of resource distribution.

The importance of case-mix differences in explaining interhospital cost variations emphasises the need for further research into developing a simple yet reliable means of accounting for those differences in any allocation formula that might be devised. The measures developed in this study, while going some way towards this objective, are subject to too many problems and criticisms to be considered adequate for the purpose.

The considerable impact of teaching on hospital costs also suggests the need for an intensive research project aimed at assessing more accurately the nature and extent of its impact. Clearly if hospitals offering teaching programmes are to be adequately funded for so doing the implications of teaching for all aspects of a hospital's activities requires investigation.

Finally, the suggestion in the results that economies of scale exist in New Zealand's hospital industry is a factor that should be borne in mind and, possibly, subjected to further, more intensive research, when future hospitals are being planned.

## DATA APPENDIX TABLES

TABLE 6-1  
HOSPITAL EXPENDITURES DURING, NEW ZEALAND HOSPITAL DATES 1962-71

| Hospital Board   | 1962  | 1963  | 1964  | 1965  | 1966  | 1967  | 1968  | 1969  | 1970  | 1971   |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
|                  | \$m   | \$m   | \$m   | \$m   | \$m   | \$m   | \$m   | \$m   | \$m   | \$m    |
| Northland        | 1.60  | 1.96  | 2.16  | 2.39  | 2.75  | 2.99  | 3.09  | 3.23  | 3.47  | 4.13   |
| Auckland         | 7.81  | 8.63  | 9.57  | 11.63 | 14.08 | 16.10 | 17.00 | 18.29 | 20.59 | 25.17  |
| Waikato          | 3.93  | 4.34  | 4.81  | 5.11  | 5.79  | 6.55  | 6.89  | 7.66  | 9.05  | 10.86  |
| Thames           | 0.56  | 0.60  | 0.66  | 0.75  | 0.84  | 0.92  | 0.93  | 1.01  | 1.07  | 1.25   |
| Tauranga         | 0.71  | 0.80  | 0.90  | 1.08  | 1.30  | 1.45  | 1.45  | 1.57  | 1.75  | 1.99   |
| Whakatane        | 0.40  | 0.43  | 0.48  | 0.58  | 0.67  | 0.70  | 0.75  | 0.80  | 0.88  | 1.08   |
| Opotiki          | 0.16  | 0.17  | 0.18  | 0.17  | 0.18  | 0.19  | 0.18  | 0.20  | 0.21  | 0.24   |
| Waipatu          | 0.13  | 0.13  | 0.15  | 0.16  | 0.19  | 0.19  | 0.18  | 0.20  | 0.21  | 0.26   |
| Cook             | 0.94  | 0.98  | 1.08  | 1.17  | 1.26  | 1.40  | 1.39  | 1.43  | 1.61  | 1.88   |
| Wairoa           | 0.23  | 0.24  | 0.23  | 0.32  | 0.35  | 0.37  | 0.36  | 0.39  | 0.43  | 0.50   |
| Hawkes Bay       | 1.59  | 1.76  | 1.97  | 2.14  | 2.47  | 2.63  | 2.59  | 2.74  | 2.98  | 3.57   |
| Tammarunui       | 0.40  | 0.42  | 0.45  | 0.47  | 0.52  | 0.57  | 0.56  | 0.60  | 0.63  | 0.73   |
| Waipawa          | 0.43  | 0.45  | 0.48  | 0.49  | 0.56  | 0.58  | 0.59  | 0.61  | 0.66  | 0.75   |
| Dannevirke       | 0.35  | 0.36  | 0.38  | 0.39  | 0.44  | 0.47  | 0.47  | 0.50  | 0.54  | 0.63   |
| Taranaki         | 1.71  | 1.80  | 2.07  | 2.26  | 2.52  | 2.66  | 2.58  | 2.83  | 3.09  | 3.59   |
| Wanganui         | 1.34  | 1.39  | 1.59  | 1.79  | 1.96  | 2.02  | 2.06  | 2.18  | 2.32  | 2.69   |
| Palmerston North | 1.69  | 1.80  | 1.96  | 2.13  | 2.41  | 2.62  | 2.90  | 3.18  | 3.39  | 3.94   |
| Wellington       | 5.35  | 5.54  | 6.16  | 6.62  | 7.25  | 8.51  | 8.80  | 9.33  | 10.22 | 11.80  |
| Wairarapa        | 0.78  | 0.84  | 0.91  | 0.99  | 1.11  | 1.17  | 1.15  | 1.25  | 1.37  | 1.62   |
| North Island     | 30.11 | 32.64 | 36.23 | 40.65 | 46.64 | 52.08 | 53.93 | 57.99 | 64.47 | 76.59  |
| Marlborough      | 0.61  | 0.64  | 0.69  | 0.75  | 0.85  | 0.90  | 0.95  | 1.00  | 1.12  | 1.32   |
| N. Canterbury    | 4.55  | 5.00  | 5.42  | 6.28  | 7.01  | 7.76  | 7.96  | 8.35  | 9.18  | 11.12  |
| Nelson           | 0.92  | 1.02  | 1.11  | 1.16  | 1.32  | 1.39  | 1.35  | 1.44  | 1.57  | 1.84   |
| West Coast       | 1.13  | 1.22  | 1.28  | 1.40  | 1.52  | 1.61  | 1.53  | 1.60  | 1.70  | 1.98   |
| Ashburton        | 0.43  | 0.44  | 0.48  | 0.53  | 0.59  | 0.62  | 0.67  | 0.69  | 0.87  | 1.09   |
| S. Canterbury    | 1.06  | 1.14  | 1.27  | 1.41  | 1.59  | 1.72  | 1.74  | 1.87  | 2.04  | 2.36   |
| Waitaki          | 0.42  | 0.47  | 0.50  | 0.55  | 0.67  | 0.71  | 0.69  | 0.72  | 0.74  | 0.83   |
| Otago            | 2.96  | 3.09  | 3.43  | 3.80  | 4.34  | 4.91  | 4.95  | 5.43  | 5.94  | 7.09   |
| S. Otago         | 0.39  | 0.40  | 0.43  | 0.46  | 0.53  | 0.56  | 0.56  | 0.60  | 0.65  | 0.73   |
| Maniototo        | 0.06  | 0.07  | 0.07  | 0.08  | 0.08  | 0.09  | 0.09  | 0.09  | 0.10  | 0.12   |
| Vincent          | 0.15  | 0.15  | 0.17  | 0.19  | 0.20  | 0.21  | 0.22  | 0.23  | 0.24  | 0.29   |
| Southland        | 1.44  | 1.64  | 1.82  | 1.96  | 2.22  | 2.48  | 2.71  | 2.95  | 3.28  | 4.15   |
| South Island     | 14.11 | 15.29 | 16.70 | 18.56 | 20.93 | 22.96 | 23.41 | 24.99 | 27.41 | 32.92  |
| NEW ZEALAND      | 44.22 | 47.92 | 52.92 | 59.21 | 67.57 | 75.04 | 77.34 | 82.98 | 91.88 | 109.61 |

Source: N.Z. Dept. of Health, Hospital Statistics, Wellington, Government Printer for years 1962-71, (Table 6)

| Hospital Board   | 1962  | 1963  | 1964  | 1965  | 1966  | 1967  | 1968  | 1969  | 1970  | 1971  |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | \$    | \$    | \$    | \$    | \$    | \$    | \$    | \$    | \$    | \$    |
| Northland        | 142.5 | 167.5 | 179.1 | 201.7 | 233.0 | 242.4 | 246.5 | 252.9 | 262.1 | 300.1 |
| Auckland         | 157.0 | 199.9 | 209.0 | 237.2 | 271.3 | 289.0 | 232.7 | 237.7 | 331.2 | 377.7 |
| Waikato          | 150.8 | 157.8 | 166.5 | 179.0 | 197.4 | 216.7 | 213.2 | 227.6 | 253.8 | 294.1 |
| Thames           | 161.4 | 171.4 | 185.4 | 181.5 | 214.3 | 213.0 | 217.3 | 233.8 | 244.7 | 278.6 |
| Tauranga         | 166.4 | 169.4 | 181.8 | 197.7 | 231.6 | 213.9 | 207.2 | 213.7 | 233.1 | 281.9 |
| Whakatane        | 100.4 | 101.4 | 109.5 | 130.0 | 156.2 | 166.3 | 175.2 | 185.3 | 195.5 | 236.8 |
| Opotiki          | 129.0 | 129.5 | 134.4 | 123.9 | 139.5 | 183.8 | 161.7 | 172.6 | 202.7 | 218.7 |
| Waiaapu          | 144.6 | 163.8 | 200.4 | 201.1 | 218.1 | 250.2 | 231.5 | 244.2 | 279.6 | 337.9 |
| Cook             | 166.4 | 186.3 | 196.7 | 214.7 | 248.9 | 258.5 | 260.6 | 279.6 | 296.8 | 338.6 |
| Waioa            | 108.9 | 116.2 | 120.9 | 132.5 | 152.5 | 179.2 | 167.4 | 187.2 | 218.7 | 237.3 |
| Hawkes Bay       | 153.8 | 169.4 | 175.3 | 183.3 | 207.5 | 215.5 | 203.1 | 211.5 | 225.9 | 255.2 |
| Taumarunui       | 163.9 | 159.5 | 176.3 | 183.0 | 200.9 | 216.8 | 208.4 | 190.7 | 206.2 | 247.8 |
| Waipawa          | 196.9 | 228.1 | 249.5 | 255.5 | 299.5 | 304.8 | 316.8 | 314.4 | 347.9 | 387.2 |
| Dannevirke       | 179.0 | 171.3 | 172.8 | 200.4 | 217.3 | 243.6 | 269.0 | 272.8 | 290.9 | 387.6 |
| Taranaki         | 163.3 | 163.5 | 187.2 | 196.1 | 224.8 | 244.1 | 223.4 | 233.8 | 251.8 | 297.4 |
| Wanganui         | 169.2 | 170.3 | 177.6 | 188.0 | 200.6 | 208.4 | 220.8 | 232.6 | 242.7 | 286.8 |
| Palmerston North | 149.2 | 157.0 | 167.6 | 175.0 | 194.9 | 216.5 | 225.1 | 238.1 | 251.0 | 285.1 |
| Wellington       | 185.2 | 184.6 | 204.5 | 217.0 | 219.0 | 241.6 | 241.2 | 244.0 | 260.8 | 300.2 |
| Wairarapa        | 149.0 | 159.3 | 171.1 | 190.5 | 207.1 | 208.7 | 205.9 | 214.7 | 243.6 | 276.0 |
| North Island     | 166.3 | 174.4 | 186.3 | 202.6 | 225.8 | 242.2 | 239.8 | 250.2 | 272.3 | 314.4 |
| Marlborough      | 153.1 | 163.9 | 172.3 | 188.8 | 209.9 | 229.1 | 213.9 | 227.1 | 267.4 | 314.6 |
| North Canterbury | 209.9 | 221.7 | 231.2 | 241.8 | 263.5 | 281.8 | 272.3 | 284.4 | 291.6 | 332.6 |
| Nelson           | 150.7 | 156.9 | 170.9 | 194.7 | 207.3 | 213.2 | 229.2 | 228.4 | 262.6 | 294.2 |
| West Coast       | 197.9 | 227.5 | 242.7 | 263.6 | 274.8 | 295.0 | 269.2 | 298.1 | 324.2 | 356.2 |
| Ashburton        | 147.8 | 148.5 | 160.8 | 184.9 | 209.1 | 196.0 | 218.0 | 218.3 | 316.9 | 365.1 |
| South Canterbury | 164.6 | 178.5 | 192.4 | 200.4 | 230.0 | 248.7 | 255.0 | 266.7 | 272.5 | 317.5 |
| Waitaki          | 145.8 | 160.5 | 167.2 | 179.4 | 228.6 | 247.0 | 240.8 | 265.8 | 265.7 | 297.2 |
| Otago            | 191.0 | 195.7 | 209.2 | 232.3 | 261.0 | 285.6 | 272.1 | 295.8 | 338.6 | 402.0 |
| South Otago      | 154.5 | 156.8 | 160.0 | 185.9 | 207.2 | 215.6 | 212.3 | 221.5 | 237.0 | 273.9 |
| Maniototo        | 156.3 | 171.5 | 138.8 | 152.5 | 154.5 | 178.7 | 198.3 | 193.7 | 218.1 | 228.9 |
| Vincent          | 141.0 | 147.3 | 158.0 | 169.6 | 183.6 | 191.6 | 182.1 | 206.6 | 223.6 | 263.9 |
| Southland        | 144.1 | 165.5 | 179.4 | 176.1 | 201.8 | 228.2 | 226.2 | 231.3 | 251.3 | 321.3 |
| South Island     | 178.7 | 190.3 | 201.8 | 216.5 | 240.4 | 259.0 | 253.3 | 266.4 | 289.5 | 337.7 |
| NEW ZEALAND      | 170.1 | 179.2 | 190.9 | 206.8 | 230.2 | 247.1 | 243.8 | 254.9 | 277.2 | 321.0 |

Source: Calculated from other tables - Hospital maintenance costs per year divided by the number of inpatients treated per year.

TABLE A-1

AVERAGE COST PER PATIENT DAY, NEW ZEALAND HOSPITAL BOARDS 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
|                  | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   |
| Northland        | 8.2  | 9.9  | 10.0 | 11.5 | 13.3 | 14.3 | 14.1 | 14.7 | 15.9 | 18.6 |
| Auckland         | 11.8 | 13.0 | 14.1 | 16.4 | 18.6 | 20.1 | 20.4 | 21.6 | 23.9 | 28.8 |
| Waikato          | 9.5  | 10.5 | 11.3 | 12.0 | 13.4 | 14.9 | 15.1 | 15.2 | 17.7 | 21.4 |
| Thames           | 7.5  | 8.4  | 8.4  | 8.7  | 9.8  | 10.3 | 10.3 | 10.9 | 11.4 | 13.0 |
| Tauranga         | 9.0  | 9.9  | 11.2 | 13.2 | 14.6 | 15.4 | 14.3 | 15.0 | 16.6 | 19.3 |
| Whakatane        | 9.0  | 9.5  | 10.3 | 11.6 | 13.6 | 14.7 | 15.1 | 15.6 | 17.2 | 20.9 |
| Opotiki          | 9.4  | 10.8 | 10.7 | 12.1 | 13.3 | 16.4 | 14.1 | 14.0 | 15.5 | 19.3 |
| Waipatu          | 10.5 | 11.7 | 13.2 | 15.1 | 17.0 | 17.9 | 16.2 | 16.6 | 19.4 | 27.1 |
| Cook             | 8.8  | 9.6  | 10.1 | 11.0 | 11.8 | 12.8 | 13.1 | 14.1 | 15.3 | 16.9 |
| Waioa            | 8.0  | 10.2 | 9.5  | 10.1 | 11.9 | 13.6 | 11.9 | 12.5 | 13.5 | 16.2 |
| Hawkes Bay       | 9.1  | 10.0 | 10.8 | 12.0 | 13.5 | 14.5 | 14.1 | 15.2 | 16.5 | 19.2 |
| Taumarunui       | 10.0 | 10.8 | 12.8 | 13.6 | 14.8 | 15.5 | 13.4 | 14.5 | 15.2 | 18.6 |
| Waipawa          | 10.2 | 10.9 | 11.3 | 11.4 | 12.6 | 13.0 | 12.6 | 13.7 | 14.9 | 17.1 |
| Dannevirke       | 10.1 | 10.7 | 11.2 | 12.3 | 14.6 | 14.7 | 14.3 | 14.9 | 15.8 | 17.6 |
| Taranaki         | 9.8  | 9.9  | 11.3 | 11.9 | 13.3 | 14.7 | 14.2 | 15.2 | 16.1 | 18.5 |
| Mangamui         | 9.2  | 9.5  | 10.2 | 11.5 | 12.8 | 13.7 | 14.0 | 14.9 | 15.4 | 18.1 |
| Palmerston North | 8.4  | 8.8  | 9.4  | 10.4 | 11.9 | 13.1 | 13.0 | 14.0 | 14.9 | 17.5 |
| Wellington       | 10.8 | 11.0 | 12.1 | 13.5 | 14.2 | 15.8 | 16.0 | 17.1 | 17.9 | 21.2 |
| Wairarapa        | 9.1  | 10.1 | 11.1 | 11.7 | 12.9 | 13.6 | 13.5 | 14.7 | 15.6 | 18.2 |
| North Island     | 10.0 | 10.7 | 11.6 | 13.0 | 14.5 | 15.8 | 15.8 | 16.7 | 18.2 | 21.7 |
| Nairnborough     | 7.7  | 8.4  | 9.3  | 10.1 | 11.6 | 12.7 | 12.5 | 12.9 | 14.3 | 17.3 |
| North Canterbury | 10.6 | 11.6 | 12.5 | 14.0 | 15.1 | 16.6 | 16.8 | 17.7 | 20.8 | 24.4 |
| Nelson           | 9.6  | 10.7 | 11.0 | 11.8 | 12.9 | 13.7 | 13.8 | 14.0 | 15.7 | 18.1 |
| West Coast       | 9.2  | 10.5 | 11.0 | 11.2 | 12.8 | 13.3 | 12.6 | 13.6 | 15.1 | 17.6 |
| Ashburton        | 9.9  | 10.1 | 11.0 | 12.0 | 12.0 | 12.0 | 14.1 | 14.6 | 12.4 | 15.1 |
| South Canterbury | 8.3  | 8.9  | 9.6  | 10.5 | 11.6 | 12.9 | 12.3 | 13.3 | 13.9 | 16.2 |
| Waitaki          | 7.6  | 8.3  | 8.6  | 9.4  | 12.0 | 13.0 | 12.0 | 13.1 | 14.0 | 15.6 |
| Otago            | 11.3 | 11.9 | 13.1 | 14.5 | 16.6 | 18.7 | 19.1 | 20.7 | 22.0 | 26.7 |
| South Otago      | 8.5  | 9.1  | 9.1  | 9.8  | 11.6 | 12.0 | 11.4 | 12.1 | 13.4 | 15.8 |
| Maniototo        | 11.8 | 13.6 | 11.5 | 12.7 | 12.3 | 11.5 | 12.3 | 12.6 | 14.0 | 15.2 |
| Vincent          | 10.9 | 10.2 | 11.3 | 12.3 | 13.5 | 13.1 | 12.0 | 12.6 | 15.2 | 17.2 |
| Southland        | 8.0  | 8.8  | 9.6  | 10.0 | 11.0 | 12.4 | 13.4 | 15.1 | 16.6 | 20.8 |
| South Island     | 9.7  | 10.5 | 11.3 | 12.3 | 13.7 | 15.0 | 15.1 | 16.2 | 17.8 | 21.2 |
| NEW ZEALAND      | 9.9  | 10.7 | 11.5 | 12.7 | 14.2 | 15.6 | 15.6 | 16.6 | 18.1 | 21.5 |

Source: Calculated from other tables - Hospital maintenance costs per year divided by the number of inpatient days per year.



TABLE 1  
AVERAGE COST PER PATIENT PER YEAR, NEW ZEALAND HOSPITALS, 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
|                  | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   |
| Northland        | 7.1  | 7.8  | 8.1  | 8.8  | 10.3 | 10.7 | 10.9 | 10.9 | 11.7 | 13.1 |
| Auckland         | 6.8  | 7.1  | 8.2  | 8.2  | 9.7  | 10.3 | 10.8 | 11.4 | 12.6 | 14.8 |
| Waikato          | 6.3  | 6.5  | 6.8  | 7.2  | 7.9  | 8.5  | 8.2  | 8.3  | 9.2  | 10.3 |
| Tairāne          | 6.6  | 7.3  | 7.5  | 6.0  | 6.5  | 7.9  | 7.9  | 8.5  | 9.0  | 9.9  |
| Tauranga         | 6.4  | 6.8  | 7.6  | 8.6  | 10.2 | 10.7 | 10.3 | 10.8 | 12.0 | 13.9 |
| Whakatane        | 7.8  | 8.1  | 8.0  | 9.3  | 10.4 | 10.9 | 11.0 | 10.7 | 11.2 | 13.1 |
| Opoitiki         | 7.2  | 7.3  | 6.7  | 7.0  | 7.2  | 7.4  | 4.7  | 6.9  | 6.8  | 7.9  |
| Waiaapu          | 8.3  | 8.9  | 10.1 | 11.1 | 12.1 | 12.5 | 11.2 | 12.0 | 13.1 | 15.0 |
| Cook             | 6.4  | 7.2  | 7.7  | 8.4  | 8.5  | 9.2  | 8.8  | 8.7  | 9.6  | 10.2 |
| Wairoa           | 6.7  | 9.7  | 5.7  | 8.0  | 9.4  | 10.5 | 9.3  | 9.8  | 10.4 | 12.7 |
| Hawkes Bay       | 6.7  | 7.1  | 7.7  | 8.1  | 9.2  | 9.8  | 9.7  | 10.2 | 10.9 | 12.5 |
| Tauararunui      | 9.4  | 10.0 | 11.7 | 12.7 | 13.4 | 14.3 | 12.4 | 13.1 | 13.7 | 16.9 |
| Waipawa          | 8.2  | 8.8  | 8.8  | 8.9  | 9.7  | 9.8  | 9.5  | 9.9  | 10.9 | 11.6 |
| Dannevirke       | 8.6  | 8.4  | 7.5  | 7.8  | 9.3  | 9.0  | 9.6  | 11.0 | 12.1 | 13.2 |
| Taranaki         | 7.1  | 7.0  | 7.7  | 8.4  | 9.7  | 10.8 | 10.3 | 11.5 | 11.7 | 13.3 |
| Wanganui         | 6.9  | 7.2  | 7.8  | 8.8  | 9.4  | 9.8  | 10.0 | 10.5 | 10.7 | 13.1 |
| Palmerston North | 5.7  | 5.9  | 6.2  | 6.5  | 7.3  | 8.0  | 8.1  | 8.6  | 9.2  | 10.4 |
| Wellington       | 6.3  | 6.3  | 7.2  | 7.6  | 8.1  | 9.1  | 9.3  | 9.8  | 10.5 | 12.1 |
| Wairarapa        | 7.2  | 7.9  | 8.1  | 8.3  | 8.9  | 9.1  | 8.6  | 9.2  | 9.9  | 11.1 |
| North Island     | 6.6  | 6.9  | 7.6  | 7.9  | 8.9  | 9.6  | 9.6  | 10.1 | 10.9 | 12.5 |
| Marlborough      | 6.0  | 6.4  | 6.8  | 7.3  | 8.5  | 9.2  | 8.9  | 9.5  | 10.5 | 12.1 |
| North Canterbury | 7.6  | 8.0  | 8.1  | 8.8  | 9.5  | 10.3 | 10.6 | 10.9 | 12.4 | 14.5 |
| Nelson           | 6.9  | 7.4  | 7.6  | 8.0  | 8.7  | 9.5  | 10.0 | 9.7  | 10.6 | 12.2 |
| West Coast       | 6.6  | 7.7  | 7.9  | 8.0  | 8.6  | 8.9  | 8.9  | 9.7  | 10.5 | 12.6 |
| Ashburton        | 6.6  | 7.2  | 7.9  | 8.7  | 9.0  | 9.1  | 10.7 | 11.0 | 11.8 | 14.1 |
| South Canterbury | 6.7  | 7.1  | 7.7  | 8.1  | 8.9  | 9.7  | 9.3  | 10.0 | 10.2 | 11.7 |
| Waitaki          | 5.9  | 6.5  | 6.7  | 7.1  | 8.9  | 9.4  | 8.8  | 9.4  | 10.1 | 11.2 |
| Otago            | 5.7  | 7.1  | 7.8  | 8.4  | 9.5  | 10.9 | 10.7 | 11.7 | 12.5 | 14.6 |
| South Otago      | 7.0  | 7.3  | 7.2  | 7.7  | 8.7  | 8.9  | 8.6  | 9.1  | 9.7  | 11.3 |
| Maricetoto       | 8.9  | 11.0 | 10.9 | 12.1 | 10.7 | 10.0 | 10.4 | 10.9 | 11.9 | 12.3 |
| Vincent          | 10.5 | 10.2 | 11.3 | 12.3 | 13.5 | 13.1 | 12.0 | 12.6 | 15.2 | 17.2 |
| Southland        | 5.9  | 6.5  | 6.8  | 7.0  | 7.9  | 8.7  | 8.3  | 9.3  | 9.7  | 11.7 |
| South Island     | 6.9  | 7.3  | 7.7  | 8.2  | 9.1  | 9.9  | 9.9  | 10.5 | 11.4 | 13.3 |
| NEW ZEALAND      | 6.7  | 7.1  | 7.6  | 8.0  | 9.0  | 9.7  | 9.7  | 10.2 | 11.1 | 12.8 |

Source: Calculated from other tables - Hospital maintenance costs per year divided by the sum of the number of inpatient days per year and the number of outpatient visits per year.

TABLE A-1  
SALARY PAYMENTS TO ALL HOSPITAL STAFF, NEW ZEALAND HOSPITAL BOARD FOR 1962-71

| Hospital Board   | 1962    | 1963    | 1964    | 1965    | 1966    | 1967    | 1968    | 1969    | 1970    | 1971    |
|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|                  | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) | (\$000) |
| Northland        | 934.7   | 1085.1  | 1362.4  | 1539.0  | 1850.0  | 1990.2  | 2117.8  | 2185.8  | 2377.1  | 2836.2  |
| Auckland         | 5406.5  | 6095.4  | 7189.6  | 8759.8  | 10033.3 | 12264.2 | 12912.5 | 13915.3 | 15336.8 | 18527.0 |
| Waikato          | 2440.1  | 2799.7  | 3432.9  | 3639.2  | 4309.6  | 4821.8  | 5115.4  | 5705.5  | 6782.7  | 8348.4  |
| Thames           | 346.7   | 375.3   | 463.9   | 520.0   | 616.9   | 666.7   | 682.0   | 740.1   | 783.4   | 931.4   |
| Tauranga         | 392.6   | 450.5   | 585.8   | 671.9   | 850.8   | 938.0   | 1008.3  | 1103.4  | 1231.8  | 1365.7  |
| Whakatane        | 213.8   | 238.8   | 305.1   | 364.1   | 448.6   | 486.5   | 519.1   | 544.4   | 599.8   | 716.5   |
| Opotiki          | 103.5   | 109.2   | 125.7   | 128.4   | 136.2   | 139.6   | 132.3   | 142.8   | 158.8   | 174.1   |
| Waiaapu          | 74.1    | 78.7    | 97.0    | 103.7   | 120.2   | 125.9   | 129.8   | 139.5   | 148.0   | 188.4   |
| Cook             | 591.9   | 633.1   | 733.1   | 802.9   | 906.3   | 979.6   | 885.0   | 1026.0  | 1162.6  | 1365.4  |
| Wairoa           | 139.3   | 162.4   | 196.5   | 221.5   | 255.0   | 254.9   | 259.3   | 266.6   | 307.3   | 358.8   |
| Hawkes Bay       | 1076.7  | 1201.9  | 1493.1  | 1635.6  | 1924.0  | 2048.7  | 2058.9  | 2164.9  | 2354.9  | 2822.1  |
| Taumarunui       | 201.6   | 213.9   | 261.6   | 289.0   | 319.1   | 352.0   | 361.7   | 396.0   | 420.5   | 506.5   |
| Waipawa          | 282.2   | 298.5   | 340.4   | 361.0   | 404.3   | 446.6   | 445.5   | 454.3   | 500.2   | 605.8   |
| Dannevirke       | 183.1   | 195.8   | 236.1   | 248.0   | 294.0   | 305.1   | 317.7   | 340.0   | 369.3   | 433.7   |
| Taranaki         | 969.6   | 1058.4  | 1328.0  | 1469.9  | 1703.0  | 1810.2  | 1843.2  | 1965.9  | 2192.5  | 2522.3  |
| Wanganui         | 733.7   | 795.7   | 1014.6  | 1150.3  | 1272.5  | 1317.8  | 1379.1  | 1443.5  | 1552.0  | 1807.3  |
| Palmerston North | 1030.0  | 1116.4  | 1369.9  | 1493.5  | 1771.6  | 1913.0  | 2094.5  | 2305.0  | 2446.5  | 2840.2  |
| Wellington       | 3377.6  | 3642.9  | 4427.2  | 4803.2  | 5380.0  | 6176.1  | 6334.1  | 6789.4  | 7281.3  | 8398.2  |
| Wairarapa        | 496.0   | 551.9   | 632.7   | 660.6   | 738.6   | 760.3   | 773.7   | 822.4   | 860.8   | 1047.8  |
| North Island     | 18993.9 | 21103.7 | 25595.9 | 28861.5 | 33393.8 | 37797.3 | 39407.2 | 42456.7 | 46903.2 | 55797.8 |
| Marlborough      | 332.9   | 352.7   | 436.2   | 480.7   | 552.7   | 587.8   | 619.6   | 642.1   | 717.5   | 854.5   |
| North Canterbury | 2821.2  | 3131.9  | 3762.2  | 4305.6  | 5086.3  | 5486.4  | 5792.4  | 6070.8  | 6647.2  | 7974.2  |
| Nelson           | 612.3   | 680.7   | 836.0   | 882.1   | 1051.0  | 1095.5  | 1085.0  | 1157.6  | 1230.8  | 1479.9  |
| West Coast       | 600.8   | 679.6   | 800.7   | 867.3   | 988.3   | 1037.2  | 954.0   | 1020.1  | 1072.0  | 1302.0  |
| Ashburton        | 234.7   | 253.1   | 305.7   | 329.9   | 387.9   | 413.5   | 431.1   | 471.9   | 585.4   | 646.5   |
| South Canterbury | 613.6   | 680.7   | 840.3   | 936.7   | 1126.3  | 1215.1  | 1275.5  | 1334.7  | 1427.7  | 1660.2  |
| Waikati          | 272.6   | 307.6   | 375.1   | 412.3   | 463.7   | 466.1   | 493.1   | 501.5   | 511.5   | 594.8   |
| Otago            | 1667.6  | 1837.5  | 2194.3  | 2416.8  | 2798.9  | 3268.7  | 3436.8  | 3769.2  | 4110.3  | 4970.7  |
| South Otago      | 244.3   | 263.8   | 311.8   | 329.0   | 387.2   | 421.5   | 436.3   | 466.9   | 533.9   | 565.9   |
| Maniototo        | 35.1    | 39.5    | 40.7    | 38.7    | 43.6    | 45.8    | 47.5    | 47.1    | 51.3    | 65.8    |
| Vincent          | 81.7    | 90.0    | 80.6    | 88.2    | 96.9    | 102.9   | 104.2   | 110.9   | 117.2   | 147.7   |
| Southland        | 970.1   | 1091.1  | 1356.6  | 1442.6  | 1679.2  | 1835.6  | 1892.1  | 1961.5  | 2082.1  | 2642.5  |
| South Island     | 8488.0  | 9408.1  | 11340.3 | 12529.8 | 14666.9 | 15976.3 | 16567.6 | 17554.0 | 19078.0 | 22904.8 |
| NEW ZEALAND      | 27432.0 | 30511.8 | 36936.1 | 41391.3 | 48060.7 | 53773.6 | 55974.9 | 60010.7 | 65981.2 | 78702.6 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer for years 1962-71 (Table 3).

TABLE A-6  
FULL TIME EQUIVALENT HOSPITAL STAFF, FULL-TIME HOSPITAL STAFFS 1962-71

| Hospital Board   | 1962    | 1963    | 1964    | 1965    | 1966    | 1967    | 1968    | 1969    | 1970    | 1971    |
|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northland        | 767.5   | 860.5   | 908.8   | 966.1   | 987.8   | 956.3   | 1004.8  | 1017.8  | 1059.3  | 1050.4  |
| Auckland         | 3931.1  | 4078.1  | 4453.8  | 4783.3  | 5878.0  | 5966.3  | 5794.5  | 6226.1  | 6411.0  | 6632.5  |
| Waikato          | 1914.0  | 2106.3  | 2038.8  | 2134.3  | 2219.1  | 2508.8  | 2448.5  | 2784.3  | 2977.3  | 3032.5  |
| Thames           | 293.6   | 307.8   | 330.3   | 342.0   | 347.8   | 353.5   | 351.8   | 366.8   | 350.3   | 367.7   |
| Tauranga         | 346.3   | 368.6   | 382.6   | 437.5   | 468.1   | 507.6   | 512.5   | 557.3   | 557.1   | 526.6   |
| Whakatane        | 182.6   | 199.5   | 216.3   | 233.1   | 230.8   | 246.3   | 253.3   | 264.8   | 273.3   | 256.3   |
| Opotiki          | 79.0    | 84.6    | 82.3    | 79.8    | 73.3    | 71.1    | 67.1    | 75.8    | 73.5    | 69.3    |
| Waipatu          | 62.1    | 67.8    | 66.8    | 64.1    | 55.5    | 68.1    | 69.8    | 68.3    | 70.8    | 78.1    |
| Cook             | 463.0   | 480.3   | 457.8   | 480.5   | 477.0   | 520.0   | 478.1   | 504.1   | 530.3   | 523.3   |
| Waioira          | 116.1   | 117.8   | 136.6   | 139.8   | 136.6   | 132.5   | 130.6   | 134.3   | 142.5   | 145.3   |
| Hawkes Bay       | 870.1   | 918.6   | 921.8   | 958.5   | 973.3   | 971.3   | 942.0   | 961.5   | 975.1   | 1022.8  |
| Tauararua        | 158.8   | 160.8   | 163.0   | 159.8   | 182.3   | 174.3   | 185.3   | 177.0   | 212.0   | 203.9   |
| Waipawa          | 204.6   | 222.6   | 222.8   | 221.5   | 214.8   | 221.3   | 219.3   | 226.0   | 223.8   | 220.2   |
| Dannevirke       | 156.0   | 141.3   | 158.3   | 175.6   | 161.1   | 153.3   | 152.1   | 155.8   | 158.8   | 241.3   |
| Taranaki         | 773.8   | 811.8   | 866.1   | 890.6   | 889.1   | 902.5   | 923.3   | 977.3   | 958.8   | 958.8   |
| Manawatu         | 561.3   | 579.6   | 646.8   | 660.0   | 658.1   | 640.3   | 646.0   | 699.0   | 652.0   | 701.0   |
| Palmerston North | 853.0   | 866.8   | 884.8   | 908.0   | 935.6   | 984.8   | 1071.1  | 1098.8  | 1116.5  | 1079.7  |
| Wellington       | 2344.3  | 2482.8  | 2527.1  | 2545.8  | 2652.3  | 2889.8  | 2834.5  | 2862.0  | 2859.8  | 3120.8  |
| Wairarapa        | 393.0   | 421.8   | 389.3   | 400.8   | 366.8   | 346.3   | 343.6   | 349.8   | 358.6   | 403.1   |
| North Island     | 14470.0 | 15277.3 | 15903.4 | 16850.7 | 17906.8 | 18614.0 | 18427.9 | 19503.5 | 19960.5 | 20651.6 |
| Marlborough      | 245.6   | 261.0   | 285.5   | 284.6   | 281.3   | 307.3   | 284.5   | 314.6   | 306.8   | 317.2   |
| North Canterbury | 2270.0  | 2380.8  | 2433.3  | 2559.3  | 2652.8  | 2767.3  | 2724.3  | 2769.0  | 2836.6  | 2935.8  |
| Nelson           | 526.1   | 542.8   | 532.8   | 558.8   | 555.3   | 537.1   | 526.5   | 525.8   | 537.6   | 556.3   |
| West Coast       | 487.8   | 509.0   | 488.3   | 506.3   | 525.0   | 511.3   | 484.3   | 471.8   | 424.3   | 433.4   |
| Ashburton        | 188.3   | 184.1   | 181.0   | 180.5   | 189.3   | 182.3   | 190.8   | 186.3   | 237.0   | 231.5   |
| South Canterbury | 491.8   | 511.5   | 536.8   | 564.0   | 579.8   | 591.1   | 616.5   | 607.1   | 589.8   | 611.9   |
| Waitaki          | 228.5   | 240.5   | 249.3   | 257.3   | 246.8   | 233.3   | 236.1   | 220.5   | 225.1   | 237.4   |
| Otago            | 1314.1  | 1316.8  | 1341.1  | 1403.5  | 1506.8  | 1545.8  | 1610.0  | 1703.3  | 1708.8  | 1741.9  |
| South Otago      | 193.3   | 199.6   | 202.5   | 208.3   | 208.5   | 204.3   | 219.8   | 227.1   | 215.3   | 220.5   |
| Maniototo        | 23.6    | 25.6    | 19.8    | 17.3    | 16.5    | 20.3    | 19.3    | 18.1    | 19.8    | 21.7    |
| Vincent          | 59.5    | 56.3    | 42.8    | 42.1    | 42.3    | 42.3    | 47.6    | 41.8    | 47.8    | 46.8    |
| Southland        | 768.0   | 848.8   | 859.5   | 896.0   | 916.3   | 952.1   | 891.8   | 894.6   | 911.3   | 1042.4  |
| South Island     | 6796.4  | 7076.5  | 7177.4  | 7477.9  | 7720.5  | 7894.0  | 7851.4  | 7979.6  | 8059.8  | 8409.8  |
| NEW ZEALAND      | 21264.8 | 22352.8 | 23080.3 | 24328.5 | 25624.3 | 26507.3 | 26278.3 | 27482.3 | 28019.6 | 29061.4 |

\* One quarter the number of part time hospital staff per year added to the number of full time hospital staff per year

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer for years 1962-71 (Table 3).

TABLE 11  
HOSPITAL TREATMENT STAFF, NEW ZEALAND HOSPITAL BOARDS 1962-71

| Hospital Board   | 1962    | 1963    | 1964    | 1965    | 1966    | 1967    | 1968    | 1969    | 1970    | 1971    |
|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northland        | 480.0   | 555.0   | 593.8   | 624.0   | 642.3   | 629.0   | 672.0   | 650.5   | 729.5   | 711.7   |
| Auckland         | 2268.3  | 2352.8  | 2615.5  | 2963.0  | 3681.5  | 3617.5  | 3699.5  | 4068.3  | 4261.0  | 4311.9  |
| Waikato          | 1111.0  | 1215.5  | 1227.5  | 1260.3  | 1316.3  | 1539.8  | 1534.5  | 1768.5  | 1897.5  | 1954.8  |
| Thames           | 172.3   | 179.0   | 197.8   | 205.5   | 211.8   | 222.0   | 220.0   | 232.0   | 216.8   | 224.4   |
| Tauranga         | 246.3   | 262.8   | 273.8   | 313.0   | 349.8   | 385.8   | 394.0   | 435.8   | 434.3   | 400.0   |
| Whakatane        | 126.8   | 140.5   | 153.3   | 165.8   | 160.5   | 176.8   | 181.5   | 198.0   | 203.5   | 190.5   |
| Opotiki          | 43.0    | 49.8    | 47.5    | 47.0    | 41.5    | 39.3    | 38.3    | 45.3    | 44.0    | 41.5    |
| Waipatu          | 27.8    | 31.5    | 31.5    | 28.8    | 21.5    | 31.8    | 36.0    | 33.0    | 34.3    | 39.1    |
| Cook             | 237.0   | 244.3   | 221.8   | 236.5   | 240.0   | 275.0   | 258.3   | 274.8   | 280.0   | 262.7   |
| Wairoa           | 65.3    | 67.8    | 81.8    | 80.3    | 75.3    | 72.0    | 72.8    | 74.8    | 80.5    | 82.0    |
| Hawkes Bay       | 519.3   | 563.3   | 555.8   | 579.0   | 600.8   | 616.0   | 597.0   | 621.5   | 637.3   | 667.3   |
| Taumarunui       | 96.8    | 99.0    | 100.5   | 96.3    | 118.8   | 110.3   | 125.5   | 118.0   | 151.0   | 142.9   |
| Waipawa          | 102.8   | 116.8   | 115.8   | 117.0   | 122.3   | 117.5   | 118.0   | 125.0   | 121.5   | 115.6   |
| Dannevirke       | 107.5   | 95.5    | 109.8   | 128.8   | 114.8   | 106.0   | 105.3   | 110.5   | 111.8   | 191.1   |
| Taranaki         | 465.3   | 497.5   | 544.3   | 560.3   | 560.8   | 568.5   | 618.3   | 667.5   | 648.0   | 655.6   |
| Wanganui         | 335.5   | 352.3   | 407.8   | 426.5   | 419.3   | 421.8   | 427.0   | 481.0   | 448.0   | 433.4   |
| Palmerston North | 561.5   | 576.0   | 596.3   | 625.5   | 663.8   | 710.3   | 779.3   | 807.8   | 824.5   | 739.1   |
| Wellington       | 1404.3  | 1529.8  | 1584.8  | 1595.3  | 1685.3  | 1860.3  | 1918.5  | 1942.5  | 2016.0  | 2155.6  |
| Wairarapa        | 237.5   | 257.0   | 259.3   | 264.5   | 245.5   | 233.5   | 232.3   | 242.3   | 246.8   | 284.9   |
| North Island     | 8607.8  | 9215.8  | 9718.0  | 10317.8 | 11271.3 | 11732.8 | 12027.8 | 12936.8 | 13386.0 | 13537.1 |
| Marlborough      | 142.3   | 155.0   | 178.0   | 172.8   | 174.8   | 194.8   | 136.0   | 211.3   | 215.3   | 221.5   |
| North Canterbury | 1435.0  | 1552.0  | 1591.8  | 1677.5  | 1754.8  | 1855.3  | 1851.5  | 1899.5  | 1962.8  | 2034.8  |
| Nelson           | 319.8   | 342.0   | 333.8   | 363.0   | 359.3   | 339.8   | 340.0   | 340.5   | 346.3   | 367.1   |
| West Coast       | 327.5   | 348.5   | 326.8   | 339.8   | 348.0   | 335.3   | 330.8   | 321.0   | 316.0   | 320.5   |
| Ashburton        | 122.3   | 125.3   | 133.0   | 131.5   | 140.0   | 132.8   | 141.5   | 140.3   | 163.0   | 170.1   |
| South Canterbury | 330.5   | 339.5   | 361.0   | 382.5   | 395.0   | 396.8   | 415.5   | 408.8   | 408.3   | 416.7   |
| Waitaki          | 139.5   | 152.0   | 159.8   | 160.5   | 171.0   | 155.8   | 158.8   | 143.5   | 151.3   | 156.8   |
| Otago            | 797.3   | 793.8   | 822.8   | 839.0   | 999.0   | 1021.0  | 1084.5  | 1147.8  | 1131.3  | 1171.1  |
| South Otago      | 112.0   | 112.8   | 113.5   | 120.0   | 123.0   | 118.3   | 131.5   | 137.8   | 132.5   | 133.8   |
| Maniototo        | 13.8    | 15.8    | 15.8    | 14.0    | 14.0    | 18.0    | 17.0    | 16.8    | 16.8    | 18.4    |
| Vincent          | 37.5    | 36.3    | 36.5    | 35.8    | 35.8    | 35.8    | 42.3    | 36.3    | 43.3    | 40.5    |
| Southland        | 436.0   | 471.8   | 491.5   | 517.0   | 528.5   | 533.8   | 591.5   | 624.8   | 641.8   | 739.9   |
| South Island     | 4213.3  | 4444.5  | 4564.0  | 4803.3  | 5043.0  | 5137.0  | 5290.8  | 5423.0  | 5528.3  | 5791.2  |
| NEW ZEALAND      | 12820.3 | 13660.3 | 14282.0 | 15121.0 | 16314.3 | 16869.8 | 17318.5 | 18364.8 | 18914.3 | 19428.3 |

\* One quarter the number of part time hospital treatment staff per year added to the number of full time hospital treatment staff per year.

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 11).

TABLE 1  
ANNUAL AVERAGE SALARIES OF HOSPITAL STAFF, NEW ZEALAND HOSPITALS 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
|                  | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   | \$   |
| Northland        | 1217 | 1261 | 1499 | 1593 | 1883 | 2081 | 2103 | 2145 | 2244 | 2700 |
| Auckland         | 1375 | 1495 | 1614 | 1831 | 1715 | 2056 | 2228 | 2235 | 2392 | 2793 |
| Waikato          | 1275 | 1329 | 1643 | 1705 | 1942 | 1922 | 2089 | 2049 | 2278 | 2700 |
| Thames           | 1181 | 1219 | 1405 | 1520 | 1774 | 1886 | 1939 | 2018 | 2236 | 2533 |
| Tauranga         | 1134 | 1222 | 1531 | 1536 | 1818 | 1848 | 1967 | 1980 | 2211 | 2523 |
| Whakatane        | 1171 | 1197 | 1411 | 1562 | 1944 | 1975 | 2049 | 2056 | 2195 | 2796 |
| Opotiki          | 1310 | 1291 | 1528 | 1609 | 1859 | 1964 | 1972 | 1964 | 2160 | 2512 |
| Waiaapu          | 1194 | 1161 | 1451 | 1617 | 2166 | 1849 | 1960 | 2042 | 2091 | 2412 |
| Cook             | 1278 | 1318 | 1601 | 1671 | 1900 | 1884 | 1851 | 2035 | 2192 | 2611 |
| Wairoa           | 1200 | 1379 | 1439 | 1584 | 1867 | 1924 | 1986 | 1985 | 2157 | 2469 |
| Hawkes Bay       | 1237 | 1308 | 1520 | 1706 | 1977 | 2109 | 2186 | 2252 | 2415 | 2759 |
| Taumarunui       | 1269 | 1330 | 1605 | 1808 | 1750 | 2020 | 1952 | 2237 | 1983 | 2484 |
| Waipawa          | 1379 | 1341 | 1528 | 1630 | 1882 | 2018 | 2032 | 2010 | 2235 | 2756 |
| Dannevirke       | 1174 | 1386 | 1492 | 1413 | 1825 | 1990 | 2089 | 2183 | 2326 | 1798 |
| Taranaki         | 1253 | 1304 | 1533 | 1651 | 1915 | 2006 | 1996 | 2012 | 2287 | 2551 |
| Wanganui         | 1307 | 1373 | 1569 | 1743 | 1934 | 2058 | 2135 | 2065 | 2380 | 2578 |
| Palmerston North | 1207 | 1288 | 1548 | 1645 | 1894 | 1943 | 1956 | 2103 | 2191 | 2631 |
| Wellington       | 1441 | 1467 | 1752 | 1887 | 2028 | 2137 | 2252 | 2372 | 2546 | 2691 |
| Wairarapa        | 1262 | 1308 | 1625 | 1648 | 2014 | 2195 | 2252 | 2351 | 2233 | 2599 |
| North Island     | 1313 | 1381 | 1609 | 1713 | 1865 | 2031 | 2138 | 2177 | 2350 | 2702 |
| Marlborough      | 1355 | 1351 | 1528 | 1689 | 1965 | 1913 | 2178 | 2041 | 2339 | 2694 |
| North Canterbury | 1243 | 1315 | 1543 | 1682 | 1917 | 1983 | 2126 | 2192 | 2343 | 2713 |
| Nelson           | 1164 | 1254 | 1569 | 1579 | 1893 | 2040 | 2061 | 2202 | 2289 | 2613 |
| West Coast       | 1232 | 1335 | 1640 | 1713 | 1882 | 2029 | 1970 | 2162 | 2526 | 3004 |
| Ashburton        | 1247 | 1375 | 1689 | 1828 | 2049 | 2268 | 2259 | 2533 | 2470 | 2793 |
| South Canterbury | 1248 | 1331 | 1565 | 1661 | 1943 | 2056 | 2069 | 2198 | 2421 | 2713 |
| Waitaki          | 1193 | 1279 | 1505 | 1602 | 1899 | 1998 | 2089 | 2274 | 2273 | 2506 |
| Otago            | 1259 | 1395 | 1636 | 1722 | 1858 | 2115 | 2135 | 2213 | 2405 | 2854 |
| South Otago      | 1264 | 1322 | 1540 | 1579 | 1857 | 2063 | 1985 | 2056 | 2480 | 2567 |
| Maniototo        | 1529 | 1543 | 2055 | 2237 | 2640 | 2256 | 2462 | 2601 | 2593 | 3033 |
| Vincent          | 1373 | 1599 | 1882 | 2095 | 2290 | 2433 | 2190 | 2652 | 2451 | 3156 |
| Southland        | 1263 | 1285 | 1578 | 1610 | 1833 | 1928 | 2122 | 2193 | 2285 | 2535 |
| South Island     | 1249 | 1329 | 1580 | 1676 | 1900 | 2024 | 2110 | 2200 | 2367 | 2724 |
| NEW ZEALAND      | 1292 | 1365 | 1600 | 1701 | 1876 | 2029 | 2130 | 2184 | 2355 | 2708 |

Source - Calculated from other tables - Salary payments per year to hospital staff divided by the number of full time equivalent hospital staff employed per year.

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 1.45 | 1.55 | 1.55 | 1.69 | 1.74 | 1.67 | 1.68 | 1.70 | 1.77 | 1.73 |
| Auckland         | 2.18 | 2.24 | 2.41 | 2.46 | 2.83 | 2.71 | 2.55 | 2.68 | 2.72 | 2.77 |
| Waikato          | 1.69 | 1.87 | 1.80 | 1.83 | 1.87 | 2.09 | 1.97 | 2.02 | 2.13 | 2.22 |
| Thames           | 1.45 | 1.56 | 1.54 | 1.45 | 1.49 | 1.44 | 1.43 | 1.44 | 1.36 | 1.41 |
| Tauranga         | 1.62 | 1.66 | 1.74 | 1.96 | 1.92 | 1.97 | 1.85 | 1.94 | 1.93 | 1.86 |
| Whakatane        | 1.50 | 1.61 | 1.69 | 1.70 | 1.72 | 1.89 | 1.86 | 1.88 | 1.95 | 1.82 |
| Opotiki          | 1.66 | 1.95 | 1.85 | 2.05 | 1.98 | 2.24 | 1.93 | 1.94 | 1.94 | 2.00 |
| Waipatu          | 1.88 | 2.19 | 2.20 | 2.23 | 1.83 | 2.37 | 2.25 | 2.25 | 2.38 | 2.96 |
| Cock             | 1.58 | 1.72 | 1.56 | 1.65 | 1.63 | 1.74 | 1.64 | 1.82 | 1.85 | 1.72 |
| Wairoa           | 1.45 | 1.83 | 1.70 | 1.63 | 1.68 | 1.79 | 1.58 | 1.60 | 1.64 | 1.72 |
| Hawkes Bay       | 1.83 | 1.90 | 1.85 | 1.96 | 1.95 | 1.95 | 1.88 | 1.94 | 1.97 | 2.01 |
| Taumarunui       | 1.47 | 1.51 | 1.71 | 1.68 | 1.90 | 1.72 | 1.62 | 1.57 | 1.87 | 1.88 |
| Waipawa          | 1.78 | 1.99 | 1.92 | 1.88 | 1.78 | 1.81 | 1.72 | 1.85 | 1.84 | 1.83 |
| Dannevirke       | 1.64 | 1.54 | 1.71 | 2.00 | 1.94 | 1.77 | 1.70 | 1.71 | 1.69 | 2.44 |
| Taranaki         | 1.61 | 1.62 | 1.73 | 1.71 | 1.72 | 1.82 | 1.86 | 1.91 | 1.82 | 1.86 |
| Wanganui         | 1.39 | 1.45 | 1.52 | 1.54 | 1.56 | 1.59 | 1.61 | 1.75 | 1.58 | 1.72 |
| Palmerston North | 1.55 | 1.54 | 1.55 | 1.62 | 1.68 | 1.80 | 1.75 | 1.77 | 1.79 | 1.75 |
| Wellington       | 1.73 | 1.80 | 1.82 | 1.89 | 1.90 | 1.96 | 1.89 | 1.91 | 1.82 | 2.05 |
| Wairarapa        | 1.67 | 1.86 | 1.74 | 1.74 | 1.55 | 1.47 | 1.47 | 1.50 | 1.49 | 1.65 |
| North Island     | 1.75 | 1.84 | 1.87 | 1.96 | 2.03 | 2.07 | 1.98 | 2.05 | 2.06 | 2.13 |
| Marlborough      | 1.14 | 1.24 | 1.41 | 1.39 | 1.40 | 1.57 | 1.36 | 1.48 | 1.43 | 1.51 |
| North Canterbury | 1.93 | 2.02 | 2.06 | 2.08 | 2.09 | 2.17 | 2.11 | 2.15 | 2.35 | 2.36 |
| Nelson           | 2.01 | 2.07 | 1.93 | 2.08 | 1.99 | 1.94 | 1.97 | 1.86 | 1.97 | 2.03 |
| West Coast       | 1.45 | 1.60 | 1.53 | 1.49 | 1.62 | 1.54 | 1.46 | 1.46 | 1.37 | 1.40 |
| Ashburton        | 1.56 | 1.53 | 1.52 | 1.49 | 1.40 | 1.28 | 1.47 | 1.43 | 1.22 | 1.17 |
| South Canterbury | 1.40 | 1.45 | 1.48 | 1.54 | 1.55 | 1.62 | 1.59 | 1.57 | 1.46 | 1.53 |
| Waitaki          | 1.51 | 1.55 | 1.57 | 1.60 | 1.61 | 1.57 | 1.50 | 1.46 | 1.55 | 1.62 |
| Otago            | 1.83 | 1.86 | 1.87 | 1.96 | 2.10 | 2.15 | 2.27 | 2.37 | 2.31 | 2.40 |
| South Otago      | 1.55 | 1.64 | 1.57 | 1.63 | 1.69 | 1.59 | 1.65 | 1.67 | 1.62 | 1.74 |
| Maniototo        | 1.57 | 1.84 | 1.13 | 1.01 | 0.89 | 0.96 | 0.94 | 0.88 | 1.03 | 1.02 |
| Vincent          | 1.61 | 1.36 | 1.03 | 1.01 | 1.04 | 0.95 | 0.97 | 0.82 | 1.11 | 1.03 |
| Southland        | 1.55 | 1.67 | 1.65 | 1.68 | 1.66 | 1.73 | 1.62 | 1.67 | 1.68 | 1.91 |
| South Island     | 1.70 | 1.77 | 1.77 | 1.81 | 1.84 | 1.83 | 1.85 | 1.88 | 1.91 | 1.98 |
| NEW ZEALAND      | 1.73 | 1.82 | 1.84 | 1.91 | 1.97 | 2.01 | 1.94 | 2.00 | 2.02 | 2.06 |

Source: Calculated from other tables - Full Time equivalent hospital staff per year divided by the average number of occupied hospital beds per day in each year.

TABLE A-11  
HOSPITAL TREATMENT STAFF PER YEAR AND ALL HOSPITAL STAFF PER YEAR, 1962-1971

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 62.5 | 64.5 | 65.3 | 64.7 | 65.0 | 65.8 | 66.9 | 67.8 | 68.9 | 67.8 |
| Auckland         | 57.7 | 57.7 | 58.7 | 61.9 | 62.6 | 60.6 | 63.8 | 65.3 | 66.5 | 65.0 |
| Waikato          | 58.0 | 59.1 | 58.8 | 59.0 | 59.3 | 61.4 | 62.7 | 63.5 | 63.7 | 63.2 |
| Thames           | 58.7 | 58.2 | 59.9 | 60.1 | 60.9 | 62.8 | 62.5 | 63.2 | 61.9 | 61.0 |
| Tauranga         | 71.1 | 71.3 | 71.6 | 71.5 | 74.7 | 76.0 | 76.9 | 78.2 | 78.0 | 76.0 |
| Whakatane        | 69.4 | 70.4 | 70.9 | 71.1 | 69.5 | 71.8 | 71.7 | 74.8 | 74.5 | 74.3 |
| Opotiki          | 54.4 | 58.9 | 57.7 | 58.9 | 56.6 | 55.3 | 57.1 | 59.8 | 59.9 | 59.9 |
| Waiaapu          | 44.8 | 46.5 | 47.2 | 44.9 | 38.7 | 46.7 | 51.6 | 48.3 | 48.4 | 50.1 |
| Cook             | 51.2 | 50.9 | 48.4 | 49.2 | 50.3 | 52.9 | 54.0 | 54.5 | 52.8 | 50.2 |
| Wairoa           | 56.2 | 57.6 | 59.9 | 57.4 | 55.1 | 54.3 | 55.7 | 55.7 | 56.5 | 56.4 |
| Hawkes Bay       | 59.7 | 61.3 | 60.3 | 60.4 | 61.7 | 63.4 | 63.4 | 64.6 | 65.4 | 65.2 |
| Taumarunui       | 61.0 | 61.6 | 61.7 | 60.3 | 65.2 | 63.3 | 67.7 | 66.7 | 71.2 | 70.1 |
| Waipawa          | 50.2 | 52.5 | 52.0 | 52.8 | 56.9 | 53.1 | 53.8 | 55.3 | 54.3 | 52.5 |
| Danversville     | 68.9 | 67.6 | 69.4 | 73.3 | 71.3 | 69.1 | 69.2 | 70.9 | 70.4 | 79.2 |
| Taranaki         | 60.1 | 61.3 | 62.8 | 62.9 | 63.1 | 63.0 | 67.0 | 68.3 | 67.6 | 66.3 |
| Wanganui         | 59.8 | 60.8 | 63.0 | 64.6 | 63.7 | 65.9 | 66.1 | 63.8 | 68.7 | 69.7 |
| Palmerston North | 65.8 | 66.5 | 67.4 | 68.9 | 70.9 | 72.1 | 72.8 | 73.7 | 73.8 | 73.1 |
| Wellington       | 59.9 | 61.6 | 62.7 | 62.7 | 63.5 | 64.4 | 67.7 | 67.9 | 70.5 | 69.1 |
| Wairarapa        | 60.4 | 60.9 | 66.6 | 66.0 | 66.9 | 67.4 | 67.6 | 69.3 | 68.8 | 70.7 |
| North Island     | 59.5 | 60.3 | 61.1 | 61.2 | 62.9 | 63.0 | 65.3 | 66.3 | 67.1 | 66.0 |
| Marlborough      | 57.9 | 59.4 | 62.3 | 60.7 | 62.1 | 63.4 | 65.4 | 67.2 | 70.2 | 69.8 |
| North Canterbury | 63.2 | 65.2 | 65.3 | 65.5 | 66.1 | 67.0 | 68.0 | 68.6 | 69.2 | 69.2 |
| Nelson           | 60.8 | 63.0 | 62.7 | 65.0 | 64.7 | 63.3 | 64.6 | 64.8 | 64.4 | 64.8 |
| West Coast       | 67.1 | 68.5 | 66.9 | 67.1 | 66.3 | 65.6 | 68.3 | 68.0 | 74.5 | 74.0 |
| Ashburton        | 64.9 | 68.1 | 73.5 | 72.9 | 74.0 | 72.8 | 74.2 | 75.3 | 68.8 | 73.5 |
| South Canterbury | 67.2 | 66.4 | 67.3 | 67.8 | 68.1 | 67.1 | 67.4 | 67.3 | 69.2 | 68.1 |
| Waitaki          | 61.1 | 63.2 | 64.1 | 62.4 | 69.3 | 66.8 | 67.3 | 65.1 | 67.2 | 66.0 |
| Otago            | 60.7 | 60.3 | 61.4 | 63.3 | 66.3 | 66.0 | 67.4 | 67.4 | 66.2 | 67.2 |
| South Otago      | 57.9 | 56.5 | 56.0 | 57.6 | 59.0 | 57.9 | 59.8 | 60.7 | 61.5 | 60.7 |
| Maricoto         | 58.5 | 61.7 | 79.3 | 80.9 | 84.8 | 88.7 | 88.1 | 92.8 | 84.8 | 84.8 |
| Vincent          | 63.0 | 64.5 | 85.3 | 85.0 | 84.6 | 84.6 | 88.9 | 86.8 | 90.6 | 86.5 |
| Southland        | 56.8 | 55.6 | 57.2 | 57.7 | 57.7 | 56.1 | 66.3 | 69.8 | 70.4 | 71.0 |
| South Island     | 62.0 | 62.8 | 63.6 | 64.2 | 65.3 | 65.1 | 67.4 | 68.0 | 68.6 | 68.9 |
| NEW ZEALAND      | 60.3 | 61.1 | 61.9 | 62.2 | 63.7 | 63.6 | 65.9 | 66.8 | 67.5 | 66.9 |

Source: Calculated from other tables - Full-time equivalent hospital treatment staff per year divided by all Full-time equivalent hospital staff per year, times 100.

TABLE 1  
HOSPITALS AND BEDS, NEW ZEALAND HOSPITAL DATA 1962-71

| Hospital Board   | 1962  |       | 1963  |       | 1964  |       | 1965  |       | 1966  |       | 1967  |       | 1968  |       | 1969  |       | 1970  |       | 1971  |       |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  | Hosps | Beds  |
| Northland        | 12    | 648   | 12    | 759   | 12    | 753   | 12    | 744   | 12    | 786   | 12    | 808   | 12    | 812   | 12    | 812   | 12    | 802   | 12    | 810   |
| Auckland         | 16    | 2336  | 16    | 2267  | 16    | 2278  | 16    | 2434  | 16    | 2541  | 17    | 2724  | 17    | 2772  | 17    | 2855  | 17    | 2948  | 17    | 2972  |
| Waikato          | 18    | 1319  | 19    | 1359  | 19    | 1347  | 19    | 1418  | 19    | 1515  | 20    | 1532  | 19    | 1487  | 20    | 1637  | 20    | 1761  | 20    | 1814  |
| Thames           | 6     | 257   | 6     | 294   | 6     | 309   | 6     | 339   | 6     | 339   | 6     | 339   | 6     | 339   | 6     | 339   | 6     | 334   | 6     | 332   |
| Tauranga         | 4     | 253   | 4     | 269   | 4     | 269   | 3     | 318   | 3     | 323   | 3     | 351   | 3     | 352   | 3     | 352   | 3     | 349   | 3     | 348   |
| Waikaitane       | 3     | 137   | 3     | 137   | 3     | 198   | 3     | 169   | 3     | 187   | 3     | 187   | 3     | 187   | 3     | 187   | 3     | 187   | 3     | 183   |
| Opoiki           | 1     | 75    | 1     | 75    | 1     | 61    | 1     | 61    | 1     | 61    | 1     | 61    | 1     | 66    | 1     | 66    | 1     | 66    | 1     | 66    |
| Waipatu          | 1     | 48    | 1     | 48    | 1     | 48    | 1     | 44    | 1     | 44    | 1     | 44    | 1     | 44    | 1     | 44    | 1     | 44    | 1     | 44    |
| Cook             | 6     | 361   | 5     | 361   | 5     | 368   | 5     | 370   | 5     | 370   | 5     | 370   | 4     | 363   | 3     | 353   | 4     | 397   | 4     | 397   |
| Waioia           | 1     | 132   | 1     | 132   | 1     | 126   | 1     | 126   | 1     | 126   | 1     | 126   | 1     | 131   | 1     | 131   | 1     | 131   | 1     | 131   |
| Hawkes Bay       | 4     | 645   | 4     | 645   | 4     | 624   | 4     | 642   | 4     | 654   | 4     | 627   | 4     | 632   | 4     | 625   | 4     | 638   | 4     | 667   |
| Tannarunui       | 2     | 128   | 2     | 128   | 2     | 128   | 2     | 128   | 2     | 151   | 2     | 151   | 2     | 151   | 2     | 151   | 2     | 151   | 2     | 151   |
| Waipawa          | 3     | 180   | 3     | 158   | 3     | 162   | 3     | 162   | 3     | 162   | 3     | 169   | 2     | 163   | 2     | 165   | 2     | 157   | 2     | 159   |
| Dannevirke       | 2     | 148   | 2     | 158   | 2     | 142   | 2     | 142   | 2     | 142   | 2     | 142   | 2     | 142   | 2     | 142   | 2     | 138   | 2     | 155   |
| Taranaki         | 10    | 668   | 10    | 668   | 10    | 668   | 10    | 666   | 10    | 666   | 10    | 666   | 9     | 658   | 8     | 669   | 8     | 682   | 8     | 634   |
| Hanganui         | 9     | 522   | 8     | 526   | 8     | 545   | 8     | 563   | 7     | 550   | 7     | 553   | 6     | 541   | 6     | 541   | 7     | 543   | 7     | 552   |
| Palmerston North | 8     | 738   | 7     | 742   | 7     | 714   | 6     | 685   | 6     | 684   | 6     | 676   | 7     | 726   | 7     | 726   | 7     | 726   | 7     | 726   |
| Wellington       | 10    | 1781  | 10    | 1695  | 10    | 1681  | 9     | 1664  | 9     | 1703  | 10    | 1843  | 8     | 1877  | 8     | 1904  | 8     | 1972  | 8     | 1905  |
| Wairarapa        | 9     | 352   | 9     | 352   | 9     | 322   | 9     | 337   | 9     | 337   | 9     | 335   | 9     | 335   | 8     | 327   | 8     | 350   | 8     | 350   |
| North Island     | 125   | 10728 | 123   | 10773 | 123   | 10743 | 120   | 11010 | 119   | 11341 | 122   | 11704 | 116   | 11778 | 114   | 12026 | 116   | 12376 | 116   | 12451 |
| Karlborough      | 5     | 280   | 5     | 282   | 4     | 266   | 4     | 267   | 4     | 267   | 4     | 267   | 4     | 267   | 4     | 267   | 4     | 267   | 4     | 268   |
| North Canterbury | 22    | 1544  | 22    | 1504  | 21    | 1495  | 22    | 1558  | 22    | 1588  | 22    | 1588  | 21    | 1602  | 21    | 1578  | 20    | 1526  | 20    | 1527  |
| Nelson           | 8     | 401   | 8     | 399   | 8     | 392   | 7     | 374   | 7     | 373   | 5     | 365   | 5     | 369   | 6     | 338   | 6     | 353   | 5     | 346   |
| West Coast       | 9     | 452   | 8     | 438   | 8     | 442   | 9     | 459   | 9     | 453   | 9     | 451   | 9     | 448   | 9     | 419   | 9     | 450   | 9     | 457   |
| Ashburton        | 3     | 203   | 3     | 204   | 3     | 204   | 3     | 162   | 3     | 162   | 3     | 162   | 2     | 157   | 1     | 151   | 2     | 277   | 2     | 277   |
| South Canterbury | 7     | 446   | 7     | 460   | 7     | 460   | 7     | 453   | 7     | 464   | 7     | 459   | 8     | 472   | 8     | 477   | 8     | 477   | 8     | 479   |
| Waitaki          | 4     | 231   | 4     | 231   | 3     | 214   | 3     | 217   | 3     | 227   | 3     | 229   | 3     | 210   | 3     | 210   | 3     | 210   | 4     | 217   |
| Otago            | 12    | 961   | 10    | 940   | 11    | 889   | 11    | 887   | 10    | 910   | 10    | 910   | 9     | 889   | 10    | 915   | 10    | 916   | 10    | 919   |
| South Otago      | 4     | 206   | 4     | 206   | 4     | 197   | 4     | 206   | 4     | 206   | 4     | 206   | 4     | 205   | 4     | 205   | 4     | 211   | 4     | 200   |
| Hanietoto        | 1     | 25    | 1     | 25    | 1     | 25    | 1     | 25    | 1     | 27    | 1     | 27    | 1     | 27    | 1     | 27    | 1     | 27    | 1     | 33    |
| Vincent          | 2     | 81    | 2     | 90    | 2     | 83    | 2     | 83    | 2     | 83    | 2     | 83    | 2     | 87    | 2     | 86    | 2     | 86    | 2     | 86    |
| Southland        | 17    | 690   | 17    | 690   | 17    | 690   | 17    | 709   | 17    | 695   | 16    | 691   | 15    | 692   | 14    | 686   | 14    | 693   | 14    | 704   |
| South Island     | 94    | 5520  | 91    | 5469  | 89    | 5357  | 90    | 5400  | 89    | 5455  | 86    | 5438  | 83    | 5425  | 83    | 5359  | 83    | 5498  | 83    | 5513  |
| NEW ZEALAND      | 219   | 16248 | 214   | 16242 | 212   | 16100 | 210   | 16410 | 208   | 16796 | 208   | 17142 | 199   | 17203 | 197   | 17385 | 199   | 17874 | 199   | 17954 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 1).



Table 2

Table 2: Hospital Statistics, 1962-71

| Hospital Board   | 1962  |      | 1963  |      | 1964  |      | 1965  |      | 1966  |      | 1967  |      | 1968  |      | 1969  |      | 1970  |      | 1971  |      |
|------------------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|
|                  | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds | Hosps | Beds |
| Northland        | 1     | 19   | 1     | 19   | 1     | 20   | 1     | 20   | 1     | 20   | 1     | 20   | 1     | 20   | 1     | 20   | 1     | 20   | 1     | 20   |
| Auckland         | 55    | 957  | 56    | 1045 | 53    | 1059 | 54    | 1124 | 54    | 1166 | 54    | 1204 | 55    | 1251 | 53    | 1277 | 51    | 1269 | 51    | 1308 |
| Waikato          | 14    | 168  | 11    | 124  | 12    | 148  | 11    | 152  | 11    | 169  | 9     | 151  | 8     | 148  | 8     | 150  | 9     | 150  | 8     | 195  |
| Taranaki         | -     | -    | 1     | 8    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Tairāngā         | 2     | 34   | 2     | 34   | 2     | 34   | 1     | 23   | 1     | 23   | 1     | 23   | 1     | 23   | 1     | 23   | 2     | 43   | 2     | 43   |
| Whakatane        | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Opotiki          | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Waiaapu          | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Cook             | 2     | 32   | 2     | 32   | 2     | 32   | 2     | 32   | 2     | 32   | 2     | 34   | 2     | 34   | 2     | 34   | 2     | 34   | 2     | 34   |
| Waioa            | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Hawkes Bay       | 6     | 78   | 6     | 94   | 6     | 94   | 5     | 87   | 5     | 87   | 5     | 87   | 5     | 87   | 5     | 86   | 5     | 86   | 5     | 88   |
| Tairānui         | 1     | 4    | 1     | 4    | 1     | 4    | 1     | 4    | 1     | 4    | 1     | 6    | -     | -    | -     | -    | -     | -    | -     | -    |
| Waipawa          | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 14   | 1     | 12   | 1     | 12   |
| Dannevirke       | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Taranaki         | 6     | 77   | 6     | 77   | 5     | 63   | 5     | 89   | 5     | 89   | 5     | 89   | 5     | 89   | 5     | 89   | 5     | 89   | 4     | 76   |
| Manawatu         | 7     | 105  | 7     | 105  | 6     | 96   | 6     | 96   | 6     | 97   | 5     | 91   | 7     | 100  | 7     | 103  | 6     | 101  | 6     | 104  |
| Palmerston North | 5     | 94   | 5     | 104  | 5     | 116  | 5     | 116  | 5     | 116  | 5     | 114  | 5     | 114  | 5     | 118  | 6     | 121  | 6     | 155  |
| Wellington       | 10    | 280  | 11    | 325  | 13    | 352  | 14    | 362  | 14    | 357  | 15    | 372  | 14    | 377  | 15    | 397  | 15    | 412  | 17    | 443  |
| Wairarapa        | 5     | 36   | 5     | 37   | 5     | 36   | 5     | 35   | 6     | 46   | 6     | 46   | 6     | 46   | 6     | 46   | 4     | 46   | 5     | 46   |
| North Island     | 115   | 1898 | 115   | 2022 | 112   | 2068 | 111   | 2154 | 112   | 2220 | 110   | 2251 | 110   | 2303 | 109   | 2357 | 107   | 2433 | 108   | 2524 |
| Marlborough      | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   | 1     | 15   |
| North Canterbury | 12    | 446  | 12    | 451  | 13    | 489  | 13    | 505  | 12    | 482  | 12    | 482  | 12    | 497  | 13    | 537  | 14    | 570  | 14    | 570  |
| Nelson           | 2     | 16   | 2     | 20   | 2     | 20   | 3     | 22   | 3     | 24   | 4     | 39   | 4     | 41   | 4     | 41   | 4     | 41   | 5     | 45   |
| West Coast       | 1     | 3    | 1     | 3    | 1     | 3    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Ashburton        | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| South Canterbury | 2     | 37   | 2     | 37   | 2     | 38   | 2     | 38   | 2     | 38   | 2     | 48   | 3     | 48   | 3     | 48   | 3     | 48   | 3     | 48   |
| Waitaki          | 2     | 50   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   | 2     | 52   |
| Otago            | 12    | 304  | 11    | 294  | 11    | 291  | 12    | 314  | 13    | 326  | 13    | 328  | 12    | 312  | 12    | 312  | 12    | 343  | 12    | 353  |
| South Otago      | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Maniototo        | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Vincent          | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    | -     | -    |
| Southland        | 6     | 110  | 5     | 101  | 5     | 101  | 6     | 107  | 6     | 107  | 6     | 107  | 6     | 107  | 7     | 133  | 6     | 127  | 6     | 133  |
| South Island     | 38    | 981  | 36    | 973  | 37    | 1009 | 39    | 1053 | 39    | 1044 | 40    | 1071 | 40    | 1072 | 42    | 1138 | 42    | 1196 | 43    | 1216 |
| NEW ZEALAND      | 153   | 2879 | 151   | 2995 | 149   | 3077 | 150   | 3207 | 151   | 3264 | 150   | 3322 | 150   | 3375 | 151   | 3495 | 149   | 3629 | 151   | 3740 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 2).

TABLE 1  
HOSPITAL INPATIENTS, NEW ZEALAND, 1962-71

| Hospital Board   | 1962    | 1963    | 1964    | 1965    | 1966    | 1967    | 1968    | 1969    | 1970    | 1971    |
|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northland        | 536.3   | 545.4   | 538.0   | 571.2   | 566.1   | 572.1   | 598.7   | 600.3   | 598.2   | 603.7   |
| Auckland         | 1807.1  | 1822.8  | 1850.0  | 1942.1  | 2077.9  | 2198.6  | 2276.0  | 2321.4  | 2359.9  | 2393.2  |
| Waikato          | 1130.3  | 1129.3  | 1159.7  | 1167.3  | 1197.6  | 1203.2  | 1245.5  | 1330.1  | 1395.5  | 1391.6  |
| Thames           | 202.5   | 196.7   | 215.1   | 236.3   | 234.0   | 245.2   | 246.5   | 254.2   | 255.5   | 261.6   |
| Tauranga         | 214.3   | 222.0   | 219.9   | 223.4   | 243.9   | 258.1   | 277.7   | 287.5   | 288.4   | 283.2   |
| Whakatane        | 121.6   | 123.9   | 128.2   | 137.3   | 134.0   | 130.6   | 136.5   | 141.2   | 140.5   | 141.1   |
| Opoitiri         | 47.7    | 43.4    | 44.5    | 39.0    | 37.0    | 31.8    | 34.8    | 39.1    | 37.8    | 34.6    |
| Waipatu          | 33.1    | 30.9    | 30.3    | 28.8    | 30.4    | 28.7    | 31.0    | 30.3    | 29.8    | 26.4    |
| Cook             | 293.6   | 279.7   | 293.4   | 291.7   | 292.3   | 299.2   | 291.5   | 277.5   | 287.3   | 304.4   |
| Waioa            | 80.2    | 64.5    | 80.5    | 85.9    | 81.2    | 74.0    | 82.7    | 84.1    | 87.0    | 84.4    |
| Hawkes Bay       | 476.5   | 483.5   | 497.1   | 488.8   | 500.1   | 497.3   | 502.3   | 494.7   | 496.0   | 507.8   |
| Tairarunui       | 108.3   | 106.7   | 95.4    | 95.4    | 95.7    | 101.5   | 114.2   | 113.0   | 113.6   | 103.3   |
| Waipara          | 114.7   | 112.1   | 115.9   | 118.1   | 120.9   | 122.1   | 127.2   | 122.2   | 121.4   | 120.6   |
| Dannevirke       | 95.1    | 92.0    | 92.5    | 87.7    | 83.1    | 86.7    | 89.4    | 91.3    | 94.2    | 98.9    |
| Taranaki         | 481.2   | 501.3   | 501.0   | 520.9   | 516.9   | 496.7   | 497.1   | 511.5   | 525.7   | 531.3   |
| Wanganui         | 402.5   | 399.8   | 425.8   | 428.2   | 420.8   | 403.5   | 401.6   | 399.8   | 411.6   | 407.3   |
| Palmerston North | 552.0   | 563.0   | 570.2   | 559.1   | 556.4   | 547.2   | 612.2   | 620.6   | 623.1   | 616.7   |
| Wellington       | 1355.5  | 1330.6  | 1397.7  | 1344.1  | 1394.3  | 1477.7  | 1499.6  | 1499.0  | 1567.7  | 1525.2  |
| Wairarapa        | 235.1   | 227.3   | 223.3   | 230.6   | 237.0   | 235.2   | 233.4   | 233.7   | 240.0   | 244.0   |
| North Island     | 8231.6  | 8324.9  | 8518.5  | 8595.9  | 8809.6  | 9009.4  | 9297.9  | 9501.5  | 9678.2  | 9689.3  |
| Marlborough      | 215.2   | 209.9   | 202.5   | 204.5   | 200.6   | 195.5   | 208.5   | 212.3   | 214.4   | 209.4   |
| North Canterbury | 1177.4  | 1177.5  | 1185.9  | 1232.3  | 1270.7  | 1276.9  | 1294.0  | 1289.2  | 1209.6  | 1245.8  |
| Nelson           | 261.6   | 261.7   | 275.7   | 268.3   | 279.5   | 277.3   | 267.5   | 283.0   | 273.0   | 278.9   |
| West Coast       | 337.4   | 313.0   | 319.8   | 340.9   | 324.1   | 331.5   | 332.5   | 322.2   | 308.8   | 308.8   |
| Ashburton        | 119.1   | 120.2   | 119.4   | 120.9   | 135.6   | 142.3   | 129.6   | 129.9   | 193.5   | 198.3   |
| South Canterbury | 351.2   | 353.2   | 362.0   | 366.6   | 375.2   | 364.6   | 387.2   | 386.1   | 402.7   | 399.7   |
| Waitaki          | 151.3   | 154.8   | 159.1   | 160.6   | 153.1   | 149.0   | 157.7   | 151.2   | 144.8   | 146.4   |
| Otago            | 716.5   | 703.4   | 716.0   | 715.8   | 718.8   | 718.8   | 708.8   | 718.4   | 739.8   | 726.6   |
| South Otago      | 125.0   | 121.6   | 129.3   | 128.1   | 123.6   | 123.1   | 133.4   | 135.6   | 133.0   | 126.5   |
| Maniototo        | 15.0    | 13.9    | 17.5    | 17.1    | 18.6    | 21.1    | 20.5    | 20.5    | 19.3    | 21.2    |
| Vincent          | 36.9    | 41.5    | 41.5    | 41.5    | 40.5    | 44.4    | 49.1    | 50.7    | 43.1    | 45.4    |
| Southland        | 494.8   | 507.9   | 519.7   | 534.4   | 553.2   | 550.0   | 550.4   | 535.0   | 540.9   | 546.1   |
| South Island     | 4001.4  | 3938.6  | 4048.4  | 4131.0  | 4193.5  | 4199.5  | 4239.2  | 4234.6  | 4222.9  | 4253.1  |
| NEW ZEALAND      | 12283.0 | 12313.5 | 12566.9 | 12726.9 | 13003.1 | 13208.9 | 13537.1 | 13736.1 | 13901.1 | 13942.4 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 1).

Table 1  
 Hospital Statistics, New Zealand, 1962-71

| Hospital Board   | 1962  | 1963  | 1964  | 1965  | 1966  | 1967  | 1968  | 1969  | 1970  | 1971  |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | (000) | (000) | (000) | (000) | (000) | (000) | (000) | (000) | (000) | (000) |
| Northland        | 11.2  | 11.7  | 12.1  | 11.9  | 11.8  | 12.3  | 12.5  | 12.8  | 13.2  | 13.8  |
| Auckland         | 41.5  | 43.2  | 45.8  | 49.0  | 51.9  | 55.7  | 60.1  | 61.4  | 62.2  | 66.6  |
| Waikato          | 26.0  | 27.5  | 28.9  | 28.5  | 29.3  | 30.2  | 32.3  | 33.6  | 35.6  | 36.9  |
| Tairāpapa        | 3.4   | 3.5   | 3.6   | 4.1   | 3.9   | 4.3   | 4.3   | 4.3   | 4.4   | 4.5   |
| Tairāpapa        | 4.2   | 4.7   | 5.0   | 5.4   | 5.6   | 6.8   | 7.0   | 7.3   | 7.5   | 7.1   |
| Whakatane        | 4.0   | 4.2   | 4.4   | 4.5   | 4.3   | 4.2   | 4.3   | 4.3   | 4.5   | 4.5   |
| Opoitiki         | 1.3   | 1.3   | 1.3   | 1.4   | 1.3   | 1.0   | 1.1   | 1.2   | 1.1   | 1.1   |
| Waipatu          | 0.9   | 0.8   | 0.7   | 0.8   | 0.9   | 0.7   | 0.8   | 0.8   | 0.8   | 0.8   |
| Cook             | 5.7   | 5.2   | 5.5   | 5.5   | 5.1   | 5.4   | 5.3   | 5.1   | 5.4   | 5.6   |
| Waikato          | 2.1   | 2.1   | 2.3   | 2.4   | 2.3   | 2.0   | 2.1   | 2.1   | 2.0   | 2.1   |
| Hawkes Bay       | 10.0  | 10.4  | 11.2  | 11.7  | 11.9  | 12.2  | 12.8  | 13.0  | 13.2  | 14.0  |
| Tairāpapa        | 2.4   | 2.5   | 2.5   | 2.6   | 2.6   | 2.6   | 2.7   | 3.1   | 3.1   | 3.0   |
| Waipatu          | 2.2   | 2.0   | 1.9   | 1.9   | 1.9   | 1.9   | 1.9   | 2.0   | 1.9   | 1.9   |
| Dannevirke       | 2.0   | 2.1   | 2.2   | 2.0   | 2.0   | 1.9   | 1.7   | 1.8   | 1.9   | 1.6   |
| Tairāpapa        | 10.5  | 11.0  | 11.0  | 11.5  | 11.2  | 10.9  | 11.5  | 12.1  | 12.3  | 12.1  |
| Wairarapa        | 7.9   | 8.2   | 8.9   | 9.5   | 9.8   | 9.7   | 9.3   | 9.4   | 9.5   | 9.4   |
| Palmerston North | 11.3  | 11.5  | 11.7  | 12.2  | 12.4  | 12.1  | 12.9  | 13.4  | 13.5  | 13.8  |
| Wellington       | 23.9  | 30.0  | 30.1  | 30.5  | 33.1  | 35.2  | 36.5  | 38.2  | 39.2  | 39.3  |
| Wairarapa        | 5.3   | 5.3   | 5.3   | 5.2   | 5.4   | 5.6   | 5.6   | 5.8   | 5.6   | 5.9   |
| North Island     | 181.0 | 187.1 | 194.5 | 200.6 | 206.5 | 215.0 | 224.9 | 231.7 | 236.8 | 243.9 |
| Marlborough      | 3.9   | 3.9   | 4.0   | 4.0   | 4.1   | 3.9   | 4.4   | 4.4   | 4.2   | 4.2   |
| North Canterbury | 21.7  | 22.5  | 23.4  | 26.0  | 26.6  | 27.5  | 29.2  | 29.4  | 31.5  | 33.4  |
| Nelson           | 6.1   | 6.5   | 6.5   | 5.9   | 6.4   | 6.5   | 5.9   | 6.3   | 6.0   | 6.3   |
| West Coast       | 5.7   | 5.4   | 5.3   | 5.3   | 5.5   | 5.5   | 5.7   | 5.4   | 5.2   | 5.6   |
| Ashburton        | 2.9   | 3.0   | 3.0   | 2.9   | 2.8   | 3.2   | 3.1   | 3.2   | 2.8   | 3.0   |
| South Canterbury | 6.4   | 6.4   | 6.6   | 7.0   | 6.9   | 6.9   | 6.8   | 7.0   | 7.5   | 7.4   |
| Waitaki          | 2.9   | 2.9   | 3.0   | 3.1   | 2.9   | 2.9   | 2.9   | 2.7   | 2.8   | 2.8   |
| Otago            | 15.5  | 15.8  | 16.4  | 16.4  | 16.6  | 17.2  | 18.2  | 18.4  | 17.6  | 17.6  |
| South Otago      | 2.5   | 2.6   | 2.7   | 2.5   | 2.5   | 2.6   | 2.6   | 2.7   | 2.8   | 2.7   |
| Maniototo        | 0.4   | 0.4   | 0.5   | 0.5   | 0.5   | 0.5   | 0.5   | 0.5   | 0.5   | 0.5   |
| Vincent          | 1.0   | 1.0   | 1.1   | 1.1   | 1.1   | 1.1   | 1.2   | 1.1   | 1.1   | 1.1   |
| Southland        | 10.0  | 9.9   | 10.2  | 11.1  | 11.0  | 10.9  | 12.0  | 12.8  | 13.0  | 12.9  |
| South Island     | 79.0  | 80.3  | 82.8  | 85.7  | 87.0  | 88.7  | 92.4  | 93.8  | 94.7  | 97.5  |
| NEW ZEALAND      | 260.0 | 267.4 | 277.2 | 286.4 | 293.6 | 303.7 | 317.3 | 325.6 | 331.5 | 341.4 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 1).

TABLE 11  
INPATIENT DAYS, NEW ZEALAND HOSPITALS 1962-71

| Hospital Board   | 1962   | 1963   | 1964   | 1965   | 1966   | 1967   | 1968   | 1969   | 1970   | 1971   |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  |
| Northland        | 193.6  | 199.1  | 215.2  | 203.5  | 206.6  | 208.8  | 219.1  | 219.1  | 218.3  | 222.2  |
| Auckland         | 659.6  | 665.3  | 677.1  | 708.9  | 758.4  | 802.5  | 833.0  | 847.3  | 861.4  | 873.5  |
| Waikato          | 412.6  | 412.2  | 424.5  | 426.1  | 433.5  | 439.2  | 455.9  | 503.7  | 509.7  | 507.9  |
| Thames           | 73.9   | 71.8   | 78.7   | 86.2   | 85.4   | 89.5   | 90.2   | 92.8   | 94.4   | 95.5   |
| Tauranga         | 78.2   | 81.0   | 80.5   | 81.5   | 89.0   | 94.2   | 101.6  | 104.9  | 105.3  | 103.4  |
| Whakatane        | 44.4   | 45.2   | 46.9   | 50.1   | 48.9   | 47.7   | 50.0   | 51.5   | 51.3   | 51.5   |
| Opotiki          | 17.4   | 15.8   | 16.3   | 14.2   | 13.5   | 11.6   | 12.7   | 14.3   | 13.8   | 12.6   |
| Waipatu          | 12.1   | 11.3   | 11.1   | 10.5   | 11.1   | 10.5   | 11.3   | 11.1   | 10.9   | 9.6    |
| Cook             | 107.2  | 102.1  | 107.4  | 106.5  | 106.7  | 109.2  | 106.7  | 101.3  | 104.9  | 111.1  |
| Waioa            | 29.3   | 23.5   | 29.5   | 31.4   | 29.6   | 27.0   | 30.3   | 30.7   | 31.8   | 30.8   |
| Hawkes Bay       | 173.9  | 176.5  | 181.9  | 178.4  | 182.5  | 181.5  | 183.8  | 180.6  | 181.0  | 185.3  |
| Taumarunui       | 39.5   | 38.9   | 34.9   | 34.8   | 34.9   | 37.0   | 41.8   | 41.2   | 41.5   | 39.5   |
| Waipawa          | 41.9   | 40.9   | 42.4   | 43.1   | 44.1   | 44.6   | 46.6   | 44.6   | 44.3   | 44.0   |
| Dannevirke       | 34.7   | 33.6   | 33.9   | 32.0   | 30.3   | 31.6   | 32.7   | 33.3   | 34.4   | 36.1   |
| Taranaki         | 175.6  | 183.0  | 183.4  | 190.1  | 188.7  | 181.3  | 181.9  | 186.7  | 192.2  | 193.9  |
| Wanganui         | 146.9  | 145.9  | 155.8  | 156.3  | 153.6  | 147.3  | 147.0  | 145.9  | 150.2  | 148.7  |
| Palmerston North | 201.5  | 205.5  | 208.7  | 204.1  | 203.1  | 199.7  | 224.1  | 226.5  | 227.4  | 225.1  |
| Wellington       | 494.8  | 503.9  | 507.9  | 490.6  | 508.9  | 539.4  | 548.9  | 547.1  | 572.2  | 556.7  |
| Wairarapa        | 85.8   | 83.0   | 81.7   | 84.2   | 86.5   | 85.8   | 85.4   | 85.3   | 87.6   | 89.1   |
| North Island     | 3022.8 | 3038.6 | 3117.8 | 3137.5 | 3215.5 | 3238.4 | 3403.0 | 3468.0 | 3532.5 | 3536.6 |
| Marlborough      | 78.5   | 76.6   | 74.1   | 74.6   | 73.2   | 71.4   | 76.3   | 77.7   | 78.3   | 76.4   |
| North Canterbury | 429.8  | 429.8  | 434.0  | 449.8  | 463.8  | 466.1  | 473.6  | 470.6  | 441.5  | 454.7  |
| Nelson           | 95.5   | 95.5   | 100.9  | 97.9   | 102.0  | 101.2  | 97.9   | 103.3  | 99.6   | 101.8  |
| West Coast       | 123.2  | 116.1  | 117.0  | 124.4  | 118.3  | 121.0  | 121.7  | 117.6  | 112.7  | 112.7  |
| Ashburton        | 43.5   | 43.9   | 43.7   | 44.1   | 49.5   | 51.9   | 47.4   | 47.4   | 70.6   | 72.4   |
| South Canterbury | 128.2  | 128.9  | 132.5  | 133.8  | 136.9  | 133.1  | 141.7  | 140.9  | 147.0  | 145.9  |
| Waitaki          | 55.2   | 56.5   | 58.2   | 58.6   | 55.9   | 54.4   | 57.7   | 55.2   | 52.9   | 53.4   |
| Otago            | 261.5  | 258.6  | 262.1  | 261.3  | 262.4  | 262.4  | 259.4  | 262.2  | 270.0  | 265.2  |
| South Otago      | 45.6   | 44.4   | 47.3   | 46.8   | 45.1   | 46.8   | 48.8   | 49.5   | 48.5   | 46.2   |
| Maniototo        | 5.5    | 5.1    | 6.4    | 6.2    | 6.8    | 7.7    | 7.5    | 7.5    | 7.0    | 7.7    |
| Vincent          | 13.5   | 15.1   | 15.2   | 15.1   | 14.8   | 16.2   | 18.0   | 18.5   | 15.7   | 16.6   |
| Southland        | 180.6  | 185.4  | 190.2  | 195.1  | 201.9  | 200.8  | 201.4  | 195.3  | 197.4  | 199.3  |
| South Island     | 1460.5 | 1455.8 | 1481.7 | 1507.8 | 1530.6 | 1532.8 | 1551.5 | 1545.6 | 1541.4 | 1552.4 |
| NEW ZEALAND      | 4433.3 | 4494.4 | 4599.5 | 4645.3 | 4746.1 | 4821.2 | 4954.6 | 5013.7 | 5073.9 | 5089.0 |

Source: Calculated from other tables - the average number of occupied beds per day in a given year multiplied by 365 (366 in a leap year).

TABLE 1  
HOSPITAL IN-PATIENTS, NEW ZEALAND HOSPITALS, 1962-71

| Hospital Board   | 1962   | 1963   | 1964   | 1965   | 1966   | 1967   | 1968   | 1969   | 1970   | 1971   |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  |
| Northland        | 32.2   | 53.1   | 51.6   | 62.6   | 60.9   | 70.2   | 65.2   | 76.2   | 78.3   | 93.3   |
| Auckland         | 493.1  | 541.6  | 483.8  | 714.0  | 693.3  | 754.6  | 746.5  | 759.5  | 777.5  | 821.8  |
| Waikato          | 215.7  | 250.4  | 281.2  | 282.3  | 296.1  | 323.9  | 380.2  | 413.7  | 477.2  | 549.4  |
| Thames           | 10.0   | 11.4   | 9.6    | 39.6   | 42.8   | 27.6   | 27.0   | 26.2   | 24.3   | 29.9   |
| Tauranga         | 32.4   | 36.4   | 38.3   | 43.3   | 39.2   | 40.7   | 39.5   | 41.0   | 40.8   | 39.4   |
| Whakatane        | 7.1    | 7.7    | 13.6   | 12.2   | 15.0   | 16.4   | 18.8   | 23.7   | 27.2   | 30.5   |
| Opotiki          | 5.6    | 7.6    | 9.9    | 10.3   | 11.5   | 14.0   | 25.5   | 14.5   | 17.8   | 18.2   |
| Waipatu          | 3.2    | 3.5    | 3.4    | 3.9    | 4.5    | 4.5    | 5.1    | 5.7    | 5.2    | 7.8    |
| Cook             | 40.4   | 34.1   | 33.2   | 33.5   | 41.4   | 43.9   | 52.5   | 63.6   | 63.3   | 73.4   |
| Wairoa           | 5.3    | 1.2    | 20.2   | 8.3    | 7.8    | 7.9    | 8.3    | 8.5    | 9.4    | 8.4    |
| Hawkes Bay       | 63.4   | 71.9   | 73.8   | 85.3   | 87.6   | 87.6   | 83.0   | 87.6   | 92.0   | 100.5  |
| Taumarunui       | 2.7    | 3.2    | 3.2    | 2.5    | 3.7    | 2.9    | 3.5    | 4.3    | 4.4    | 3.9    |
| Waipara          | 10.3   | 9.9    | 12.2   | 12.1   | 13.2   | 14.4   | 15.4   | 17.1   | 16.4   | 20.6   |
| Dannevirke       | 6.3    | 9.2    | 16.8   | 18.8   | 17.1   | 20.1   | 16.3   | 12.0   | 10.7   | 11.8   |
| Taranaki         | 67.5   | 74.3   | 83.3   | 80.7   | 69.9   | 63.8   | 67.4   | 60.7   | 72.8   | 77.2   |
| Wanganui         | 47.8   | 46.6   | 47.4   | 47.3   | 56.2   | 57.5   | 60.2   | 60.5   | 66.0   | 57.3   |
| Palmerston North | 96.2   | 101.8  | 109.4  | 124.9  | 127.7  | 126.5  | 132.9  | 142.3  | 140.4  | 152.4  |
| Wellington       | 350.8  | 374.5  | 353.4  | 38.3   | 386.8  | 393.6  | 392.8  | 402.8  | 398.4  | 422.6  |
| Wairarapa        | 22.3   | 24.0   | 30.0   | 34.3   | 37.9   | 42.3   | 47.9   | 51.0   | 51.1   | 56.1   |
| North Island     | 1512.3 | 1662.5 | 1679.2 | 1999.3 | 2017.6 | 2117.2 | 2188.1 | 2271.0 | 2373.2 | 2574.5 |
| Marlborough      | 23.6   | 23.5   | 27.4   | 23.8   | 27.1   | 27.0   | 30.9   | 27.9   | 28.0   | 32.8   |
| North Canterbury | 166.4  | 197.9  | 235.0  | 267.0  | 271.2  | 289.0  | 279.5  | 293.8  | 299.8  | 309.5  |
| Nelson           | 37.0   | 42.6   | 45.6   | 46.5   | 50.2   | 44.2   | 37.5   | 45.3   | 47.7   | 49.3   |
| West Coast       | 48.3   | 41.9   | 46.1   | 50.3   | 58.7   | 60.1   | 50.3   | 47.4   | 49.1   | 44.5   |
| Ashburton        | 21.1   | 17.7   | 17.1   | 16.8   | 16.3   | 16.7   | 15.0   | 15.5   | 3.6    | 5.0    |
| South Canterbury | 29.8   | 33.1   | 34.0   | 39.2   | 41.9   | 43.5   | 44.3   | 45.4   | 51.8   | 56.4   |
| Waitaki          | 15.8   | 15.1   | 16.1   | 18.6   | 19.2   | 21.3   | 21.5   | 21.1   | 19.8   | 20.9   |
| Otago            | 181.7  | 176.9  | 177.2  | 191.6  | 195.9  | 188.0  | 201.0  | 201.5  | 204.0  | 222.1  |
| South Otago      | 10.1   | 11.3   | 12.5   | 12.9   | 15.1   | 16.0   | 16.2   | 16.3   | 19.0   | 18.4   |
| Maniototo        | 1.7    | 1.2    | 0.4    | 0.3    | 1.0    | 1.2    | 1.3    | 1.2    | 1.2    | 1.8    |
| Vincent          | 0.5    | -      | -      | -      | -      | -      | -      | -      | -      | -      |
| Southland        | 62.6   | 67.5   | 77.6   | 85.3   | 80.9   | 84.3   | 122.7  | 122.7  | 138.7  | 156.5  |
| South Island     | 598.6  | 628.5  | 689.0  | 757.2  | 777.5  | 791.2  | 820.3  | 839.0  | 862.7  | 917.4  |
| NEW ZEALAND      | 2110.9 | 2291.0 | 2368.2 | 2756.5 | 2795.0 | 2908.4 | 3008.4 | 3110.1 | 3235.9 | 3491.9 |

Source: NZ Department of Health, Hospital Statistics, Wellington, Government Printer, for years 1962-71 (Table 1).

TABLE A-17  
HOSPITAL OCCUPANCY RATES, NEW ZEALAND HOSPITAL BOARD 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
|                  | %    | %    | %    | %    | %    | %    | %    | %    | %    | %    |
| Northland        | 81.8 | 71.9 | 78.1 | 76.8 | 72.0 | 70.8 | 73.7 | 73.9 | 74.6 | 75.1 |
| Auckland         | 77.4 | 80.4 | 81.2 | 79.8 | 81.8 | 80.7 | 82.1 | 81.3 | 80.1 | 80.5 |
| Waikato          | 85.7 | 83.1 | 86.1 | 82.3 | 78.4 | 78.5 | 83.8 | 84.3 | 79.3 | 76.7 |
| Tairātea         | 78.8 | 66.9 | 69.6 | 69.7 | 69.0 | 72.3 | 72.7 | 75.0 | 77.4 | 78.8 |
| Tauranga         | 84.7 | 82.5 | 81.7 | 70.3 | 75.5 | 73.5 | 78.9 | 81.7 | 82.6 | 81.4 |
| Whakatane        | 88.8 | 90.4 | 64.7 | 81.2 | 71.7 | 69.8 | 73.0 | 75.5 | 75.1 | 75.1 |
| Opotiki          | 63.6 | 57.9 | 73.0 | 63.9 | 60.7 | 52.1 | 52.7 | 59.2 | 57.3 | 52.4 |
| Waiaxu           | 69.0 | 64.4 | 63.1 | 65.5 | 69.1 | 65.2 | 70.5 | 68.9 | 67.7 | 60.0 |
| Cook             | 81.3 | 77.5 | 79.7 | 78.8 | 79.0 | 80.9 | 80.3 | 78.6 | 72.4 | 76.7 |
| Wairoa           | 60.8 | 48.9 | 63.9 | 68.2 | 64.4 | 58.7 | 63.1 | 64.2 | 66.4 | 64.4 |
| Hawkes Bay       | 73.9 | 75.0 | 79.7 | 76.1 | 76.5 | 79.3 | 79.5 | 79.2 | 77.7 | 76.1 |
| Taumarunui       | 84.6 | 83.4 | 74.5 | 74.5 | 63.4 | 67.2 | 75.6 | 74.8 | 75.2 | 71.7 |
| Waipawa          | 63.7 | 70.9 | 71.5 | 72.9 | 74.6 | 72.2 | 78.0 | 74.1 | 77.3 | 75.8 |
| Dannevirke       | 64.3 | 58.2 | 65.1 | 61.8 | 58.5 | 61.1 | 63.0 | 64.3 | 68.3 | 63.8 |
| Taranaki         | 72.0 | 75.0 | 75.0 | 78.2 | 77.6 | 74.6 | 75.5 | 76.5 | 77.2 | 77.7 |
| Wanganui         | 77.1 | 76.0 | 78.1 | 76.1 | 76.5 | 73.0 | 74.2 | 73.9 | 75.8 | 73.8 |
| Palmerston North | 74.8 | 75.9 | 79.9 | 81.6 | 81.3 | 80.9 | 84.3 | 85.5 | 85.8 | 84.9 |
| Wellington       | 76.1 | 81.5 | 82.6 | 80.8 | 81.9 | 80.2 | 79.9 | 78.7 | 79.5 | 80.1 |
| Wairarapa        | 66.8 | 64.6 | 69.3 | 68.4 | 70.3 | 70.2 | 69.7 | 71.5 | 68.6 | 69.7 |
| North Island     | 77.2 | 77.3 | 79.3 | 78.1 | 77.7 | 77.0 | 78.9 | 79.0 | 78.2 | 77.8 |
| Marlborough      | 76.9 | 74.4 | 76.1 | 76.6 | 75.1 | 73.2 | 78.1 | 79.7 | 80.3 | 78.1 |
| North Canterbury | 76.3 | 78.3 | 79.3 | 79.1 | 80.0 | 80.4 | 80.8 | 81.7 | 79.3 | 81.6 |
| Nelson           | 65.2 | 65.6 | 70.3 | 71.7 | 74.9 | 76.0 | 72.5 | 83.7 | 76.3 | 80.6 |
| West Coast       | 74.6 | 72.6 | 72.4 | 74.3 | 71.5 | 73.5 | 74.2 | 76.9 | 68.6 | 67.6 |
| Ashburton        | 58.7 | 58.9 | 58.5 | 74.6 | 83.7 | 87.8 | 82.5 | 86.0 | 69.9 | 71.6 |
| South Canterbury | 78.7 | 76.8 | 78.7 | 80.9 | 80.9 | 79.4 | 82.0 | 80.9 | 84.4 | 83.4 |
| Waitaki          | 65.5 | 67.0 | 74.3 | 74.0 | 67.4 | 65.1 | 75.1 | 72.0 | 69.0 | 67.5 |
| Otago            | 74.6 | 75.4 | 80.5 | 80.7 | 79.0 | 79.0 | 79.7 | 78.5 | 80.8 | 79.1 |
| South Otago      | 60.7 | 59.0 | 65.6 | 62.2 | 60.0 | 62.2 | 65.1 | 66.1 | 63.0 | 63.3 |
| Maniototo        | 60.0 | 55.6 | 70.0 | 68.4 | 68.9 | 78.1 | 75.9 | 75.9 | 71.5 | 64.2 |
| Vincent          | 45.6 | 46.1 | 50.0 | 50.0 | 48.8 | 53.5 | 56.4 | 59.0 | 50.1 | 52.8 |
| Southland        | 71.7 | 73.6 | 75.3 | 75.4 | 79.6 | 79.6 | 79.5 | 78.0 | 78.1 | 77.6 |
| South Island     | 72.5 | 72.9 | 75.6 | 76.5 | 76.9 | 77.2 | 78.1 | 79.0 | 76.8 | 77.1 |
| NEW ZEALAND      | 75.6 | 75.8 | 78.1 | 77.6 | 77.4 | 77.1 | 78.7 | 79.0 | 77.8 | 77.6 |

Source: Calculated from other tables - Average number of occupied beds per day in a given year divided by the total number of available beds per year, times 100.

TABLE A-14  
 AVERAGE LENGTH OF STAY (IN DAYS), NEW ZEALAND HOSPITAL PATIENTS 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 17.3 | 17.0 | 17.9 | 17.6 | 17.5 | 16.9 | 17.5 | 17.2 | 16.5 | 16.1 |
| Auckland         | 15.8 | 15.4 | 14.8 | 14.5 | 14.6 | 14.4 | 13.9 | 13.8 | 13.9 | 13.1 |
| Waikato          | 15.8 | 15.0 | 14.7 | 14.9 | 14.8 | 14.5 | 14.1 | 15.0 | 14.3 | 13.8 |
| Thames           | 21.4 | 20.4 | 22.0 | 20.9 | 21.8 | 20.7 | 21.1 | 21.5 | 21.5 | 21.4 |
| Tairāngia        | 18.4 | 17.1 | 16.2 | 15.0 | 15.8 | 13.9 | 14.5 | 14.3 | 14.0 | 14.6 |
| Whakatane        | 11.1 | 10.7 | 10.7 | 11.2 | 11.5 | 11.3 | 11.6 | 11.9 | 11.4 | 11.3 |
| Opotiki          | 13.7 | 12.0 | 12.5 | 10.2 | 10.5 | 11.2 | 11.4 | 12.3 | 13.1 | 11.3 |
| Waipatu          | 13.7 | 14.5 | 15.2 | 13.3 | 12.8 | 14.0 | 14.3 | 13.5 | 14.4 | 12.5 |
| Cook             | 18.9 | 19.5 | 19.6 | 19.5 | 21.1 | 20.1 | 20.0 | 19.8 | 19.3 | 20.0 |
| Wairoa           | 13.7 | 11.4 | 12.7 | 13.1 | 12.8 | 13.2 | 14.1 | 14.9 | 16.1 | 14.7 |
| Hawkes Bay       | 17.4 | 17.0 | 16.2 | 15.3 | 15.3 | 14.9 | 14.4 | 13.9 | 13.7 | 13.3 |
| Tairāhūmūi       | 16.8 | 15.7 | 13.8 | 13.4 | 13.6 | 14.0 | 15.5 | 13.2 | 13.6 | 13.3 |
| Waipawa          | 19.3 | 20.8 | 22.1 | 22.4 | 23.7 | 23.5 | 25.2 | 22.9 | 23.4 | 22.7 |
| Dannevirke       | 17.7 | 16.0 | 15.5 | 16.2 | 14.9 | 16.6 | 18.8 | 18.3 | 18.4 | 22.0 |
| Taranaki         | 16.7 | 16.6 | 16.6 | 16.5 | 16.9 | 16.6 | 15.8 | 15.4 | 15.7 | 16.1 |
| Wanganui         | 18.5 | 17.9 | 17.4 | 16.4 | 15.7 | 15.2 | 15.7 | 15.6 | 15.7 | 15.8 |
| Palmerston North | 17.8 | 17.9 | 17.8 | 16.8 | 16.4 | 16.5 | 17.4 | 17.0 | 16.8 | 16.3 |
| Wellington       | 17.1 | 16.8 | 16.9 | 16.1 | 15.4 | 15.3 | 15.0 | 14.3 | 14.6 | 14.2 |
| Wairarapa        | 16.3 | 15.7 | 15.4 | 16.3 | 16.1 | 15.3 | 15.3 | 14.6 | 15.6 | 15.2 |
| North Island     | 16.7 | 16.2 | 16.0 | 15.6 | 15.6 | 15.3 | 15.1 | 15.0 | 14.9 | 14.5 |
| Marlborough      | 20.4 | 19.6 | 18.4 | 18.7 | 18.1 | 18.1 | 17.2 | 17.6 | 18.8 | 18.2 |
| North Canterbury | 19.8 | 19.1 | 18.5 | 17.3 | 17.4 | 16.9 | 16.2 | 16.0 | 14.0 | 13.6 |
| Nelson           | 15.6 | 14.7 | 15.5 | 16.5 | 16.0 | 15.5 | 16.6 | 16.3 | 16.7 | 16.3 |
| West Coast       | 21.6 | 21.6 | 22.1 | 23.5 | 21.4 | 22.1 | 21.4 | 21.9 | 21.5 | 20.3 |
| Ashburton        | 15.0 | 14.7 | 14.6 | 15.4 | 17.5 | 16.3 | 15.5 | 14.9 | 25.6 | 24.2 |
| South Canterbury | 19.9 | 20.1 | 20.0 | 19.0 | 19.8 | 19.3 | 20.8 | 20.1 | 19.7 | 19.6 |
| Waitaki          | 19.2 | 19.4 | 19.5 | 19.1 | 19.1 | 19.0 | 20.0 | 20.4 | 19.0 | 19.1 |
| Otago            | 16.9 | 16.4 | 16.0 | 16.0 | 15.8 | 15.3 | 14.3 | 14.3 | 15.4 | 15.0 |
| South Otago      | 18.1 | 17.2 | 17.5 | 19.0 | 17.8 | 18.0 | 18.6 | 18.2 | 17.7 | 17.3 |
| Maniototo        | 13.3 | 12.7 | 12.0 | 12.0 | 12.6 | 15.6 | 16.2 | 15.4 | 15.6 | 15.1 |
| Vincent          | 13.0 | 14.5 | 13.9 | 13.8 | 13.6 | 14.6 | 15.1 | 16.4 | 14.7 | 15.3 |
| Southland        | 18.1 | 18.7 | 18.7 | 17.5 | 18.4 | 18.5 | 16.8 | 15.3 | 15.1 | 15.4 |
| South Island     | 18.5 | 18.1 | 17.9 | 17.6 | 17.6 | 17.3 | 16.8 | 16.5 | 16.3 | 15.9 |
| NEW ZEALAND      | 17.2 | 16.8 | 16.6 | 16.2 | 16.2 | 15.9 | 15.6 | 15.4 | 15.3 | 14.9 |

Source: Calculated from other tables - Total hospital inpatient days per year divided by the total number of hospital inpatients per year.

TABLE A-19

RATIO OF FARMING REVENUE TO NON-SPECIFIED EARNINGS IN NEW ZEALAND, 1962-71

| Hospital Board   | 1962  | 1963  | 1964  | 1965  | 1966  | 1967  | 1968  | 1969  | 1970  | 1971  |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Northland        | 0.366 | 0.368 | 0.385 | 0.401 | 0.398 | 0.399 | 0.417 | 0.423 | 0.431 | 0.439 |
| Auckland         | 0.373 | 0.381 | 0.385 | 0.390 | 0.397 | 0.399 | 0.413 | 0.415 | 0.421 | 0.427 |
| Waikato          | 0.352 | 0.353 | 0.364 | 0.390 | 0.401 | 0.385 | 0.399 | 0.412 | 0.421 | 0.430 |
| Thames           | 0.355 | 0.355 | 0.346 | 0.383 | 0.367 | 0.366 | 0.364 | 0.372 | 0.375 | 0.377 |
| Tauranga         | 0.363 | 0.365 | 0.399 | 0.394 | 0.427 | 0.419 | 0.434 | 0.450 | 0.463 | 0.475 |
| Waikataane       | 0.310 | 0.320 | 0.337 | 0.366 | 0.371 | 0.377 | 0.399 | 0.414 | 0.428 | 0.443 |
| Opotiki          | 0.302 | 0.329 | 0.306 | 0.366 | 0.365 | 0.345 | 0.408 | 0.404 | 0.419 | 0.433 |
| Waiaapu          | 0.363 | 0.372 | 0.402 | 0.414 | 0.391 | 0.387 | 0.471 | 0.449 | 0.461 | 0.473 |
| Cook             | 0.337 | 0.345 | 0.373 | 0.371 | 0.375 | 0.395 | 0.414 | 0.420 | 0.432 | 0.444 |
| Waioea           | 0.285 | 0.306 | 0.330 | 0.327 | 0.348 | 0.378 | 0.398 | 0.410 | 0.428 | 0.446 |
| Hawkes Bay       | 0.357 | 0.371 | 0.387 | 0.385 | 0.417 | 0.419 | 0.436 | 0.448 | 0.461 | 0.474 |
| Taumarunui       | 0.327 | 0.338 | 0.359 | 0.368 | 0.384 | 0.383 | 0.415 | 0.422 | 0.435 | 0.449 |
| Waipawa          | 0.293 | 0.313 | 0.321 | 0.366 | 0.378 | 0.357 | 0.423 | 0.427 | 0.446 | 0.465 |
| Dannevirke       | 0.306 | 0.327 | 0.343 | 0.345 | 0.376 | 0.393 | 0.409 | 0.425 | 0.441 | 0.458 |
| Taranaki         | 0.383 | 0.379 | 0.409 | 0.404 | 0.417 | 0.418 | 0.422 | 0.434 | 0.441 | 0.448 |
| Wanganui         | 0.344 | 0.357 | 0.368 | 0.370 | 0.390 | 0.409 | 0.408 | 0.423 | 0.435 | 0.446 |
| Palmerston North | 0.353 | 0.349 | 0.381 | 0.384 | 0.377 | 0.409 | 0.390 | 0.410 | 0.418 | 0.426 |
| Wellington       | 0.368 | 0.409 | 0.406 | 0.413 | 0.424 | 0.444 | 0.519 | 0.503 | 0.523 | 0.542 |
| Wairarapa        | 0.298 | 0.311 | 0.316 | 0.346 | 0.360 | 0.371 | 0.372 | 0.394 | 0.408 | 0.422 |
| North Island     | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    |
| Marlborough      | 0.363 | 0.382 | 0.382 | 0.403 | 0.373 | 0.404 | 0.444 | 0.433 | 0.442 | 0.452 |
| North Canterbury | 0.400 | 0.411 | 0.419 | 0.436 | 0.452 | 0.463 | 0.462 | 0.481 | 0.492 | 0.504 |
| Nelson           | 0.358 | 0.365 | 0.367 | 0.389 | 0.397 | 0.391 | 0.405 | 0.414 | 0.422 | 0.430 |
| West Coast       | 0.369 | 0.376 | 0.372 | 0.400 | 0.406 | 0.387 | 0.411 | 0.415 | 0.421 | 0.427 |
| Ashburton        | 0.404 | 0.391 | 0.427 | 0.427 | 0.405 | 0.437 | 0.417 | 0.431 | 0.435 | 0.439 |
| South Canterbury | 0.355 | 0.360 | 0.336 | 0.399 | 0.404 | 0.415 | 0.429 | 0.442 | 0.455 | 0.467 |
| Waitaki          | 0.351 | 0.326 | 0.380 | 0.364 | 0.375 | 0.367 | 0.351 | 0.370 | 0.373 | 0.376 |
| Otago            | 0.340 | 0.360 | 0.367 | 0.380 | 0.398 | 0.418 | 0.429 | 0.444 | 0.458 | 0.473 |
| South Otago      | 0.295 | 0.313 | 0.311 | 0.344 | 0.363 | 0.371 | 0.377 | 0.398 | 0.413 | 0.428 |
| Maniototo        | 0.336 | 0.384 | 0.336 | 0.340 | 0.350 | 0.401 | 0.413 | 0.406 | 0.416 | 0.426 |
| Vincent          | 0.345 | 0.397 | 0.348 | 0.384 | 0.383 | 0.452 | 0.448 | 0.459 | 0.475 | 0.491 |
| Southland        | 0.347 | 0.351 | 0.376 | 0.378 | 0.398 | 0.415 | 0.403 | 0.427 | 0.438 | 0.449 |
| South Island     | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    | NA    |
| NEW ZEALAND      | NA    | 0.371 | 0.380 | 0.392 | 0.402 | 0.410 | 0.421 | NA    | NA    | NA    |

Source: See chapters 3 and 5 for details of definition and estimation.



TABLE A-21  
HOSPITAL STATISTICS, NEW ZEALAND 1962-71

| Hospital Board   | 1962   | 1963   | 1964   | 1965   | 1966   | 1967   | 1968   | 1969   | 1970   | 1971   |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  | (000)  |
| Northland        | 87.0   | 88.3   | 89.4   | 90.7   | 93.1   | 93.0   | 94.3   | 94.3   | 94.6   | 95.9   |
| Auckland         | 521.6  | 540.8  | 557.6  | 575.2  | 612.2  | 621.4  | 637.0  | 648.2  | 662.4  | 696.3  |
| Waikato          | 240.7  | 247.0  | 251.9  | 256.2  | 263.9  | 269.1  | 276.2  | 279.7  | 283.6  | 289.3  |
| Thames           | 27.3   | 27.4   | 27.5   | 27.5   | 28.3   | 28.4   | 28.5   | 28.5   | 28.6   | 28.9   |
| Tairāngā         | 41.9   | 44.0   | 45.8   | 47.3   | 48.4   | 49.0   | 50.1   | 50.8   | 51.7   | 55.9   |
| Whakatane        | 30.7   | 32.4   | 33.3   | 34.3   | 33.8   | 33.6   | 33.3   | 33.3   | 33.8   | 33.8   |
| Opotiki          | 7.5    | 7.5    | 7.6    | 7.7    | 7.2    | 7.1    | 7.0    | 7.0    | 6.9    | 6.6    |
| Waiau            | 7.5    | 7.5    | 7.4    | 7.2    | 5.9    | 5.8    | 5.6    | 5.4    | 5.2    | 5.0    |
| Cook             | 36.3   | 36.7   | 37.1   | 37.5   | 38.3   | 38.5   | 38.9   | 39.0   | 39.4   | 39.9   |
| Waikōa           | 12.0   | 12.1   | 12.1   | 12.2   | 11.7   | 11.7   | 11.6   | 11.5   | 11.5   | 11.3   |
| Hawkes Bay       | 78.9   | 81.9   | 84.0   | 86.2   | 88.1   | 89.2   | 90.8   | 92.1   | 93.7   | 98.2   |
| Tairārumui       | 15.5   | 15.7   | 15.8   | 15.9   | 14.9   | 15.0   | 15.2   | 15.3   | 15.3   | 13.5   |
| Waipara          | 13.7   | 13.9   | 13.9   | 13.9   | 13.9   | 13.9   | 13.9   | 13.9   | 13.8   | 13.1   |
| Dannevirke       | 13.4   | 13.4   | 13.4   | 13.4   | 13.2   | 13.2   | 13.2   | 13.1   | 13.1   | 12.5   |
| Taranaki         | 90.1   | 91.6   | 92.5   | 93.3   | 91.9   | 91.9   | 92.0   | 92.0   | 92.4   | 92.9   |
| Manawatu         | 74.4   | 75.7   | 76.9   | 78.0   | 76.6   | 76.4   | 76.1   | 75.8   | 75.8   | 74.5   |
| Palmerston North | 97.3   | 99.9   | 102.4  | 104.7  | 106.5  | 107.3  | 108.4  | 108.9  | 110.3  | 113.1  |
| Wellington       | 263.3  | 270.1  | 276.3  | 283.5  | 295.8  | 299.4  | 304.6  | 303.0  | 312.6  | 320.7  |
| Wairarapa        | 43.4   | 44.1   | 44.5   | 45.0   | 45.2   | 45.3   | 45.4   | 45.3   | 45.5   | 45.1   |
| North Island     | 1702.3 | 1749.8 | 1789.5 | 1829.7 | 1889.0 | 1909.1 | 1941.8 | 1962.0 | 1990.0 | 2046.5 |
| Marlborough      | 25.0   | 25.6   | 26.1   | 26.5   | 26.6   | 26.8   | 27.2   | 27.4   | 27.6   | 28.6   |
| North Canterbury | 274.0  | 281.0  | 284.5  | 292.9  | 299.5  | 302.9  | 307.4  | 309.6  | 311.7  | 319.1  |
| Nelson           | 50.6   | 52.0   | 52.9   | 54.0   | 55.0   | 55.5   | 56.1   | 56.3   | 56.7   | 58.0   |
| West Coast       | 37.3   | 37.3   | 37.3   | 37.5   | 36.1   | 36.1   | 35.9   | 35.5   | 35.1   | 33.1   |
| Ashburton        | 23.4   | 23.9   | 24.1   | 24.4   | 24.3   | 24.5   | 24.6   | 24.5   | 24.6   | 24.5   |
| South Canterbury | 52.8   | 53.5   | 53.8   | 54.2   | 54.2   | 54.4   | 54.6   | 54.5   | 54.5   | 56.6   |
| Waitaki          | 24.1   | 24.9   | 25.9   | 27.0   | 25.5   | 25.5   | 24.9   | 23.6   | 23.4   | 22.5   |
| Otago            | 121.8  | 123.4  | 124.4  | 125.5  | 124.7  | 125.1  | 125.4  | 125.3  | 125.1  | 126.5  |
| South Otago      | 17.2   | 17.4   | 17.6   | 17.7   | 17.5   | 17.6   | 17.6   | 17.5   | 17.4   | 17.1   |
| Maniototo        | 3.0    | 3.0    | 3.0    | 3.0    | 2.9    | 2.9    | 2.9    | 2.9    | 2.8    | 2.7    |
| Vincent          | 7.3    | 7.4    | 7.6    | 7.8    | 8.3    | 8.4    | 8.5    | 8.6    | 8.7    | 8.5    |
| Southland        | 97.7   | 100.0  | 102.1  | 104.6  | 106.5  | 108.1  | 110.3  | 111.3  | 111.1  | 111.1  |
| South Island     | 734.2  | 749.3  | 761.2  | 775.0  | 781.2  | 787.7  | 795.3  | 796.0  | 798.6  | 808.4  |
| NEW ZEALAND      | 2436.5 | 2499.1 | 2550.6 | 2604.7 | 2670.2 | 2696.8 | 2737.1 | 2758.1 | 2788.5 | 2854.9 |

Source: NZ Department of Health, Hospital Statistics, Wellington, for years 1962-71 (Table 1).

TABLE A-21  
POPULATION DENSITY PER SQUARE KILOMETRE, NEW ZEALAND REGIONAL BOARDS 1962-71

| Hospital Board   | Area in Square<br>Kilometres | 1962  | 1963  | 1964  | 1965  | 1966  | 1967  | 1968  | 1969  | 1970  | 1971  |
|------------------|------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Northland        | 12519                        | 6.9   | 7.1   | 7.1   | 7.2   | 7.4   | 7.4   | 7.5   | 7.5   | 7.6   | 7.7   |
| Auckland         | 4669                         | 111.7 | 115.8 | 119.4 | 123.2 | 131.1 | 133.1 | 136.4 | 138.8 | 141.9 | 149.1 |
| Waikato          | 24192                        | 9.9   | 10.2  | 10.4  | 10.6  | 10.9  | 11.1  | 11.4  | 11.6  | 11.7  | 12.0  |
| Tairāra          | 3403                         | 8.0   | 8.0   | 8.1   | 8.1   | 8.3   | 8.3   | 8.4   | 8.4   | 8.4   | 8.5   |
| Tauranga         | 1829                         | 22.9  | 24.0  | 25.0  | 25.8  | 26.5  | 26.8  | 27.4  | 27.8  | 28.3  | 30.6  |
| Whakatane        | 4196                         | 7.3   | 7.7   | 7.9   | 8.2   | 8.1   | 8.0   | 7.9   | 7.9   | 8.1   | 8.1   |
| Opotiki          | 3124                         | 2.4   | 2.4   | 2.4   | 2.5   | 2.3   | 2.3   | 2.3   | 2.2   | 2.2   | 2.1   |
| Waipā            | 2818                         | 2.7   | 2.6   | 2.6   | 2.6   | 2.1   | 2.0   | 2.0   | 1.9   | 1.8   | 1.8   |
| Cook             | 5502                         | 6.6   | 6.7   | 6.7   | 6.8   | 7.0   | 7.0   | 7.1   | 7.1   | 7.2   | 7.3   |
| Hawke Bay        | 4128                         | 2.9   | 2.9   | 2.9   | 2.9   | 2.8   | 2.8   | 2.8   | 2.8   | 2.8   | 2.7   |
| Hawkes Bay       | 4846                         | 16.3  | 17.0  | 17.3  | 17.8  | 18.2  | 18.4  | 18.7  | 19.0  | 19.3  | 20.3  |
| Tairāra          | 4851                         | 3.2   | 3.2   | 3.3   | 3.3   | 3.1   | 3.1   | 3.1   | 3.1   | 3.1   | 2.8   |
| Waipā            | 3375                         | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 3.9   |
| Dannevirke       | 1818                         | 7.3   | 7.4   | 7.4   | 7.4   | 7.3   | 7.3   | 7.2   | 7.2   | 7.2   | 6.9   |
| Taranaki         | 6308                         | 14.3  | 14.5  | 14.7  | 14.8  | 14.6  | 14.6  | 14.6  | 14.6  | 14.6  | 14.7  |
| Wanganui         | 10562                        | 7.0   | 7.2   | 7.3   | 7.4   | 7.3   | 7.2   | 7.2   | 7.2   | 7.2   | 7.1   |
| Palmerston North | 4649                         | 20.9  | 21.5  | 22.0  | 22.5  | 22.9  | 23.1  | 23.3  | 23.4  | 23.7  | 24.3  |
| Wellington       | 1357                         | 194.1 | 199.0 | 203.6 | 208.9 | 218.0 | 220.6 | 224.4 | 227.0 | 230.4 | 236.3 |
| Wairarapa        | 8397                         | 5.2   | 5.2   | 5.3   | 5.4   | 5.4   | 5.4   | 5.4   | 5.4   | 5.4   | 5.4   |
| North Island     | 112543                       | 15.1  | 15.5  | 15.9  | 16.3  | 16.8  | 17.0  | 17.3  | 17.4  | 17.7  | 18.2  |
| Marlborough      | 10515                        | 2.4   | 2.4   | 2.5   | 2.5   | 2.5   | 2.5   | 2.6   | 2.6   | 2.6   | 2.7   |
| North Canterbury | 21534                        | 12.7  | 13.0  | 13.3  | 13.6  | 13.9  | 14.0  | 14.2  | 14.3  | 14.4  | 14.8  |
| Nelson           | 10129                        | 5.0   | 5.1   | 5.2   | 5.3   | 5.4   | 5.5   | 5.5   | 5.6   | 5.6   | 5.7   |
| West Coast       | 22857                        | 1.6   | 1.6   | 1.6   | 1.6   | 1.6   | 1.6   | 1.6   | 1.6   | 1.5   | 1.4   |
| Ashburton        | 6177                         | 3.8   | 3.9   | 3.9   | 3.9   | 3.9   | 4.0   | 4.0   | 4.0   | 4.0   | 4.0   |
| South Canterbury | 13694                        | 3.9   | 3.9   | 3.9   | 4.0   | 4.0   | 4.0   | 4.0   | 4.0   | 4.0   | 4.1   |
| Waitaki          | 6250                         | 3.9   | 4.0   | 4.1   | 4.3   | 4.1   | 4.1   | 4.0   | 3.8   | 3.7   | 3.6   |
| Otago            | 7623                         | 16.0  | 16.2  | 16.3  | 16.5  | 16.4  | 16.4  | 16.5  | 16.4  | 16.4  | 16.6  |
| South Otago      | 4061                         | 4.2   | 4.3   | 4.3   | 4.4   | 4.3   | 4.3   | 4.3   | 4.3   | 4.3   | 4.2   |
| Maniototo        | 3471                         | 0.9   | 0.9   | 0.9   | 0.9   | 0.8   | 0.8   | 0.8   | 0.8   | 0.8   | 0.8   |
| Vincent          | 7568                         | 1.0   | 1.0   | 1.0   | 1.0   | 1.1   | 1.1   | 1.1   | 1.1   | 1.1   | 1.1   |
| Southland        | 38876                        | 2.5   | 2.6   | 2.6   | 2.7   | 2.7   | 2.8   | 2.8   | 2.9   | 2.9   | 2.9   |
| South Island     | 152815                       | 4.8   | 4.9   | 5.0   | 5.1   | 5.1   | 5.2   | 5.2   | 5.2   | 5.2   | 5.3   |
| NEW ZEALAND      | 265358                       | 9.2   | 9.4   | 9.6   | 9.8   | 10.1  | 10.2  | 10.3  | 10.4  | 10.5  | 10.8  |

Sources: (i) Department of Statistics, Census of Population and Dwellings, Wellington, Government Printer (1971), Vol. 1  
(ii) Data appendix Table A-20.

TABLE 22  
POPULATION PER HOSPITAL BED, NEW ZEALAND AND THE ISLANDS 1962-74

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 134  | 116  | 119  | 122  | 113  | 115  | 116  | 116  | 118  | 115  |
| Auckland         | 223  | 239  | 245  | 236  | 241  | 228  | 230  | 227  | 225  | 234  |
| Waikato          | 132  | 132  | 137  | 131  | 174  | 176  | 186  | 171  | 151  | 159  |
| Tairātea         | 106  | 93   | 89   | 81   | 83   | 84   | 84   | 84   | 86   | 87   |
| Tairātea         | 165  | 163  | 170  | 149  | 150  | 140  | 142  | 144  | 148  | 161  |
| Waikato          | 224  | 236  | 168  | 203  | 181  | 180  | 178  | 178  | 131  | 180  |
| Otago            | 99   | 100  | 124  | 127  | 117  | 116  | 107  | 105  | 104  | 99   |
| Wairarapa        | 156  | 155  | 154  | 163  | 133  | 131  | 126  | 122  | 117  | 113  |
| Cook             | 100  | 102  | 101  | 101  | 104  | 104  | 107  | 110  | 99   | 101  |
| Wairoa           | 91   | 92   | 96   | 96   | 93   | 93   | 89   | 88   | 87   | 86   |
| Hawkes Bay       | 122  | 127  | 135  | 134  | 135  | 142  | 144  | 147  | 147  | 147  |
| Tairātea         | 121  | 122  | 123  | 124  | 99   | 99   | 101  | 101  | 101  | 90   |
| Waipawa          | 76   | 88   | 86   | 86   | 86   | 82   | 85   | 84   | 88   | 83   |
| Dannevirke       | 90   | 85   | 95   | 95   | 93   | 93   | 93   | 92   | 95   | 81   |
| Tairātea         | 135  | 137  | 139  | 140  | 138  | 138  | 140  | 138  | 135  | 136  |
| Wairarapa        | 143  | 144  | 141  | 139  | 139  | 138  | 141  | 140  | 140  | 135  |
| Palmerston North | 132  | 135  | 143  | 153  | 156  | 159  | 149  | 150  | 152  | 156  |
| Wellington       | 148  | 159  | 164  | 170  | 174  | 162  | 162  | 162  | 159  | 168  |
| Wairarapa        | 123  | 125  | 138  | 134  | 134  | 135  | 135  | 139  | 130  | 129  |
| North Island     | 159  | 162  | 167  | 166  | 167  | 163  | 165  | 163  | 161  | 164  |
| Marlborough      | 89   | 91   | 98   | 99   | 100  | 100  | 102  | 103  | 103  | 107  |
| North Canterbury | 177  | 187  | 192  | 188  | 189  | 191  | 192  | 196  | 204  | 209  |
| Nelson           | 126  | 130  | 135  | 144  | 148  | 152  | 152  | 167  | 158  | 168  |
| West Coast       | 83   | 85   | 84   | 82   | 80   | 80   | 80   | 85   | 78   | 72   |
| Ashburton        | 115  | 117  | 118  | 151  | 150  | 151  | 156  | 162  | 189  | 98   |
| South Canterbury | 118  | 116  | 117  | 120  | 117  | 119  | 116  | 114  | 114  | 118  |
| Waitaki          | 104  | 108  | 121  | 125  | 112  | 111  | 119  | 112  | 111  | 104  |
| Otago            | 127  | 131  | 140  | 141  | 137  | 137  | 141  | 137  | 137  | 138  |
| South Otago      | 84   | 85   | 89   | 86   | 85   | 85   | 86   | 85   | 82   | 86   |
| Maniototo        | 118  | 118  | 118  | 118  | 107  | 107  | 106  | 106  | 104  | 83   |
| Vincent          | 90   | 82   | 91   | 93   | 100  | 101  | 98   | 100  | 101  | 99   |
| Southland        | 142  | 145  | 148  | 148  | 153  | 156  | 159  | 162  | 160  | 158  |
| South Island     | 133  | 137  | 142  | 144  | 143  | 145  | 147  | 149  | 145  | 147  |
| NEW ZEALAND      | 150  | 154  | 158  | 159  | 159  | 157  | 159  | 159  | 156  | 159  |

Source: Calculated from other tables - Population numbers per year divided by public hospital bed numbers per year.

ANNUAL RETURNS OF PAYMENTS TO MEDICAL PRACTITIONERS, NEW ZEALAND 1962-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 62   | 61   | 62   | 74   | 62   | 61   | 62   | 65   | 53   | 61   |
| Auckland         | 526  | 536  | 536  | 552  | 567  | 590  | 610  | 628  | 627  | 665  |
| Waikato          | 175  | 170  | 167  | 164  | 169  | 163  | 179  | 196  | 213  | 237  |
| Tairātea         | 16   | 16   | 17   | 17   | 18   | 16   | 17   | 17   | 22   | 20   |
| Tauranga         | 41   | 38   | 37   | 38   | 38   | 45   | 46   | 42   | 46   | 46   |
| Waikātane        | 16   | 18   | 15   | 16   | 15   | 16   | 13   | 13   | 13   | 13   |
| Opotiki          | 4    | 4    | 4    | 4    | 3    | 4    | 3    | 3    | 3    | 5    |
| Waipā            | 2    | 2    | 2    | 3    | 2    | 2    | 2    | 2    | 2    | 2    |
| Cook             | 25   | 27   | 25   | 27   | 27   | 27   | 29   | 28   | 33   | 29   |
| Waioa            | 4    | 4    | 5    | 5    | 5    | 5    | 5    | 4    | 4    | 3    |
| Hawkes Bay       | 70   | 65   | 69   | 68   | 68   | 65   | 68   | 65   | 62   | 61   |
| Tairānui         | 8    | 6    | 6    | 6    | 6    | 5    | 6    | 7    | 5    | 6    |
| Waipā            | 9    | 6    | 6    | 6    | 6    | 7    | 8    | 7    | 7    | 8    |
| Dannevirke       | 10   | 11   | 9    | 9    | 9    | 10   | 9    | 8    | 7    | 11   |
| Taranaki         | 56   | 60   | 64   | 63   | 58   | 59   | 60   | 56   | 61   | 58   |
| Wanganui         | 48   | 53   | 52   | 52   | 55   | 51   | 47   | 48   | 44   | 53   |
| Palmerston North | 61   | 68   | 63   | 65   | 66   | 71   | 72   | 81   | 81   | 89   |
| Wellington       | 224  | 232  | 247  | 253  | 237  | 252  | 273  | 271  | 270  | 273  |
| Wairarapa        | 26   | 25   | 31   | 34   | 28   | 25   | 23   | 26   | 26   | 26   |
| North Island     | 1383 | 1412 | 1417 | 1456 | 1439 | 1474 | 1532 | 1567 | 1584 | 1676 |
| Marlborough      | 14   | 15   | 16   | 14   | 14   | 14   | 18   | 17   | 14   | 16   |
| North Canterbury | 229  | 232  | 237  | 230  | 243  | 237  | 238  | 248  | 265  | 267  |
| Nelson           | 47   | 47   | 43   | 43   | 44   | 42   | 45   | 47   | 47   | 49   |
| West Coast       | 21   | 20   | 22   | 24   | 21   | 20   | 18   | 16   | 18   | 16   |
| Ashburton        | 15   | 15   | 13   | 13   | 14   | 13   | 13   | 13   | 14   | 12   |
| South Canterbury | 39   | 38   | 37   | 33   | 35   | 33   | 33   | 32   | 33   | 37   |
| Waitaki          | 16   | 15   | 14   | 15   | 12   | 13   | 14   | 16   | 13   | 12   |
| Otago            | 126  | 125  | 123  | 125  | 124  | 125  | 141  | 130  | 149  | 157  |
| South Otago      | 9    | 9    | 10   | 10   | 7    | 10   | 9    | 14   | 9    | 9    |
| Maniototo        | 2    | 2    | 2    | 2    | 4    | 2    | 2    | 1    | 1    | 2    |
| Vincent          | 4    | 3    | 5    | 3    | 2    | 4    | 5    | 6    | 4    | 6    |
| Southland        | 65   | 63   | 67   | 59   | 59   | 64   | 70   | 73   | 62   | 61   |
| South Island     | 587  | 584  | 589  | 571  | 579  | 577  | 606  | 613  | 629  | 644  |
| NEW ZEALAND      | 1970 | 1996 | 2006 | 2027 | 2018 | 2051 | 2135 | 2130 | 2213 | 2320 |

Source: NZ Department of Health, Annual Returns of payments to Medical Practitioners, Unpublished statistics, Wellington, for years 1962-71

TABLE A-24  
MEDICAL PRACTITIONER NUMBERS PER 10,000 POPULATION, NEW ZEALAND HOSPITAL BOARD 1961-71

| Hospital Board   | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 |
|------------------|------|------|------|------|------|------|------|------|------|------|
| Northland        | 7.1  | 6.9  | 6.9  | 8.2  | 6.7  | 6.6  | 6.6  | 6.9  | 6.1  | 6.4  |
| Auckland         | 10.1 | 9.9  | 9.6  | 9.6  | 9.3  | 9.5  | 9.6  | 9.7  | 9.5  | 9.6  |
| Waikato          | 7.3  | 6.9  | 6.6  | 6.4  | 6.4  | 6.1  | 6.5  | 7.0  | 7.5  | 8.2  |
| Thames           | 5.9  | 5.8  | 6.2  | 6.2  | 6.4  | 5.6  | 6.0  | 6.0  | 7.7  | 6.9  |
| Tauranga         | 9.8  | 8.6  | 8.1  | 8.0  | 7.9  | 9.2  | 9.2  | 8.3  | 8.9  | 8.2  |
| Whakatane        | 5.2  | 5.6  | 4.5  | 4.7  | 4.4  | 4.7  | 3.9  | 3.9  | 3.8  | 5.3  |
| Opotiki          | 5.4  | 5.3  | 5.3  | 5.2  | 4.2  | 5.6  | 4.3  | 4.3  | 4.4  | 7.6  |
| Waipatu          | 2.7  | 2.7  | 2.7  | 4.2  | 3.4  | 3.5  | 3.6  | 3.7  | 3.9  | 4.0  |
| Cook             | 6.9  | 7.4  | 6.7  | 7.2  | 7.0  | 7.0  | 7.5  | 7.2  | 8.4  | 7.3  |
| Wairoa           | 3.3  | 3.3  | 4.1  | 4.1  | 4.3  | 4.3  | 4.3  | 3.5  | 3.5  | 2.7  |
| Hawkes Bay       | 8.9  | 7.9  | 8.2  | 7.9  | 7.7  | 7.3  | 7.5  | 7.1  | 6.6  | 6.2  |
| Tairāhuru        | 5.2  | 3.8  | 3.8  | 3.8  | 4.0  | 3.3  | 4.0  | 4.6  | 3.3  | 4.4  |
| Waipawa          | 6.6  | 4.3  | 4.3  | 4.3  | 4.3  | 5.0  | 5.8  | 5.1  | 5.1  | 6.1  |
| Dannevirke       | 7.5  | 8.2  | 6.7  | 6.7  | 6.8  | 7.6  | 6.8  | 6.1  | 5.4  | 8.8  |
| Taranaki         | 6.2  | 6.6  | 6.9  | 6.7  | 6.3  | 6.4  | 6.5  | 6.1  | 6.6  | 6.2  |
| Wanganui         | 6.4  | 7.0  | 6.8  | 6.7  | 7.2  | 6.7  | 6.2  | 6.3  | 5.8  | 7.1  |
| Palmerston North | 6.3  | 6.8  | 6.2  | 6.2  | 6.2  | 6.6  | 6.6  | 7.4  | 7.3  | 7.9  |
| Wellington       | 8.5  | 8.6  | 8.9  | 8.9  | 8.0  | 8.4  | 9.0  | 8.8  | 8.6  | 8.7  |
| Wairarapa        | 6.0  | 5.7  | 7.0  | 7.6  | 6.2  | 5.5  | 5.1  | 5.7  | 5.7  | 5.8  |
| North Island     | 8.1  | 8.1  | 7.9  | 8.0  | 7.6  | 7.7  | 7.9  | 8.0  | 8.0  | 8.2  |
| Marlborough      | 5.6  | 5.9  | 6.1  | 5.3  | 5.3  | 5.2  | 6.6  | 6.2  | 5.1  | 5.6  |
| North Canterbury | 8.4  | 8.3  | 8.3  | 7.9  | 8.1  | 7.8  | 7.7  | 8.0  | 8.5  | 8.4  |
| Nelson           | 9.3  | 9.0  | 8.1  | 8.0  | 8.0  | 7.6  | 8.0  | 8.3  | 8.3  | 8.4  |
| West Coast       | 5.6  | 5.4  | 5.9  | 6.4  | 5.8  | 5.5  | 5.0  | 4.5  | 5.1  | 4.8  |
| Ashburton        | 6.4  | 6.3  | 5.4  | 5.3  | 5.8  | 5.3  | 5.3  | 5.3  | 5.7  | 4.9  |
| South Canterbury | 7.4  | 7.1  | 6.9  | 6.1  | 6.5  | 6.1  | 6.0  | 5.9  | 6.1  | 6.5  |
| Waitaki          | 6.6  | 6.0  | 5.4  | 5.5  | 4.7  | 5.1  | 5.6  | 6.8  | 5.6  | 5.3  |
| Otago            | 10.3 | 10.1 | 9.9  | 10.0 | 9.9  | 10.0 | 11.2 | 10.4 | 11.9 | 12.4 |
| South Otago      | 5.2  | 5.2  | 5.7  | 5.6  | 4.0  | 5.7  | 5.1  | 8.0  | 5.2  | 5.3  |
| Maniototo        | 6.8  | 6.8  | 6.8  | 6.8  | 13.9 | 6.9  | 7.0  | 3.5  | 3.6  | 7.3  |
| Vincent          | 5.5  | 4.0  | 6.6  | 3.9  | 2.4  | 4.8  | 5.9  | 7.0  | 4.6  | 7.0  |
| Southland        | 6.7  | 6.3  | 6.6  | 5.6  | 5.5  | 5.9  | 6.3  | 6.6  | 5.6  | 5.5  |
| South Island     | 8.0  | 7.8  | 7.7  | 7.4  | 7.4  | 7.3  | 7.6  | 7.7  | 7.9  | 8.0  |
| NEW ZEALAND      | 8.1  | 8.0  | 7.9  | 7.8  | 7.6  | 7.6  | 7.8  | 7.9  | 7.9  | 8.1  |

Source: Calculated from other tables - Medical practitioner numbers per year divided by population numbers per year, times 10,000.

TABLE A-25

## HOSPITAL COST FUNCTION VARIABLES FOR NEW ZEALAND PUBLIC GENERAL HOSPITALS 1969

| Hospital             | Dependent Variables                      |                                                    |                                                      |                                                     |                                                 | Independent Variables          |                                |                                             |                                                                   |                                                                             |
|----------------------|------------------------------------------|----------------------------------------------------|------------------------------------------------------|-----------------------------------------------------|-------------------------------------------------|--------------------------------|--------------------------------|---------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                      | Average <sup>a</sup><br>Cost per<br>Case | Average <sup>a</sup><br>Cost per<br>Patient<br>Day | Proportion <sup>b</sup><br>of Patients<br>14 & under | Proportion <sup>b</sup><br>of Patients<br>65 & over | Average <sup>a</sup><br>Length of<br>Stay(days) | Occupancy <sup>a</sup><br>Rate | Case Flow <sup>a</sup><br>Rate | Number of <sup>a</sup><br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients under-<br>going Operations | Outpatient <sup>a</sup><br>Expenses as a<br>Proportion of<br>Total Expenses |
|                      | \$                                       | \$                                                 | %                                                    | %                                                   |                                                 | %                              |                                |                                             | %                                                                 | %                                                                           |
| 01 Wellington        | 243.6                                    | 18.7                                               | 25.0                                                 | 16.1                                                | 13.0                                            | 79.1                           | 21.2                           | 953                                         | 35.0                                                              | 12.7                                                                        |
| 02 Waikato           | 263.2                                    | 16.9                                               | 27.8                                                 | 16.4                                                | 15.6                                            | 95.9                           | 19.2                           | 796                                         | 36.9                                                              | 10.7                                                                        |
| 03 Middlemore        | 275.8                                    | 18.2                                               | 18.5                                                 | 18.6                                                | 15.1                                            | 81.2                           | 18.6                           | 703                                         | 44.7                                                              | 10.7                                                                        |
| 04 Auckland          | 267.9                                    | 23.2                                               | 36.9                                                 | 14.5                                                | 11.5                                            | 82.7                           | 26.0                           | 536                                         | 29.6                                                              | 20.8                                                                        |
| 05 Palmerston North  | 235.1                                    | 18.0                                               | 23.7                                                 | 20.6                                                | 13.1                                            | 84.9                           | 20.5                           | 487                                         | 38.7                                                              | 7.5                                                                         |
| 06 Green Lane        | 283.1                                    | 20.6                                               | 17.1                                                 | 20.8                                                | 13.8                                            | 80.4                           | 20.7                           | 478                                         | 46.9                                                              | 14.4                                                                        |
| 07 Lower Hutt        | 182.0                                    | 16.3                                               | 27.8                                                 | 15.4                                                | 11.2                                            | 78.7                           | 22.3                           | 466                                         | 41.7                                                              | 10.9                                                                        |
| 08 Christchurch      | 240.5                                    | 23.4                                               | 27.8                                                 | 20.4                                                | 10.3                                            | 87.1                           | 27.6                           | 427                                         | 37.1                                                              | 20.1                                                                        |
| 09 Dunedin           | 331.4                                    | 29.1                                               | 12.3                                                 | 18.9                                                | 11.4                                            | 78.1                           | 21.4                           | 433                                         | 46.5                                                              | 15.6                                                                        |
| 10 Tauranga          | 225.1                                    | 16.2                                               | 24.5                                                 | 19.3                                                | 13.9                                            | 83.4                           | 18.9                           | 326                                         | 35.1                                                              | 5.4                                                                         |
| 11 Rotorua           | 229.0                                    | 18.1                                               | 34.4                                                 | 11.2                                                | 12.7                                            | 80.4                           | 19.9                           | 326                                         | 32.1                                                              | 8.0                                                                         |
| 12 Whangarei         | 298.5                                    | 18.1                                               | 25.0                                                 | 18.6                                                | 16.5                                            | 81.0                           | 15.3                           | 319                                         | 36.2                                                              | 5.5                                                                         |
| 13 Hastings Memorial | 206.4                                    | 14.8                                               | 26.1                                                 | 17.6                                                | 14.0                                            | 78.8                           | 20.0                           | 293                                         | 29.5                                                              | 7.9                                                                         |
| 14 Nelson            | 252.1                                    | 18.0                                               | 21.6                                                 | 20.2                                                | 14.0                                            | 88.2                           | 17.9                           | 269                                         | 37.4                                                              | 6.2                                                                         |
| 15 Kew               | 214.4                                    | 18.4                                               | 22.4                                                 | 15.5                                                | 11.6                                            | 82.4                           | 24.6                           | 280                                         | 37.5                                                              | 8.0                                                                         |
| 16 Napier            | 211.4                                    | 14.3                                               | 24.8                                                 | 22.1                                                | 14.8                                            | 79.3                           | 19.6                           | 272                                         | 42.6                                                              | 7.2                                                                         |
| 17 Princess Margaret | 261.4                                    | 22.6                                               | 6.6                                                  | 27.7                                                | 11.6                                            | 86.5                           | 24.6                           | 252                                         | 33.9                                                              | 1.1                                                                         |
| 18 Wanganui          | 273.3                                    | 18.1                                               | 24.4                                                 | 20.7                                                | 15.1                                            | 76.2                           | 16.7                           | 283                                         | 36.6                                                              | 4.0                                                                         |
| 19 Timaru            | 222.8                                    | 17.1                                               | 23.1                                                 | 19.4                                                | 13.0                                            | 82.1                           | 20.6                           | 257                                         | 39.2                                                              | 5.6                                                                         |
| 20 Burwood           | 338.8                                    | 13.6                                               | 29.2                                                 | 25.0                                                | 24.9                                            | 79.0                           | 11.4                           | 277                                         | 48.0                                                              | 0.2                                                                         |
| 21 New Plymouth      | 225.8                                    | 20.1                                               | 26.7                                                 | 19.2                                                | 11.2                                            | 85.2                           | 22.5                           | 241                                         | 45.2                                                              | 6.9                                                                         |
| 22 Cook              | 282.2                                    | 17.4                                               | 27.4                                                 | 18.6                                                | 16.2                                            | 78.6                           | 15.2                           | 272                                         | 30.1                                                              | 7.5                                                                         |
| 23 Wakari            | 224.0                                    | 15.6                                               | 31.4                                                 | 22.4                                                | 14.4                                            | 80.1                           | 19.0                           | 236                                         | 27.3                                                              | 6.3                                                                         |
| 24 Thames            | 247.5                                    | 14.7                                               | 21.2                                                 | 22.1                                                | 16.9                                            | 73.6                           | 13.0                           | 204                                         | 40.0                                                              | 5.4                                                                         |
| 25 Masterton         | 215.3                                    | 17.7                                               | 27.7                                                 | 17.5                                                | 12.1                                            | 71.9                           | 19.4                           | 182                                         | 31.9                                                              | 8.5                                                                         |

TABLE A-25 Cont'd

| Hospital      | Average <sup>a</sup><br>Cost per<br>Case<br>\$ | Average <sup>a</sup><br>Cost per<br>Patient<br>Day<br>\$ | Proportion <sup>b</sup><br>of Patients<br>14 & under<br>% | Proportion <sup>b</sup><br>of Patients<br>65 & over<br>% | Average <sup>a</sup><br>Length of<br>Stay(days)<br>% | Occupancy <sup>a</sup><br>Rate<br>% | Case Flow <sup>a</sup><br>Rate | Number of <sup>a</sup><br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients under-<br>going Operations<br>% | Outpatient <sup>b</sup><br>Expenses as a<br>Proportion of<br>Total Expenses<br>% |
|---------------|------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------|-------------------------------------|--------------------------------|---------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 26 Wairau     | 246.1                                          | 15.1                                                     | 25.4                                                      | 16.9                                                     | 16.3                                                 | 82.1                                | 16.9                           | 178                                         | 37.3                                                                   | 5.8                                                                              |
| 27 Whakatane  | 186.3                                          | 16.1                                                     | 33.7                                                      | 9.7                                                      | 11.6                                                 | 76.8                                | 21.6                           | 171                                         | 33.9                                                                   | 2.2                                                                              |
| 28 Coronation | 1522.0                                         | 10.6                                                     | 0.7                                                       | 68.4                                                     | 144.2                                                | 90.1                                | 1.7                            | 145                                         | 7.9                                                                    | 4.4                                                                              |
| 29 Oamaru     | 268.8                                          | 17.8                                                     | 20.5                                                      | 25.3                                                     | 15.1                                                 | 69.2                                | 14.3                           | 156                                         | 40.5                                                                   | 4.7                                                                              |
| 30 Dannevirke | 295.7                                          | 17.8                                                     | 27.2                                                      | 21.8                                                     | 16.7                                                 | 65.1                                | 11.3                           | 138                                         | 35.7                                                                   | 3.3                                                                              |
| 31 Taumarunui | 233.6                                          | 21.1                                                     | 33.1                                                      | 7.7                                                      | 11.1                                                 | 73.2                                | 17.9                           | 139                                         | 40.0                                                                   | 4.1                                                                              |
| 32 Ashburton  | 298.4                                          | 15.4                                                     | 27.9                                                      | 22.4                                                     | 19.4                                                 | 86.0                                | 14.2                           | 151                                         | 19.9                                                                   | 3.6                                                                              |
| 33 Haveria    | 264.3                                          | 21.2                                                     | 30.5                                                      | 16.5                                                     | 12.5                                                 | 62.3                                | 13.4                           | 130                                         | 32.2                                                                   | 9.7                                                                              |
| 34 Grey       | 268.8                                          | 19.1                                                     | 20.4                                                      | 20.1                                                     | 14.1                                                 | 87.5                                | 22.5                           | 95                                          | 40.0                                                                   | 7.9                                                                              |
| 35 Westown    | 489.9                                          | 23.6                                                     | 1.9                                                       | 44.7                                                     | 20.8                                                 | 75.6                                | 7.2                            | 113                                         | 0.4                                                                    | 0.1                                                                              |
| 36 Wairoa     | 224.7                                          | 15.0                                                     | 34.1                                                      | 13.6                                                     | 15.0                                                 | 64.2                                | 12.3                           | 131                                         | 18.1                                                                   | 2.3                                                                              |
| 37 Te Kuiti   | 237.6                                          | 13.6                                                     | 34.9                                                      | 12.2                                                     | 17.5                                                 | 88.0                                | 17.8                           | 89                                          | 39.9                                                                   | 3.2                                                                              |
| 38 Waipukurau | 301.3                                          | 19.1                                                     | 31.8                                                      | 13.4                                                     | 15.8                                                 | 64.4                                | 12.0                           | 117                                         | 30.9                                                                   | 6.0                                                                              |
| 39 Kaitia     | 264.9                                          | 18.5                                                     | 32.7                                                      | 13.4                                                     | 14.3                                                 | 66.2                                | 13.6                           | 114                                         | 34.7                                                                   | 3.0                                                                              |
| 40 Balclutha  | 223.7                                          | 17.2                                                     | 21.7                                                      | 18.5                                                     | 13.0                                                 | 67.1                                | 15.3                           | 134                                         | 36.3                                                                   | 5.4                                                                              |
| 41 Gore       | 175.8                                          | 15.7                                                     | 26.6                                                      | 16.8                                                     | 11.2                                                 | 72.9                                | 21.8                           | 113                                         | 29.9                                                                   | 3.8                                                                              |
| 43 Greytown   | 342.0                                          | 7.5                                                      | 29.5                                                      | 18.3                                                     | 45.4                                                 | 90.4                                | 7.0                            | 74                                          | 44.2                                                                   | 1.0                                                                              |
| 44 Stratford  | 267.3                                          | 22.6                                                     | 28.1                                                      | 17.0                                                     | 11.9                                                 | 70.7                                | 16.8                           | 82                                          | 39.0                                                                   | 6.9                                                                              |
| 45 Dargaville | 172.4                                          | 13.1                                                     | 30.3                                                      | 13.3                                                     | 13.2                                                 | 83.2                                | 20.3                           | 78                                          | 37.9                                                                   | 2.7                                                                              |
| 46 Westland   | 515.7                                          | 18.1                                                     | 20.2                                                      | 18.4                                                     | 28.5                                                 | 69.0                                | 7.6                            | 87                                          | 45.2                                                                   | 1.4                                                                              |
| 47 Waimate    | 384.6                                          | 15.2                                                     | 24.3                                                      | 33.4                                                     | 25.3                                                 | 65.1                                | 8.7                            | 76                                          | 13.5                                                                   | 2.0                                                                              |
| 48 Buller     | 315.8                                          | 15.6                                                     | 23.4                                                      | 23.1                                                     | 20.3                                                 | 73.9                                | 11.8                           | 89                                          | 27.4                                                                   | 8.9                                                                              |
| 49 Kawakawa   | 259.4                                          | 16.2                                                     | 28.2                                                      | 12.1                                                     | 16.0                                                 | 63.3                                | 15.4                           | 79                                          | 26.6                                                                   | 4.0                                                                              |
| 50 Patea      | 188.4                                          | 12.8                                                     | 40.9                                                      | 11.6                                                     | 14.7                                                 | 65.2                                | 16.8                           | 60                                          | 25.0                                                                   | 0.0                                                                              |

TABLE A-25 Cont'd

| Hospital       | Average <sup>a</sup><br>Cost per<br>Case<br>\$ | Average <sup>a</sup><br>Cost per<br>Patient<br>Day<br>\$ | Proportion <sup>b</sup><br>of Patients<br>14 & under<br>% | Proportion <sup>b</sup><br>of Patients<br>65 & over<br>% | Average <sup>a</sup><br>Length of<br>Stay(days)<br>% | Occupancy <sup>a</sup><br>Rate<br>% | Case Flow <sup>a</sup><br>Rate | Number of <sup>a</sup><br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients Under-<br>going Operations<br>% | Outpatient <sup>a</sup><br>Expenses as a<br>Proportion of<br>Total Expenses<br>% |
|----------------|------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------|-------------------------------------|--------------------------------|---------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 51 Waihi       | 257.4                                          | 10.1                                                     | 20.5                                                      | 36.9                                                     | 25.6                                                 | 78.2                                | 11.0                           | 45                                          | 23.4                                                                   | 0.3                                                                              |
| 52 Opotiki     | 204.7                                          | 13.5                                                     | 34.3                                                      | 15.1                                                     | 15.2                                                 | 59.2                                | 13.7                           | 66                                          | 22.6                                                                   | 1.5                                                                              |
| 53 Reefton     | 424.8                                          | 13.7                                                     | 28.0                                                      | 23.5                                                     | 30.9                                                 | 53.6                                | 5.3                            | 58                                          | 3.5                                                                    | 2.8                                                                              |
| 54 Ravehe      | 215.0                                          | 16.2                                                     | 35.4                                                      | 19.1                                                     | 13.3                                                 | 57.1                                | 14.3                           | 51                                          | 6.8                                                                    | 0.0                                                                              |
| 55 Taihape     | 240.3                                          | 28.6                                                     | 36.7                                                      | 11.5                                                     | 8.4                                                  | 51.9                                | 14.4                           | 54                                          | 23.5                                                                   | 2.2                                                                              |
| 56 Te Puia     | 272.0                                          | 21.4                                                     | 31.8                                                      | 15.7                                                     | 12.7                                                 | 68.9                                | 15.5                           | 44                                          | 15.7                                                                   | 7.4                                                                              |
| 57 Te Kopuru   | 1001.2                                         | 56.8                                                     | 0.0                                                       | 96.6                                                     | 17.6                                                 | 69.4                                | 4.2                            | 33                                          | 0.0                                                                    | 0.0                                                                              |
| 58 Ovaka       | 346.1                                          | 6.3                                                      | 5.4                                                       | 72.1                                                     | 54.7                                                 | 63.5                                | 5.0                            | 26                                          | 0.0                                                                    | 0.3                                                                              |
| 59 Pahiatua    | 162.8                                          | 11.6                                                     | 25.0                                                      | 21.2                                                     | 14.0                                                 | 61.5                                | 17.7                           | 41                                          | 40.1                                                                   | 1.7                                                                              |
| 60 Cromwell    | 268.4                                          | 14.3                                                     | 29.7                                                      | 20.1                                                     | 18.7                                                 | 57.1                                | 8.8                            | 45                                          | 12.9                                                                   | 3.2                                                                              |
| 61 Dunstan     | 209.0                                          | 14.8                                                     | 19.8                                                      | 23.7                                                     | 14.2                                                 | 61.0                                | 13.9                           | 41                                          | 34.6                                                                   | 3.3                                                                              |
| 62 Ranfurly    | 242.0                                          | 18.9                                                     | 35.4                                                      | 14.0                                                     | 12.8                                                 | 75.9                                | 13.6                           | 27                                          | 33.0                                                                   | 5.8                                                                              |
| 63 Milton      | 613.2                                          | 9.7                                                      | 4.6                                                       | 72.8                                                     | 63.0                                                 | 72.1                                | 3.3                            | 28                                          | 0.0                                                                    | 0.2                                                                              |
| 64 Kaeo        | 267.5                                          | 20.5                                                     | 37.5                                                      | 16.3                                                     | 13.0                                                 | 58.6                                | 13.2                           | 28                                          | 19.2                                                                   | 0.0                                                                              |
| 65 Oxford      | 742.6                                          | 9.1                                                      | 0.0                                                       | 80.0                                                     | 81.2                                                 | 98.5                                | 3.7                            | 13                                          | 0.0                                                                    | 0.0                                                                              |
| 66 Kaikoura    | 303.6                                          | 21.1                                                     | 24.3                                                      | 16.4                                                     | 14.4                                                 | 47.2                                | 8.3                            | 29                                          | 16.2                                                                   | 0.0                                                                              |
| 67 Waimarino   | 170.3                                          | 23.0                                                     | 37.6                                                      | 14.6                                                     | 7.4                                                  | 41.3                                | 18.2                           | 32                                          | 0.5                                                                    | 3.0                                                                              |
| 68 Coromandel  | 223.8                                          | 19.3                                                     | 20.4                                                      | 31.3                                                     | 11.6                                                 | 53.5                                | 9.5                            | 23                                          | 0.0                                                                    | 1.7                                                                              |
| 69 Tapanui     | 125.8                                          | 13.2                                                     | 3.6                                                       | 38.8                                                     | 9.5                                                  | 15.4                                | 15.8                           | 13                                          | 0.5                                                                    | 0.0                                                                              |
| 70 Lake County | 161.9                                          | 13.7                                                     | 17.5                                                      | 19.1                                                     | 11.8                                                 | 40.6                                | 15.1                           | 17                                          | 12.1                                                                   | 2.7                                                                              |
| 71 Mercury Bay | 273.7                                          | 20.5                                                     | 23.6                                                      | 34.6                                                     | 13.4                                                 | 90.0                                | 15.8                           | 6                                           | 0.0                                                                    | 3.6                                                                              |
| 72 Lawrence    | 286.3                                          | 22.9                                                     | 15.6                                                      | 36.5                                                     | 12.5                                                 | 50.9                                | 10.4                           | 11                                          | 0.0                                                                    | 0.0                                                                              |
| 73 Picton      | 388.9                                          | 25.0                                                     | 1.3                                                       | 72.5                                                     | 15.6                                                 | 41.8                                | 6.6                            | 11                                          | 1.4                                                                    | 0.8                                                                              |
|                | 252.8                                          | 18.2                                                     | 25.6                                                      | 18.1                                                     | 13.9                                                 | 79.2                                | 18.5                           | 181.2                                       | 36.2                                                                   | 9.6                                                                              |

Sources: <sup>a</sup> Derived from New Zealand Department of Health, Hospital Statistics, Wellington (1969).<sup>b</sup> Derived from unpublished data received from the Health Department, Wellington.



TABLE A-25  
HOSPITAL COST FUNCTION VARIABLES FOR NEW ZEALAND PUBLIC GENERAL HOSPITALS 1971.

| Hospital             | Dependent Variables                      |                                                    |                                                           |                                                       | Independent Variables                            |                                |                                |                                             |                                                                   |                                                                             |
|----------------------|------------------------------------------|----------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------|--------------------------------|--------------------------------|---------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                      | Average <sup>a</sup><br>Cost per<br>Case | Average <sup>a</sup><br>Cost per<br>Patient<br>Day | Proportion <sup>b</sup><br>of Patients<br>14 and<br>under | Proportion <sup>b</sup><br>of Patients<br>65 and over | Average <sup>a</sup><br>Length of<br>Stay (days) | Occupancy <sup>a</sup><br>Rate | Case Flow <sup>a</sup><br>Rate | Number of <sup>a</sup><br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients Under-<br>going Operations | Outpatient <sup>a</sup><br>Expenses as<br>a Proportion of<br>Total Expenses |
|                      | \$                                       | \$                                                 | %                                                         | %                                                     |                                                  | %                              |                                |                                             | %                                                                 | %                                                                           |
| 01 Wellington        | 320.2                                    | 26.0                                               | 25.0                                                      | 16.1                                                  | 12.3                                             | 84.6                           | 21.1                           | 925                                         | 36.2                                                              | 14.3                                                                        |
| 02 Waikato           | 349.6                                    | 24.1                                               | 27.8                                                      | 16.4                                                  | 14.5                                             | 84.1                           | 18.3                           | 844                                         | 33.7                                                              | 10.6                                                                        |
| 03 Middlemore        | 365.7                                    | 27.0                                               | 18.5                                                      | 18.6                                                  | 13.5                                             | 87.9                           | 20.1                           | 635                                         | 42.1                                                              | 10.1                                                                        |
| 04 Auckland          | 338.3                                    | 32.2                                               | 36.9                                                      | 14.5                                                  | 10.5                                             | 77.0                           | 26.7                           | 656                                         | 32.3                                                              | 20.6                                                                        |
| 05 Palmerston North  | 302.1                                    | 23.1                                               | 23.7                                                      | 20.6                                                  | 13.1                                             | 84.7                           | 20.1                           | 487                                         | 36.2                                                              | 7.5                                                                         |
| 06 Green Lane        | 379.5                                    | 27.4                                               | 17.1                                                      | 20.8                                                  | 13.9                                             | 73.0                           | 18.8                           | 540                                         | 45.4                                                              | 13.5                                                                        |
| 07 Lower Hutt        | 217.1                                    | 19.3                                               | 27.8                                                      | 15.4                                                  | 11.3                                             | 80.2                           | 23.3                           | 481                                         | 44.4                                                              | 10.4                                                                        |
| 08 Christchurch      | 305.8                                    | 32.1                                               | 27.8                                                      | 20.4                                                  | 9.5                                              | 85.7                           | 29.9                           | 427                                         | 37.6                                                              | 17.5                                                                        |
| 09 Dunedin           | 442.8                                    | 40.6                                               | 12.3                                                      | 18.9                                                  | 10.9                                             | 79.4                           | 21.5                           | 431                                         | 47.0                                                              | 14.3                                                                        |
| 10 Tauranga          | 284.2                                    | 20.2                                               | 24.5                                                      | 19.3                                                  | 14.0                                             | 83.4                           | 19.4                           | 322                                         | 41.5                                                              | 5.0                                                                         |
| 11 Potorua           | 290.7                                    | 25.0                                               | 34.4                                                      | 11.2                                                  | 11.6                                             | 73.8                           | 19.1                           | 362                                         | 30.9                                                              | 7.5                                                                         |
| 12 Whangarei         | 335.7                                    | 22.4                                               | 25.0                                                      | 18.6                                                  | 15.0                                             | 84.2                           | 17.8                           | 310                                         | 34.2                                                              | 6.7                                                                         |
| 13 Hastings Memorial | 241.5                                    | 18.4                                               | 26.1                                                      | 17.6                                                  | 13.0                                             | 76.8                           | 21.2                           | 306                                         | 32.2                                                              | 8.5                                                                         |
| 14 Nelson            | 279.9                                    | 20.9                                               | 21.6                                                      | 20.2                                                  | 13.4                                             | 82.6                           | 19.9                           | 281                                         | 34.2                                                              | 6.0                                                                         |
| 15 Kew               | 326.7                                    | 26.4                                               | 22.4                                                      | 15.5                                                  | 12.4                                             | 80.5                           | 24.1                           | 288                                         | 39.7                                                              | 7.5                                                                         |
| 16 Napier            | 260.4                                    | 17.1                                               | 24.8                                                      | 22.1                                                  | 15.3                                             | 74.6                           | 18.4                           | 301                                         | 43.0                                                              | 8.3                                                                         |
| 17 Princess Margaret | 345.5                                    | 26.7                                               | 6.6                                                       | 27.7                                                  | 12.9                                             | 88.4                           | 23.2                           | 251                                         | 26.0                                                              | 3.0                                                                         |
| 18 Wanganui          | 354.6                                    | 26.0                                               | 24.4                                                      | 20.7                                                  | 13.6                                             | 78.0                           | 16.8                           | 281                                         | 36.3                                                              | 4.9                                                                         |
| 19 Timaru            | 272.5                                    | 20.2                                               | 23.1                                                      | 19.4                                                  | 13.5                                             | 84.7                           | 21.2                           | 258                                         | 33.7                                                              | 7.2                                                                         |
| 20 Hurwood           | 457.6                                    | 19.4                                               | 29.2                                                      | 25.0                                                  | 23.6                                             | 75.7                           | 10.8                           | 279                                         | 50.7                                                              | 0.1                                                                         |
| 21 New Plymouth      | 305.2                                    | 27.1                                               | 26.7                                                      | 19.2                                                  | 11.3                                             | 83.6                           | 20.5                           | 252                                         | 40.7                                                              | 7.0                                                                         |
| 22 Cook              | 287.6                                    | 14.4                                               | 27.4                                                      | 18.6                                                  | 20.0                                             | 78.1                           | 18.3                           | 258                                         | 26.6                                                              | 7.9                                                                         |
| 23 Wakari            | 304.8                                    | 20.6                                               | 31.4                                                      | 22.4                                                  | 14.8                                             | 75.4                           | 17.0                           | 241                                         | 27.0                                                              | 5.9                                                                         |
| 24 Thames            | 282.1                                    | 15.7                                               | 21.2                                                      | 22.1                                                  | 18.0                                             | 77.3                           | 14.1                           | 202                                         | 40.2                                                              | 5.4                                                                         |
| 25 Masterton         | 260.5                                    | 21.9                                               | 27.7                                                      | 17.5                                                  | 11.9                                             | 71.3                           | 18.9                           | 205                                         | 35.1                                                              | 8.2                                                                         |

TABLE A-26 cont'd

| Hospital      | Average <sup>a</sup><br>Cost per<br>Case<br>\$ | Average <sup>a</sup><br>Cost per<br>Patient<br>Day<br>\$ | Proportion <sup>b</sup><br>of Patients<br>14 and<br>under<br>% | Proportion <sup>b</sup><br>of Patients<br>65 and over<br>% | Average <sup>a</sup><br>Length of<br>Stay (days) | Occupancy <sup>a</sup><br>Rate<br>% | Case Flow <sup>a</sup><br>Rate | Number of <sup>a</sup><br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients Under-<br>going Operations<br>% | Outpatient <sup>a</sup><br>Expenses as a<br>Proportion of<br>Total Expenses |
|---------------|------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------|--------------------------------------------------|-------------------------------------|--------------------------------|---------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 26 Wairau     | 302.1                                          | 18.0                                                     | 25.4                                                           | 16.9                                                       | 16.8                                             | 79.2                                | 18.1                           | 178                                         | 41.5                                                                   | 6.9                                                                         |
| 27 Whakatane  | 244.7                                          | 23.6                                                     | 33.7                                                           | 9.7                                                        | 10.4                                             | 76.5                                | 21.7                           | 172                                         | 32.9                                                                   | 3.5                                                                         |
| 28 Coronation | 4059.4                                         | 14.3                                                     | 0.7                                                            | 68.4                                                       | 284.0                                            | 87.2                                | 0.8                            | 145                                         | 0.0                                                                    | 0.0                                                                         |
| 29 Oamaru     | 303.9                                          | 20.5                                                     | 20.5                                                           | 25.3                                                       | 14.8                                             | 66.7                                | 14.6                           | 156                                         | 38.9                                                                   | 5.6                                                                         |
| 30 Dannevirke | 441.0                                          | 19.8                                                     | 27.2                                                           | 21.8                                                       | 22.3                                             | 64.8                                | 8.9                            | 151                                         | 29.1                                                                   | 3.2                                                                         |
| 31 Taumarunui | 250.7                                          | 22.1                                                     | 33.1                                                           | 7.7                                                        | 11.4                                             | 69.9                                | 19.7                           | 139                                         | 31.1                                                                   | 4.1                                                                         |
| 32 Ashburton  | 324.5                                          | 34.1                                                     | 27.9                                                           | 22.4                                                       | 9.5                                              | 55.8                                | 13.7                           | 172                                         | 29.4                                                                   | 3.8                                                                         |
| 33 Hawera     | 290.8                                          | 23.3                                                     | 30.5                                                           | 16.5                                                       | 12.5                                             | 68.4                                | 16.1                           | 133                                         | 28.0                                                                   | 7.5                                                                         |
| 34 Grey       | 282.3                                          | 28.3                                                     | 20.4                                                           | 20.1                                                       | 10.0                                             | 68.7                                | 20.9                           | 131                                         | 38.0                                                                   | 7.4                                                                         |
| 35 Westown    | 536.8                                          | 19.4                                                     | 1.9                                                            | 44.7                                                       | 27.6                                             | 76.4                                | 7.8                            | 114                                         | 0.2                                                                    | 0.1                                                                         |
| 36 Wairoa     | 263.9                                          | 18.7                                                     | 34.1                                                           | 13.6                                                       | 14.1                                             | 64.4                                | 13.7                           | 131                                         | 12.9                                                                   | 2.4                                                                         |
| 37 Te Kuiti   | 288.6                                          | 20.3                                                     | 34.9                                                           | 12.2                                                       | 14.2                                             | 69.5                                | 15.4                           | 119                                         | 35.7                                                                   | 3.0                                                                         |
| 38 Waipukurau | 382.2                                          | 17.6                                                     | 31.8                                                           | 13.4                                                       | 21.8                                             | 68.6                                | 11.7                           | 116                                         | 36.8                                                                   | 6.4                                                                         |
| 39 Kaitaia    | 328.3                                          | 25.9                                                     | 32.7                                                           | 13.4                                                       | 12.7                                             | 66.9                                | 14.1                           | 114                                         | 36.2                                                                   | 3.2                                                                         |
| 40 Balclutha  | 284.2                                          | 24.2                                                     | 21.7                                                           | 18.5                                                       | 11.7                                             | 65.5                                | 17.1                           | 114                                         | 37.8                                                                   | 6.3                                                                         |
| 41 Gore       | 233.0                                          | 22.7                                                     | 26.6                                                           | 16.8                                                       | 10.3                                             | 66.0                                | 20.3                           | 113                                         | 30.1                                                                   | 3.4                                                                         |
| 42 Tckoroa    | 196.1                                          | 23.3                                                     | 30.5                                                           | 3.0                                                        | 8.4                                              | 81.8                                | 29.0                           | 80                                          | 51.3                                                                   | 3.9                                                                         |
| 43 Greytown   | 460.6                                          | 11.2                                                     | 29.5                                                           | 18.3                                                       | 41.1                                             | 86.2                                | 7.0                            | 74                                          | 54.6                                                                   | 1.0                                                                         |
| 44 Stratford  | 377.3                                          | 25.0                                                     | 28.1                                                           | 17.0                                                       | 15.1                                             | 74.8                                | 14.6                           | 84                                          | 40.3                                                                   | 5.9                                                                         |
| 45 Dargaville | 241.7                                          | 16.9                                                     | 30.3                                                           | 13.3                                                       | 14.3                                             | 76.8                                | 18.6                           | 78                                          | 44.2                                                                   | 3.8                                                                         |
| 46 Westland   | 673.9                                          | 23.9                                                     | 20.2                                                           | 18.4                                                       | 28.2                                             | 62.7                                | 6.4                            | 91                                          | 53.1                                                                   | 1.4                                                                         |
| 47 Waimate    | 491.9                                          | 24.2                                                     | 24.3                                                           | 33.4                                                       | 20.3                                             | 72.6                                | 8.1                            | 76                                          | 17.6                                                                   | 1.9                                                                         |
| 48 Buller     | 415.6                                          | 27.9                                                     | 23.4                                                           | 23.1                                                       | 14.9                                             | 61.2                                | 10.9                           | 89                                          | 28.4                                                                   | 3.9                                                                         |
| 49 Kawakawa   | 270.4                                          | 30.0                                                     | 28.2                                                           | 12.1                                                       | 9.0                                              | 66.5                                | 18.2                           | 79                                          | 37.1                                                                   | 4.6                                                                         |
| 50 Patea      | 205.3                                          | 13.2                                                     | 40.9                                                           | 11.6                                                       | 15.6                                             | 64.8                                | 13.8                           | 69                                          | 26.3                                                                   | 4.9                                                                         |
| 51 Waihi      | 338.5                                          | 14.8                                                     | 20.5                                                           | 36.9                                                       | 22.8                                             | 85.3                                | 10.5                           | 45                                          | 19.4                                                                   | 0.2                                                                         |

Table A.1.1

| Hospital       | Average <sup>a</sup><br>Cost per<br>Case<br>\$ | Average <sup>a</sup><br>Cost per<br>Patient<br>Day\$ | Proportion <sup>b</sup><br>of Patients<br>14 and<br>Under<br>% | Proportion <sup>b</sup><br>of Patients<br>65 and over<br>% | Average <sup>a</sup><br>Length of<br>Stay (days) | Occupancy <sup>a</sup><br>Rate<br>% | Case Flow <sup>a</sup><br>Rate | Number of<br>Available<br>Beds | Proportion of <sup>b</sup><br>Patients Under-<br>going Operations<br>% | Outpatient <sup>a</sup><br>Expenses as a<br>Proportion of<br>Total <sup>a</sup> Expenses |
|----------------|------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------|--------------------------------------------------|-------------------------------------|--------------------------------|--------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 52 Opotiki     | 272.5                                          | 27.8                                                 | 34.3                                                           | 15.1                                                       | 9.8                                              | 52.4                                | 12.4                           | 66                             | 19.7                                                                   | 4.0                                                                                      |
| 53 Reefton     | 650.6                                          | 10.1                                                 | 26.0                                                           | 23.5                                                       | 64.7                                             | 57.6                                | 4.3                            | 58                             | 2.0                                                                    | 2.6                                                                                      |
| 54 Rawene      | 234.3                                          | 22.4                                                 | 35.4                                                           | 19.1                                                       | 10.4                                             | 65.3                                | 15.2                           | 51                             | 8.2                                                                    | 7.7                                                                                      |
| 55 Taihape     | 314.2                                          | 36.6                                                 | 36.7                                                           | 11.5                                                       | 8.1                                              | 58.0                                | 13.1                           | 54                             | 21.1                                                                   | 1.8                                                                                      |
| 56 Te Puia     | 360.2                                          | 31.3                                                 | 31.8                                                           | 15.7                                                       | 11.5                                             | 60.0                                | 14.9                           | 44                             | 16.3                                                                   | 9.7                                                                                      |
| 57 Te Kopuru   | 1105.4                                         | 20.5                                                 | 0.0                                                            | 96.6                                                       | 53.9                                             | 79.4                                | 4.7                            | 33                             | 0.0                                                                    | 0.0                                                                                      |
| 58 Owaka       | 388.9                                          | 4.7                                                  | 5.4                                                            | 72.1                                                       | 82.3                                             | 63.2                                | 4.1                            | 38                             | 0.6                                                                    | 0.2                                                                                      |
| 59 Pahiatua    | 256.3                                          | 17.3                                                 | 25.0                                                           | 21.2                                                       | 14.8                                             | 57.8                                | 12.9                           | 41                             | 23.7                                                                   | 2.2                                                                                      |
| 60 Cromwell    | 312.8                                          | 18.7                                                 | 29.7                                                           | 20.1                                                       | 16.7                                             | 51.1                                | 9.0                            | 45                             | 1.0                                                                    | 1.5                                                                                      |
| 61 Dunstan     | 341.5                                          | 25.0                                                 | 19.8                                                           | 23.7                                                       | 13.7                                             | 54.6                                | 10.6                           | 41                             | 25.3                                                                   | 5.9                                                                                      |
| 62 Panfurlly   | 254.7                                          | 18.8                                                 | 35.4                                                           | 14.0                                                       | 13.5                                             | 64.2                                | 13.1                           | 33                             | 32.8                                                                   | 6.1                                                                                      |
| 63 Milton      | 656.0                                          | 18.8                                                 | 4.6                                                            | 72.8                                                       | 34.9                                             | 16.0                                | 3.2                            | 31                             | 0.0                                                                    | 0.2                                                                                      |
| 64 Kaeo        | 311.7                                          | 19.6                                                 | 37.5                                                           | 16.3                                                       | 15.9                                             | 47.6                                | 10.4                           | 38                             | 13.9                                                                   | 8.9                                                                                      |
| 65 Oxford      | 1900.8                                         | 29.2                                                 | 0.0                                                            | 80.0                                                       | 65.2                                             | 98.5                                | 2.0                            | 13                             | 0.0                                                                    | 0.0                                                                                      |
| 66 Kaikoura    | 348.8                                          | 24.8                                                 | 24.3                                                           | 16.4                                                       | 14.0                                             | 42.4                                | 9.8                            | 29                             | 12.3                                                                   | 0.0                                                                                      |
| 67 Waimarino   | 240.6                                          | 27.6                                                 | 37.6                                                           | 14.6                                                       | 8.7                                              | 36.3                                | 13.6                           | 32                             | 0.0                                                                    | 2.6                                                                                      |
| 68 Coromandel  | 316.5                                          | 31.6                                                 | 20.4                                                           | 31.3                                                       | 10.0                                             | 55.6                                | 10.1                           | 18                             | 0.0                                                                    | 1.2                                                                                      |
| 69 Tapanui     | 281.0                                          | 24.8                                                 | 3.6                                                            | 38.8                                                       | 11.3                                             | 76.0                                | 20.7                           | 10                             | 1.4                                                                    | 0.0                                                                                      |
| 70 Lake County | 192.6                                          | 29.9                                                 | 17.5                                                           | 19.1                                                       | 6.4                                              | 40.0                                | 16.3                           | 17                             | 6.1                                                                    | 2.9                                                                                      |
| 71 Mercury Bay | 299.4                                          | 35.4                                                 | 23.6                                                           | 34.6                                                       | 8.5                                              | 99.9                                | 17.7                           | 6                              | 0.0                                                                    | 2.6                                                                                      |
| 72 Lawrence    | 741.6                                          | 41.9                                                 | 15.6                                                           | 36.5                                                       | 17.7                                             | 57.3                                | 6.5                            | 11                             | 0.0                                                                    | 0.0                                                                                      |
| 73 Picton      | 341.6                                          | 16.6                                                 | 1.3                                                            | 72.5                                                       | 20.6                                             | 53.6                                | 10.3                           | 11                             | 0.0                                                                    | 1.3                                                                                      |
| Averages       | 319.5                                          | 23.9                                                 | 25.6                                                           | 18.1                                                       | 13.4                                             | 77.4                                | 18.7                           | 185.0                          | 36.0                                                                   | 9.8                                                                                      |

Sources: <sup>a</sup> Derived from New Zealand Department of Health, Hospital Statistics, Wellington (1971).

<sup>b</sup> Derived from unpublished data received from the Health Department, Wellington.

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