The spatial equity and sustainability of general practitioner services:

A mixed methods analysis of the Waikato DHB region

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Jesse Whitehead

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Abstract

The New Zealand Primary Health Care Strategy states that quality primary health care is the first level of contact with the health system and should be universally accessible. Effective primary health care is an essential component of health systems, and is associated with more equitable distributions of health outcomes. However, not all New Zealanders have ready access to primary health care. For instance, adult residents of the Waikato region, and in particular Māori, have higher levels of unmet need for primay care than others. Improving the spatial equity of health services is a key step in achieving health equity. Health systems should contribute to achieving health equity and maintaining sustainable and equitable services into the future.

This thesis research examines the spatial equity and sustainability of general practitioner (GP) services in the Waikato DHB region, using a mixed-methods approach to identify not only *where* inequities exist, but *why* they occur. A conceptual framework establishes a foundation for examining spatial equity and sustainability in New Zealand. Next, a systematic literature review identifies common definitions and measures of spatial equity. Primary Health Organisation (PHO) enrolment data is used to examine patterns of patient enrolment at GP services, and a range of health needs indicators were assessed for their suitability in the New Zealand primary care context. These findings inform the development of a Geographic Information Systems (GIS) model of spatial accessibility that is tailored to the Waikato District Health Board (DHB) context. The GIS model is then used, in combination with in-depth qualitative interviews, to examine the spatial equity and sustainability of GP services in the Waikato DHB region.

Key findings include that spatial equity is commonly defined as a 'need-based distribution of resources', which can be quantified using a range of statistical and geospatial measures and techniques. PHO enrolment analysis revealed that most patients do not enrol with their closest service, and that the size of the 'catchment area' served by GP clinics varies with rurality. Analysis of indicators of health need suggest that 'Ambulatory Sensitive Hospitalisations' are a robust indicator; however, area-level socioeconomic deprivation is also strongly associated with other indicators of need and data is more widely available to researchers. Mixed-methods analysis suggests that GP services are not distributed equitably

within the Waikato DHB region and that key barriers to access include the affordability, appropriateness, and availability of services. New Zealand’s history of colonisation and discrimination are identified as fundamental drivers of health inequity. Furthermore, population growth and ageing suggest that current levels of access to GP services are unlikely to be maintained in the future, while participants identify key economic, professional, organisation, and social dimensions that influence service sustainability in New Zealand.

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Chapter 1: Introduction

1.1 Background literature

According to the New Zealand Primary Health Care Strategy (PHCS) (Ministry of Health, 2001, p. 1), quality primary health care: should be universally accessible; involves community participation; is a central function of the New Zealand health system; and is the first level of contact with the health system. While primary health care in New Zealand includes a range of diagnostic, prevention, screening, education and treatment services, general practitioner (GP) clinics are common points of primary health care delivery, and GPs often act as gatekeepers to the wider health system (Ministry of Health, 2019a). Effective primary health care is an essential component of health systems, and has been associated with more equitable distributions of health outcomes (Starfield, Shi, & Macinko, 2005). In the New Zealand Health Strategy (Ministry of Health, 2016b) the delivery of better services, sooner, and closer to people's homes is highlighted as an important focus. This is most likely to be achieved through increasing the range of services available through primary health care. Equitable access to services is a guiding principle of the New Zealand Health Strategy (Ministry of Health, 2016b). However, not all New Zealanders have ready access to primary health care. For instance, adult residents of the Waikato region, and in particular Māori, have higher levels of unmet need for primay care than other New Zealand adults (Ministry of Health, 2018). Other research also suggests that some regions and population groups have poor access to services (Bagheri, Benwell, & Holt, 2005; Brabyn & Barnett, 2004). This may influence health outcomes and exacerbate inequities as people with poor access to health care are less likely to use those services (Hiscock, Pearce, Blakely, & Witten, 2008). Furthermore, although New Zealanders are generally living longer, there are also considerable differences in health outcomes between population subgroups, with non-Māori expected to live six to seven years longer than Māori or Pacific New Zealanders (Statistics New Zealand, 2015). The causes of these inequities include differences in access to the social determinants of health such as education, employment and housing, as well as differences in access to health care and the quality of care received (Commission on the Social Determinants of Health, 2008). The health system is also a social determinant of health that plays a role in creating, perpetuating, and exacerbating health inequities

(Commission on the Social Determinants of Health, 2008). Therefore, ensuring the spatial equity of health care is one important step in achieving health equity (Dalton et al., 2013). Although researchers have recognised the importance of distributing services according to need (Reid & Robson, 2007), Barnett and Barnett (2009) have pointed out that in many health systems equitable access is not achieved. Julian Hart (1971, p. 405) described a phenomenon called the inverse care law whereby "the availability of good medical care tends to vary inversely with the need for it in the population served".

In New Zealand, Māori are more likely to experience poorer health outcomes, but are also disproportionately affected by cost and transport as barriers to accessing GP services (Ministry of Health, 2015). Pearce, Witten, Hiscock, and Blakely (2006) have highlighted that despite high and increasing life expectancy, geographic health inequalities appear to be growing, while Mel Pande (2009) argues that people living in rural areas often experience problems accessing health care.

Recognising their multifaceted causes, the New Zealand Ministry of Health (2002) has identified four levels of intervention to address health inequities:

(1) at the structural level, dealing with the underlying determinants of health such as economic and social policies, power relations, and the Treaty of Waitangi

(2) addressing intermediate pathways, which are mediating factors such as access to material resources and environmental conditions that affect health status

(3) ensuring that health and disability services provide equitable access to care by distributing resources in relation to need and removing barriers that inhibit service use for all ethnic and social groups

(4) tackling the impact of illness and disability on the socioeconomic position of individuals through income, antidiscrimination legislation, and community or carer support.

While action at each level is necessary to eliminate health inequities, the third level specifically relates to spatial equity and is one area that the Ministry of Health and District Health Boards (DHBs) have the potential to directly influence. The Ministry of Health (2002, pp. 21-22) has provided examples of interventions at the health service level that can reduce inequities including: improved access to appropriate high-quality services; monitoring of service delivery to ensure equitable intervention rates; primary care initiatives that reduce access barriers for Māori and other disadvantaged groups; ethnic-specific service delivery; and equitable resource allocation by DHBs. The Waikato District Health Board (2015) has identified heath equity for high-need populations as a key strategic imperative and within this, eliminating health inequities for Māori and people in rural communities has been recognised as a priority. Given the importance of equitable primary health care service distributions (Dalton et al., 2013; Hiscock et al., 2008; Starfield et al., 2005), monitoring and acting to improve the spatial equity of GP services is one way that the Waikato DHB could move towards the elimination of health inequities.

The sustainability of GP services in New Zealand is becoming an increasingly pressing issue and poor sustainability has the potential to exacerbate current inequities in both health outcomes and access to health services. New Zealand's population is expected to continue to age, both numerically, in terms of the total number of people aged 65 years or over, and structurally, as the proportion that this age group makes up in the total population grows (Bascand & Dunstan, 2014; Jackson, 2016). The higher general practice utilisation rates of older New Zealanders (Cumming, Stillman, Liang, Poland, & Hannis, 2010) means that population ageing is likely to lead to increased demand for services. Despite this expected increase in demand for services, The Royal New Zealand College of General Practitioners (2019) found that that almost half of GPs intend to retire within the next 10 years with many already reducing their working hours in preparation. More than one-quarter of GPs rated themselves as 'high' on the burnout scale, and 70% stated that they were working in a practice that had had a GP vacancy in the past 12 months (The Royal New Zealand College of General Practitioners, 2019). These issues recently captured popular attention when a GP in Tokoroa complained about not receiving any applications for the GP position advertised at his clinic with a $400,000 income and 12 weeks annual leave (Preston, 2016, December 27). While balancing levels of workforce supply with population demand is essential, Humphreys, Wakerman, and Wells (2006) have highlighted several other factors that threaten the sustainability of local health services, including: small population sizes; health workforce recruitment and retention; geographical isolation; and high levels of need for primary, acute and chronic care. As New Zealand's population and GP workforce continue to age, the poor sustainability of some services may exacerbate current inequities in both health outcomes and accessibility. Despite the importance of these issues, few studies directly monitor or examine the spatial equity and sustainability of primary health care services in New Zealand. Most research in this area has focussed on the spatial accessibility of health services (Bagheri et al., 2005; Brabyn & Barnett, 2004; Pearce, Witten, Hiscock, et al., 2006), largely ignoring the issues of sustainability or whether they are distributed equitably.

1.1.1 Social determinants of health and health equity

While health inequalities are differences in outcomes between groups, *inequities* refer to systematic differences that are unfair, unjust, and avoidable by reasonable action (Commission on the Social Determinants of Health, 2008). It is widely recognised that the fundamental cause of inequitable health outcomes is differential access to the social determinants of health and the fundamental structure of social hierarchies (Marmot & Commission on Social Determinants of Health, 2007). Woodward and Kawachi (2000, p. 9) suggest that reducing inequities could be thought of as "eliminating disadvantage that is due to factors beyond the individual's control". Dahlgren and Whitehead's (1991) 'rainbow model' provides an important framework for understanding how social processes, that are beyond the control of individuals, influence individual health outcomes. At the centre are individuals and populations who are surrounding by various layers of influences on health such as individual lifestyle factors, community influences, living and working conditions, and finally more general socioeconomic, cultural, and environmental conditions. Dahlgren and Whitehead's model has since been adjusted and adapted. For instance, Greenwood and de Leeuw (2012) outline a 'Web of Being' model showing the social determinants of Aboriginal people's health in Canada (see *Figure 1.2*). In the centre are children, families, and communities, who are affected by proximal determinants of health such as income, employment, education, as well as healthy physical environments such as access to adequate housing. Surrounding these are the intermediate determinants of health, which include health systems, location, cultural ways, environmental stewardship, and justice. The outer layer of the web consists of distal determinants of health and includes but is not limited to, self-determination, language, culture and heritage, racism, land resources, and poverty. Greenwood and de Leeuw's model recognises the historical and ongoing determinants of health that directly affect indigenous people, but also identifies the health system as a specific determinant that influences the health outcomes of indigenous people. Therefore, while the impact of colonisation, discrimination and other determinants of health cannot be ignored, action to improve the health system can also potentially lead to improved health outcomes for particular groups and help to achieve health equity. In its 10-year health system plan, the Waikato District Health Board (2019b) has also included a focus on the role that the determinants of health and wellbeing play in all neighbourhoods of the Waikato DHB region. *Figure 1.3* shows that the Waikato DHB has recognised the role of the global ecosystem and factors such as climate change and biodiversity in shaping health and wellbeing. Furthermore, the importance of connections with other neighbourhoods and regions is acknowledged. Braveman, Egerter, and Williams (2011) provide a useful distinction between upstream and downstream determinants that influence health. In *Figure 1.4* Braveman et al's (2011) model depicts medical care as a proximal downstream determinant which not only directly affects the health of individuals and populations, but is also influenced by key upstream factors such as economic and social opportunities and resources.

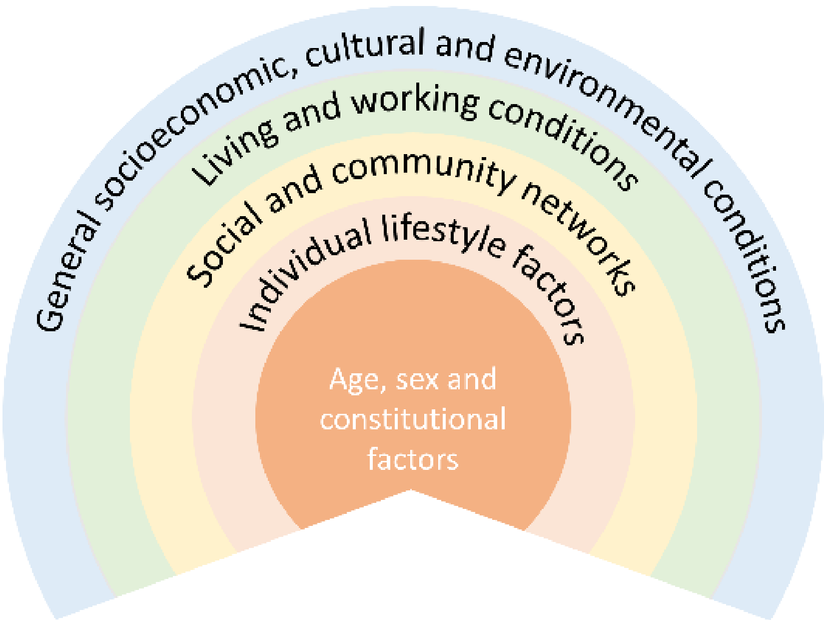

Figure 1.1 Rainbow model adapted from Dahlgren and Whitehead (1991)

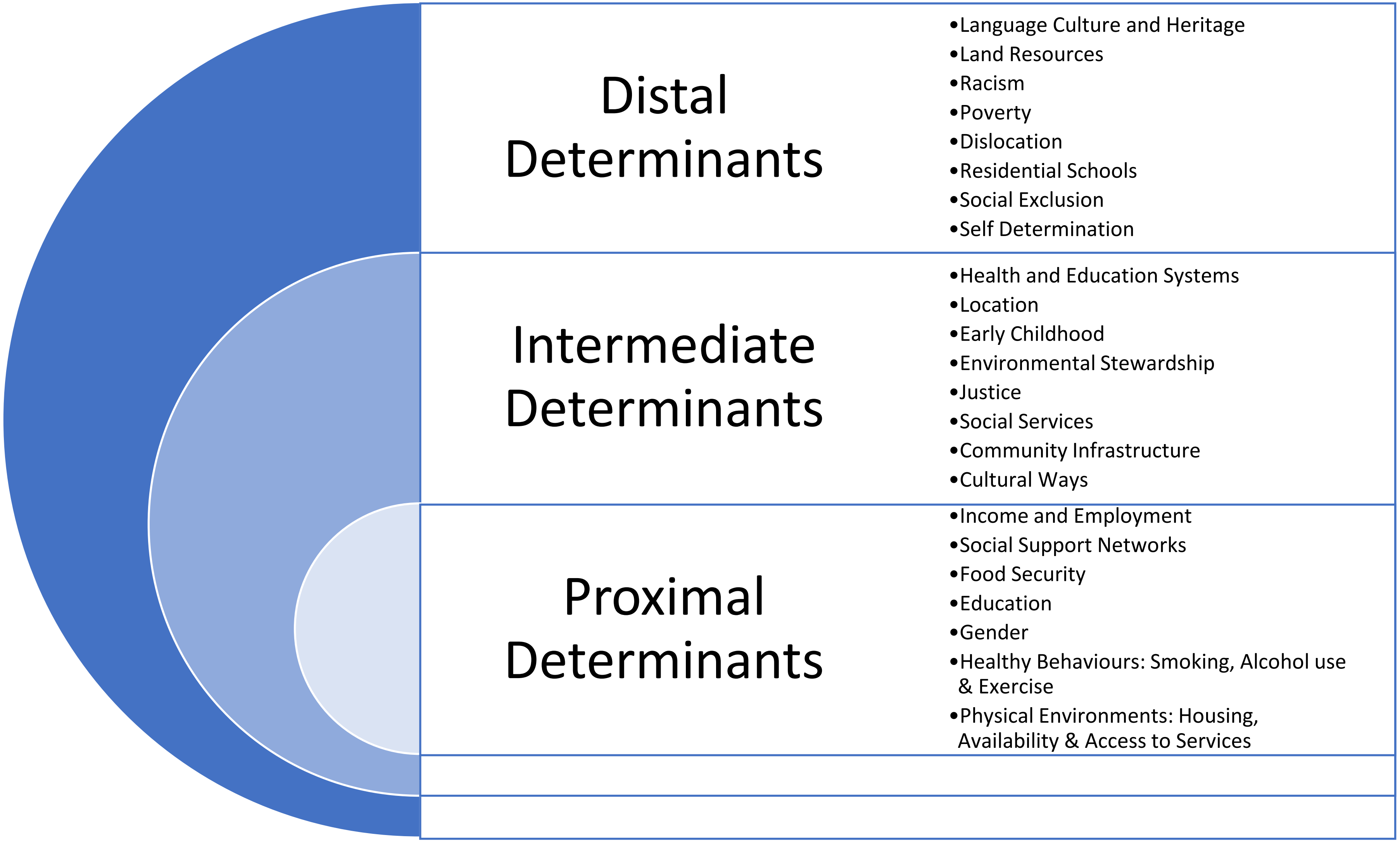

Figure 1.2 An adaptation of Greenwood and de Leeuw's (2012) web of being model

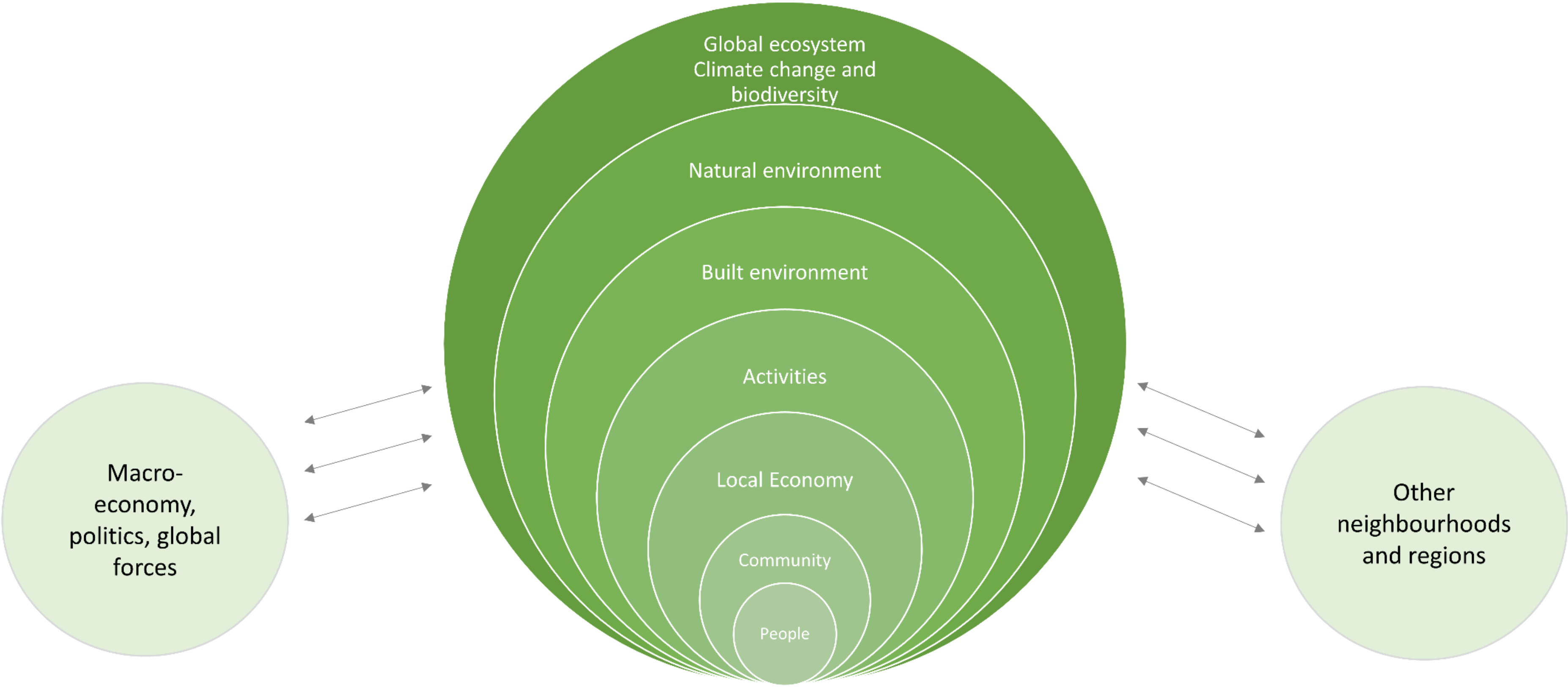

Figure 1.3 Adaptation of the Waikato District Health Board's (2019) model of determinants of health and wellbeing

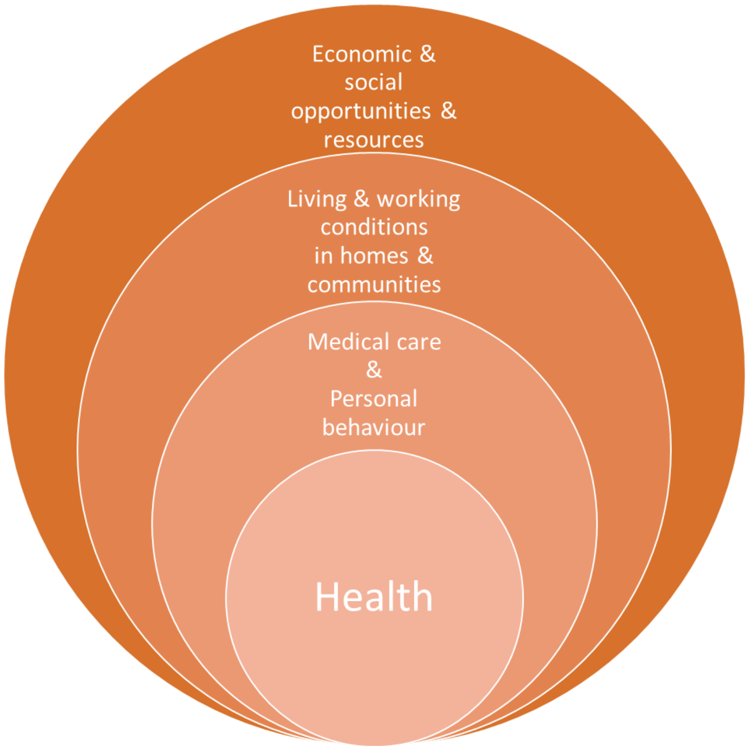

Figure 1.4 An adaptation of Braveman et al's (2011) model of upstream and downstream determinants of health

The models outlined above are important for understanding inequities in New Zealand, where ethnic health inequities are the largest and most persistent (Reid & Robson, 2007). Māori consistently experience higher levels of chronic disease earlier in life, which results in higher morbidity and lower life expectancy than non-Māori (Ministry of Health, 2015; Sheridan et al., 2011). These inequities are persistent and ongoing, and between 1992 and 2016 the Ministry of Health published 107 reports on Māori health and the disparity between Māori and non-Māori outcomes (Ministry of Health, 2017). It is important to understand the underlying, distal, causes of these differences which relate to the historical and ongoing trauma of colonisation and repeated breaches of Te Tiriti o Waitangi[1], despite Māori being guaranteed rights to protection under Article 3 of Te Tiriti, including access to

[1] Berghan et al. (2017, p. 15) state: "[Te Tiriti o Waitangi] outlined the terms and conditions of Tauiwi settlement and reaffirmed the Māori sovereignty previously recognised through *He Whakaputanga. Te Tiriti* enabled a British governor to take responsibility for British people in Aotearoa. It guaranteed the British would uphold Māori authority, ensured protection of Māori land and taonga including their health assured equity with British subjects and religious freedom. *Te Tiriti* is the closest document New Zealand has to a written constitution.....*Te Tiriti* remains a foundation, articulating rights and responsibilities between the Treaty parties".

the same quality of health and standard of living as Pākehā[2] citizens (Wepa, 2015). Ryks, Simmonds, and Whitehead (2019) have demonstrated that the ongoing impact of colonisation has produced inequities between Māori and non-Māori that exist across key social determinants of health such as housing, transport, socioeconomic deprivation, racism, access to and quality of health care. Furthermore, compared to New Zealand Europeans, Māori are disproportionately affected by lower levels of: employment, education, and home ownership (Goodyear, 2017; Houkamau & Sibley, 2015; Marriott & Sim, 2015), but higher levels of: incaceration; experiences of racism and multiple forms of discrimination, and unmet need for primary health care (Bécares, Cormack, & Harris, 2013; Cormack, Harris, & Stanley, 2019; McIntosh & Workman, 2017; Ministry of Health, 2015). Te Tiriti is of key relevance to health in Aotearoa New Zealand, and the New Zealand Public Health and Disability Act (2000) (NZPHDA), requires the health sector to work towards the elimination of health inequities between Māori and other New Zealanders through engagement with Te Tiriti (Came, Cornes, & McCreanor, 2018). Geographic inequities are also important and can be measured through area level deprivation and rurality; adults living in the most socioeconomically deprived areas of New Zealand report poorer levels of health and a higher unmet need for care (Ministry of Health, 2016a) and rural and small-town residents have poorer chances of surviving cancer (Robson, Cormack, & Purdie, 2010).

1.1.2 New Zealand primary health care delivery

In New Zealand, the delivery of primary health care has been shaped by the NZPHDA (2000), which sets the legislative framework for health service delivery, and the Primary Health Care Strategy (PHCS) (Ministry of Health, 2001), which is an attempt to set the direction of primary health care in New Zealand. District Health Boards (DHBs) were established under the NZPHDA, which also gave DHBs overall responsibility for assessing the health and disability needs of communities in their regions and effectively managing services to meet those needs. DHBs are funded according to the population size and demographic characteristics of each region through the Population Based Funding Formula which gives

[2] Pākehā is the te reo Māori word for non-Māori New Zealanders of European descent.

areas with higher needs appropriately higher funding (Ministry of Health, 2004). Under Section 22 of the NZPHDA (2000, p.23), DHBs have 12 objectives, including to;

- "seek the optimum arrangement for the most effective and efficient delivery of health services in order to meet local, regional, and national needs"
- and "reduce, with a view to eliminating, health outcome disparities between various population groups within New Zealand by developing and implementing, in consultation with the groups concerned, services and programmes designed to raise their health outcomes to those of other New Zealanders".

Section 23 of the NZPHDA (2000, p24-25) also states 15 functions DHBs should follow to pursue their objectives, including to;

- "regularly investigate, assess, and monitor the health status of its resident population, any factors that they DHB believes may adversely affect the health status of that population, and the needs of that population for services"
- and "to monitor the delivery and performance of services by it and by persons engaged by it to provide or arrange for the provision of services".

DHBs in turn fund Primary Health Organisations (PHOs), which provide primary health care to their enrolled population.

The PHCS (Ministry of Health, 2001) aims to actively reduce health inequities between groups of New Zealanders, and focus on better health outcomes for the population. The PHCS also identifies the development of the primary health workforce as a key focus. Reducing barriers for groups with the greatest health needs, through additional services and improved access, is also highlighted as a key priority of the strategy. The PHCS indicates that PHOs should be non-profit organisations which provide services that improve and maintain the health of the population. PHOs should involve communities in their governance processes, as well as all service providers and practitioners (Ministry of Health, 2001). Most PHO services are delivered through general practices and the majority of New Zealanders are enrolled with a PHO through their enrolment in a selected GP service. This enrolment results in reduced costs for doctor visits, prescription medicines and other benefits. *Figure*

1.5 outlines the structure of primary health care as outlined by the Ministry of Health (2001, p. 5)

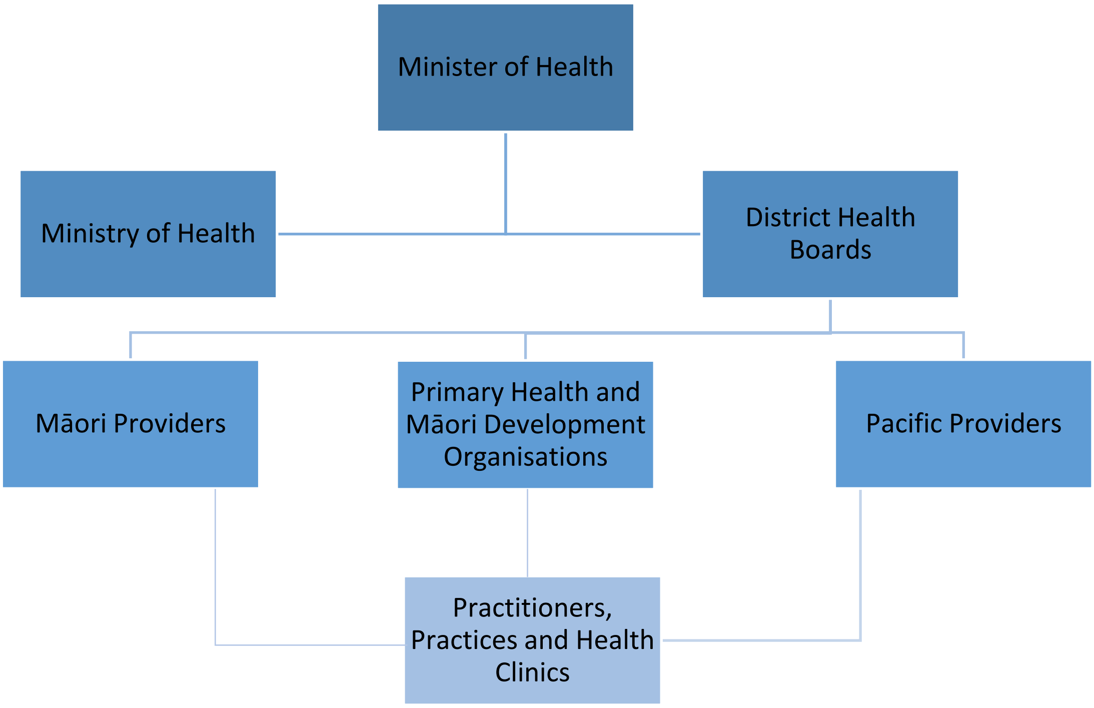

Figure 1.5 The New Zealand Primary Health System

Cumming, Mays, and Gribben (2008) examined 99 New Zealand general practices between June 2001 (pre PHCS) and mid-2005, concluding that the PHCS resulted in lower fees and higher consultation rates, particularly for practices with higher per capita funding to reflect higher population needs. However, Cumming et al. (2008) suggest that fees did not fall as much as expected, given the level of public money invested into primary care. In October 2006 the voluntary Very Low Cost Access (VCLA) scheme was introduced to support GP clinics with an enrolled population of 50% or more high needs patients (defined as Māori, Pacific, or New Zealand Deprivation Index quintile 5) (Ministry of Health, 2019b). The VCLA provides additional funding to clinics that ensure children 0-13 years old pay zero fees, 14-17-year olds are charged a maximum of NZD $13, and adults aged 18 years and over pay a maximum of $19. From December 2018, practices were able to opt-in to offering the same maximum charges to Community Services Card[3] holders regardless of the VLCA status of the clinic as a whole. While the impact of this specific change has yet to be researched, Foley (2018) argues that it is unclear whether the PHCS has had the desired impact of reducing health inequities as it relies on the local implementation of a range of interventions. Foley suggests that the success of funding approaches to address inequities also depends on local variations in uptake by private general practitioners. Furthermore, Came, McCreanor, Doole, and Rawson (2016) have critiqued the New Zealand Health Stratergy (Ministry of Health, 2016c) as downplaying Crown obligations to protect hauora[4] as a taonga[5] under Article 3 of Te Tiriti o Waitangi, and argue that high level health strategies should have deep engagement with Te Tiriti. Analysis by Came et al. (2018) shows that public health plans in New Zealand rarely address Treaty of Waitangi obligations. This is supported by the Wai 2575 Health Services and Outcomes Kaupapa Inquiry (Waitangi Tribunal, 2019, p. 162) which found that "…. the New Zealand Public Health and Disability Act does not give proper and full effect to the Treaty or its principles and is not Treaty-compliant". The Wai 2575 Inquiry also found that Māori have not been properly supported and resourced by the New Zealand Government to design and deliver primary health care, and that the legislative and policy framework around the primary health system does not address the extreme health inequities experienced by Māori. The initial findings of the New Zealand Health and Disability System Review (2019) also argue that Te Tiriti o Waitangi must be incorporated into the health system to provide a framework for meaningful relationships between iwi, Māori and the Crown that delivers a health system that works for Māori.

1.1.3 Health geographies

Issues around access to health care was one of the earliest themes in health geography, and it continues to be a core focus of the discipline (Rosenberg, 2014). Health geography approaches are also a useful starting point to investigating issues of health equity, since the field seeks to examine what Andrews, Evans, Dunn, and Masuda (2012) have termed the three 'big' questions of health geography: (1) where do inequalities exist?; (2) how is

[3] The Commuity Services Card (CSC) helps with the cost of some health services and prescriptions, and is administered the Work and Income New Zealand. The CSC is available to inviduals and families on low income, living in public housing, or receiving and accommodation supplement (Ministry of Social Development, 2019).
[4] Broadly defined as health
[5] Broadly defined as treasure

inequality produced?; and (3) what can be done about inequality? Furthermore, the sub-discipline of health care geography is particularly focussed on issues of locational variations in health service provision, the allocation of resources based on need, and variations in the utilisation of services (Brown et al., 2017). While health geography has a strong quantitative history (Brown et al., 2017; Kearns & Moon, 2002), most researchers agree that there is room for both quantitative Geographic Information Systems (GIS) based approaches that offer positivist explanations, and qualitative methods that help to interpret health care landscapes, empower individuals and understand their place in power relationships (Andrews et al., 2012; Higgs, 2004; Kearns & Moon, 2002; Rosenberg, 1998). Therefore, health geography can provide appropriate tools to examine and understand inequities in service provision and health outcomes. Kearns and Moon (2002) highlight key themes within health geography as place, theory, and critical geographies. A focus on place in health geography includes not only the debate between compositional effects (that suggest places are a sum of their individual residents) and contextual effects (that suggest places exert an independent influence on the health of their residents) (Smith & Easterlow, 2005), but a consideration of places as 'landscapes' where complex layers of history, social structure, and the built environment come together (Kearns & Moon, 2002). Kearns and Moon (2002) also highlight structure and agency (see Giddens, 1984) as a key concept in health geography, and identify inequity, inclusion, and exclusion as key constructs. This links to critical health geography, which places social justice at the core of the discipline, and has a major focus on inequity, social exclusion, and power inequities (Brown et al., 2017). Critical health geography also links politics and health and health care though themes of biopolitics, globalisation and neoliberalism (Brown et al., 2017). However, Rosenberg (2014) has identified a lack of explicit theory behind social justice research, and a lack of qualitative research that can give deeper understandings to experiences of poor access to services, as shortcomings of health geography.

1.1.4 Spatial equity

While it is generally agreed that equity is concerned with fairness, defining what is 'fair' is a difficult task that depends on the values of societies (Morrill, 2015; Talen, 1998; Truelove, 1993). Truelove (1993) has argued that an equitable distribution of services promotes greater equality in opportunities and outcomes among different groups in society. In this sense, spatial equity can be considered as a fair distribution of services that will lead to a reduction in inequitable outcomes between groups. This recognises that rather than equal distribution of resources regardless of need, "sometimes different resourcing is needed in order that different groups enjoy equitable health outcomes" (Reid & Robson, 2007, p. 4). The range of definitions and measures of spatial equity in the research literature are explored in detail later in this thesis through a systematic literature review (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019a).

1.1.5 Spatial accessibility

The analysis of spatial equity relies on measures of access to services, and GIS is an effective tool for identifying spatial inequities (Morrill, 2015; Talen & Anselin, 1998). The much cited Penchansky and Thomas (1981) model of access is based on five specific dimensions:

(1) availability – the supply of physicians, facilities, and services

(2) accessibility – the relationship between the location of supply and the location of patients

(3) accommodation – how supply is organised to accept patients

(4) affordability – the price of services

(5) acceptability – the match between patient preferences and service characteristics.

Levesque, Harris, and Russell (2013) have expanded upon this model and propose a framework of access that includes five elements (approachability, acceptability, availability and accommodation, affordability, and appropriateness) and also considers the corresponding abilities of populations to achieve access. In the Levesque model, *availability* refers to the geographic location of services, and a range of GIS methods can be used to examine this component of access (Allan, 2014; Guagliardo, 2004).

The geographical distance between populations and services is a key component of spatial access models, and several studies have noted the distance decay effect, where through the consequences of added time, cost and effort of travelling, the utilisation of health services tends to decrease with increasing distance (Cromley & McLafferty, 2012). Research also indicates that demographic and socioeconomic factors affect the amount of travel that patients consider acceptable for health care (Cromley & McLafferty, 2012). The ratio of services to population size for a given area, and the distance to the nearest service provider are two traditional measures of physical accessibility that have been used to examine inequalities in access (Yang, Goerge, & Mullner, 2006). For instance, service-to-population ratio research by Kruger, Whyman, and Tennant (2012) reveals that the distribution of private dental practices in New Zealand is uneven, and concentrated in areas of high socioeconomic advantage and in populations with lower levels of oral disease. Least Cost Path Analysis (LCPA) is another method used to assess access that can provide a more specific measure of geographical distance to services (Thornton, Pearce, & Kavanagh, 2011). Pearce, Witten, and Bartie (2006) used LCPA to determine total travel times from the centroids of all meshblocks in New Zealand to 16 health resources, and then categorised meshblocks based on their relative accessibility to each resource. Researchers in New Zealand have also used LCPA to examine geographical access to primary care by calculating travel distances and times between populations and their nearest GP clinics (Bagheri et al., 2005; Brabyn & Barnett, 2004). Further New Zealand research also suggests an inverse relationship between socioeconomic deprivation and travel time to primary health care services (Bagheri, Holt, & Benwell, 2009; Pearce, Witten, Hiscock, et al., 2006).

However, there are weaknesses to these two approaches. Ratio measures do not take patient border crossings into account, while closest facility measures do not consider the level of demand for services within an area and also assume that patients will always use their closest service. Therefore, Yang et al. (2006) argue that the two-step floating catchment area (2SFCA) method (Luo & Wang, 2003) is a better measure of spatial accessibility. The final accessibility measure in the 2SFCA shows the balance between service availability (i.e. the GP to population ratio) and service accessibility (the sum of all practices within a certain distance of a population), with higher values signifying greater accessibility (Allan, 2014). The only example of the 2SFCA being used to model spatial accessibility in New Zealand is a study by Bagheri, Benwell, and Holt (2008) which examined the distribution primary health care in rural Otago. Three main limitations to the 2SFCA method, which can be particularly problematic in rural contexts, have been identified (Luo & Whippo, 2012; McGrail & Humphreys, 2009):

(1) areas outside the catchment are assumed to have no access

(2) it does not account for distance decay within the catchment

(3) fixed catchment sizes do not account for different distances that people are willing to travel.

Recently several adaptations have been made to the 2SFCA, and a range of Floating Catchment Area (FCA) methods have been created, including: the development of an Enhanced-2SFCA (E2SFCA) method (Luo & Qi, 2009) which accounts for distance decay by applying weights to different travel time zones; the incorporation of variable catchment sizes (Luo & Whippo, 2012; McGrail & Humphreys, 2014) to account for the further distances that people in rural areas are willing to travel; and the inclusion of commuter information (Fransen, Neutens, De Maeyer, & Deruyter, 2015) to consider how travel behaviour can affect spatial accessibility. While the importance of catchment sizes on the results of FCA accessibility analyses has been demonstrated (Chen & Jia, 2019), appropriate catchment sizes have not been defined in New Zealand, and the debate surrounding appropriate catchment sizes in general remains unresolved (Bissonnette, Wilson, Bell, & Shah, 2012; Neutens, 2015; Wang, 2012). This is exacerbated by a lack of studies using data to guide the choice of catchment size, which is likely due to a lack of data available to researchers on actual patient behaviour and the relationship between access and geography that could inform the appropriate choice of catchment sizes (Allan, 2014; Bauer & Groneberg, 2016; Luo & Qi, 2009; McGrail & Humphreys, 2014). In general, most accessibility research in health geography has studied geographical distributions and distance, with only a few papers examining travel behaviour in more detail (Rosenberg, 2014). Despite these limitations the 2SFCA method is often considered the ‘default’ spatial accessibility measure and has been used as the first step to assess the equity of access to GPs in Adelaide City (Roeger, Reed, & Smith, 2010), primary health care in rural Otago (Bagheri et al., 2008) and mammography screening services in Chicago (Zenk, Tarlov, & Sun, 2006). Furthermore, Lian, Struthers, and Schootman (2012) identified an association between poor accessibility to mammography facilities, as measured by the 2SFCA, and increased risk of late-stage breast cancer. Other accessibility measures including travel time and service density did not predict neighbourhood risk of cancer. Once accessibility has been estimated, spatial equity can be quantified with a range of statistical and geospatial techniques such as the Gini coefficient and spatial autocorrelation. These measures are outlined and in greater detail in the second article of this thesis (Whitehead et al., 2019a).

1.1.6 Sustainability of health services

Although sustainability is an important aspect of health care delivery, it is a multidimensional concept which can be difficult to define (Blanchet & Girois, 2013; Giovannoni & Fabietti, 2013). In the context of rural and remote health, Humphreys et al. (2006) suggest that sustainability is the ability of a health service to provide ongoing, appropriate, effective, and cost-efficient access to quality care. Assessing both spatial equity and sustainability therefore relies on a measure of accessibility, suggesting that they can be investigated together. This means not only considering whether current services are accessible, but if they are spatially equitable, and whether they are likely to continue to be equitable into the future. There are several factors that can affect the quality, cost, and ongoing accessibility of services, which Humphreys et al. (2006) argue align with social, economic, professional, and organisational domains. Key threats to sustainability outlined in the literature (Buykx et al., 2012; Humphreys et al., 2006; Humphreys et al., 2008; Hunsaker & Kantayya, 2010; Loh et al., 2015; London, 2002; Murdoch, 2010; Rees, Crampton, Gauld, & MacDonell, 2018; Schoo, Lawn, & Carson, 2016) include:

- the geographic isolation of communities, which can pose a barrier to attracting a health workforce and make providing care more difficult
- population demand for services, population size and demographic changes, which can mean that more health professionals are needed to care for growing or elderly populations, or that it is no longer economically viable to provide care for shrinking populations
- workforce capacity and availability, which can limit the supply of health professionals in an area, region, or country
- management structures within health services and organisations, which can impact upon the efficiency services

- and government policies, which often guide funding arrangements and models of care.

Blanchet and Girois (2013) expand on this and contend that sustainability is also dependent on community capacity and an enabling social, economic and policy environment. The important and reflexive link between health services and their communities has also been recognised by Buykx et al. (2012) who argue that, not only does service sustainability depend on community capacity, but that health services also have the potential to positively influence the sustainability of local communities.

Most research on the sustainability of primary health care has been carried out in Australia and the United States of America, and there is limited literature based on the New Zealand context. Furthermore, there do not appear to be any mixed-methods analyses of GP service sustainability that attempt to integrate the findings of qualitative and quantitative approaches. Levels of workforce supply and patient demand are key professional and social factors of sustainability that are readily quantifiable and could be incorporated into a GIS model. However, the literature outlined above suggests that sustainability is dependent on a wider array of factors that may be difficult to quantify, and may need to be investigated qualitatively. Wakerman and Humphreys (2011) have argued that health services research should be multidisciplinary, and this thesis aims to examine both the perceptions of patients and service providers through a qualitative approach, and to quantify sustainability through GIS modelling.

1.1.7 Waikato DHB demographic profile and context

The Waikato DHB region has a population of around 405,000 people, an increase of 12.9% from 2013 (Statistics New Zealand, 2019a). The demographic profile of the Waikato DHB region and New Zealand is outlined below in *Figure 1.6,* and indicates that Māori make up a higher percentage of the Waikato DHB population (23.9%) than the national average (16.2%), and nearly half of children aged under 15 years in the Waikato DHB Region identify as Māori (36.9%) or Pacific (8.3%).

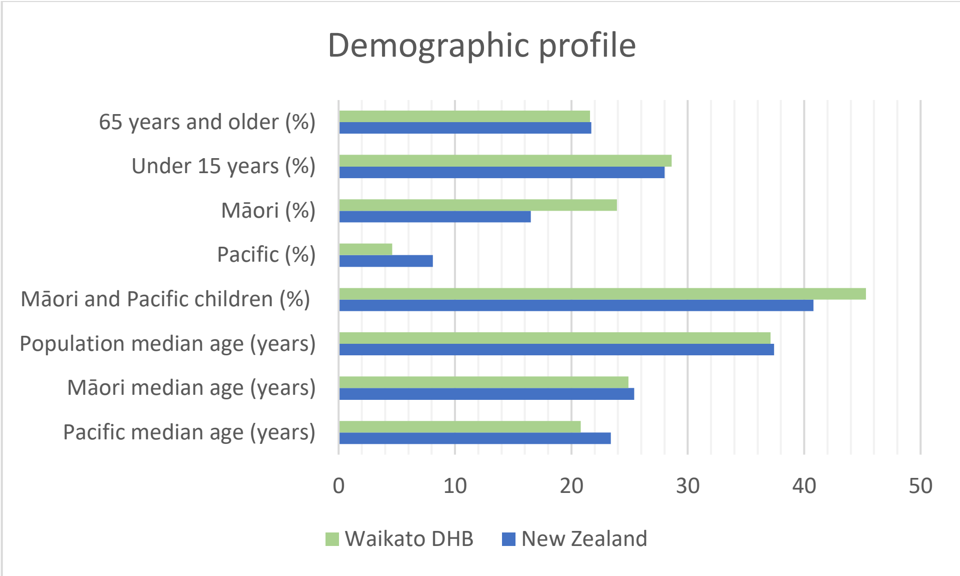

Figure 1.6 Demographic profile of Waikato DHB and New Zealand

The 2013 New Zealand Index of Deprivation (NZDep2013), and the Index of Multiple Deprivation (IMD) indicate that the Waikato DHB region has high area-level relative disadvantage according to these composite measures that take into account household features such as income, education and occupation (NIDEA, 2017; Yong et al., 2017). This is particularly true for some parts of the region, and more than half of the population in South Waikato (64%), Ruapehu (58%), and Hauraki (53%) are living in the most deprived NZDep2013 quintile (NIDEA, 2017). The Waikato DHB region is also overrepresented in several of the domains of the IMD, with higher than expected levels of unemployment, lower levels of income, and lower levels of education (Yong et al., 2017).

At a national level, New Zealand's overall steady population growth is predicted to continue, however (Spoonley, 2016) has noted that population stagnation and decline is a major concern for many of New Zealand's regions, and could affect the ability of communities to support local infrastructure. The Waikato DHB population is projected to increase to 475,400 by 2033, with approximately 60% of this growth occurring in Hamilton City, while the populations of Ruapehu, Waitomo, and South Waikato are expected to decline (NIDEA, 2017). The age structure of the Waikato DHB is also expected to change. Demographic Transition Theory (DTT) outlines how societies move from high mortality and high fertility to low mortality and low fertility (Weinstein & Pillai, 2016). One assumption of the DTT was that the final stage would be of long and stable low fertility and mortality, with total fertility rates falling to and remaining at replacement level of 2.1 births per woman (Weinstein & Pillai, 2016). However, the fertility rates of most 'industrialised' nations have now fallen below the replacement fertility rate, and are therefore projected to experience population decline (Wattenberg, 2004). Some have labelled the combination of sustained sub-replacement fertility, changing values and demographic behaviours as a 'second demographic transition' which are likely to result in both population ageing and population decline (Raymo, 2015). In New Zealand, the number of people aged 65 years and above doubled between 1980 and 2014, and is estimated to reach up to 1.25 million people by 2036 (Bascand & Dunstan, 2014). Jackson (2016) has argued that structural ageing is an inevitable force that will affect the majority of Territorial Authorities (TAs) in New Zealand leading to higher proportions of older people in certain areas and eventually to likely population decline as growth through natural increase comes to an end. Through both numeric and structural ageing, the proportion of over 65-year olds in the Waikato DHB is projected to increase to 22% by 2033 (NIDEA, 2017). Furthermore 26% of the Waikato DHB population is expected to identify as Māori by 2033 (NIDEA, 2017).

Although the definition of rurality in New Zealand is contested (Fearnley, Lawrenson, & Nixon, 2016), a consideration of the Waikato DHB region's urban-rural profile is important due to the poorer health outcomes associated with many small towns and rural areas, particularly for Māori (Robson et al., 2010). The Waikato DHB (2015) has highlighted the elimination of inequities for Māori and rural populations as a priority. Applying Statistics New Zealand (2017) definitions of urban and rural areas to the results of the latest census (Statistics New Zealand, 2019c) suggests that in the Waikato DHB region:

- around 160,000 people live in the Hamilton *major urban area* (population ≥ 100,000)
- over 44,000 people live in *medium urban areas* (population 10,000 – 29,999) such as Cambridge, Tokoroa and Te Awamutu
- over 89,000 people live in small towns, which are called *small urban areas* (population 1,000 – 9,999)

- and 111,000 people live in areas that are classified as *rural settlements* (population 200 – 1,000) or *rural other* (population < 200, mainly agricultural or conservation land use).

Depending on how these classifications are divided, approximately 204,000 residents of the Waikato DHB region could be considered as living in urban areas (Statistics New Zealand *major* and *medium urban areas*), with the remaining 200,000 people classified as residing in rural locations (Statistics New Zealand *small urban areas*, *rural settlements,* and *rural other*).

1.2 Research overview

1.2.1 Aims and objectives

This thesis aims to examine the spatial equity and sustainability of GP services in the Waikato DHB region, and identify not only *where* inequities exist, but *why* they occur and *how* they could be overcome. Therefore, the principal research question of this thesis is:

Are GP services spatially equitable and sustainable in the Waikato DHB region?

In addition, this thesis also examines three sub questions that will help to address the overarching research question:

(1) How can the spatial equity and sustainability of GP services be examined?

(2) How can GIS techniques be used to assess the spatial equity and sustainability of GP services in the New Zealand context?

(3) How and why are demographic and other factors likely to affect the spatial equity and sustainability of GP services in the Waikato DHB region?

1.3 Research Methods

Overall, this research takes a non-experimental, mixed methods approach. Mixed methods research combines elements of qualitative and quantitative research approaches for to improve the breadth and depth of understanding (Johnson, Onwuegbuzie, & Turner, 2007). In non-experimental research the researcher does not directly control the independent variables (Edmonds & Kennedy, 2017), a description which applies to both the secondary data that has already been independently collected but was analysed in this research, and the primary qualitative data. Creswell and Plano Clark (2011) outline several advantages to mixed methods research including that it:

- has strengths that offset the weaknesses of both qualitative and quantitative approaches
- provides more evidence for answering a research problem than either qualitative or quantitative approaches could provide alone
- encourages the use of multiple worldviews
- is practical and allows the use of all available methods.

The overarching research question is suited to mixed-methods research since, as previously outlined, definitions of both spatial equity and sustainability are contested, and therefore an approach that encourages multiple worldviews is appropriate. Furthermore, health care geography has tended to be dominated by quantitative approaches, and the general lack of qualitative research has been identified as a weakness of the field (Rosenberg, 2014). Therefore, a conscious decision was made to incorporate qualitative methods such as thematic analysis, which Braun and Clarke (2014) argue offers rich insights into the worlds of patients and health professionals.

Ethical approval was required as this research involved qualitative interviews with human participants and the analysis of individual, anonymised, data from health records. This study recieved ethical approval from the Human Research Ethics Committee, Faculty of Arts and Social Sciences, University of Waikato – granted 18th May, 2017. Reference: Whitehead FS2017-18. In carrying out this research I have abided by the University of Waikato's *Ethical Conduct in Human Research and Related Activities Regulations (2008)*, and *Student Research Regulations (2008).*

1.3.1 Building the study dataset

The analysis carried out in this thesis is based on a study dataset of primary and secondary data, outlined in *Table 1.1*. The quantitative analysis uses secondary data that has been collected from a number of organisations and institutions, and is a mixture of open-source and proprietary data. The qualitative analysis uses primary data collected through in-depth interviews with key informants that were digitally recorded and transcribed verbatim.

Table 1.1 Building the study dataset

Geographic Data	Source
• NZ Roads dataset	Land Information New Zealand (2019)
• NZ Address dataset	Land Information New Zealand (2019)
• GP clinic addresses	Waikato District Health Board (2019a)
• Area unit (AU) boundaries	Statistics New Zealand (2019c)
• Statistical Area 2 (SA2) boundaries	Statistics New Zealand (2019c)
Population data	**Source**
• 2013 and 2018 census counts by SA2	Statistics New Zealand (2019c)
• Ethnic group (grouped total responses) by age group and sex, for the census usually resident population count, 2001, 2006, and 2013 (RC, TA, AU)	Statistics New Zealand (2019b)
• Cigarette smoking behaviour by age group and sex, for the census usually resident population count aged 15 years and over, 2006 and 2013 Censuses (RC, TA, AU)	Statistics New Zealand (2019b)
• Subnational population estimates (TA, AU), by age and sex, at 30 June 1996, 2001, 2006-2018 (2017 boundaries) [6]	Statistics New Zealand (2019b)
• Age and sex by ethnic group (grouped total responses), for census night usually resident population counts, 2006, 2013, and 2018 Censuses (RC, TA, SA2, DHB)	Statistics New Zealand (2019b)
• Area unit population projections, by age and sex, 2013(base)-2043 update	Statistics New Zealand (2019b)
• Subnational ethnic population projections, by age and sex, 2013(base)-2038 update	Statistics New Zealand (2019b)
Socio-economic deprivation data	**Source**
• New Zealand Index of Socioeconomic Deprivation (NZDep2013)	University of Otago Wellington (2019)
• Index of Multiple Deprivation (IMD)	University of Auckland (2019)
Health outcome data	**Source**
• Publicly funded hospital discharges of people domiciled in the Waikato DHB region from July 2008 to June 2018	Ministry of Health
• Death registrations of people domiciled in the Waikato DHB region (code 031) from 2009 to 2016	Ministry of Health
• Malignant cancer registrations (site codes C00-C96, D45-D47) of people domiciled in the Waikato DHB region (code 031) from 2009 to 2018	Ministry of Health
PHO data	**Source**

[6] This dataset is no longer available from NZ.Stat and has been replaced by the *Subnational population estimates (TA, SA2), by age and sex, at 30 June 1996, 2001, 2006-2013, 2018-2019 (2019 boundaries)* dataset.

• Patient enrolment records, December 2017	Hauraki Primary Health Organisation
Qualitative data	**Source**
• Key informant interviews	In-depth interviews recorded and transcribed verbatim

1.3.2 Quantitative methods

The quantitative methods employed in this thesis are largely based on GIS techniques using ArcGIS and statistical testing in the Statistical Package for the Social Sciences v25 (SPSS) (IBM Corp., 2017) and R (R Core Team, 2017). The quantitative methods were mainly used to improve our understanding and estimation of access, as well as quantifying levels of spatial equity. Chapter 4 involved the geospatial analysis of PHO patient enrolment records. This was performed to test the assumption in LCPA models of accessibility that patients use the service closest to their residential address. After data cleaning and preparation, 133,870 patient addresses were geocoded and ArcGIS 'Closest Facility Analysis' was used to determine the road network distance between each patient and the GP clinic closest to their home. The distance between patients' residential addresses and the clinic they were actually enrolled with was calculated in order to classify patients as either enrolling with, or bypassing their closest GP. SPSS was used to perform a regression analysis with GP bypass as the outcome variable. This analysis identified spatial and non-spatial factors associated with patients not enrolling with their closest service. It also indicated that most patients did not use their closest service, and therefore rather than relying upon LCPA assumptions, the improved E2SFCA access model should be used. The E2SFCA incorporates a more flexible understanding of access, and includes measures of supply and demand, as well as distance. Chapter 5 used the same PHO dataset to address the choice of an appropriate catchment size, which Chen and Jia (2019) have indicated is one of the most critical components of FCA models. It also examined the impact of using 'variable' or 'dynamic' catchment sizes, which have been highlighted as an area for improvement in FCA models (Luo & Whippo, 2012; McGrail & Humphreys, 2014). ArcGIS 'Closest Facility Analysis' was again used to calculate the distance that each patient lived from their enrolled GP clinic. A sensitivity analysis was then performed to identify the distance a certain proportion of each clinics' patients (between 65% and 100%) lived within. Differences in average GP and population catchment sizes by the rurality of clinics was examined, and a 90% patient enrolment threshold was selected as this minimised the impact of outliers. The results suggest that dynamic, data-driven catchments can improve accessibility analyses, and these variable catchment sizes were also included in the VGP-E2SFCA model. The VGP-E2SFCA also incorporates the Butterworth distance decay function (see Langford, Fry, & Higgs, 2012), to produce a smooth transition from high access at the centre of a catchment, to low access at the periphery. Chapter 6 used methods from spatial epidemiology, such as spatial autocorrelation and cluster analysis, to examine variations in health need at the Area Unit level and determine the impact of incorporating health need weightings into spatial accessibility models. Seven indicators of health need were mapped for the Waikato DHB region and both ‘global’ and ‘local’ measures of spatial autocorrelation were used to identify the extent and location of health need clustering. Statistical testing in R, including Spearman’s rank correlations and one-way ANOVA, was used to determine the degree of similarity or difference between the seven indicators, as well as the impact of incorporating health need weightings into an E2SFCA accessibility analysis. Hart’s Inverse Care Law was tested by comparing the spatial autocorrelation of accessibility and health need, as well as by quantifying the population distribution of accessibility through the Gini coefficient. The results of chapter 6 suggest that health need weightings have minimal impact on the results of spatial accessibility analyses, and therefore these were excluded from the GIS model and reserved for a separate spatial equity analysis. *Figure 1.8* indicates how the findings of chapters 4, 5 and 6 were incorporated into the quantitative methods of chapters 7 and 8, where a mixed-methods approach combines and improved GIS model of access with an analysis of semi-structured interviews.

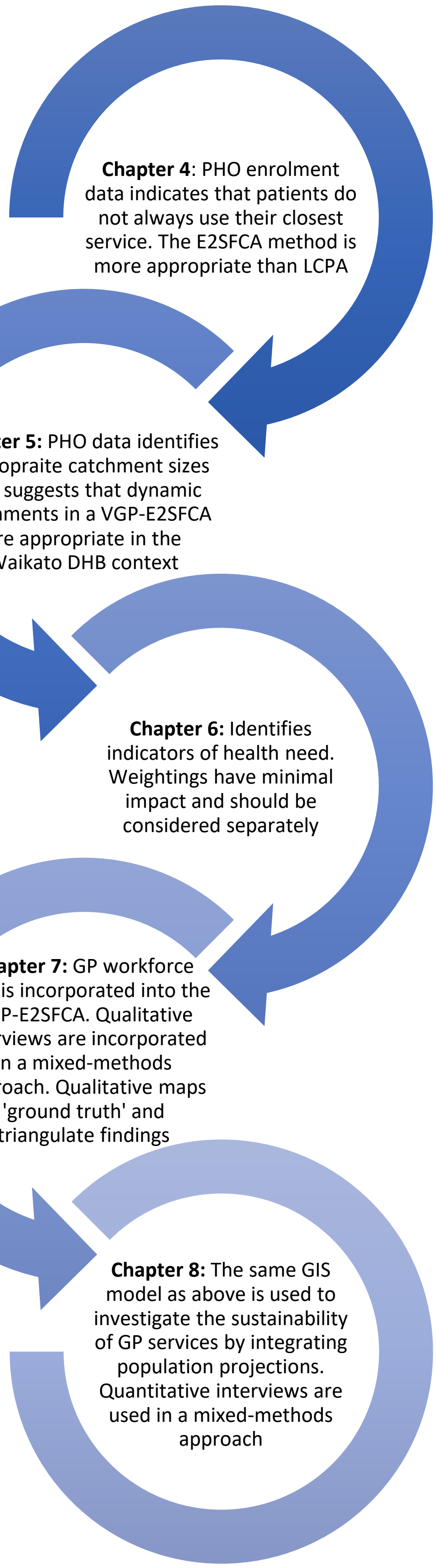

Figure 1.7 How chapters 4-8 contribute to the development of a GIS model of spatial accessibility

1.3.3 Qualitative methods

The qualitative component of this research followed the six phases to thematic analysis as outlined by Braun and Clarke (2006), as presented in chapters 7 and 8, which are similar to the general steps described by (Bryman, 2016). This qualitative research was based on interviews with key informants, and a generic purposive sampling approach was used to identify an initial sample of interviewees, after which a snowball sampling method was used to find additional participants. The 17 key informants included patient representatives (n=7), general practitioners (n=5), and representatives from Primary Health Organisations (PHO) (n=4) and the Waikato DHB (n=1), all of whom were living and/or working in the Waikato DHB region. Face-to-face semi-structured interviews lasting approximately 60 minutes were conducted with participants between August and December 2018. Semi-structured interviews were preferred since they can address more specific issues than unstructured interviews, yet still allow for flexibility in both interviewer lines of questioning and interviewee responses (Bryman, 2016). Particpants were asked a range of questions within the broad theme of GP service equity, including questions around barriers to equity, causes and effects of inequity and potential solutions. Audio from all interviews was digitally recorded, transcribed verbatim, de-identified, and imported into NVivo qualitative analysis software (QRS International, 2018). Through this process of conducting and transcribing interviews I became familiar with the data corpus, which is phase one of a thematic analysis (Braun & Clarke, 2006). Then, in phase two, an inductive approach was used to generate initial codes from the recurring ideas in the interview transcripts. As suggested by Guest, MacQueen, and Namey (2012), a single codebook with thematic definitions was created iteratively. Codebooks include a list of codes, definitions and examples for each code, and details of when to use it (Guest et al., 2012). In phase three, potential themes were discerned by sorting and grouping codes. These initial themes were reviewed in phase four to ensure that the codes within them were coherent, and that there were clear distinctions between themes. Through this process, higher order themes were discerned, which led to phase five – the definition and naming of themes and an examination of links and connections between concepts. Finally, in phase six, a narrative about the interview data was developed and chapters 7 and 8 were produced as articles to be published. In this phase, a more deductive approach was used to consider how the themes that had been discerned aligned with key frameworks and ideas in the literature.

1.4 Thesis structure

The remainder of this thesis follows the subsequent structure. Chapter 2 outlines a conceptual framework for examining the spatial equity and sustainability of GP services in New Zealand. This framework is an important contribution to the field of spatial equity and sustainability research given the lack of literature in New Zealand on this topic. The framework outlines three key steps in the process; (1) defining spatial equity and sustainability; (2) estimating current and future levels of access and need; and (3) quantifying spatial equity and sustainability through established measures. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published as an article in the *Australian Journal of Rural Health* (2018).

Chapter 3 addresses step (1) of the conceptual framework by synthesising the range of definitions and measures of spatial equity found in the research literature through a systematic literature review. Four groups of spatial equity definitions are proposed, and the most common measures of spatial equity identified, and grouped according to their associated definitions. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published as an article in the *Journal of Health Services Research and Policy* (2019a).

Chapters 4, 5 and 6 address step (2) of the conceptual framework by focusing on the estimation of access to services and health need. Chapter four takes the form of a geospatial analysis of patient enrolments with Hauraki PHO, who at the time were a significant provider of GP services in the Waikato DHB region. GIS methods are used to test the assumption that patients enrol with their closest GP clinic. This analysis shows that most patients do not use their closest service, and that a variety of spatial and non-spatial factors influence the likelihood of patients bypassing their closest service to enrol with another, more distant clinic. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published in *Rural* *and Remote Health* (2019b). Chapter 5 uses the same Hauraki PHO dataset to explore the issue of GP and population catchment sizes in Floating Catchment Area spatial accessibility models. Choosing the correct catchment size is a key step when developing GIS models to estimate the spatial accessibility of health services (Chen & Jia, 2019). This is the first study in New Zealand to specifically use real-world patient enrolment data to determine appropriate catchments for health services. This sensitivity analysis indicates that catchment sizes vary for individual GP clinics, and that there are considerable differences in the sizes of catchments for clinics located in urban and rural areas. This appears to support the suggestion by McGrail and Humphreys (McGrail & Humphreys, 2014) that variable catchment sizes should be used when FCA models are applied to mixed-urban-rural contexts. Incorporating variable catchment sizes into an E2SFCA spatial accessibility model appears to improve analysis results. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published in *Applied Geography* (2020). Chapter 6 focuses on the estimation of health needs at the small area level in the Waikato DHB region. Seven potential indicators of need were identified and assessed against 10 indicator selection criteria and mapped across the Waikato DHB region. Strong and significant Spearman rho correlations are identified between several of the indicators, suggesting that they estimate the spatial distribution of health needs in similar ways. Socioeconomic deprivation, Ambulatory Sensitive Hospitalisations (ASH), and the crude mortality rate are significantly correlated with all other indicators. Incorporating indicators of health need into FCA models through population weightings does not have a significant impact on the results of spatial equity analyses, although models with health needs weightings incorporated did have lower average accessibility scores. However, a Gini coefficient for the distribution of accessibility scores across the Waikato DHB population suggests that services are not evenly distributed. Comparing the spatial clustering of areas with high access to services, and areas with high health needs indicates that GP clinics are not spatially equitable. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, has been submitted to and is being reviewed for publication by *The Journal of Rural Health.*

Chapters 7 and 8 are focussed on step three, the quantification of spatial equity and sustainability. These chapters take a mixed-methods approach by incorporating GIS and qualitative methods to provide a deeper understanding of the causes of spatial inequity and poor sustainability of GP services in the Waikato DHB region. Chapter 7 focusses on spatial equity by incorporating findings from previous chapters into an improved model of accessibility. Gini and spatial autocorrelation are then used to determine whether services are equitably distributed when population need is considered. In-depth interviews with key informants provide key evidence on the non-spatial factors that act as barriers to accessing primary health care, and, importantly, identify they key systemic and structural factors that have led to the provision of inequitable services. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is under review with the *New Zealand Population Review.* Chapter 8 focuses on the sustainability of GP services by examining their projected spatial accessibility and equity under six simulated scenarios. Population projections from Statistics New Zealand for the years 2028, 2033, 2038, and 2043, as well as historical workforce data from the Medical Council of New Zealand are used. Projected distributions of spatial accessibility are also compared to an estimate of future health need using the projected future age structure. In-depth interviews with key informants provide evidence on key barriers to sustainability, and the systemic and structural factors that impact on the sustainability of GP services in the Waikato DHB region. A thematic analysis of interview transcripts is used to synthesise key themes into a model of GP service sustainability for Aotearoa New Zealand. This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is ready for submission to the *Journal of Mixed Methods Research.*

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Chapter 2: Article 1 – Framework for examining the spatial equity and sustainability of general practitioner services[7]

Jesse Whitehead, BSocSci (Hons),[1] **Amber L. Pearson**, PhD, MPH,[2] **Ross Lawrenson** MBBS, MD, DRCOG, Dip.Comm Health, FP Cert, DHMSA, FAFPHM, FFPH, FRCGP,[1,3] and **Polly Atatoa Carr**, MBChB, MSc, MPH, FNZCPHM[1,4]

[1]National Institute of Demographic and Economic Analysis, University of Waikato, [3]Waikato Medical Research Centre, University of Waikato, [4]Waikato District Health Board, Hamilton, New Zealand, and [2]Department of Geography, Environment and Spatial Sciences, Michigan State University, East Lansing, Michigan, USA

[7] Whitehead et al. (2018) – This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published in the *Australian Journal of Rural Health.*

Abstract

Objective: To propose a framework for examining both the spatial equity and sustainability of general practitioner (GP) services.

Design: A conceptual discussion based on a systematic literature review of spatial equity definitions and methods.

Setting: Improving the spatial equity of health services is a key step in achieving health equity. Health systems should contribute to achieving health equity and maintain equitable services into the future. GP services are a key component of primary health care which often aims to promote health equity. Despite the importance of spatially equitable and sustainable GP services, a framework for analysis has not yet been established.

Main outcome measure: Examples of how the proposed framework could be implemented are provided from the New Zealand health care context.

Result: The framework entails three steps: (1) defining spatial equity and sustainability, (2) estimating current and future distributions of health services and needs, and (3) quantifying spatial equity and sustainability. In step (1) a needs-based distribution is the most common definition of spatial equity, while sustainability is the ability to provide ongoing equitable access. Step (2) depends on current and future estimates of access and need within a well-defined geographical area. In step (3) spatial equity and sustainability should be quantified through measures such as the Gini coefficient. Current and future levels of spatial equity should then be compared to assess the sustainability of equitable GP services.

Conclusion: This article outlines a novel conceptual framework for examining the spatial equitability and sustainability of GP services.

What is already known on this subject:

- Spatial equity is one of the first steps in achieving health equity
- People with poor access to services are less likely to use those services
- The sustainability of health services can be threatened by small population and health workforce sizes, geographic isolation, and high health needs.

What this paper adds:

- This paper proposes a novel framework and methods for examining both the spatial equity and sustainability of GP services in three main steps.
- The implementation of each step is described and the most appropriate definitions and methods for the New Zealand health care context are discussed.
- Incorporating sustainability into spatial equity analysis could lead to better decision making about health resource distribution and better planning for eliminating health inequities.

2.1 Introduction

Health inequities are systematic and unfair differences in health that suggest populations are not benefiting from equitable opportunities for health and related services (Marmot, 2005; World Health Organization, 2008). Populations are affected by health inequities resulting from differential access to the social determinants of health, such as education, employment, and access to health care, which is inequitably distributed both globally and within nations (World Health Organization, 2008). This is an issue of spatial equity. People with poor access to health services are less likely to use those services (Hiscock, Pearce, Blakely, & Witten, 2008). Improving the spatial equity of health care is one of the first steps in achieving health equity (Dalton et al., 2013). Effective primary health care is associated with more equitable distributions of health (Starfield, Shi, & Macinko, 2005) and therefore health equity can be advanced through improved spatial equity of primary care, a key component of which are general practitioner (GP) services. While the New Zealand Primary Care Strategy incorporates population health perspectives, the system has grown like topsy-turvy under neoliberal pressures. Government funding is distributed to District Health Boards (DHBs) based on the age, sex, ethnicity, and socioeconomic deprivation of each DHB region's population to give areas with higher health needs appropriately higher funding (Ministry of Health, 2004). However, New Zealand still has significant socioeconomic and ethnic health inequities, especially between Māori - the Indigenous population of New Zealand - and non-Māori (Reid & Robson, 2007). Furthermore, since heath service funding is linked to population demographics, future changes to regional populations could affect the long-term equity and sustainability of primary health care. The spatial equity of health services is dynamic and therefore should be monitored regularly to ensure that current and future service distributions match population need.

2.2 Method

The proposed framework is based on a systematic literature review that followed the PRISMA systematic review guidelines (Liberati et al., 2009). Inclusion criteria were providing a definition of spatial equity or analysing the spatial equity of health services. The following search terms were applied to the PubMed and Web of Science Core Collection (1965-present): spatial equity, geographic, distribution, healthcare, GP, general practitioner, health service. This identified 2,792 papers, 75 of which were deemed appropriate for inclusion.

2.3 Results

A three-step framework (outlined in *Figure 2.1*) was determined from the literature. Step 1 defines spatial equity and sustainability of GP services; Step 2 estimates access and need; Step 3 quantifies spatial equity and sustainability of GP services.

2.3.1 Step 1: Defining spatial equity and sustainability of GP services

First, the meaning of spatial equity and sustainability must be stated. The definition adopted depends on the context of analysis and the researchers' perspectives. One definition is a needs-based distribution of resources which can be subcategorised as either horizontal or vertical equity (Jang, An, Yi, & Lee, 2017). Under horizontal equity people with equal needs and should be treated equally, while vertical equity means people with greater needs should receive more resources (Jang et al., 2017). Vertical equity aligns with a population health perspective which argues that when inequities exist resourcing can favour certain populations to ensure equitable health outcomes between groups (Reid & Robson, 2007). Through vertical equity a compensatory distribution of resources can offset social inequities (Talen, 2001) and in a health care setting means that areas and groups with higher health needs should have more resources than those with lower needs (Gan, Chan, Hoe, & Ng, 2015). Spatial inequity is also viewed as discrimination among groups based on their location (Goddard & Smith, 2001). It is important to analyse the impact that the distribution of GP services has on opportunities for different groups, such as Māori, to access primary care, especially since Māori are affected by differentially poorer access to health care (Reid & Robson, 2007).

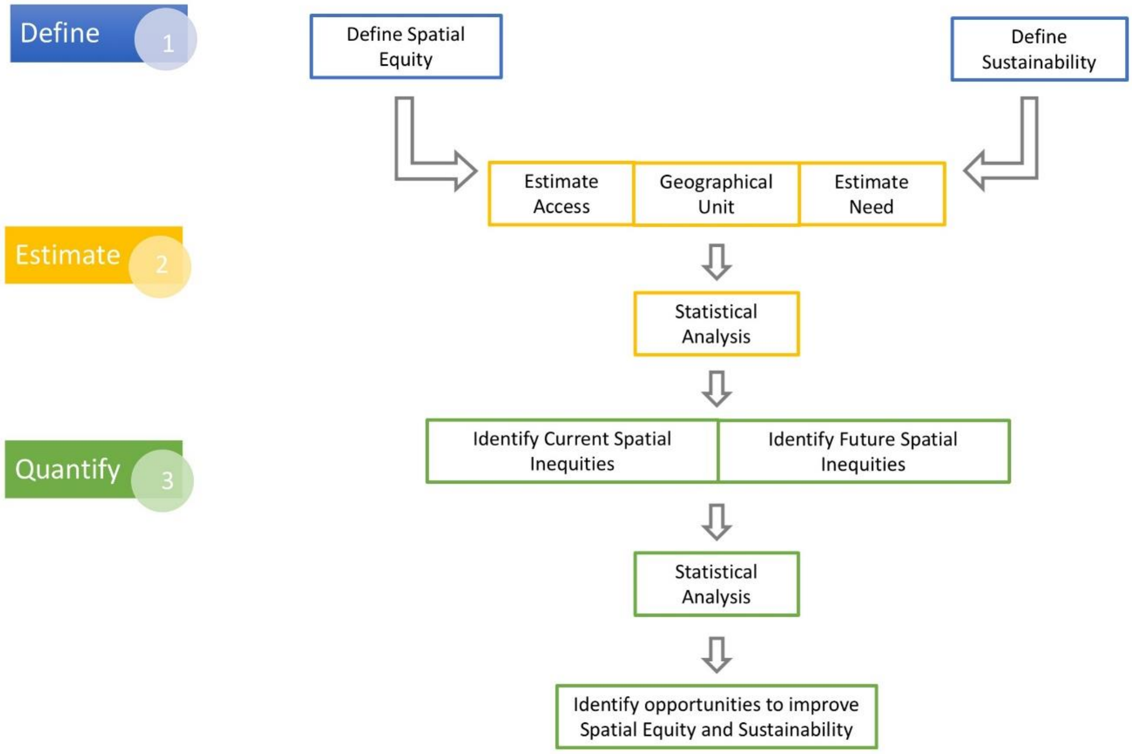

Figure 2.1 A conceptual framework of spatial equity and sustainability analysis

Sustainable health services are able to provide ongoing access to care (Humphreys, Wakerman, & Wells, 2006) and in the context of spatial equity analysis implies that the spatial equity of services should be maintained (and ideally improved) over time. Several factors threaten the sustainability of local health services, including: small population sizes; health workforce recruitment and retention; geographic isolation; and high levels of need for primary, acute, and chronic care (Humphreys et al., 2006). A framework of spatial equity and sustainability should take these factors into account and aim to compare the current and estimated future equitability of GP services. Spatial equity and sustainability analysis can therefore be thought of as assessing whether the distribution of services is fair relative to population need, whether spatial equity is likely to be maintained or improved over time, and how the distribution of GP services affects social groups differently.

2.3.2 Step 2: Estimating spatial equity: current and future distributions of access and need

Talen and Anselin (1998) argue that spatial equity analysis should be based on a measure of access to services. Since health systems should be responsive to population needs, researchers should also estimate need, particularly under a vertical equity approach.

Estimating access

Penchansky and Thomas (1981) outlined a general model of access to health care that considers five dimensions; (1) *Availability* refers to the supply of services relative to the needs of a population; (2) *Accessibility* highlights the geographic location relative to a population; (3) *Accommodation* includes aspects such as opening hours that affect how well a service can meet patient needs; (4) *Affordability* is related to financial costs, and the ability of people to pay for a service; (5) *Acceptability* incorporates barriers related to gender, culture, ethnicity, and sexual orientation. Geographic Information Systems (GIS) can integrate different types of data, and are a useful tool for estimating access and spatial equity (Morrill, 2015). Distance and travel time calculations have been used to examine the *accessibility* of services. Hiscock et al. (2008) investigated the relationship between access to and utilisation of GP services, finding that respondents with poor travel times were less likely to undergo consultations than respondents with good travel time access. More recent studies have used variations of the two-step-floating-catchment-area (2SFCA) method (Vadrevu & Kanjilal, 2016) which takes into account service supply relative to population demand (*availability*), and the distance between populations and services (*accessibility*) to produce an accessibility score. The *affordability, accommodation,* and *acceptability* of services could also be incorporated into access models by considering service fees, after-hours care options, staff demographics, and the availability of services delivered from a Māori or Pacific perspective.

Estimating need

Estimating population health needs is difficult and therefore a combination of census-based demographic and socioeconomic indicators as well as health outcome measures are often used (Cromley & McLafferty, 2012). The New Zealand Deprivation Index is a census-based, area level measure of socioeconomic deprivation that has been used to estimate need (Salmond & Crampton, 2012). Need can also be estimated through health outcomes measured by morbidity and mortality (Barnett, Roderick, Martin, Diamond, & Wrigley, 2002). One measure of morbidity is Ambulatory Sensitive Hospitalisations (ASH) for conditions such as asthma, diabetes, or COPD. ASH conditions are considered preventable by effective primary care and could be used to estimate population need for primary care services. Once an estimate of need is selected it can be incorporated into the accessibility measure following a similar method to McGrail and Humphreys (2009) who adapted the 2SFCA method to incorporate population health needs.

Estimating future spatial equity

Threats to the sustainability of health services include changes to the population, health workforce, and levels of health need (Humphreys et al., 2006), and could be incorporated into an estimate of the future spatial equity of GP services. Local variations in future population growth, decline, and structural ageing could be assessed through subnational population projections. In New Zealand, these are produced by Statistics New Zealand at five-year intervals up to 30 years into the future. Information about the GP workforce could be used to estimate the future distribution of GPs and the effect that this would have on the supply of services.

Selecting an appropriate geographical unit

Since variations in the geographical units of analysis influence accessibility estimates, Shah, Milosavljevic, and Bath (2017) emphasise the importance of selecting an appropriate geographical unit. This often depends on data availability. In New Zealand meshblocks (MBs) are the smallest scale for which census data have been released. Yet, some population projections are only available at the Territorial Authority level. MBs aggregate to Area Units (AU) and Territorial Authorities (TA) respectively. These scales do not always align with the

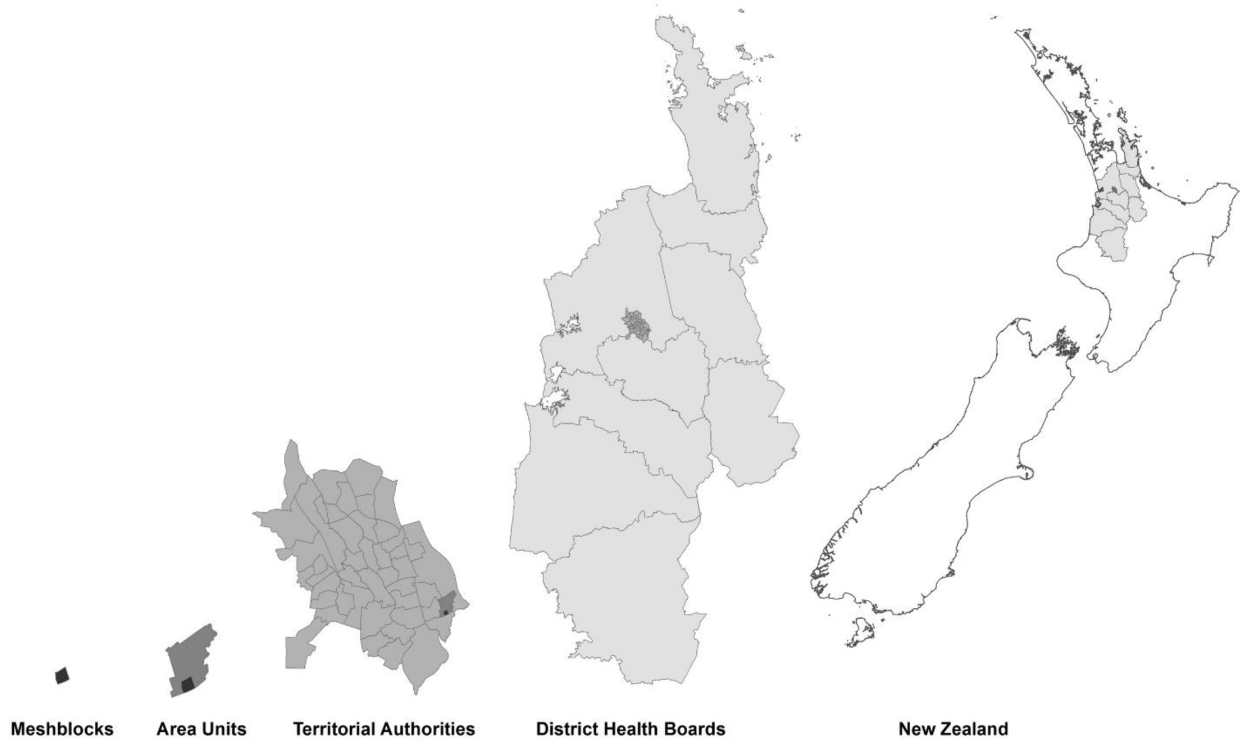

Figure 2.2 Statistical areas that could be used as geographical units of analysis

availability of health data which is often provided at either DHB or AU level by the Ministry of Health. From the 2018 census, these units are changing to Statistical Area 1 (SA1s) and SA2s which will align to current TAs.

2.3.3 Step 3: Quantifying spatial equity and sustainability information

The next step is to quantify spatial equity and sustainability using one or more of a variety of techniques. The Gini coefficient is a widely used measure that represents the overall degree of inequality in a system (Jang et al., 2017). Spatial autocorrelation assesses the degree of similarity between features that are spatially close to each other (Stanley et al., 2016) and includes Local Indicators of Spatial Association (LISA) that can identify local level patterns in data (Talen & Anselin, 1998). Spatial autocorrelation and LISA can be used to identify whether the patterns of access overlap with patterns of need and highlight clusters of alignment or mismatch between access and need. Regression analysis is useful for gaining an understanding of why spatial patterns may occur and identifying factors that may be associated with poor access relative to need (Sanders, Aguilar, & Bacon, 2013). Both current and future levels of spatial equity should be quantified so that a comparison can be made to determine whether spatial equity is likely to be maintained or improved over time.

Comparisons could be made at the whole-system level or involve an analysis of likely localised changes in spatial equity. A system level approach could compare current and future Gini coefficients. Hara, Otsubo, Kunisawa, and Imanaka (2017) examined the longitudinal decline in the equity of Japan's geographic distribution of physicians by comparing Gini coefficients between 2002 and 2014, and their approach could be applied to estimate future changes to spatial equity. A more localised evaluation of the sustainability of GP services could identify potential changes to spatial equity at a smaller scale using LISA. Any statistical analysis should also examine the spatial equity of services for specific subpopulations such as those that identify as Māori in order to monitor structural discrimination and institutional racism and ensure that public services in Aotearoa New Zealand meet their Treaty of Waitangi commitment to protect Māori health and achieve equity.

2.4 Discussion

Although the systematic literature review identified a wide range of spatial equity definitions and methods, only one framework was found (Mortazavi & Akbarzadeh, 2017). Mortazavi and Akbarzadeh (2017) define and examine spatial equity in the context of public transportation using the Gini index to compare differences between the 'needs for' and 'benefit from' public transport within geographic units. Their framework is similar to the one described here, but without the focus on health services or incorporation of sustainability. To our knowledge no spatial equity studies of health services have included sustainability in their analysis. This limits the ability of spatial equity research to inform planning decisions that could improve the future spatial equity of health services. Further, snapshots of current spatial equity such as McGrail & Humphreys' (McGrail & Humphreys, 2009) index of rural access often rely on census data that, in New Zealand, could be up to 5 years out of date and therefore may not accurately reflect either current or future spatial equity. To our knowledge, we present the first framework to assess both the spatial equity and sustainability of GP services. The lack of focus on sustainability in the spatial equity literature may represent a disconnect between the views of health geographers and the concerns of healthcare organisations or policy makers. Health geographers may emphasise spatial techniques and research methods rather than the impact that future population changes may have on the ability of health systems to deliver equitable services. We hope that the framework outlined in this paper encourages further research leading to the improved spatial equity and sustainability of health services and ultimately health equity. Research to test and validate our framework is underway.

Author contributions

All authors contributed to the design and writing of this paper

Conflicts of interest

None declared

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Chapter 3: Article 2 – How can the spatial equity of health services be defined and measured? A systematic review of spatial equity definitions and methods[8]

Jesse Whitehead,[1] **Amber L. Pearson**,[2] **Ross Lawrenson,**[3,4] and **Polly Atatoa Carr**[5,6]

[1]Doctoral Student, National Institute of Demographic and Economic Analysis, University of Waikato, New Zealand

[2]Assistant Professor, Department of Geography, Environment, & Spatial Sciences, Michigan State University, USA

[3]Professor of Population Health, National Institute of Demographic and Economic Analysis, University of Waikato, New Zealand

[4]Professor, Waikato Medical Research Centre, University of Waikato, New Zealand

[5]Associate Professor, National Institute of Demographic and Economic Analysis, University of Waikato, New Zealand

[6]Public Health Physician, Waikato District Health Board, New Zealand

[8] (Whitehead et al., 2019a) - This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published in the *Journal of Health Services Research and Policy*.

Abstract

Background: Spatial equity analysis has been carried out in a variety of contexts, and on a range of health services. However, there is no clear consensus on spatial equity definitions or measures. This review seeks to summarise spatial equity definitions and methods of analysis.

Methods: We systematically searched two electronic databases and six journals for papers providing a definition of spatial equity, or performing a spatial equity analysis on health services. Studies were classified according to four definition themes: (1) distributional fairness; (2) needs-based distribution; (3) focus on outcomes or causes; and (4) none provided.

Results: Seventy-five studies met our inclusion criteria. Sixty-one papers provided a definition of spatial equity, while a further 14 papers analysed the spatial equity of health services without providing a definition. A needs-based definition of spatial equity was preferred by most authors, while the Gini coefficient was the most common equity measure. However, analysis approaches varied according to the definition provided by each paper. Among needs-based definitions spatial autocorrelation was the most common spatial equity measure.

Conclusions: To our knowledge, this is the first systematic review summarising spatial equity definitions and analysis methods. A lack of consensus on definitions and measures persists. However, the classification of measures according to definition themes makes this review a useful tool for planning and interpreting spatial equity investigations. Future research should examine the impact different measures of accessibility and need have on the results of spatial equity research.

Keywords

Equity, geography, resource allocation, spatial equity, systematic reviews

3.1 Introduction

Many countries experience systematic and unfair differences in health, called health inequities. Populations may experience inequitable opportunities for health and related services.[1, 2] Working to achieve health equity requires eliminating disadvantage beyond the control of individuals.[3] The health system is a fundamental determinant of health that can both reduce or exacerbate inequities.[1] Globally, health services are inequitably distributed, affecting low-, middle-, and high-income countries alike. While recognising the importance of factors such as the quality of healthcare and discrimination[4], ensuring spatial equity of health services is a core step to achieve equity.[5] Studies have examined spatial equity in relation to hospitals, maternity care, and general practitioner clinics.[6-8] Spatial equity is also of interest to urban planners in relation to public spaces and resources such as parks, playgrounds, and public transport**.**[9, 10] However, studies of spatial equity use a variety of definitions and methods, and there is a lack of consensus about their use.[11, 12] As a result, studies may not measure the same concept with agreed-upon techniques, meaning that findings are not easily comparable or generalisable. This study aims to clarify the range of definitions of spatial equity and how it can be measured, by means of a systematic review.

At the outset it is important to distinguish between *inequity* and *inequality.* Inequality generally refers to the uneven distribution of health or health resources that may occur as a result of biological variations, choice or the external environment and conditions, and which are unavoidable. In contrast, inequity describes the uneven distribution of health and health resources that can be seen as unnecessary and avoidable as well as unjust and unfair.[13] For example, accessibility is an important component of spatial equity[10], but geographic *inequalities* in accessibility are not always considered spatially *inequitable* as some level of difference is inevitable and not necessarily unfair.[14] Thus, allocating higher levels of resourcing, such as health services, to high-needs populations may be seen as unequal, but can be considered pro-equity. A distinction should also be made between measures of upstream, socially determined population needs, and downstream, individual patient needs, as the equity impact of health systems organised to address socially determined 'causes of causes' [2] is likely to differ from those responding to downstream needs.

3.2 Methods

A systematic review of spatial equity definitions and methods was conducted following the PRISMA 2009[15] guidelines.

3.2.1 Search strategy

Studies were identified by searching PubMed and Web of Science databases, the Journal of Health Services Research & Policy, International Journal of Health Geographics, International Journal for Equity in Health, Health Services Research, Health & Place, and Social Science & Medicine. The following search terms were used: spatial equity; spatial equity and ("health" or "healthcare" or "GP" or "Physician" or "general practitioner" or "health service*"); ("spatial" or "distribution" or "geographic") and "equit*" and "Health*"; ("spatial" and "*equit*" and "Health*").

3.2.2 Inclusion and exclusion criteria

Studies were included if they provided a definition of spatial equity, or analysed the spatial equity of health services. We did not impose limitations on population groups studied. A range of fields including healthcare, public transportation and urban planning were included. Studies measuring accessibility without specifically assessing spatial equity were excluded. Only English-language studies published between January 1950 and August 2017 were considered.

3.2.3 Study selection

Title and abstracts of records identified from database and individual journal searches were screened and articles not meeting the eligibility criteria were excluded. The full text of potentially eligible papers was reviewed and only those meeting the eligibility criteria were included in the review.

3.2.4 Data extraction

The following information was extracted: (1) the definition of spatial equity used; (2) the methods used to assess spatial equity; (3) data sources; and (4) the study context, location, and type of resource (e.g. hospital, public transport network, urban park) to which the spatial equity analysis was applied.

3.2.5 Risk of bias in individual studies

The methods, data quality, type of spatial analysis, study context and other risks of bias in each eligible paper were assessed to ascertain their validity. Papers at risk of bias were identified and their potential impact on the results was assessed.

3.2.6 Analysis

This review focused on definitions and methods, therefore a meta-analysis of quantitative results from each study was not deemed appropriate. Definitions from each paper were identified and recorded. Four definition themes emerged during this process; (1) distributional fairness; (2) needs-based distribution, categorised into (a) vertical equity, (b) horizontal equity, (c) unclear; (3) outcomes or causes; or (4) none provided. Vertical equity refers to an unequal distribution where populations with higher needs receive appropriately higher resourcing, while horizontal equity assumes equal population needs and therefore an equal distribution of resources.[16] Definitions were categorised into the most appropriate theme. Papers that used multiple definitions, or definitions which fit into more than one theme, were classified according to the crux of the discussion and/or the type of spatial equity analysis performed. If a paper described both vertical and horizontal equity, the definition was categorised based on how the spatial equity analysis incorporated need. Cases where the role of need in analysis was unclear were classified as unclear needs-based distributions (Theme 2c).

Approaches to measuring spatial equity were identified and recorded. While Talen and Anselin[10] assert that any spatial equity analysis “relies on a measure of access to services”, reviews of contemporary accessibility methods have been published elsewhere.[17, 18] Therefore, this paper focused on identifying measures and analytical techniques for assessing spatial equity. Common spatial equity measures included: the Gini coefficient, which provides an equity score between 0 and 1, with 0 representing a perfectly equal distribution of resources and 1 representing a completely unequal distribution[19]; the Lorenz curve, which visually represents the cumulative distribution of ‘benefit’ across a population, and is used to calculate the Gini coefficient[19]; spatial autocorrelation, which measures the degree of similarity between features that are spatially close to each other[20]; and Local Indicators of Spatial Association (LISA), which are a type of spatial autocorrelation useful for identifying local level patterns in data that can be obscured by global measures.[10]

3.3 Results

The searches identified 2,387 records in the Web of Science database and 402 records in the PubMed database, with a further 64 identified from specifically searched academic journals (*Figure 3.1*). After duplicates were removed there were 2,792 initial records. Title and abstract screening identified 173 articles potentially eligible for inclusion, with a further 98 studies excluded following full-text review. This yielded 75 papers considered eligible for inclusion in this review (see *Table 3.2 in Appendix*). There appeared to be general agreement that spatial equity is difficult to define, with little consensus.[11, 12, 21-25] Still, of the included studies, 61 provided a definition of spatial equity, while 14 papers analysed spatial equity of health services without providing an explicit definition. A total of 16 papers were identified as having potential risk of bias. Of these, 14 studies were flagged due to concerns around the approach such as a lack of geospatial or population-based analysis, while 11 papers were based on survey data or had unclear data sources. We decided that despite their potential risk of bias, these 16 papers should be included in the review as potential bias was not directly related to defining spatial equity, and methodological shortcomings were related to accessibility analysis which, as previously discussed, is distinct from the assessment of spatial equity. Of the 16 papers considered at potential risk of bias, 11 used need-based definitions of spatial equity. A further four papers had unclear definitions, while one paper defined spatial equity as distributional fairness. In terms of methods used, five papers used a concentration index, three used the Gini coefficient, three focused on accessibility measures, and two used correlations. Regression analysis, spatial autocorrelation/LISA, the Theil index, and the Atkinson index were used by a single paper each.

3.3.1 Definitions of spatial equity

Reported definitions of spatial equity were classified into one of the four themes identified in the ’Methods’ section (Supplemental Material). Overall, the themes appear mutually exclusive, with only Lara-Valencia and García-Pérez [26] referring to both distributional fairness (Theme 1) and causes of spatial inequity (Theme 3).

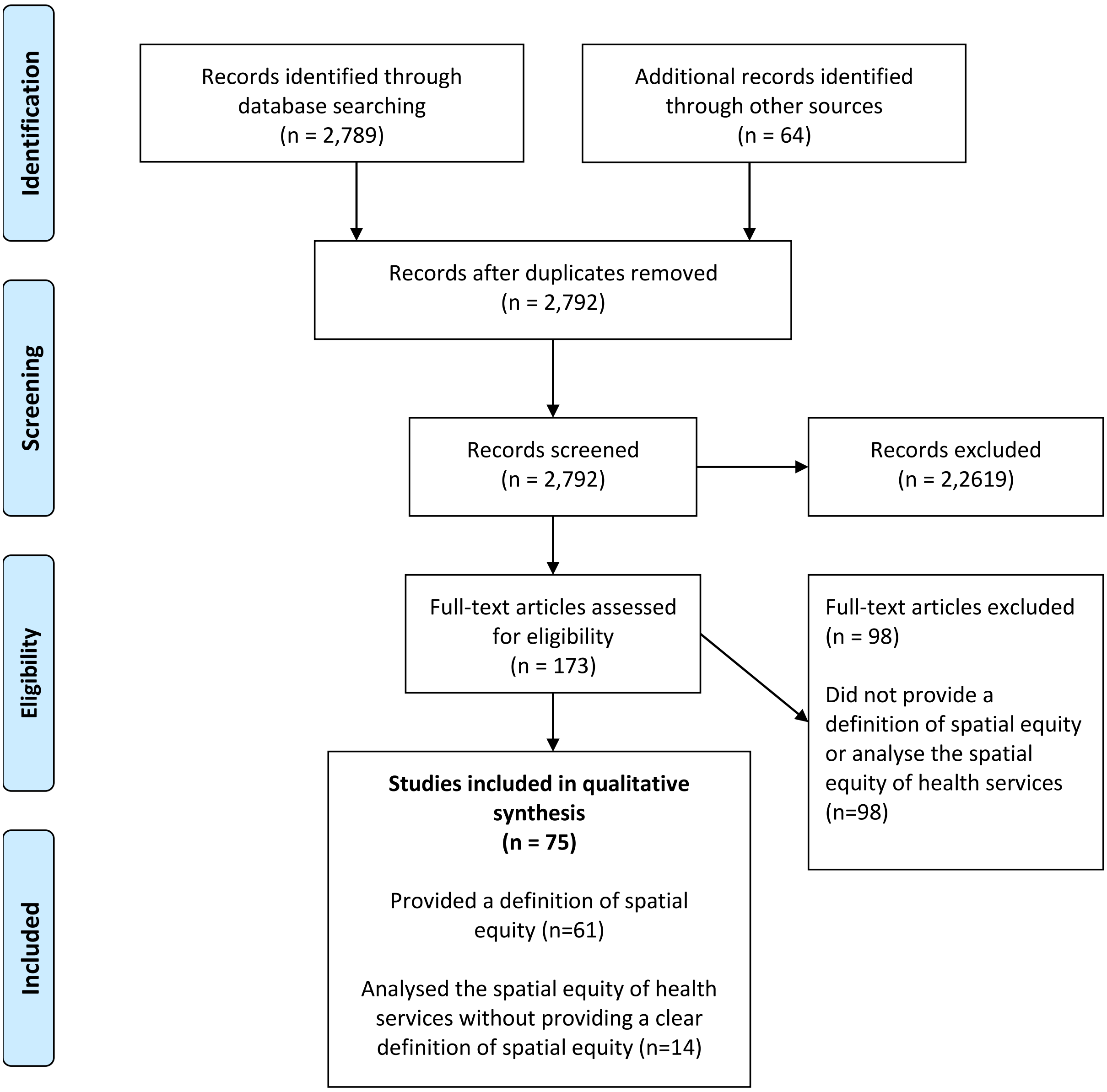

Figure 3.1 PRISMA flow chart

Theme 1: distributional fairness

Eleven articles provided a definition of spatial equity that aligned with the concept of distributional fairness. Five studies referred to spatial equity as the fairness of the distribution of both benefits and burdens.[20, 22, 26-28] Five further studies suggested that resource distributions and access should be fair.[23, 24, 29-31] One study was set in the context of environmental health, referring to spatial equity as the fair distribution of hazards.[32]

Theme 2: needs-based distribution

Most articles (45) defined spatial equity as a needs-based distribution of resources. Sixteen papers highlighted that spatial equity can be distinguished into vertical and horizontal components.[9, 16, 19, 22, 24, 32-35] Horizontal equity refers to the idea that people with equal needs should receive equal treatment, while vertical equity postulates that people with greater needs should receive more resources.[16, 19, 22, 24, 33] Vertical equity further suggests that a compensatory distribution of resources can offset or mitigate social inequities.[36] In a health care setting this aligns with the assertion that areas with higher health needs should be provided more resources, such as health facilities, than those with lower needs.[35] Of the 45 studies that provided a needs-based definition of spatial equity, 14 aligned with a vertical equity definition or approach to analysis, 11 used a horizontal equity definition or approach, while the remainder did not further specify the needs-based definition or approach. The definition and measures of need used in each healthcare focused study were also inconsistent. Fourteen papers used downstream measures of need in the context of healthcare, such as Gan et al.[35] who used the crude death rate to estimate health needs in Malaysia. Ten studies used upstream measures, such as Vadrevu and Kanjilal[8] who took village-level socioeconomic status into consideration to differentiate inequality from inequity when analysisng the spatial equity of maternity facilities. Eight studies included a combination of both measures such as Hanson and Jones[37] who used a combination of direct health need, such as long-term illness and self-rated health, and upstream need such as socioeconomic deprivation, to determine that provision of one English public health intervention was not associated with the highest population need and may lead to widening inequities. Ten healthcare studies with needs-based definitions used downstream need (four horizontal, four unclear, and two vertical), while six used upstream need (two each of vertical, horizontal, and unclear). Six needs-based healthcare studies used a mixture of up- and downstream need, of which four had an unclear-needs-based definition, while one examined horizontal equity.

Theme 3: outcomes or causes of spatial inequity

Three articles focused on outcomes in their descriptions of spatial equity. Dalton et al.[5] argued that spatial equity is one of the first steps in achieving health equity, and suggest that without accurate targeting of interventions equitable health outcomes are unlikely to be achieved. Culyer and Wagstaff [34] proposed that health care should be distributed in a way that makes the distribution of health as equal as possible, while Hay[21] introduced the notion of equity focussed on equality of outcomes, referred to as 'substantive equality'. Three studies focussed on the causes of spatial inequities, with Lara-Valencia and García-Pérez [26] examining socioeconomic forces and processes leading to spatial inequity within the context of globalisation, and Duncan et al.[38] looking at the effects of residential segregation. Markham and Doran[39] investigated political and bureaucratic hypotheses underlying spatial inequity in service delivery, with the former asserting that politically motivated decision-making results in discriminatory outcomes while the bureaucratic hypothesis assumes that spatial differences do not follow a particular pattern and are the result of applying decision making criteria.

Theme 4: None provided

Fourteen studies did not provide an explicit definition of spatial equity but were included because they analysed the spatial equity of health services. Four studies highlighted the difficulty involved in defining and measuring spatial equity.[11, 12, 25, 40] Seven studies mentioned the distribution of healthcare resources without specific reference to equity or providing sufficient detail around what can be considered an equitable distribution of healthcare.[40-46] Five studies referred to the accessibility or availability of services without detailing exactly how access *inequities* can be differentiated from *inequalities* in access.[6, 7, 43, 47, 48] Three studies cited the Gini coefficient as a key equity measure that could be used in spatial equity research without clearly defining what is meant by spatial equity.[40-42]

3.3.2 Measuring spatial equity: approaches and measures

Table 3.1 juxtaposes the ten most common approaches to measuring equity and the spatial equity definitions described in the previous section. Some authors argued that there is no single direct and objective way to define or measure spatial equity [20, 40] and 26 papers used more than one equity measure in their analysis. The most commonly used approach was the Gini coefficient. Of the 17 studies using the Gini coefficient, eight did not provide an explicit definition spatial equity, while another five studies used a needs-based definition. Three studies[41, 42, 49] applied a need, or demand-adjusted, weighting to the Gini index, or used the measure alongside other weighted measures, such as the Atkinson index. Two studies used the Gini coefficient to assess changes in spatial equity over time, or across different service sectors. Hara et al.[42] used a weighted Gini coefficient to examine changes in the equity of physician distribution in Japan between 2000 and 2014, finding worsening equity over the period, and Zhang et al.[46] compared the spatial equity of hospitals and primary care facilities in China, finding slightly higher levels of inequity in the primary care system. Fourteen studies used spatial autocorrelation or LISA, with these methods most commonly used in conjunction with a need-based definition of spatial equity. For example, Smoyer-Tomic, Hewko and Hodgson[50] used this method to assess the spatial equity of playgrounds in Edmonton, Canada finding that playgrounds were distributed according to social need, but that many playgrounds in high-social-need areas were low quality. Regression and correlation analyses were used by 14 and 13 studies respectively. Truelove [24] used correlations to examine the relationship between socioeconomic factors and the distribution of day-care spaces in Toronto, while Roeger, Reed and Smith[7] performed a regression analysis to understand equity of access to general practitioners (GPs) in an Australia capital city, finding people living the outer suburbs and those with lower socioeconomic status had worse accessibility. Nine studies used the concentration index of accessibility as a measure of spatial equity among the population, and of these, eight studies used a needs-based distribution definition of spatial equity.

Table 3.1 Ten most common methods of spatial equity analysis classified by the associated definitions used by each article

Spatial equity measure	Definition (1) Distributional fairness (*n* = 11)	(2) Needs-based distribution (*n* = 45)	(3) Outcomes or causes (*n* = 6)	(4) Not provided (*n* = 14)	Total (*n* = 75)
Gini Index	2	6	n/a	9	17
Regression	2	6	2	4	14
Spatial autocorrelation or LISA	1	10	2	1	14
Correlation	4	7	1	1	13
Concentration Index	n/a	8	n/a	1	9
Lorenz curve	n/a	3	n/a	2	5
Population analysis of accessibility	1	2	n/a	1	4
ANOVA	2	1	1	n/a	3[a]
Atkinson Index	n/a	n/a	n/a	1	2
Robbin Hood Index	n/a	2	n/a	n/a	2
Service ratios	n/a	n/a	n/a	1	1

[a]Some papers included more than one definition, and the total number of papers using this method has been adjusted accordingly and does not equal the sum of the row. Furthermore, 26 Papers used more than one method, and so the total number of papers in each definitional category does not equal the sum of the column.

Five studies used the Lorenz curve to examine spatial equity. Of these, four also calculated the Gini coefficient. Four studies used population-based accessibility analyses that examined implications for population sub-groups. Other measures and methods such as analysis of variance (ANOVA), the Atkinson Index, Robbin Hood Index, and service-to-population ratios were less commonly used to assess spatial equity (Table 3.1).

3.4 Discussion

This review sought to clarify the range of spatial equity definitions and measures. It identified four themes of definitions, with most studies using a needs-based definition in relation to the distribution of resources, and a slightly higher proportion emphasising vertical over horizontal equity. Papers were eligible for this review if they provided a spatial equity definition or analysed the spatial equity of health services, and therefore it included literature from a range of fields including healthcare, public transportation, and urban planning. This allowed for the inclusion of a wide range of views on the definition and measurement of spatial equity, however it must also be recognised that the type of resource being investigated may influence spatial equity definitions and measures. Indeed, Graber-Naidich, Carter and Verter[40] suggest that the issue being investigated should help to define the choice of spatial equity measure. Jang et al.[19] argued that equity in urban public transportation was closely associated with horizontal equity, whereas vertical equity analysis may be more appropriate for studies of health care resources. A similar view was taken by Wang and Yaung[16] who noted that the definition of health equity includes the creation of equal opportunities for health; therefore, a resource allocation which recognises that people with higher health needs should receive more health care resources than people with fewer needs may be most appropriate. Yet, while a needs-based definition appeared to be the most common, there was no clear consensus on what is meant by need, and the degree to which this refers to ‘upstream’ social need at population level or ‘downstream’ individual patient need. Measures of downstream need were more common, and more likely to be used in studies of horizontal equity, while upstream measures were more often used in vertical equity investigations. The research focus is also likely to influence the type of need measure and definition used. For instance, healthcare systems aiming to eliminate health inequities are likely to focus on upstream measures of need to ensure that they have a vertical-needs-based distribution of a wide range of services that will reduce inequitable health outcomes. However, in investigations of specific specialist services, such as haemodialysis, the use of downstream measures, such as the distribution of patients with kidney failure, would be more appropriate.

Although a wide variety of methods were used, the Gini coefficient was identified as the most common method of spatial equity analysis, followed by correlations, regression, and spatial autocorrelation. Studies often included more than one analysis method, indicating that researchers may be aware of the weaknesses of different approaches, and use several analysis techniques to provide additional information. For instance, while the Gini coefficient can be used to quantify the overall level of inequity, spatial autocorrelation and LISA are more useful for identifying specific locations with inequitable access to health services. Correlation and regression analysis could provide information about the socio-demographic factors associated with spatial inequities in health services. Marsh and Schilling[23] argued that the Gini coefficient is the most recognised equity measure. One strength of the Gini coefficient is that it gives an easily interpretable value representing the level of inequity in the distribution of a given resource. However, it must be noted that equal distributions are not always *equitable* and are unlikely to reduce (and may even exacerbate) already existing health inequities, as people with high and low needs would have the same access to services. Thus, a low Gini coefficient does not necessarily represent a system that will improve equity of outcomes, and researchers should carefully consider whether the Gini coefficient appropriately aligns with their chosen definition of spatial equity. Most studies using the Gini coefficient provided an unclear definition of spatial equity. This may represent a view that the Gini coefficient is a strongly established equity measure[23] and therefore spatial equity does not need to be explicitly defined when the Gini coefficient is used.

Although accessibility research would not usually be considered spatial equity analysis, four papers were identified that used population-based accessibility analysis to investigate spatial equity: Grubesic & Durbin[30] examined the equity of drive time to breastfeeding support services for demographic and socioeconomic groups; Jin et al[47] and Verdon et al[51] focussed on rural – urban differences in service accessibility; while Chang & Liao[52] incorporated population mobility measures into their urban park equity analysis. These studies are considered spatial equity analyses as they focus on the implications of accessibility differences for particular population sub-groups, and it has been argued that spatial equity research should examine whether socially disadvantaged groups live in spatially disadvantaged places.[50]

This review highlights the range of different spatial equity definitions and measures available to researchers, which may produce contrasting results. For instance, the spatial analysis of service accessibility would be interpreted differently within horizontal- and vertical equity definitions. If city residents had similar average drive-times to general practitioner services, and similar health needs were assumed, this would be considered equitable access under a horizontal definition. However, a vertical equity approach would incorporate levels of population need and may conclude that areas with higher needs are being underserved and therefore the distribution is spatially inequitable. This emphasises the importance of clearly defining terms and measures at the outset of spatial equity research. While Truelove[24] argued that it is impossible to define fairness and therefore spatial equity is also undefinable, this review is a useful tool for both the planning and interpretation of spatial equity investigations. Researchers can refer to commonly used definitions and measures of spatial equity and select the most appropriate for their particular investigation, while those seeking to interpret the results of spatial equity analyses can determine whether appropriate definitions and measures have been used.

3.4.1 Limitations

As previously discussed, this review did not consider the types of spatial accessibility measurement used by individual papers. Different spatial accessibility measures may give slightly different results; however, an analysis of this potential impact was considered beyond the scope of this review. Furthermore, although spatial equity analysis may be applied to a variety of health (and non-health related) services, we have decided not to categorise definitions and methods according to the different types of services investigated, since the definition of spatial equity does not necessarily change based on the type of facility being investigated. The search strategy was applied to two databases and six relevant journals, and may have produced a limited number of results. However, more than 2,700 initial results were returned after the removal of duplicates and we are confident that key papers have been identified. The validity and risk of bias of eligible papers was assessed by examining the methods, data quality, and type of spatial analysis. If the 16 papers showing some potential for risk of bias had been excluded, a need-based distribution would still be the most common definition of spatial equity and the Gini coefficient the most commonly used method. This suggests that the spatial equity definitions and methods identified by this review are reliable.

3.5 Conclusions

To our knowledge, this is the first systematic review that has synthesised spatial equity definitions and methods of analysis. Four themes of spatial equity definitions and a range of methods were identified. The Commission on the Social Determinants of Health[1] recognises the importance of monitoring health systems and ensuring equitable access to health services, which can promote greater equity between groups in society.[24] While spatial equity can be considered the first step in achieving health equity[5] there does not appear to be a strong consensus on a single spatial equity definition or method of analysis. Further, a range of definitions and measures of need are used. Future research should examine the impact that different measures of accessibility and need may have on the results of spatial equity analysis to determine the extent to which results and conclusions are influenced by the choice of measure. This would help researchers to determine the most appropriate accessibility and need measures for their studies, and could be used in combination with this review to design robust studies of spatial equity. Future research should also consider whether groups, such as patients and consumers, service providers, or government departments, hold similar views on spatial equity and whether those views align with the academic literature. While these groups are arguably in a better position to advocate for, or implement, equitable health services, they may view spatial equity differently, which could impact the way services are provided and, in turn, the equity of health outcomes.

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Appendix Chapter 3

Table 3.2 Categories of spatial equity definitions and methods of spatial equity analysis

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Asaria, Cookson, Fleetcroft, & Ali, 2016)	"…geographical inequality in GP supply relative to need..."				X			Slope index of inequality, Relative index of inequality
(Baum & Hassan, 1993)	"…. a manifestation in space of the problems of unequal access to collective social and economic resources."	X						Correlations
(Bonfrer et al., 2013)	"An equitable distribution of healthcare use, distributed according to people's needs instead of ability to pay...Socio-economic inequalities in healthcare utilisation are only considered unfair, or inequitable, when these do not correspond to differences in need for health care across socio-economic groups....Horizontal equity means individuals with equal need for care should receive equal amounts..."			X				Concentration Index
(Bowen et al., 1995)	"...equity is premised on the notion of fairness in the distribution of environmental hazards …"	X						Correlations, ANOVA
(Brook, 2016)	"...Spatial equity [means] comparing the distribution of public services to perceived need…"		X					Regression
(Chang & Liao, 2011)	"...Spatial equity implies that there is an even distribution of services in relation to the needs, mobility, and service standards of each inhabitant of the city. The connotation of spatial equity is that all residents should be treated equally regardless of their mobility potential."			X				Index of access
(Chapman et al., 2005)	"...the principle of equity includes the allocation and application of resources in relation to need."				X			Correlations
(Culyer & Wagstaff, 1993)	"...Equity in health care should therefore entail distributing care in such a way as to get as close as is feasible to an equal distribution of health."					X		N/A
(Dadashpoor et al., 2016)	"Spatial equity, theoretically derived from social equity, means that the residents must be treated equally, regardless of their location. It also means easy access, regardless of socioeconomic characteristics, satisfaction, or disability. It also implies unequal treatment with unequals and equal treatment with equals.... certain areas need more facilities in accordance with the particular needs of their population"		X					Gini Index

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Dalton et al., 2013)	"Spatial equity is the first step in a process towards reducing health inequity via structural or area-based interventions and should therefore be evaluated accordingly."					X		Proportion of population with poor access
(Duncan et al., 2012)	"…the spatial mismatch in educational and employment opportunities disproportionately experienced by certain population groups (e.g. racial/ethnic minorities and low-income individuals) which is in part attributable to residential segregation."					X		Spatial Autocorrelation, Spearman correlations, OLS regression
(Gan et al., 2015)	"…geographic equity of health care can be achieved if the geographic distribution of health care services is according to health needs…areas where health needs are higher should correspondingly receive more facilities than those with lower needs."		X					Concentration Index
(Gerdtham & Sundberg, 1998)	"Healthcare should be delivered according to need…equal treatment for equal need [is] a definition of equity in the Swedish health care delivery system."			X				Concentration Index
(Goddard & Smith, 2001)	"…equal access to healthcare for people in equal need…"			X				N/A
(Goddard et al., 2010)	"…we used the Gini coefficient to measure the inequity in the distribution of GPs per capita, adjusted for levels of need in the population."						X	Gini, Multiple regression
(Graber-Naidich, Carter, & Verter, 2017)	"…the equity measure should be selected in accordance with the problem at hand, as many possible metrics exist and there is no universally appropriate one…the maldistribution of health professionals is measured often times by applying the Gini coefficient to the physician-to-population ratios."						X	Gini
(Griffin & Sener, 2016)	"…the concept of horizontal equity [is] where fairness of services across income groups is considered…vertical equity [is where] disadvantaged households would pay a smaller share or receive greater services than others."			X				Spatial Autocorrelation
(Grubesic & Durbin, 2017)	"The fundamental premise of spatial equity is a simple one. Within any region, goods and services should be equally available to all members of society, regardless of race, economic status, place of residence, or culture…spatial inequities are especially acute between urban and rural areas."	X						Spatial accessibility as measured by drive time to service
(Hanson & Jones, 2015)	"…geographical variations in [service] provision in England are linked and then compared to variations in a range of measures of population need…. spatial equity is the first step in a process towards reducing health inequities."				X			ANOVA

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Hara et al., 2017)	"...we assessed the equity of the geographic distribution of physicians. The Gini coefficient was used as the indicator of equity, and has been widely used in similar analyses."						X	Gini
(Hay, 1995)	"Despite this continuing interest [in spatial equity] there remains considerable uneasiness about the underlying concepts...geographical differences and inequalities are in some sense inequitable, unfair and unjust, and…policies and programmes should be judged on the extent to which they serve to eliminate or at least reduce (rather than increase or create) such inequities."					X	X	N/A
(Hewko, 2001)	"Needs-based equity requires the 'unequal treatment of unequals. From this perspective, equity exists if poorer…neighbourhoods have greater access to playgrounds than wealthier neighbourhoods…service provision is proportional to service need [and] involves examining associations between accessibility and population need (typically represented by census indicators)."		X					LISA, Correlations
(Isaksson et al., 2016)	"Equity in geographical accessibility…can be understood as all citizens having a similar, or minimum, travel distance to the nearest health care provider."			X				t-test, OLS regression
(Jang et al., 2017)	"Horizontal equity concerns the distribution of impacts between individuals and groups considered equal in abilities and needs, whereas vertical equity concerns the distribution of impacts between individuals and groups that differ in abilities and needs…equity in public transportation in a city is closely related with horizontal equity..."			X				Gini, Lorenz curve
(Jin et al., 2015)	"Spatial inequity [is] inequity in the spatial accessibility…"						X	Accessibility
(Johnston & Wilkinson, 2001)	"…distribution equity [is] the number of people sharing each GP divided by the crude mortality rate..."				X			Robbin Hood Index
(Kaphle, 2006)	"…spatial equity issues like who has access to a particular good or service and whether there is any pattern to these varying levels of access…. [by] examining the spatial relationship between need and accessibility."				X			Spatial autocorrelation, LISA
(Kiadarili et al., 2011)	"…the geographic distribution of health facilities is considered as a major health policy issue....it is believed that the utilization of, and access to, healthcare among individuals should not be affected by the geographical region in which they reside."						X	Gini, Lorenz curve

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Kim & Sultana, 2015)	"…the concept of equity...is rather ambiguous. In general equity refers to the fairness and justice with which benefits and costs are appropriately distributed…"	X					X	Coefficients of variation index
(Kinman, 1999)	"…a just distribution of services in relation to need, in recognition that some people will require more of a service than their equal share."		X					Lorenz curve
(Kunzmann, 1998)	"…. definitions and ambitions of [spatial equity] vary, as do the indicators with which they try to measure [spatial equity]."						X	Correlations, ANOVA
(Landry & Chakraborty, 2009)	"…spatial equity…evaluates the benefits and burdens associated with the distribution of environmental and social amenities."	X						OLS regression, spatial regression
(Lara-Valencia & García-Pérez, 2015)	"Spatial equity research [is] the body of knowledge that systematically studies the geographical distribution of environmental burdens and amenities as a function of socio-political factors and processes…"	X				X		ANOVA
(Markham & Doran, 2015)	"Two competing hypotheses have been proposed to explain the creation and persistence of spatial inequity in service delivery…a political hypothesis [which] predicts that when it comes to service distribution 'some groups suffer because of their race, because of their social status or because of their paucity of political power'....the second hypothesis asserts that service allocation is largely a bureaucratic rather than political function and therefore suggests that because bureaucratic decisions are usually routinized and made without reference to race or class, there should be no systematic pattern to service delivery inequalities."					X		Multivariate regression
(Maroko et al., 2009)	"…the fair and equitable distribution of both the environmental 'bads'….and the environmental 'goods'…"	X						Correlations, Regression, KDE
(Marsh & Schilling, 1994)	"Equity [is] when each group receives its fair share of the effect of the facility siting decision…there has been little agreement…as to how equity should be measured."						X	N/A
(Mortazavi & Akbarzadeh, 2017)	"…that the geographical distribution of transit service benefits conform to the geographical distribution of the citizens with th greatest need for public transportation…is the essence of vertical equity."		X					Gini, Correlations
(Nakamura et al., 2017)	"For achieving equity of the accessibility to primary healthcare, measuring potential geographical accessibility is essential."						X	Gini, Lorenz curve, correlations

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Neutens, 2015)	"…there is at yet little agreement on how to define and quantify equity of health care accessibility."						X	Gini
(Neutens et al., 2010)	"…access to urban services is equitable [if] no segments of the population are disadvantaged [by the resource distribution]."	X						Gini
(Nicholls, 2001)	"Equity refers to the fairness or justice of a situation or distribution…. a compensatory or need-based approach to equity implies... that unequals should be treated unequally. Thus disadvantaged residents or areas are awarded extra increments of resources."		X					Mann-Whitney U test
(Oliveira & Bevan, 2003)	"…equal opportunity of access for those in equal need."			X				Need
(Omer, 2006)	"… spatial equity refers to the degree to which services or amenities are distributed in an equal way over different areas as well as economic, ethnic and political groups, with appropriate consideration given to the needs of special groups such as children and the elderly... the aim of spatial equity research is to ascertain whether the distribution of public services is equitable and correlates with observed socio-economic spatial patterns."		X					Correlation
(Omrani-Khoo et al., 2013)	"Equity, by definition, means equal distribution of resources among people in consideration of their needs."				X			Gini, Lorenz, Robbin Hood Index
(Ozegowski, 2013)	The concept of 'equity' relies on the notion that health care services should be provided according to the level of health care 'need' of each individual….there is neither a consensus as to how to define 'need' nor a common understanding of valid need indicators."				X			N/A
(Park, 2012)	"Equity of access to health care is measured based on the relative importance of need compared with the other determinants of health services utilisation. Access is equitable to the extent that predisposing, need-related demographic factors such as age and gender, as well as illness, account for health care utilisation."				X			Bivariate analysis, Logistic regression
(Pan & Shallcross, 2016)	"...the absolute level and relative distribution of healthcare resources..."						X	Gini
(Peacock et al., 1999)	"Horizontal equity [means] that equals should be treated equally."			X				Concentration index
(Powell & Boyne, 2001)	"Most geographical studies that examine equity rather than equality focus on distribution according to need..."				X			N/A

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Rice & Smith, 2001)	"Almost all geographically based systems of health care therefore have implicit or explicit objectives that reflect horizontal and vertical equity concerns relating to the geographical distribution of resources."				X			N/A
(Roeger et al., 2010)	"…that services are available for all geographical areas and population groups."						X	Regression
(Rosero-Bixby, 2004)	"… [examining] underserved populations or unmet needs to measure inequity."						X	Regression
(Sanders et al., 2013)	"… determine the extent to which the geographic distribution of musculoskeletal health care clinics varies across urban Auckland in comparison to GP clinics..."						X	Spatial autocorrelation, OLS regression, GW regression
(Sharkey et al., 2009)	"…spatial equity [is] the distribution of food resources in relation to population need."				X			Spearman correlation, Spatial autocorrelation, multivariate regression
(Smoyer-Tomic et al., 2004)	"...the spatial distribution of and access to a particular amenity correspond to the geographical variation of 'need' for that amenity or, more generally, whether socially disadvantaged populations live in spatially disadvantaged areas."		X					Correlation, LISA
(Stanley et al., 2016)	"The concept of equity describes an ideal of 'fairness' [and] spatial social scientists mainly focus on mapping distributive equity of harms and benefits."	X						Spatial autocorrelation
(Taleai et al., 2014)	"Spatial equity is understood as the degree to which services are distributed spatially in an equal way over different areas corresponding to the spatial variation of 'need' for that service."				X			Integrated spatial equity evaluation
(Talen, 1998)	"In planning, equitable distribution entails locating resources or facilities so that as many different spatially defined social groups as possible benefit...in the purest sense, equity can be achieved only after society has arrived at a consensus about what is fair."				X			LISA
(Talen, 2001)	"Accessibility can be used as a tool to discover whether or not equity, variously defined, has been achieved….equity can be defined as equality, in which everyone receives the same public benefit, regardless of socioeconomic status , willingness to pay, or other criteria."			X				Correlations, regression

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Talen & Anselin, 1998)	"...any geographical analysis of spatial equity relies on a measure of access to services…when coupled with an investigation of need or social justice [it] becomes more appropriately termed spatial *equity*….spatial equity is concerned with comparing the locational distribution of facilities or services to the locational distribution of different socioeconomic groups....		X					Spatial autocorrelation, LISA
(Tan & Samsudin, 2017)	"… spatial equity of parks [is] the equality of opportunity to access to parks and benefit from its usage independent of socio-economic status and locality of residence."				X			Spatial autocorrelation
(Truelove, 1993)	"Equity is often called distributional fairness…yet achieving a consensus concerning the fairness of a particular distribution is almost impossible....[and] it is difficult, if not impossible, to provide one definition of equity that is applicable in all situations."	X					X	Mapping, service-to-needs ratios, correlation, Gini
(Tsou et al., 2005)	"…spatial equity implies that there is an even distribution of services in relation to the needs, preferences and service standards of each resident."				X			Spatial autocorrelation, LISA
(Vadrevu & Kanjilal, 2016)	"Availability, distribution and physical accessibility of health services according to the need of the population determine spatial equity."		X					Concentration index
(Van de Poel et al., 2012)	"Most empirical research on equity in health care delivery examines horizontal equity defined as equal treatment for equal need irrespective of characteristics, such as socioeconomic status (SES), across which variation in health care is claimed to be illegitimate... [however] legitimate variation in utilisation implies that the average response of use to need is an acceptable vertical equity norm - the appropriate unequal treatment of unequals."				X			Concentration index
(Verdon et al., 2011)	"The aim of the equity objective is to achieve equal access to quality health services for equal need, regardless of consumers' locations or socioeconomic status."				X			Accessibility
(von dem Knesebeck, 2015)	"It is useful to differentiate between horizontal and vertical equity. Horizontal equity means that persons with equal needs have equal access to care, whereas vertical equity means that those with unequal needs (e.g. people with a low socioeconomic position and increased morbidity risks have more needs) have appropriately unequal (advanced) opportunities to access health care."				X			N/A

Author (Year)	Definition	(1) Distributional fairness	(2) Needs based distribution			(3) Outcomes or causes	(4) None provided	Method of analysis
			(a) Vertical	(b) Horizontal	(c) Unclear			
(Wagner et al., 2009)	"…mismatch between population health needs and GP supply…"						X	Gini, Atkinson, Service ratios
(Wang & Yaung, 2013)	"…vertical equity [means] people with greater health needs should receive more healthcare than those with lesser needs, and horizontal equity [means] equal treatment for equivalent needs."		X					Concentration index
(Waters, 2000)	"…there is little agreement on how to measure equity, or even how to define what the term means."						X	Gini, Concentration & Atkinson index, utilitarian social welfare function
(Welch, 2013)	"[An] important area of equity analysis….is the match between the distribution of services and the need for those services."				X			Gini
(Yoon & Srinivasan, 2015)	"Spatial equity refers to the concept that social equity involves a 'geographic dimension'…in evaluating spatial equity it is crucial to incorporate people's needs into consideration...allocating limited resources to the most needy groups or places seems a more legitimate strategy as opposed to evenly distributing them in space."		X					Spatial autocorrelation
(Zenk et al., 2006)	"…. a just spatial distribution of resources in relation to need"		X					OLS regression
(Zhang, Xu, Ren, Sun, & Liu, 2017)	"…equality of the distribution of health resources and health services..."						X	Gini, Concentration index
(Zhong, 2010)	"Horizontal equity requires that persons in equal need should receive the same amount of treatment."			X				Concentration & Thiel index

Chapter 4: Article 3 – Spatial equity and realised access to healthcare – a geospatial analysis of general practitioner enrolments in Waikato, New Zealand[9]

Jesse Whitehead, BSocSci (Hons), National Institute of Demographic and Economic Analysis, University of Waikato, Hamilton, New Zealand. * jesse.whitehead@waikato.ac.nz

Amber L. Pearson, PhD, Assistant Professor, Department of Geography, Environment and Spatial Sciences, Michigan State University, East Lansing, Michigan, USA. apearson@msu.edu

Ross Lawrenson, MBBS, MD, Professor, Waikato Medical Research Centre, University of Waikato, Hamilton, New Zealand. ross.lawrenson@waikato.ac.nz

Polly Atatoa Carr, MBChB, MSc, Associate Professor, National Institute of Demographic and Economic Analysis, University of Waikato, Hamilton, New Zealand. patatoac@waikato.ac.nz

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[9] (Whitehead et al., 2019b) - - This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is published in *Rural and Remote Health*.

Abstract

Introduction: Geographic measures of accessibility can quantify inequitable distributions of healthcare. Although closest-distance measures are often used in Aotearoa New Zealand these may not reflect patient use of healthcare. This research examines patterns of patient enrolment in general practitioner (GP) services from a geospatial perspective.

Method: Patient enrolment records (*n*=137,596) from one Primary Health Organisation were examined and geographic information systems (GIS) used to determine whether patients enrolled with their closest GP service. A binomial logistic regression was performed to examine factors associated with the bypass of GP services closer to patients' homes.

Results: Overall 68.1% of patients in the sample bypassed the GP service closest to their home, while rates of GP bypass varied across the Waikato region and between rural and urban areas. A binary logistic regression analysis revealed that rurality of patient residence, patient ethnicity, patient age, area-level socioeconomic deprivation, sex, distance to the closest GP clinic, clinic after-hours availability, Māori Service Provider status, GP and nurse Full Time Equivalent hours, and clinic fees were statistically significant predictors of increased closest-GP bypass. While residents of major urban areas had high rates of GP bypass, this was followed by patients living in rural areas and, in fact, patients living more than 20 kilometres from the closest GP service had exceptionally high rates of GP bypass.

Conclusions: This study suggests that most patients in the Waikato region do not enrol with the GP service closest to their home and outlines several factors, including rurality of residence, that are associated with the GP bypass. Closest-distance accessibility measures may be inappropriate in mixed urban-rural settings, and researchers should consider other approaches to quantifying spatial equity. Health services should also be designed to better reflect the realities of the populations they serve.

4.1 Introduction

Health inequities are systematic, avoidable, and unfair differences in health caused by differential access and exposure to the social determinants of health such as poverty, housing, and the health system itself (World Health Organization, 2008). Achieving health equity depends on eliminating disadvantage beyond individual control (Marmot, 2005; Woodward & Kawachi, 1998). As health systems can cause and perpetuate inequities (Marmot & Commission on Social Determinants of Health, 2007), ensuring the equity of healthcare such as primary care services is a critical step to achieving health equity (Dalton et al., 2013). Spatial equity is in turn a key component of equitable service delivery (Markham & Doran, 2015; Neutens, Schwanen, Witlox, & De Maeyer, 2010). Researchers can investigate the equitable distribution of healthcare using geographical measures of access to services (Bissonnette, Wilson, Bell, & Shah, 2012; Guagliardo, 2004; Higgs, 2009; Neutens et al., 2010), which are the foundation of spatial equity investigations (Talen & Anselin, 1998). Accessibility studies in Aotearoa New Zealand have examined population-to-provider ratios and the distance between populations and services (Brabyn & Barnett, 2004; Hiscock, Pearce, Blakely, & Witten, 2008; Pearce, Witten, & Bartie, 2006). However, population-to-provider ratios are susceptible to the modifiable area unit problem and overlook patient 'border crossings', while distance-based measures disregard the supply and demand of services (Bissonnette et al., 2012). Further, both techniques assess *potential* accessibility, rather than measuring *realised* access to healthcare. While research suggests that greater distance to healthcare results in reduced utilisation and increased health inequities (Hiscock et al., 2008), there is no clear evidence that patients use services closest to where they live. In fact, patient surveys and enrolment records suggest that most patients bypass their closest service (Alford-Teaster et al., 2016; Haynes, Lovett, & Sünnenberg, 2003; Hays, Kearns, & Moran, 1990; Lewis & Longley, 2012). Therefore, researchers should be aware that that potential accessibility measures may not reflect realised access and could misrepresent the equitability of service distributions. This study uses an extensive dataset of more than 130,000 patients to examine primary healthcare enrolment in the Waikato region of Aotearoa New Zealand. The rate of GP bypass in the Waikato is calculated, and the factors affecting the likelihood of a patient bypassing their closest clinic are investigated. This analysis makes an important contribution to understandings of the relationship between geography and access to health services, which can inform an improved understanding of spatial equity and the development of health services that support health equity.

4.1.1 Setting

Government health funding in New Zealand is distributed to District Health Boards (DHBs) according the population size and demographic characteristics of each region. DHBs then allocate funding to Primary Health Organisations (PHOs) that provide primary healthcare to their enrolled population. Most of these services are delivered through general practices (GPs). The majority of New Zealanders are enrolled with a PHO through their enrolment in a selected GP service. This enrolment results in reduced costs for doctor visits, prescription medicines, and other benefits. Co-payment charges to patients, particularly for those over the age of 14 years, are common. This study focuses on the enrolment data from Hauraki PHO in the Waikato region, in the North Island of New Zealand. Around 400,000 people live in the Waikato with around 140,000 residing in the main urban centre (Hamilton City), with the remainder in small towns or rural areas (Statistics New Zealand, 2013). Public transport services are minimal, and are only used by 1% of Waikato commuters (Statistics New Zealand, 2013). A greater proportion of the Waikato population identify as Indigenous (Māori; 22%) compared to the national average of 15% (Statistics New Zealand, 2013). Compared to the national average, the New Zealand Health Survey has found that adults living in the Waikato region have higher levels of obesity, ischaemic heart disease, diabetes, high cholesterol and blood pressure, as well as higher levels of unmet need for primary care (Ministry of Health, 2018). As with elsewhere in Aotearoa New Zealand inequities in these indicators of poor health outcomes are experienced in the Waikato region, particularly for Māori (Ministry of Health, 2018).

4.2 Methods

4.2.1 Data

The anonymised patient enrolment records (*n*=137,596) of Hauraki PHO's 36 GP clinics, 11 of which are Māori Service Provider Clinics (MSPC), and information about GP and Nurse Full Time Equivalent (FTE) hours at each clinic was provided in December 2017. Enrolment records included each patient's age, residential address with associated GPS coordinates, a geocoding uncertainty score, ethnicity (according to 6 major ethnic group categories: European, Māori, Asian, Pacific, Middle Eastern/Latin American/African – MELAA, or 'Other'), socioeconomic status according to area-level New Zealand Deprivation Index 2013 (NZDep2013) quintile (Atkinson, Salmond, & Crampton, 2014), date of last consultation, and the name of the clinic that they were enrolled with. For the purposes of these analyses, the 'MELAA' ethnic group (n=2,237) were combined with the 'Other' (n=980). The New Zealand road network GIS layer was obtained from the Land Information New Zealand data service. Statistical Area 2 (SA2) geographical boundaries, and the 2018 urban/rural form classification (UR2018) were downloaded from the Statistics New Zealand geographic data service. The UR2018 classifies areas as 'major urban', 'medium urban', 'small urban', 'rural settlement', or 'rural other'. The 'rural settlement' and 'rural other' categories of the UR2018 were combined into a single 'rural' category for the purposes of this analysis. The location of all GP clinics within the Waikato DHB region, including clinics associated with other PHOs, were geocoded based on information from the Waikato DHB website. During data cleaning any records with a geocoding uncertainty score greater than 5, indicating that the chance of incorrect geocoding was 50% or higher, were removed from the sample. Any patients residing outside the North Island mainland were also removed from the sample. A small proportion of patients (1,891 or 1.4%) had residential addresses outside the Waikato DHB region, and these were also removed. The total sample for this analysis included 133,870 enrolled patients. Information regarding the cost of services, after-hours care, and Māori service provider status was located on the Hauraki PHO website and incorporated into the dataset.

4.2.2 Analytical methods

The ArcGIS (ESRI, Redlands, CA, USA) *Closest Facility* function was used to: (a) calculate the road network distance from each patients' residential address to their closest GP clinic; and (b) calculate the distance from each patient's residential address to their enrolled GP clinic. Patients were classified as either enrolling with, or bypassing their closest GP. All GP clinics in the Waikato DHB region were included in (a) to account for patients bypassing other PHOs' clinics. Some patients were enrolled with clinics that operated satellite services and the exact clinic patients used was unknown (n=42,706), so it was assumed that patients used the satellite service closest to their home. A binomial logistic regression was performed with the SPSS statistical software package (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) using "Bypassed closest clinic" (Yes/No) as the dependent variable. Predictor variables included patient residential area (Major urban, medium urban, small urban, or rural), ethnicity (European, Māori, Pacific, Asian, Other), age (in bands of 0-4, 5-14, 15-24, 25-44, 45-64, 65+), area-level deprivation (NZDep2013 quintile), sex (male/female), distance to closest GP, clinic afterhours availability, MSPC status, clinic total FTE hours, and clinic fees. Interaction effects were calculated for ethnicity * age, ethnicity * deprivation, and residential area * deprivation.

4.2.3 Ethics approval

This research was approved by the Human Research Ethics Committee, University of Waikato – granted 18th May, 2017. Reference: Whitehead FS2017-18.

4.3 Results

4.3.1 Bypass of closest GP service

Overall, 68.1% of enrolled Hauraki PHO patients in the Waikato DHB region bypassed the GP service closest to their residential address. *Table 4.1* displays bypass rates for key variables.

Table 4.1 Rates of GP bypass according to key variables

Variable	Population (%)	Bypass rate (%)
Rurality of patient residence		
Major urban area	46.4	89.2
Medium urban area	5.7	25.1
Small urban area	26.7	45.3
Rural area	21.2	65.6
Patient ethnicity		
European	52.6	63.7
Asian	9.3	86.5
Māori	31.0	70.8
Pacific	4.7	72.2
Other (includes MELAA)	2.4	81.0
Age		
00-04 years	7.6	71.0
05-14 years	15.7	70.8
15-24 years	15.0	68.9

25-44 years	26.0	74.2
45-64 years	22.4	67.3
65+ years	13.3	57.3
Area level socioeconomic deprivation		
Quintile 1 (Low deprivation)	12.2	87.6
Quintile 2	6.4	70.1
Quintile 3	15.9	68.3
Quintile 4	29.1	66.1
Quintile 5 (High deprivation)	36.4	65.5
Sex		
Male	47.9	68.5
Female	52.1	69.1
Distance to closest GP clinic		
Less than 5km	83.1	68.9
5 – 10km	7.8	65.8
10 – 20km	7.5	67.0
20 – 30 km	1.4	90.1
More than 30km	0.2	97.1
Clinic attributes		
After hours care available	46.3	75.2
Māori service provider	16.4	76.1
Total FTE Hours		
Less than 5	15.9	59.8
5 to 10	56.1	76.7
More than 10	28.0	60.3
Fees		
Less than NZ$20	77.2	75.5
More than NZ$20	22.8	46.2
Total Patients	100	68.8

4.3.2 Logistic regression analysis

The logistic regression model (*Table 4.2*) returned a statistically significant Hosmer & Lemeshow test $X^2(8) = 1586.480$, $p<.001$, explained 39% (Nagelkerke R^2) of the variation in the dependent variable and correctly classified 79% of the cases.

Table 4.2 Results of binomial logistic regression with GP bypass as the dependent variable

Predictor	β	SE	p	OR
Residence (Baseline = Major urban area)			.000	
Medium urban area	-1.484	.088	.000	.227
Small urban area	-3.724	.147	.000	.024
Rural	-1.598	.064	.000	.202
Ethnicity (Baseline = European)			.000	
Māori	.216	.093	.020	1.241
Pacific	1.016	.299	.001	2.763
Asian	.628	.115	.000	1.873
Other (includes MELAA)	.243	.207	.240	1.275
Age (Baseline = 25-44 years)			.000	
0-4	-.028	.045	.530	.972
5-14	-.037	.034	.276	.964
15-24	-.367	.032	.000	.693
45-64	-.068	.027	.012	.934
65+	-.238	.028	.000	.788
Deprivation (Baseline = NZDep2013 Q1)			.000	
NZDep Q2	-.506	.070	.000	.603
NZDep Q3	-.758	.063	.000	.469
NZDep Q4	-.900	.059	.000	.407
NZDep Q5	-.864	.058	.000	.421
Sex (Baseline = Male)	.059	.014	.000	1.091
Distance to nearest GP	.000	.000	.000	1.000
Enrolled in an after-hours service	.911	.017	.000	2.488
Enrolled in a Māori service provider clinic	1.029	.026	.000	2.798
Total FTE hours	-.068	.002	.000	.934
Fees	-.027	.001	.000	.973

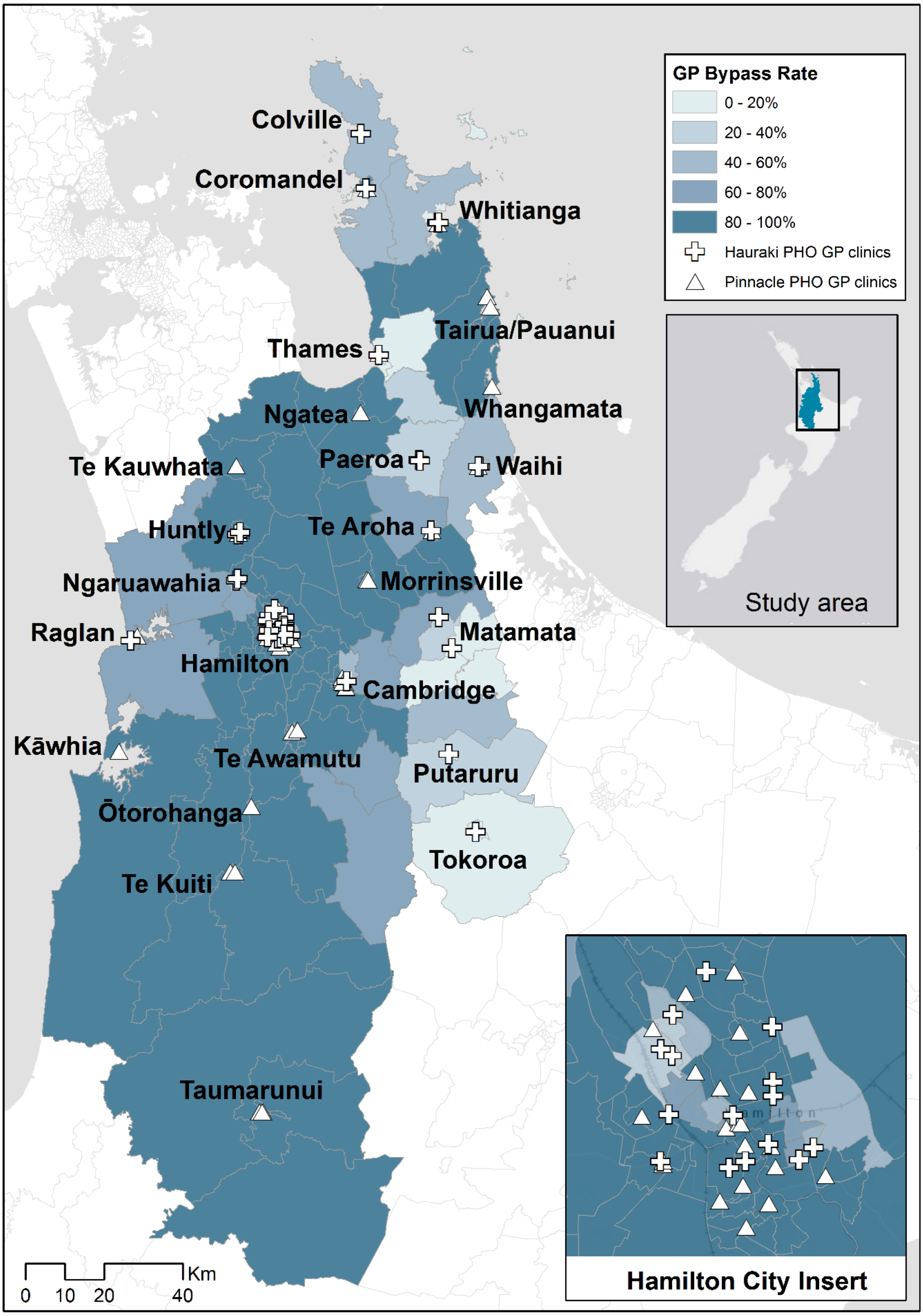

Figure 4.1 Proportion of patients bypassing their closest GP clinic

4.3.3 Residential rurality

Compared to major urban areas, patients living in medium urban, small urban, and rural areas were less likely to bypass their closest GP service. This may reflect the availability of services in urban and rural locations. Hamilton has more GP services located within a relatively small area and therefore residents are able to travel shorter additional distances to use a particular clinic. While rural residents live further from their closest clinic, they may be willing to travel further to a certain service, as they must already travel significant distances to *any* service. *Table 4.3* displays the average distances to patients' closest GP and enrolled GP for each UR2018 category of residence, the average additional travel for those patients who did bypass their closest GP, the total number of clinics in each UR2018 category, and the average number of clinics per spatial unit in each UR2018 category.

Table 4.3 Number of clinics and average distances travelled by rural and urban patients

SA2 of residence (UR2018 category)	Distance to closest GP clinic (km)	Distance to enrolled GP clinic (km)	Average additional travel (km)	Number of SA2s	Clinics per UR2018 category	Average clinics per SA2
Major Urban	1.1	3.8	3.0	62	36	0.6
Medium Urban	1.6	5.3	14.5	26	11	0.4
Small Urban	1.3	4.5	7.0	36	36	1.0
Rural	9.9	14.9	7.5	78	4	0.1
Total	3.1	6.4	4.8	202	87	0.4

Overall, patients who bypassed their closest GP tended to travel relatively short additional distances. The median additional travel among 'bypassers' was 2.2km, while 79% of patients bypassing their closest GP travelled less than 5km to their enrolled clinic. However, there do appear to be significant differences between the additional distances travelled by patients in major urban areas compared to other smaller settlements. For instance, major urban residents lived closest to their enrolled clinic and those who bypassed travelled the shortest average additional distance of 3km. While rural patients had the furthest to travel to access their closest clinic (9.9km) and also travelled the furthest additional distance to attend their enrolled clinic (14.9km), the additional travel among those who bypassed (7.5km) may not be viewed as a barrier compared to the benefits of enrolling with a preferred service.

Interestingly, patients in medium urban areas had the highest additional travel distance (14.5km), despite living within relatively short distances of their closest GP (1.6km). This may reflect commuter patterns in the Waikato (and particularly for the areas surrounding Hamilton City), as people could be choosing to enrol with GP services close to their work or study locations rather than their home addresses. In most towns more than 90% of patients enrolled with services inside their town, except for 5 towns where more than 20% of patients were enrolled with external clinics. Patients living in Cambridge, Coromandel, Ngāruawāhia, Putāruru, and Raglan were more likely to 'cross borders' and enrol with services outside their town of residence. Over 98% of Hamilton residents were enrolled with GPs in the city.

4.3.4 Ethnicity

The rate of GP bypass varies by patient ethnicity. Compared to European patients, Māori, Asian and Pacific patients were statistically significantly more likely to bypass their closest GP service. More than 80% of Asian patients enrolled in GP clinics more distant from their residential address, and more than 70% of Māori and Pacific patients also bypassed their closest services, while European patients had the lowest GP bypass rate (64%). These ethnic patterns could be due to a variety of reasons, which may change for different groups. For instance, patients may prefer GPs of a certain ethnicity and/or with particular language skills. Thirty-seven percent of all Māori patients were enrolled with a MSPC, and 77% of Māori who were enrolled in a MSPC bypassed a closer service to attend that MSPC. It appears that the urban-rural distribution of ethnic groups may be moderating these ethnic variations in bypass rates. Eighty percent of Asian patients lived in major urban areas, compared to 67% of Pacific patients, 50% of Māori patients and only 35% of European patients. In contrast, a larger proportion (30%) of European and Māori patients lived in small urban or rural areas compared to other ethnicities. *Table 4.4* displays the distribution of each ethnic group among urban and rural areas, while *Figure 4.2* shows the variation in GP bypass rates among Māori patients, and the distribution of MSPCs in the Waikato DHB region.

Table 4.4 Ethnicity and urban/rural residence of patients

Ethnicity	GP bypass (%)	Major urban (%)	Medium urban (%)	Small urban (%)	Rural (%)
Asian	86.5	79.5	2.3	10.3	7.8
Other	81.0	74.5	2.4	10.8	12.4
Pacific	72.2	67.2	15.0	12.6	5.1
Māori	70.8	49.5	6.4	30.0	14.1
European	63.7	35.7	5.1	29.6	29.5
All Patients	68.8	46.4	5.7	26.7	21.2

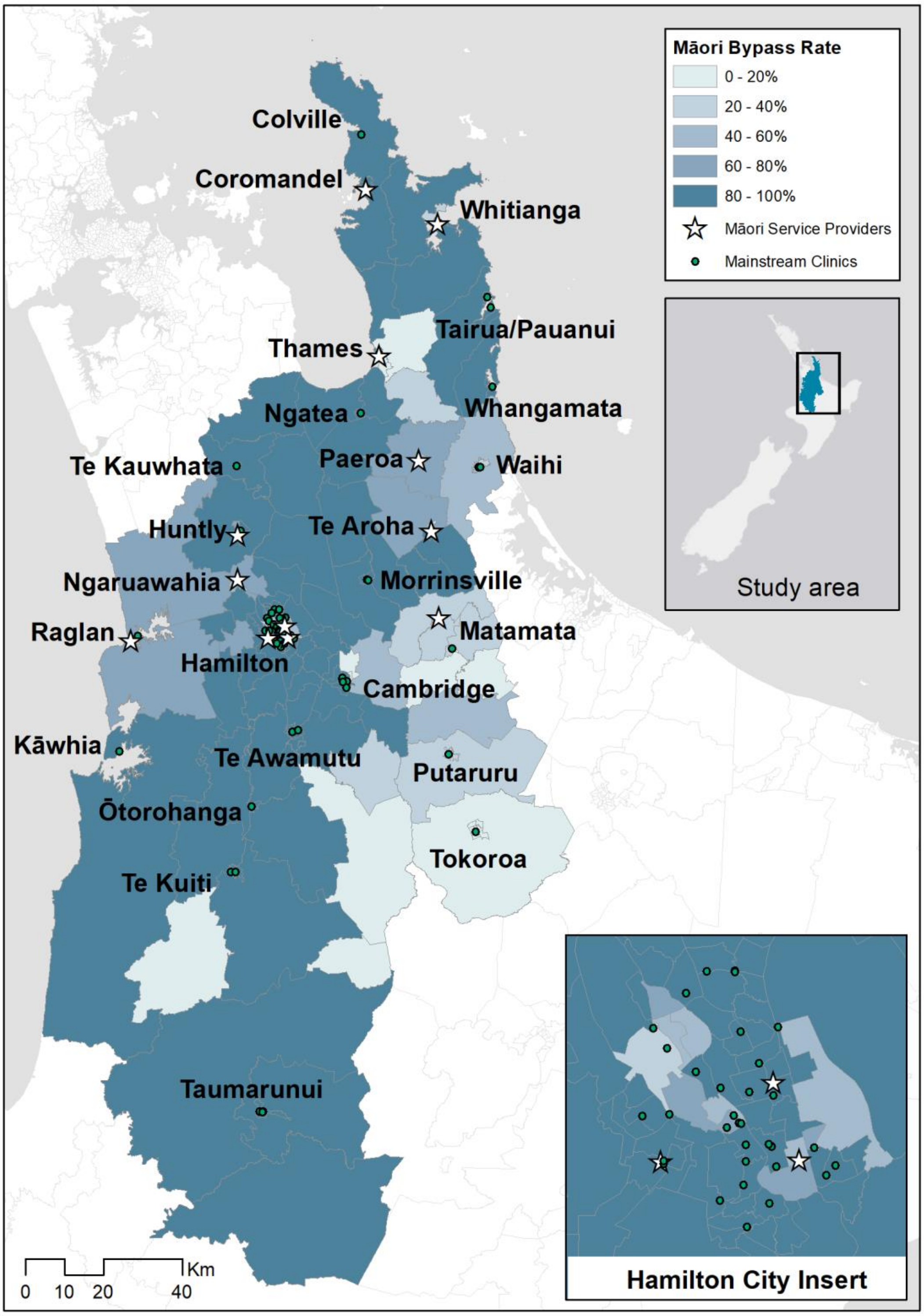

Figure 4.2 GP bypass rates among Māori patients and distribution of MSPCs

4.3.5 Age

The highest rates of GP bypass were among the 25-44-year-old age group (74%). Compared to this age group, 15-24-year-olds, and those aged over 45 were less likely to bypass their closest GP, while no significant difference was found between those aged 25-44, and the 0-4 and 5-14-year-old age groups. The high rate of GP bypass among 25-44-year-olds may reflect the lower rates of GP utilisation among this group (who on average last had a consultation 12 months ago) as well as their increased access to personal transportation. Patients in this age group may also be more likely to choose a practice that is closer to their work address than their home. Patients under 14 years old also had high rates of GP bypass and no statistically significant difference to the 25-44-year-old group was identified by the regression analysis. On the other hand, the lowest rates of GP bypass were among the 65+ age group (57%) who also had the shortest time since their last consultation (6.8 months on average). Older patients were more likely to enrol in services closer to home, which may reflect the increased importance of convenience, lower transport accessibility, and higher GP utilisation rates among this age group. A statistically significant interaction term between age and ethnicity was identified. Asian and Māori patients aged 15-24, Asian and Other patients aged 45-65, and Māori patients older than 65 were more likely to bypass their closest GP service.

4.3.6 Socioeconomic deprivation

Compared to the least socioeconomically deprived neighbourhoods, patients living in more deprived areas were less likely to bypass the GP service closest to their home. Overall, 88% of patients living in the least socioeconomically deprived neighbourhoods bypassed the GP closest to their residence compared to 66% of patients living in the most deprived areas. Statistically significant interaction terms were identified between socioeconomic deprivation and ethnicity, and socioeconomic deprivation and residential rurality (*see Table 4.6 in Appendix)*. *Table 4.5* displays the breakdown of differences in rates of GP bypass between areas of high and low deprivation across patient ethnicity and rurality of residence. Each ethnic group displayed a deprivation gradient, with patients living in affluent areas the most likely to bypass their closest GP services. Pacific patients had the greatest difference in bypass rates between residents of high- and low-deprivation areas, and were 1.5 times more likely to bypass their closest GP when living in areas of low deprivation. The effect of deprivation also appears to vary across rural and urban areas, with a relatively small difference in bypass rates among major urban residents living in areas of low- compared to high-socioeconomic deprivation. Rural patients were 2.6 times more likely to bypass their closest GP if they lived in areas of low deprivation, while medium urban residents in areas of high deprivation showed very low rates of bypass and an OR of 12.9. Patients residing in small urban areas showed an inverse pattern, with those living in areas of high deprivation more likely to bypass GP clinics. This could be because patients living in small towns with more than one clinic may choose a cheaper service even if it is slightly further away. Of the residents of socioeconomically deprived small urban areas who bypassed their closest GP, 78% travelled less than 3km to their clinic and 96% paid less than NZ$20 for an appointment.

Table 4.5 Differences in bypass rates between areas of high and low deprivation by ethnicity and residence

Ethnicity	NZDep Q1 bypass (%)	NZDep Q5 bypass (%)	OR (Q1:Q5)
Asian	96.2	75.5	1.3
MELAA	94.4	84.7	1.1
Māori	89.2	66.7	1.3
Pacific	96.4	65.8	1.5
NZ European	51.7	41.6	1.2
Residence	NZDep Q1 bypass (%)	NZDep Q5 bypass (%)	OR (Q1:Q5)
Major urban	95.0	87.0	1.1
Medium urban	67.8	5.2	12.9
Small urban	19.3	51.5	0.4
Rural	41.9	15.9	2.6
Total	*87.6*	*65.5*	*1.3*

4.3.7 Sex

Rates of GP bypass for male and female patients were relatively similar at 68.5% and 69.1% respectively while the regression analysis returned an odds ratio of 1.091 suggesting little difference in enrolment patterns between male and female patients.

4.3.8 Distance to closest GP service

A breakdown of the differences in rates of GP bypass according to the distance between patients' residential addresses and their closest GP clinic (see *Figure 4.3*) reveals little difference in rates of bypass among patients living up to 20km from their nearest service. Rates of bypass were generally between 60% and 70%. However, for patients living 20 to 30km from their closest clinic, GP bypass rates rise above 90% and for those who live more than 30km from a clinic the rate of bypass was generally 100%. Overall, in the Waikato region, only 2% of patients lived further than 20km from a GP clinic. Of these patients, more than half travelled less than 10 additional kilometres to their enrolled GP clinic, and two-thirds used services located in rural areas or small towns.

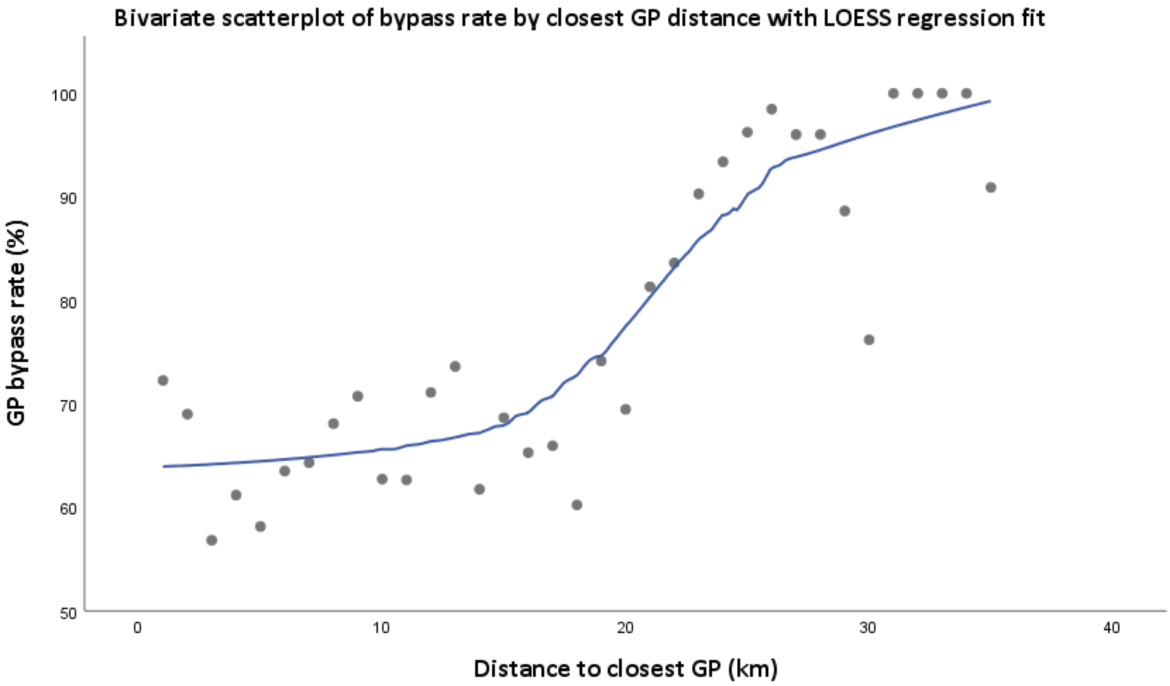

Figure 4.3 Scatterplot of GP bypass rate versus distance to closest GP clinic

4.3.9 Clinic attributes

The main clinic attributes associated with increased rates of GP bypass were whether or not the clinic had after-hours care, and whether or not the clinic was a MSPC. Total GP and nurse FTE hours and clinic fees were statistically significant predictors of lower bypass rates. Overall, 21,953 patients were enrolled in MSPCs (70% of whom were Māori) and 62,031 in after-hours clinics. Of those enrolled with MSPCs, 76% had bypassed a GP clinic closer to their home, while the same was true for 75% of patients enrolled in services providing after-hours care. Patients enrolled with MSPCs and clinics with after-hours care on average travelled an additional 3.4km and 3.3km respectively past their closest clinics. Clinic fees also appears to influence patients' enrolment choices. Three quarters of patients enrolled in clinics that charged less than $20 for an appointment had bypassed closer services, while the same was true for less than half of those patients enrolled in clinics charging more than $20 for an appointment. Although the FTE hours of clinics was a statistically significant predictor variable in the logistic regression the nature of the relationship between GP bypass is unclear. Clinics with less than 5 FTE hours and those with more than 10 FTE hours had the lowest rates of bypass (60%), while patients enrolled at clinics with between 5 to 10 FTE hours were more likely to bypass closer GPs (77%). One key finding is that across the Hauraki PHO network, there were on average 1314.9 patients per GP FTE and 1520.3 patients per nurse FTE, significantly lower than the New Zealand average clinician workload of 1529.9 patients per GP FTE and 2022.7 patients per nurse FTE (Leitch et al., 2018).

4.4 Discussion

The analysis of over 130,000 patient enrolment records indicates that almost 70% of Hauraki PHO patients in the Waikato region are not enrolled with a GP clinic closest to their residential address, and that rates of GP bypass vary according to several key factors. This has important implications for methodological approaches to measuring spatial accessibility. Despite several key limitations, to date the majority of healthcare accessibility research in Aotearoa New Zealand has taken a 'closest facility' approach. The general lack of data on "real" patient behaviour and the relationship between access and geography has been cited as one reason for the assumption that patients use the facility closest to where they live (Alford-Teaster et al., 2016). However, the results of this study, based on detailed data, suggest that such measures are unlikely to accurately reflect how people actually access and use healthcare. This adds to the somewhat contradictory evidence from previous research where surveys have identified varying rates of GP bypass in different settings. For instance, more than 80% of participants from Gisborne, New Zealand bypassed their closest GP (Hays et al., 1990), 32% of respondents in a US study bypassed their closest primary health care provider (Liu, Bellamy, Barnet, & Weng, 2008), while only 28% of middle-aged or older adults surveyed in rural Montana bypassed their local primary health care providers (Sanders, Erickson, Call, & McKnight, 2017). It also supports the previous analysis of patient enrolment data in the UK which revealed that the majority of patients did not register with their closest GP (Lewis & Longley, 2012), and US data which suggests that 65% of women bypass their closest mammography clinic (Alford-Teaster et al., 2016). These findings suggest that, not only are closest facility approaches limited by their disregard for levels of service supply and demand (Bissonnette et al., 2012), but also that assumptions that patients will use their closest service appear to be incorrect. The use of closest facility measures could therefore create a misleading representation of access that does not necessarily reflect the realities of how patients interact with services, and this may impact understandings of spatial equity. The regression analysis appears to confirm that non-spatial factors are key components of accessibility. Higher rates of bypass for patients enrolled in clinics offering lower fees, after-hours care, and Māori-focussed services suggest that Penchansky and Thomas (1981) were correct in considering the affordability, accommodation, and acceptability of services as key non-spatial dimensions of access alongside service availability and accessibility. Furthermore, it is important to consider not only service attributes, but the abilities of individuals and populations to access and interact with health services (Levesque, Harris, & Russell, 2013). Therefore, a key flaw of most accessibility measures is that they tend to be ‘place-based’ rather than ‘people-based’ (Miller, 2007), and don’t consider the interaction of spatial, temporal, and social components of access. Harris, Harris, and Roland (2004) also argue that to improve access equity it is essential to consider whether primary care services: (1) provide high quality care for socially disadvantaged groups, (2) provide access that is appropriate to needs; (3) promote prevention and early intervention and address the underlying social determinants of health. Researchers should therefore carefully consider the importance of both spatial and non-spatial domains on access equity, and incorporate these components into more holistic measures of access. For instance, while availability and spatial accessibility are privileged in the two-step-floating-catchment-area (2SFCA) method (Luo & Wang, 2003) and its various derivatives (Luo & Qi, 2009), it has also been used to incorporate non-spatial aspects of accessibility such as population health (McGrail & Humphreys, 2009), and the 2SFCA is considered a valid measure of accessibility that is associated with health outcomes (Lian, Struthers, & Schootman, 2012). However, in order to more effectively evaluate the equity of access, researchers must develop an accessibility measure which more appropriately captures all domains of access. This could involve synthesising the Levesque or Penchansky and Thomas models of access with the 2SFCA using weightings to account for the affordability (e.g. clinic fees), accommodation (e.g. after-hours or drop-in availability), acceptability (e.g. availability of Māori or Pacific services, female or bilingual staff), as well as considering the differing abilities of populations to access care.

While the results suggest that enrolment patterns appear to be associated with residential rurality, most patients are enrolled with services in the town or city they live in, suggesting that when GP bypass does occur, patients are enrolling with other local services. Rates of GP bypass may therefore be related to the differing availability of services in rural and urban locations. For instance, in Hamilton, which has 36 GP clinics, 98.2% of residents are enrolled in local clinics, while 89.2% bypassed their closest service. Conversely, small and medium urban areas have fewer enrolment options (on average 1.0 and 0.4 GP clinics per SA2 respectively) and much lower GP bypass rates. Commuter travel may also influence enrolment patterns. More than 20% of patients residing in Cambridge, Raglan and Ngāruawāhia were enrolled in services outside their town, and in each case more than 80% of these patients had enrolled in Hamilton GP clinics. These three towns are all located within close proximity of Hamilton and therefore patients may be enrolling in clinics closer to their work or study locations rather than their home address. The relatively high rate of GP bypass for rural areas may also be related to service availability and commuter patterns. Only 4 GP clinics in the Waikato were inside SA2s classified as rural, meaning an average of 0.1 clinics for each rural SA2 in the region. Therefore, most rural patients must travel further to access primary healthcare and may be inclined to enrol with services near their work or place of study.

Spatial equity is not only concerned about the equitable distribution of services geographically, but also among socioeconomic and ethnic population groups (Omer, 2006). This can be thought of as investigating "…whether socially disadvantaged populations live in spatially disadvantaged areas" (Smoyer‐Tomic, Hewko, & Hodgson, 2004, p. 288). Since spatial equity and realised access are particularly under-researched in Aotearoa New Zealand, where the greatest and most persistent health inequities experienced are among Māori, Pacific, and people living in areas of high socioeconomic deprivation (Ministry of Health, 2017; Reid & Robson, 2007), this study also sought to examine the socio-demographic factors associated with varying rates of GP bypass. The results highlight that residents of major urban areas, those living in areas of low socio-economic deprivation, patients identifying as Asian, and patients living more than 20km from any GP clinic were the most likely to bypass their closest GP. Patients enrolled in clinics that offered after-hours care, were Māori service providers, or offered lower fees were also more likely to bypass closer GP services. Māori and Pacific patients had higher than average rates of GP bypass, and a large proportion of patients enrolled with Māori service providers also bypassed their closest GP. This supports evidence of the importance of Māori-governed GP clinics with underlying philosophies of health and wellbeing for Māori for Māori patients (Abel, Gibson, Arataki, Ehau, & Leach, 2005). This compliments Australian research demonstrating that Indigenous Australian patients bypassed several mainstream services in order to access primary care delivered by Indigenous organisations, and 20% of Indigenous Australian patients using these services travel more than 30 minutes (Panaretto et al., 2017). A 2004 survey of Māori health providers suggested that compared to mainstream GP services, MSPCs were more likely to: have a higher proportion of Māori patients enrolled; provide a wider range of services such as maternity care and group health promotion; and serve populations disproportionately drawn from the most deprived areas (Ministry of Health, 2004). Although MSPCs tended to have fewer GPs working for them, the contribution of nurses meant that on average the overall FTE hours were higher than mainstream services. In Aotearoa New Zealand an average GP and nurse FTE hours per clinic of 3.5 and 3.3 respectively and the average clinician workload of 1529.9 patients per GP FTE and 2022.7 patients per nurse FTE has been suggested (Leitch et al., 2018). We found that MSPCs in our sample had similar GP FTE hours (3.1) but higher nurse FTE hours (4.7). The ratio of patients to health-professionals was much lower in MSPCs with an average of 1191.1 patients per GP FTE and 777.9 patients per nurse FTE. Furthermore, the ratio of overall FTEs to enrolled patients was lowest for MSPCs, and no clinics charged more than $17.50 for an appointment. This information may provide some insight as to why MSPCs appear to be valued by patients. Not only are services delivered from a Māori perspective, but fees tend to be lower while GPs and nurses are caring for relatively fewer patients. Our results suggest that area level deprivation may influence enrolment patterns as there is an overall deprivation gradient in bypass rates for all patients, with 88% of people living in the wealthiest areas bypassing their closest GP compared to 66% in the most deprived areas. The distance between a patient's residential address and their GP clinic could be a greater consideration for those patients who live in areas of higher socio-economic deprivation, or conversely, those who live in areas of low deprivation may be more able to travel to a preferred clinic further away from their home address. It also appears that the bypass rates of ethnic groups are affected differently by area level deprivation, while there are large differences between the deprivation gradients of urban and rural areas. European patients living in areas of high deprivation were the least likely to bypass their closest GP, as were patients living in deprived rural and 'medium urban' areas. Further analysis is required to understand these patterns, however the availability of transportation and additional costs involved in travelling to more distant clinics may act as a barrier for patients living in areas of high deprivation. NZDep2013 is calculated based on several census variables including a measure of access to a private vehicle (Atkinson et al., 2014). Patients living in areas of low deprivation are less likely to experience economic or transport-related barriers that could prevent them from enrolling in a preferred clinic of their choice which may not necessarily be closest to their home.

4.4.1 Limitations

One limitation of this study is that patient enrolment data was only available from one of the PHO's operating in the Waikato DHB region meaning that this study only reflects a sample of patients within the region, rather than the entire enrolled patient population. However, all GP clinics in the DHB region were included in the analysis. The dataset did not include 'non-enrolled' patients who may still access GP services albeit at a higher cost, and who may well have very different spatial equity and need. The number of consultations patients had each year was not available either, and therefore it is assumed that enrolment in a GP service is equated to accessing that service. It is assumed that patients' residential addresses are correct and current despite Aotearoa New Zealand's high rates of residential mobility (Berry et al., 2017). It is also important to consider the potential impact of residential mobility on the results of this analysis, as people may wish to keep their regular GP despite changing addresses. Younger people and Māori tend to have higher rates of residential mobility (Morrison & Nissen, 2010) which may explain some of the higher rates of GP bypass among these groups. Furthermore, 17 practices in the Hauraki PHO network are practices with low fees (Very Low Cost Access), which may mean that the impact of cost on enrolment decisions and bypass rates has been underestimated. This study does not consider other components to GP clinic location preference, such as daily travel patterns of patients to locations such as work, study, or school, and how this may impact on enrolment. This information was not available from Hauraki PHO, however there is potential for further research using integrated datasets such as the Statistics New Zealand Integrated Data

Infrastructure. Finally, the definition of rurality for the purposes of health research is currently unclear and contested (Fearnley, Lawrenson, & Nixon, 2016). This study has used the latest UR2018 classification from Statistics New Zealand which is the only classification for SA2s currently available and is based on urban/rural form rather than function. The results of this study may have differed if previous or alternative classifications had been used.

4.5 Conclusion

It is understood that this is the first study in Aotearoa New Zealand to examine enrolment patterns and the reasons for variation in rates of GP bypass using a geospatial approach. This study is based on a highly accurate and detailed patient enrolment dataset geocoded at the street-address level. This is likely the first study to use such data to examine GP clinic enrolments in a mixed urban-rural setting to understand how travel behaviour for healthcare is influenced by a variety of factors, including clinic attributes, rurality of residence, patient characteristics, and area level socioeconomic deprivation. The results suggest that closest facility accessibility measures, which assume patients use the service closest to their home, should be treated with caution as the decisions people make around which service to access and where appear to be much more complex. These results also suggest that a variety of factors influence the choice of patients to either use or bypass their closest GP service, and primary health services in Aotearoa New Zealand should be developed to reflect the realities of the populations they serve.

4.6 Acknowledgements

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Appendix Chapter 4

Table 4.6 Statistically significant interaction terms

Predictor	β	SE	Wald	*df*	*p*	OR
Residence * Deprivation			1993.786	12	.000	
NZDep Q2 by Rural	-.401	.081	24.346	1	.000	.670
NZDep Q2 by Small urban area	.402	.165	5.940	1	.015	1.494
NZDep Q3 by Rural	-.396	.075	28.12	1	.000	.673
NZDep Q3 by Small urban area	1.351	.154	76.491	1	.000	3.860
NZDep Q4 by Medium urban area	-.756	.111	46.262	1	.000	.469
NZDep Q4 by Rural	-.383	.075	26.481	1	.000	.682
NZDep Q4 by Small urban area	1.789	.150	141.406	1	.000	5.981
NZDep Q5 by Medium urban area	-2.903	.115	641.484	1	.000	.055
NZDep Q5 by Small urban	1.881	.149	158.336	1	.000	6.558
Ethnicity * Deprivation			151.817	16	.000	
Asian by NZDep Q2	-.441	.139	10.093	1	.001	.644
Asian by NZDep Q4	-.470	.124	14.432	1	.000	.625
Asian by NZDep Q5	-.659	.122	29.366	1	.000	.517
Māori by NZDep Q5	-.298	.092	10.529	1	.001	.742
Pacific by NZDep Q2	-1.287	.330	15.176	1	.000	.276
Pacific by NZDep Q3	-.681	.313	4.743	1	.029	.506
Pacific by NZDep Q4	-1.292	.300	18.5	1	.000	.275
Pacific by NZDep Q5	-.976	.298	10.729	1	.001	.377
Other by NZDep Q5	-.427	.216	3.897	1	.048	.652
Age * Ethnicity			51.813	20	.000	
Age (15-24) by Asian	.285	.110	6.703	1	.010	1.329
Age (15-24) by Māori	.166	.051	10.619	1	.001	1.181
Age (45-64) by Asian	.232	.094	6.151	1	.013	1.261
Age (45-64) by Other	.307	.156	3.878	1	.049	1.359
Age (65+) by Māori	.161	.066	5.876	1	.015	1.175

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Chapter 5: Article 4 – Defining general practitioner and population catchments for spatial equity studies using patient enrolment data in Waikato, New Zealand[10]

Jesse Whitehead [a *]

Amber L. Pearson [b]

Ross Lawrenson [a, c]

Polly Atatoa Carr [a]

[a] National Institute of Demographic and Economic Analysis, University of Waikato, Gate 1, Knighton Road, Hamilton, New Zealand.

[b] Department of Geography, Environment and Spatial Sciences, Michigan State University, East Lansing, Michigan, USA.

[c] Waikato Medical Research Centre, University of Waikato, Hamilton, New Zealand.

[*] Corresponding author:
Email addresses: jwhitehe@waikato.ac.nz (J. Whitehead), apearson@msu.edu (A.L. Pearson), ross.lawrenson@waikato.ac.nz (R. Lawrenson), patatoac@waikato.ac.nz (P. Atatoa Carr).

Key words: Spatial accessibility, E2SFCA method, Rural health, Primary health care, Access to health care, Spatial equity

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Abstract

The enhanced-two-step-floating-catchment-area (E2SFCA) method is a popular measure of the spatial accessibility of healthcare such as general practitioner (GP) services. However, the key step of defining appropriate GP and population catchment sizes is often overlooked. Applications of E2SFCA methods use a range of catchment sizes, most of which are arbitrarily defined due to a lack of real-world data to inform this decision. The use of inappropriate catchment sizes may under- or over-estimate spatial accessibility in some areas. In this paper patient enrolment data is used to determine appropriate GP and population catchment sizes in the Waikato, central North Island, region of New Zealand. A range of thresholds were tested, including: 100, 95, 90, 85, 75, and 65 percent of enrolled patients. Initial results suggest that catchment sizes vary across rural and urban areas. Further, incorporating variable data-driven population catchments recognises patient travel patterns and appears to improve spatial accessibility results in a mixed urban-rural context, although further modification may be necessary. This study has demonstrated an effective approach to defining appropriate GP and population catchments for use with the E2SFCA method, where access to patient enrolment data is available.

5.1 Introduction

Health inequities are systematic and unfair differences in health resulting from differential access to the social determinants of health, such as education, employment, and access to healthcare (World Health Organization, 2008). Inequitable service distributions are an issue of spatial equity since people with poor access to health services are less likely to use those services (Hiscock, Pearce, Blakely, & Witten, 2008). Researchers can monitor the spatial equity of services by estimating potential accessibility (Talen & Anselin, 1998). The Floating Catchment Area (FCA) group of methods, which are based on the two-step-floating-catchment-area method (2SFCA) (Luo & Wang, 2003), are commonly used spatial accessibility measures (Allan, 2014). FCA approaches estimate spatial accessibility by calculating and combining population to provider ratios within pre-defined health-service and population catchments that represent the distance from a facility that is considered accessible, and the distance patients are willing or able to travel to access healthcare services respectively. A key and often over-looked step of FCA approaches is defining appropriate service and population catchment sizes, which have a direct impact on analysis results (Chen & Jia, 2019; McGrail & Humphreys, 2014). Luo and Wang (2003) originally proposed 30km catchments, and in studies of general practitioner (GP) services a range of GP catchment sizes have been applied, from 3km in Canadian urban areas (Shah, Bell, & Wilson, 2016) to a 60 min drive time in the United Kingdom (Bauer, Müller, Brüggmann, & Groneberg, 2018). We are unaware of any studies that have defined GP or population catchment sizes in New Zealand, and the debate surrounding appropriate catchment sizes in general remains unresolved (Bissonnette, Wilson, Bell, & Shah, 2012; Neutens, 2015; Wang, 2012). This is exacerbated by a lack of studies using data to guide the choice of catchment size, which is likely due to a lack of data available to researchers on actual patient behaviour and the relationship between access and geography that could inform the appropriate choice of catchment sizes (Allan, 2014; Bauer & Groneberg, 2016; Luo & Qi, 2009; McGrail & Humphreys, 2014). Using a snapshot of patient enrolment data from one Primary Health Organisation (PHO) in New Zealand, we describe a method to define data-driven GP and population catchments, and perform an experimental analysis to examine the effects of using such catchments with the Enhanced-2SFCA (E2SFCA).

5.1.1 Setting

Government health funding in New Zealand is distributed to District Health Boards (DHBs) according the population size and demographic characteristics of each DHB region. DHBs then allocate funding to Primary Health Organisations (PHOs) that provide primary healthcare, such as GP services, to their enrolled population. Patients can enrol in any primary healthcare service. This study focuses on the Waikato region in the central North Island of New Zealand, which is home to around 400,000 people (Statistics New Zealand, 2013). Hamilton City is the main urban centre with a population of 140,000 while the remaining population live in small and medium sized towns or rural parts of the region (Statistics New Zealand, 2013). Urban and regional public transport services are limited and only 1% of Waikato commuters use public transport (Statistics New Zealand, 2013). Compared to the New Zealand population as a whole, people living in the Waikato region have higher levels of obesity, ischaemic heart disease, diabetes, high cholesterol and blood pressure, as well as higher levels of unmet need for primary healthcare (Ministry of Health, 2018). Hauraki PHO delivers primary care services to over 135,000 patients in the Waikato region through 36 GP clinics (Hauraki PHO, 2018).

5.2 Materials and Methods

5.2.1 Data

Anonymised records for all 137,596 patients enrolled at Hauraki PHO GP clinics during December 2017 were provided by Hauraki PHO. Records included the residential address, geocoded coordinates, a geocoding uncertainty score, and the enrolled clinic of each patient. During data cleaning any patients with a geocoding uncertainty score greater than 5, indicating that the chance of incorrect geocoding was 50% or higher, were removed from the sample. Patients residing outside the North Island mainland were removed from the sample. A small minority of patients (1,891 or 1.4% of the sample) had residential addresses outside the Waikato DHB region, and these were also removed. The total sample for this analysis included 133,870 enrolled patients. The New Zealand road network GIS layer was obtained from the Land Information New Zealand Data Service. Statistical Area 2 (SA2) geographical boundaries and urban/rural form classifications (UR2018) were downloaded from the Statistics New Zealand Geographic Data Service. The UR2018 classifies areas according to population size and density as: ‘major urban’ (>100,000 residents), ‘large urban’ (30,000 – 99,999), ‘medium urban’ (10,000 – 29,999), ‘small urban’ (1,000-9,999), ‘rural settlement’ (200-999), or ‘rural other’ (<200). There are no ‘large urban’ areas in the study region and the ‘rural settlement’ and ‘rural other’ categories of the UR2018 were combined into a single ‘rural’ category for the purposes of this analysis. The locations of all Hauraki PHO GP clinics were geocoded, and clinic rurality was determined by assigning each GP clinic the Statistics New Zealand UR2018 category of the SA2 geographical area within which it was located.

5.2.2 Analytical methods

Stage 1: ArcGIS (ESRI, Redlands, CA, USA) network analysis was used to calculate the distance from each patient’s residential address to their enrolled GP clinic. Some patients were registered to clinics operating satellite services. For instance, Tui Medical has a main clinic in central Hamilton, and operates another four clinics in Hamilton and one in Huntly. Since the data did not include the exact satellite clinic that patients were enrolled in (and in the case of Tui Medical patients are able to access services in any of their 6 clinics), it was assumed that patients would access the satellite service closest to their residential address. GP catchments were defined by identifying the road network distances within which a certain proportion of patients resided. There is no consensus on ideal GP catchment sizes or the methodology to determine them. Previous research has defined catchments using thresholds between 75% (for hospital boundaries) (Phibbs & Robinson, 1993) and 95-99% for GPs in an urban context, where patients must live within a GP’s ‘legal’ catchment (Sofianopoulou, Rushton, Rubin, & Pless-Mulloli, 2012). It has also been argued that 90% catchments could be appropriate when patients are widely distributed, so as to remove outliers (Sofianopoulou et al., 2012). A sensitivity analysis was carried out to examine an appropriate catchment using 100%, 95%, 90%, 85%, 75%, and 65% patient enrolment thresholds. Differences in spatial accessibility results derived from each catchment threshold were examined, and ANOVA and Spearman’s rank correlations were performed. Individualised population catchments were defined by determining the distance that 90% of Hauraki PHO patients living in each SA2 travelled between their residence and their enrolled GP clinic. The average size of GP and population catchments for each UR2018 classification of rurality were examined. Stage 2: An analysis of the effects of using data-driven variable catchments was assessed by performing three separate E2SFCA analyses. The first was a 'traditional' E2SFCA analysis that applied the 30km catchments originally proposed (Luo & Wang, 2003). The ArcGIS OD-Matrix was used to identify all SA2 centroids (and their associated resident populations) and GP clinics that were within 30km from each other. In step 1, the OD-Matrix was used to calculate a supply-to-demand ratio for each GP clinic based on the total population able to access it. In step 2, the ratio scores of GP clinics within reach of each SA2 centroid were then summed to give an accessibility score for each SA2 in the study region. The Butterworth continuous distance-decay function (Langford, Fry, & Higgs, 2012) was applied at both steps and was selected as it produces a flat zone without impedance, followed by a continuous decay to a zero weighting at the threshold distance. This is similar to McGrail and Humphrey's (McGrail & Humphreys, 2009a) stepped approach which recognises that short travel for healthcare is not a significant barrier in the Australian rural context. Previous analysis of the same patient enrolment data used in the current study also suggests that short distances do not significantly impact travel behaviour in the mixed urban-rural New Zealand context (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019), indicating that the Butterworth function is an appropriate distance-decay function. The second analysis, a Variable-GP-E2SFCA (VGP-E2SFCA), used data-driven variable GP catchments that were informed by the results of stage 1. First, three separate OD-Matrices with different distance thresholds were developed based on average GP catchments in major urban, small/medium urban, and rural areas. In step 1, the Butterworth distance-decay function was applied separately to each OD-Matrix to calculate the weighted population potentially accessing each GP clinic. The OD-Matrices were then combined, and each clinic's supply-to-demand ratio was calculated. In step 2, the same three OD-Matrices were used to identify GP clinics (and associated ratios) that each SA2 was able to access. After applying distance-decay, the OD-Matrices were combined and the ratio scores accessible by each SA2 summed to give a final accessibility score. The same procedure was applied to the third analysis, a Variable-Population-E2SFCA (VPOP-E2SFCA). However, OD-Matrix thresholds were based on the average population catchments in major/medium/small urban and rural areas, as identified in the results of stage 1. No supply-side capacity weighting was included in either of the three analyses.

5.3 Results

5.3.1 GP Catchment Sizes

Overall, 95% of Hauraki PHO patients live within 24 kilometres of their GP clinic, however the size of individual GP catchments defined using patient enrolment data greatly varied between clinics. For instance, 95% of patients enrolled at one urban clinic lived within 12km of their GP compared to 60km for patients of a rural health centre. *Table 5.1* displays the variation in the average catchment sizes of GP clinics located in urban and rural locations for each proportion of enrolled patients. Rural catchments were consistently larger than all other catchments, while small urban GP clinics tended to have larger catchments than clinics in major- and medium urban areas.

Table 5.1 Average GP catchment sizes based on patient enrolments and Statistics New Zealand UR2018 classifications

Enrolled patients	Major urban	Medium urban	Small urban	Rural	Total
65%	4.5km	4.3km	5.5km	15.3km	4.5km
75%	5.9km	6.7km	9.4km	16.2km	6.5km
85%	8.2km	10.6km	14.9km	19.1km	11.9km
90%	11.1km	18.3km	18.4km	29.7km	16.1km
95%	19.6km	26.1km	24.0km	40.4km	24.0km

5.3.2 Population Catchment Sizes

Overall, the average size of population catchments in the study area was 29.0km, while individual catchments ranged from 1.5km to 254.8km. *Table 5.2* illustrates the average size of population catchments classified by rurality, while *Figure 5.1* displays the GP and population catchments of six cities, towns, and rural areas. As expected, on average rural population catchments were the largest, suggesting that rural residents do (or must) travel further to access GP services. Major urban population catchments were small, suggesting that most patients enrol with services in the city. An examination of rates of major urban GP enrolment for patients living in each UR2018 class supports this assumption. Of patients living in major urban areas, 98% were enrolled in major urban GP clinics. Fewer patients living in medium (8%) or small (10%) urban areas enrolled in major urban services, while 27% of rural patients were enrolled with major urban GP clinics. Furthermore, 63% of rural patients were found to be enrolled with clinics in small urban areas.

Table 5.2 Average population catchment sizes for Statistics New Zealand UR2018 classifications

90% Enrolled patients	Major urban	Medium urban	Small urban	Rural	Total
Minimum	3.8km	1.6km	1.5km	8.8km	1.5km
Maximum	10.9km	35.9km	178.0km	254.8km	254.8km
Average	6.2km	21.0km	39.0km	45.4km	29.0km

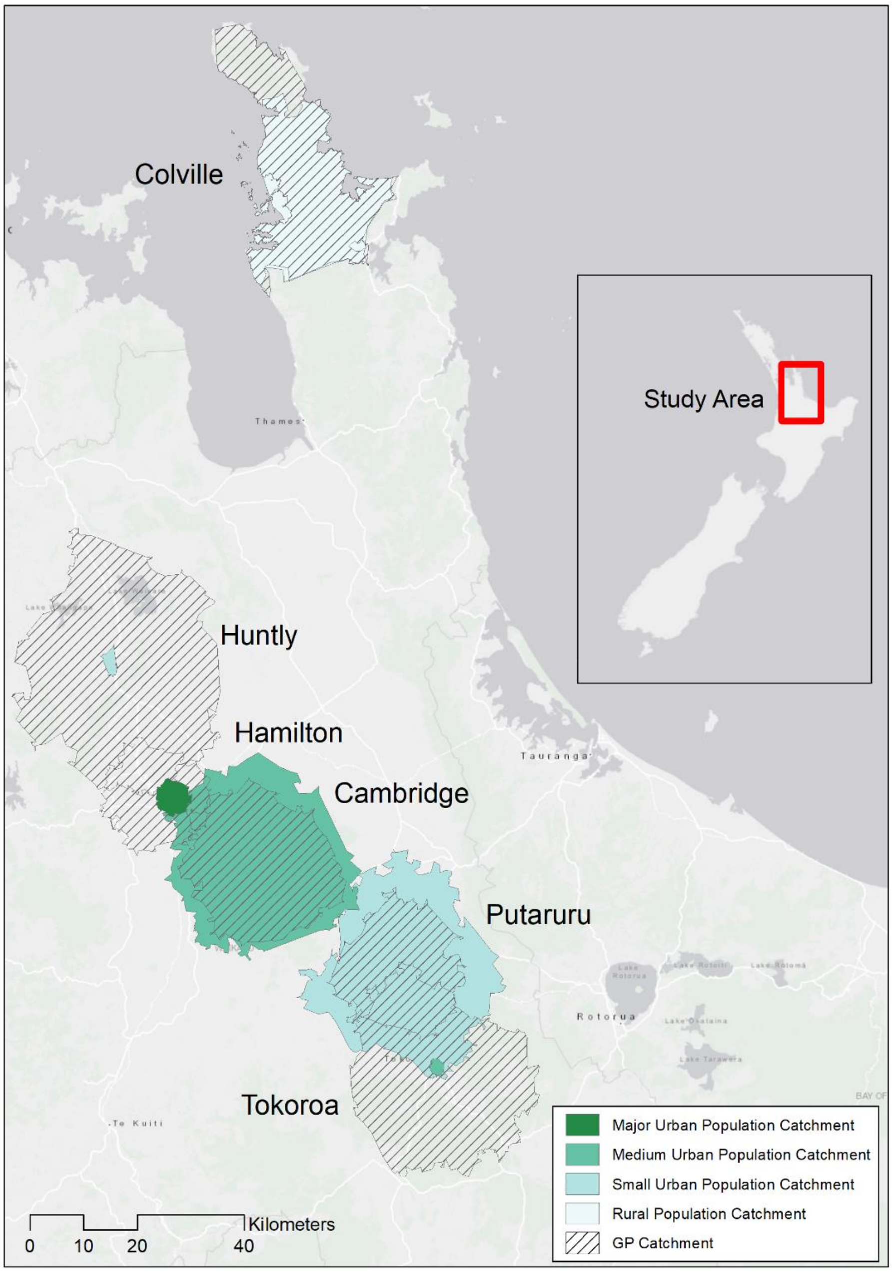

Figure 5.1 Comparison of six population and GP catchment areas classified by rurality

5.3.3 Catchment size sensitivity analysis

A sensitivity analysis of accessibility scores produced by different catchment thresholds showed that that 85-65% thresholds produced a large number of low scores and underestimate accessibility in many areas. While 100% thresholds provided a regional overview of accessibility patterns, they failed to accurately identify local variations in accessibility, which are better represented by 90% or 95% catchments. A one-way ANOVA ($F(2,603) = 0.126$, $p = .88$) indicated no significant differences in mean accessibility scores produced by 100%, 95%, and 90% thresholds, while the results of 95% and 90% thresholds were strongly correlated ($rs(200) = .85$, $p<.001$) suggesting that either catchment size is appropriate in this study context.

5.3.4 Generalised GP and Population Catchments

Researchers following our approach for data-driven catchments can freely define their own ‘threshold’ points. However, since it depends on access to patient enrolment records, which may not always be possible, we also propose ‘generalised’ GP and population catchments for use in New Zealand. Based on our sensitivity analysis and mixed urban-rural study context with widely distributed patients, the proposed GP catchments are based on a 90% threshold of patient enrolments (see *Table 5.1*). This threshold point excludes significant outliers while maintaining a consistent 10km increase in size from major urban, to small/medium urban, and rural catchments. Population catchments are based on the ‘average’ row from *Table 5.2*. *Table 5.3* outlines the proposed sizes of both GP and population catchments for each classification of rurality. The largest proposed GP catchments are 30km, the same size as in the original 2SFCA (Luo & Wang, 2003), while our largest population catchments are 45km.

Table 5.3 Proposed GP and population catchment sizes

Geographic area (UR2018)	GP Catchment	Population Catchment
Major urban areas	10km	5km
Medium urban areas	20km	20km
Small urban areas	20km	40km
Rural areas	30km	45km

5.3.5 E2SFCA analysis

The effect of using data-driven variable catchments was assessed by comparing the results of E2SFCA analyses using differing catchment sizes, which are shown in *Figure 5.2.* First, a 'traditional' E2SFCA analysis was executed using fixed GP and population catchments of 30km, and is labelled (A). Next, the generalised GP catchments outlined in *Table 5.3* were applied, and associated population catchments determined through the OD matrix. This VGP-E2SFCA is labelled (B). The third analysis used the generalised population catchments from *Table 5.3*, with associated GP catchments determined through the OD matrix. This VPOP-E2SFCA is labelled as (C). Finally, the difference in accessibility scores between the E2SFCA and VGP-E2SFCA was calculated and is labelled (D). The differences in results between these three approaches is displayed in *Figure 5.2*, with scores for eight different locations shown in *Table 5.4.*

Table 5.4 Comparison of accessibility scores for eight locations using the three different catchment size approaches

Location	UR2018	E2SFCA*	VGP-E2SFCA**	VPOP-E2SFCA***
Suburb A	Major urban	0.000197	0.000124	0.000014
Suburb B	Major urban	0.000227	0.000251	0.000062
Town C	Medium urban	0.00007	0.000107	0.000049
Town D	Medium urban	0.000115	0.000239	0.000142
Town E	Small urban	0.000464	0.000596	0.000265
Town F	Small urban	0.000087	0.000189	0.00039
Area G	Rural	0.00014	0.000028	0.00077
Area H	Rural	0.000156	0.000347	0.000297

* 30km GP & population catchments
** 10/20/30km GP catchments
***5/20/40/45km population catchments

Using data-driven variable catchments effects the results of spatial accessibility analyses differently depending on whether GP-defined or population-defined catchments are used. The direction of these changes also varied across the region by rurality, as displayed in *Table 5.5*. The reasons for these changes are outlined in the discussion.

Table 5.5 Percentage of SA2s showing variation in changes to accessibility scores compared to an E2SFCA approach

UR2018	Change	VGP-E2SFCA	VPOP-E2SFCA
Major urban	Increase	75%	5%
	Decrease	25%	95%
Medium urban	Increase	100%	42%
	Decrease	0%	58%
Small urban	Increase	100%	69%
	Decrease	0%	31%
Rural	Increase	58%	96%
	Decrease	33%	1%
	No change	9%	3%

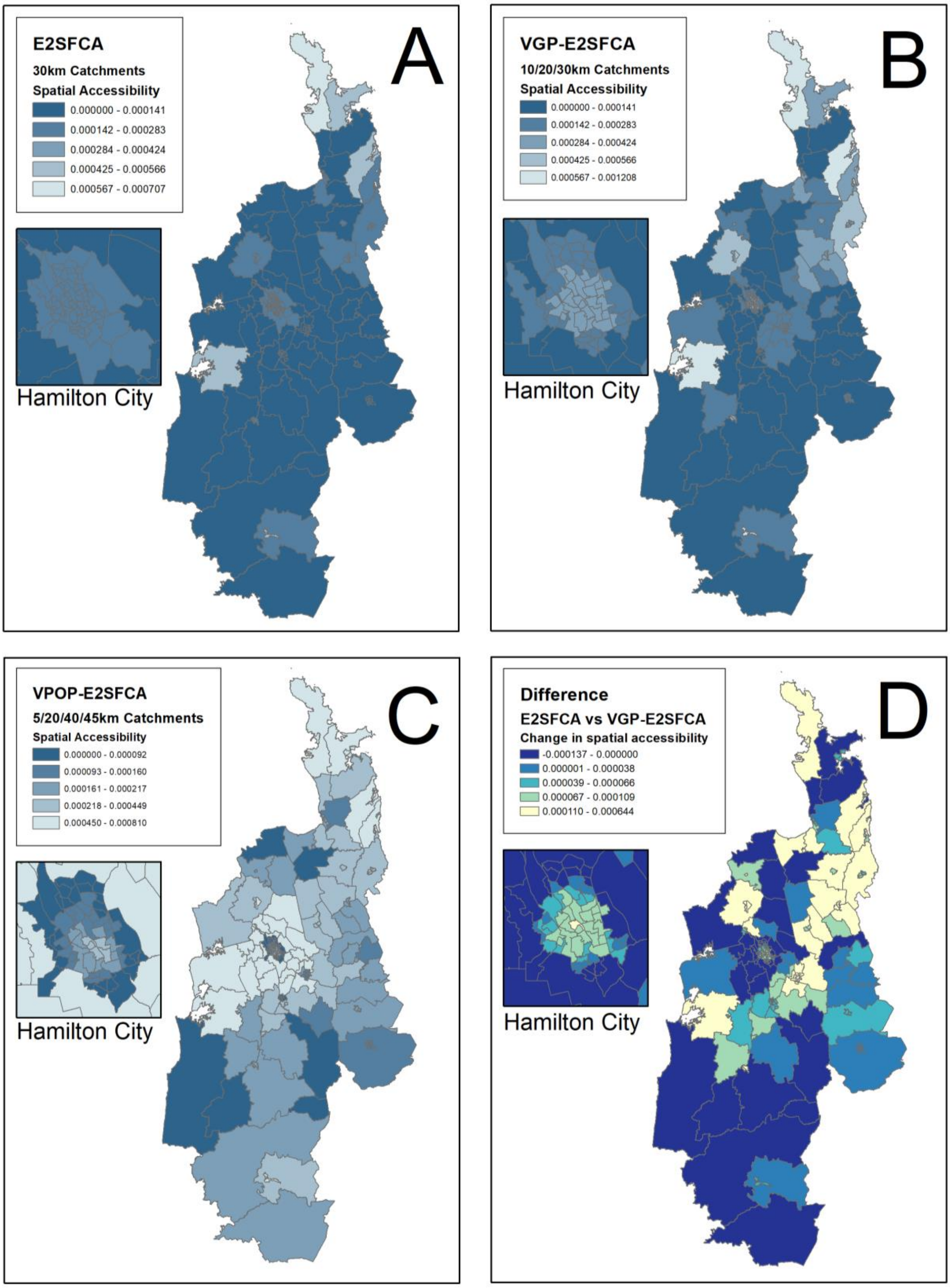

Figure 5.2 Comparison of results. (A) E2SFCA, (B) VGP-E2SFCA, (C) VPOP-E2SFCA method, (D) Difference between A and B

5.4 Discussion

We have outlined a new approach for defining individual GP and population catchments for use with FCA methods that is based on street-address-level patient enrolment data. Previously Sofianopoulou et al. (2012) have defined GP practice areas in Newcastle and North Tyneside based on patient utilisation, and Lewis and Longley (2012) have developed GP services areas in the borough of Southwark, London. However, the GP services areas in these studies were not developed specifically for use with FCA methods, and both were applied to urban environments in the UK using postcode-level address data. Furthermore, the kernel density methodology used by both studies ignores the impact of the built environment, such as transport infrastructure, on service accessibility and defines GP service areas based on the density of patient addresses. This is problematic and unlikely to be appropriate for use in a mixed urban-rural setting such as the Waikato where population density varies, and the geographic accessibility of services is tied to the physical transport infrastructure. By contrast, our method considers the road transport network, the use of which is a key component of accessing health services, especially in rural areas. This means that catchment sizes can also be directly applied to an FCA analysis.

The wide range of catchment sizes defined by using data in our study suggests that, when possible, using patient enrolment records is an important step for defining both GP catchments, and developing an improved understanding of how geography influences health service use. While data is often unavailable to guide the choice of appropriate catchment sizes (Bauer & Groneberg, 2016; Bissonnette et al., 2012; Neutens, 2015; Wang, 2012), various catchment sizes have been used in FCA studies, and our results suggest that these may be inappropriate for the Waikato region. All data-defined GP catchments in our study were smaller than the 60-minute drive time (equivalent to 45-50km in urban areas and 80-100km in rural areas) used in the UK. Only two GP clinics in our study had a catchment size larger than the 30km catchment first proposed by Luo and Wang (2003) that has often been used without critical reflection (Neutens, 2015). Our results also suggest that 3km catchments (Shah et al., 2016) would be inappropriate for rural areas where the minimum distance travelled by patients to a GP clinic was almost 6km. This indicates that assumptions about patient travel behaviour may not reflect the reality of how services are accessed. While we recognise that data access restrictions means it is not always possible to define catchments with our approach, we have shown that the sizes of both GP and population catchments vary by rurality, supporting calls for the use of dynamic catchments in FCA studies (Luo & Whippo, 2012; McGrail & Humphreys, 2014). Our results confirm that the catchments of small town and rural GP clinics are larger than urban practices, while populations living in small towns and rural areas are also likely to travel much further for healthcare than urban residents. The use of fixed catchments may result in inaccurate assessments of accessibility in urban and rural areas by underestimating the demand on urban services while overestimating service availability for urban residents, and also underestimating the size of populations being served by healthcare in small towns and rural locations (Bauer & Groneberg, 2016; Luo & Whippo, 2012; McGrail & Humphreys, 2009b, 2014). This is especially important in a mixed urban-rural context. Having large catchments on the fringe of urban areas means that urban populations dominate nearby rural services, despite urban residents being highly unlikely to access rural clinics (McGrail & Humphreys, 2009b). Our finding that major urban areas have small population catchments of around 4km, suggests that urban residents are unlikely to enrol with services outside their city, while urban GP catchments were around 10km, indicating that patients residing outside major urban areas also access these services. While our results validate the proposal (McGrail & Humphreys, 2014) that rural population catchments should be larger than urban population catchments, we found mixed results for the claim that GP catchments should be larger than population catchments. This only appears to be the case in cities, and further work is necessary in other contexts to explore this relationship. Our findings also indicate that if patient data is unavailable to researchers, catchment sizes should be defined with careful consideration of the study context and how travel for healthcare varies between rural and urban populations.

Our study suggests that using patient enrolment records offers the opportunity to define a range of catchment sizes for either supply-side GP catchments, or demand-side population catchments. Conceptually, FCA analysis based on data-driven population catchments is more appropriate. FCA methods are a placed-based measure of accessibility from the perspective of populations living in each geographical unit, and the final output is an accessibility score for each area. This represents how accessible services are for the population living in that place. Data-driven population catchments (defined by how populations living in each location enrol with services) are a closer representation of which services populations living in each location are able/willing to access than data-driven GP catchments which are created from the 'perspective' of GP clinics. GP catchments represent the area and associated population that a particular clinic is likely to serve. When GP catchments are used as the basis of FCA measures, the associated population catchments are defined through the OD-Matrix by their relationship with GP catchments. If a population is within a GP catchment, it is considered able to access that service. The final accessibility score is a measure of the number of GP catchments that a population falls within (considering the size of the population with potential access to the same clinics and distance decay). This is a subtle but important difference from FCA measures based on population-defined catchments. However, it must also be noted that the patient enrolment data used in our study is collected by services. It is not a population survey of patients in each SA2. The data does not include unenrolled patients who are still able to use any GP service (although at a greater, unsubsidised cost) and patients enrolled with other PHOs. This means that while we can be confident that the GP-defined catchments created are an accurate representation of the locations of patients enrolled with these particular services, population-defined catchments are less accurate as the dataset only represents a sample of all people living in each SA2.

Applying data-driven variable GP and population catchment sizes to the E2SFCA method echoed previous research demonstrating that the choice of catchment size does impact the outcome of accessibility analyses (Chen & Jia, 2019; Luo & Whippo, 2012; McGrail & Humphreys, 2014). Our results suggest that the decision to base FCA analysis on GP-defined or population-defined catchments is important as the size of population catchments (and associated FCA results) will vary depending on whether they are directly defined by enrolment data, or passively defined through GP catchments. This difference can affect the number of services considered available from a population location when variable catchment sizes are used. For example, in our VPOP-E2SFCA analysis a medium urban area would have a population-defined catchment of 20km. It is assumed that any clinic within 20km is accessible, which may include clinics in nearby major urban areas. If GP-defined catchments were used, then the number of accessible clinics changes depending on the GP catchment size. All rural clinics within 30km, small/medium urban clinics within 20km, and major urban clinics within 10km of the population location would be considered accessible. This means that some rural clinics that were previously inaccessible would now be considered within reach, while any urban clinics more than 10km away would become inaccessible.

Table 5.5 indicates how the effect of using variable catchment sizes varies for each class of rurality depending on whether GP-defined or population-defined catchments are used. GP-defined catchments increased accessibility scores for centrally located major urban SA2s in the VGP-E2SFCA. Smaller GP catchments resulted in decreased demand from neighbouring small towns and rural areas in step 1, while maintaining similar levels of service availability for major urban neighbourhoods in step 2. Peripheral SA2s in major urban areas had decreased accessibility scores because even though demand in step 1 was reduced, the availability of clinics in step 2 was also reduced. All SA2s in medium and small urban areas had increased accessibility scores as demand from surrounding SA2s was decreased in step 1 with smaller catchments, while the availability of services in step 2 was unaffected since all towns have at least one GP clinic. Rural SA2s where accessibility scores increased (58%) were located within 20km of small and medium urban areas. Increased accessibility for these SA2s was due to decreased demand from major urban and rural areas more than 20km from clinics in small/medium in step 1, while the availability of services in step 2 was unaffected. Rural SA2s more than 20km from small/medium urban areas, or located in the Hamilton hinterland had decreased accessibility scores because the availability of services in step 2 was reduced by smaller GP catchment sizes. This pattern differed in the VPOP-E2SFCA results, where major and medium urban catchment sizes were reduced, while small urban and rural catchment sizes increased. The majority of major urban SA2s (95%) had decreased accessibility. In step 1, demand from small urban and rural areas is increased while in step 2, service availability is decreased as major urban population catchments are reduced to 5km. The only major urban SA2s with increased accessibility scores were in the central city, where demand from peripheral areas was decreased while similar levels of service availability were maintained. Most medium urban areas also showed decreased accessibility (58%) due to increased demand from small urban and rural areas in step 1, with decreased service availability in step 2. Medium urban areas with increased accessibility were located within

20km of a major urban area, meaning that demand from cities was likely reduced (due to smaller major urban catchments) while similar levels of service availability were maintained. Most small urban (69%) and rural (96%) SA2s had increased accessibility due to decreased demand from major/medium urban areas in step 1, and increased service availability due to larger catchment sizes in step 2. Small urban and rural SA2s where accessibility decreased were remote areas where demand from major/medium areas would be unaffected, but would increase from rural areas in step 1, and availability in step 2 would remain unchanged as neighbouring services remained out of reach.

It is important to consider whether these changes are appropriate, and whether further modifications should be made. At face value, the VGP-E2SFCA appears to have resulted in a pattern of accessibility that is: appropriately higher in the urban core where service availability is high; appropriately lower in more remote rural areas where service availability is low; and appropriately lower in rural areas of the urban hinterland where demand is high. However, this approach underestimates levels of demand for urban services from rural populations. Furthermore, the levels of demand from rural patients on clinics in small and medium urban areas is underestimated, resulting in inappropriately high levels of accessibility for some towns. The VPOP-E2SFCA better recognises the impact of patients' travel for healthcare through larger population catchments for small urban and rural areas. This leads to appropriately higher levels of demand for services in major urban areas, as well as some small and medium urban areas. The effect is that SA2s in more isolated small and medium urban areas have appropriately reduced accessibility scores, while those close to the city have appropriately higher accessibility scores. On the other hand, 5km population catchments for major urban areas means that accessibility scores in the city may be inappropriately low. While it is appropriate to include increased demand from rural and small-town populations, smaller population catchments for major urban areas limit the availability of services to a very small area. This has resulted in low accessibility scores for peripheral urban areas while the immediately adjacent rural areas are considered to have very high levels of access. While this may be a result of inappropriate definitions of rurality in New Zealand (Fearnley, Lawrenson, & Nixon, 2016), the use of 10km population catchments in major urban areas may be a better reflection of intra-urban mobility and the availability of services to city residents. Finally, while the VPOP-E2SFCA recognises that many rural patients do travel long distances to access healthcare, the ability of rural populations to travel may be overestimated leading to inappropriately high accessibility scores for these areas. A lack of public transportation in rural areas means that children and the elderly may be less able to travel long distances to urban centres, and the financial and time costs of travel for healthcare are higher. Given the considerations outlined above, it appears that a VPOP-E2SFCA approach, with modified major urban and rural catchment sizes, may be the most appropriate FCA method.

Our study does include some limitations. As mentioned, our data is sourced from a PHO and is not a population survey of healthcare access. We also recognise that New Zealand has high rates of residential mobility (Berry et al., 2017) and some patient address details may be out of date. While developing catchments we were unable to consider the activity spaces of patients as data on work or school locations was unavailable. We recognise that the three E2SFCA analyses performed are based on some assumptions that could impact results. For instance, the catchment threshold distance was set at 90%, however our sensitivity analysis suggested that using a 100% threshold would have resulted in overly large catchments that masked local variations. The choice of distance decay function has also been shown to impact 2SFCA results (Chen & Jia, 2019) however, as discussed previously, the Butterworth function is appropriate for our mixed urban-rural context. Furthermore, selecting appropriate catchment sizes and distance-decay functions are key decisions for all FCA studies which can be improved with access to patient enrolment data. Finally, the supply side capacity was not included, meaning that all clinics were assumed to be the same size and provide the same services. Unfortunately, detailed data on GP numbers and Full-Time-Equivalent (FTE) hours was only available for some clinics and therefore was unable to be incorporated across the entire study region. While incorporating supply-side capacity would improve the results of any FCA analysis, and selecting a different distance-decay function may have produced different results, the key purpose of this research was to develop an approach for creating data-driven catchment sizes, and demonstrate how they could be incorporated into FCA analyses in a mixed urban-rural context. Future research using our approach could incorporate appropriate supply-side measures such as FTE hours or fees, as well as demand-side indicators of population health needs.

To our knowledge this is the first study carried out in New Zealand to define GP or population catchments, so we are unable to directly compare our results to other studies and it is difficult to speculate on the appropriateness of our catchments to other areas of New Zealand. However, the Waikato region is a good example of a mixed urban-rural environment that is representative of New Zealand as a whole. More data is required to test whether the catchment sizes we have proposed are appropriate for other parts of the country such as Auckland - New Zealand's largest city – or more remote regions such as Southland where there are larger distances between towns. While we recognise that most accessibility studies will not have access to patient enrolment data, which limits the generalisability of our approach, this study has highlighted the value of such data to accessibility researchers to inform improved measures of potential accessibility. Further research is currently underway to examine patient enrolment patterns as they relate to realised access.

5.5 Conclusion

This study makes important contributions to the spatial equity and healthcare accessibility literature. To our knowledge it is the first study to use patient enrolment data that has been geocoded to the street address level to develop both GP and population catchment areas. We have outlined a method for easily creating individual catchments based on actual enrolment data that can give a much more accurate picture of how patients interact with services. Further, this is the first study to propose appropriate variable catchment sizes for the New Zealand context.

5.6 Acknowledgements

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Chapter 6: Article 5 – Selecting health need indicators for spatial equity analysis in the New Zealand primary care context[11]

Jesse Whitehead, BSocSci (Hons)[1 *]

Amber L. Pearson, PhD[2]

Ross Lawrenson, MBBS, MD [3]

Polly Atatoa Carr, MBChB, MSc [1]

[1] National Institute of Demographic and Economic Analysis, University of Waikato, Gate 1, Knighton Road, Hamilton, New Zealand.

[2] Department of Geography, Environment and Spatial Sciences, Michigan State University, East Lansing, Michigan, USA.

[3] Waikato Medical Research Centre, University of Waikato, Hamilton, New Zealand.

[*]Corresponding author: National Institute of Demographic and Economic Analysis, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand, jesse.whitehead@waikato.ac.nz, +64 7 838 4040

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Abstract

Purpose: To examine potential indicators of health need for primary care in spatial equity research, and evidence of the Inverse Care Law in the Waikato region of New Zealand.

Methods: A cross-sectional analysis of seven health need indicators (Ambulatory Sensitive Hospitalizations; Cancer rate; Mortality rate; New Zealand Index of Multiple Deprivation - Health Domain; Age; New Zealand Index of Deprivation; Smoking rate) that were identified through a systematic review was carried out. Values of indicators were mapped and analyzed using Geographic Information Systems (GIS). Spearman's correlations were calculated between indicators, and clusters of high need identified through spatial autocorrelation. The impact of incorporating indicator-based-weightings into an accessibility model was tested using ANOVA and Spearman's correlations. General practice (GP) service spatial equity was assessed by comparing clusters of high access versus need, and quantified through the Gini coefficient.

Findings: Ambulatory sensitive hospitalization (ASH) rates were significantly correlated with all indicators. Health needs were significantly clustered, but incorporating indicator weightings into the spatial accessibility analysis did not impact accessibility scores. A misalignment of access and need, and Gini coefficient of .281 suggests that services are not equitably distributed.

Conclusion: ASH rates seem a robust indicator of health need. However, data access issues may restrict their use. Area-level socioeconomic deprivation measures incorporate some social determinants of health, and have potential for wider use. High need clusters vary spatially according to the indicator used. GIS techniques can identify 'hot-spots' of need, but these can be masked in accessibility models.

6.1 Introduction

Health inequities are systematic, unjust and avoidable differences in health caused by differential access to the social determinants of health including the health system itself.[1] Access to health care can be inequitable and, according to Hart's Inverse Care Law, inversely proportionate to population need.[2] Spatial equity is recognized as a fair distribution of services proportionate to need.[3] To achieve health equity, places and populations with higher needs should receive appropriately higher access to resources.[4] Spatial equity research compares levels of health care access with estimates of health need using a variety of spatial techniques and indicators of health need.[3] In New Zealand, primary care is funded to promote health equity, and the Primary Health Care Strategy aims to reduce health inequalities between groups.[5] In the 2000s local decision-making was devolved from the Ministry of Health to District Health Boards (DHBs) and Primary Health Organizations (PHOs). Under the New Zealand Public Health and Disability Act,[6] DHB objectives include: reducing health inequities; improving, promoting, and protecting community health; and seeking the most effective delivery of services to meet local, regional, and national needs. However, DHBs are not directed on how to allocate resources within their region, and it is not clear whether DHBs or PHOs use health needs indicators to determine the most equitable funding and service delivery arrangements. Therefore, spatial equity research on primary care in New Zealand, such as the examining sub-regional distribution of general practitioner (GP) services, is important for monitoring the equity of service delivery. However, the selection of appropriate health need indicators is often overlooked. A range of epidemiological, demographic, and social indicators of health need have been applied, often in combination, to spatial equity investigations.[3] The National Health Committee[7] has called for the development of a suite of New Zealand rural health status indicators. However, to our knowledge, there is no agreed-upon indicator of health need for spatial equity research on primary care, either internationally or in New Zealand. While the importance of selecting appropriate geographical units,[8] as well as appropriate accessibility criteria and thresholds[9] in spatial equity research has been established, the impact of using different health needs indicators is, to our knowledge, untested in the New Zealand context. In Canada,[10] two different sets of indicators highlighted significant differences in need according to the indicator used. To address this gap, we examined the appropriateness of seven indicators of health need in a New Zealand primary care setting, by comparing them with indicator selection criteria outlined by the Ministry of Social Development.[11] We then applied the indicators to a spatial equity case study in the Waikato DHB region of New Zealand that tested Hart's Inverse Care Law. This research can help to guide the selection of appropriate health need indicators when considering primary care delivery in New Zealand and internationally. This work does not evaluate the spatial equity of emergency hospital services in an event such as an infectious disease outbreak.

6.2 Methods

This research involved four main stages: first, identifying potential indicators of health need; second, analyzing indicators for the Waikato DHB region; third incorporating indicators into an accessibility analysis; and four using statistical tests in examine the impact of indicators on the results of a spatial equity analysis, including the Inverse Care Law.[2] These four stages are outlined in *Figure 6.1*, and described below.

1 - Selection of health need indicators

- Identify potential indicators
- Assess indicators against selection criteria
- Access data

2 - Analysis of health need indicator

- Select appropriate unit of analysis
- Examine variations in health need by indicator
- Create health need weightings for each indicator

3 - Accessibility analysis

- Calculate accessibility scores using the E2SFCA
- Calculate and incorporate health need weightings into the E2SFCA

4 - Statistical tests

- Calculate Spearman's correlation coefficients between health need indicators
- Calculate Global Moran's *I* and Anselin Local Moran's *I* spatial autocorrelation measures
- Calculate ANOVA of all spatial accessibility scores
- Calculate Spearman's correlation coefficients between all spatial accessibility scores
- Calculate the Gini coefficient for the distribution of spatial accessibility scores across the population

Figure 6.1 The four main stages of the methods section

6.2.1 Selecting health need indicators

Potential health need indicators were identified by examining research articles included in our recent systematic review of spatial equity definitions and measures,[3] and by referring to the World Health Organization 'Global Reference List of 100 Core Health Indicators.[12] Seven potential indicators were identified and assessed against selection criteria by JW. Selection criteria in *Table 6.1* were adapted from the Ministry of Social Development Social Report.[11] Although these selection criteria were not weighted, some are more important than others. For instance, indicators *must* be a relevant measure of need for primary care. While the number of hemodialysis patients is a good indicator of need for hemodialysis beds,[13] this is not an appropriate indicator of the need for primary care. GP clinics deal with a wide range of non-urgent health conditions, and therefore the use of very specific diagnoses as indicators of need may not be appropriate. On the other hand, quarterly data collection and reporting is less important if the indicator is a robust and valid measure of health need. Furthermore, data availability is an essential consideration as some indicators may not be readily accessible to researchers, may involve data extraction fees, or may have privacy considerations which prevent the release of data at a suitable spatial scale. Criteria 9 and 10 were included because data availability and the choice of spatial unit are important considerations in spatial equity research.[14] The Modifiable Areal Unit Problem (MAUP) has shown that results of analyses can vary according to the size, number, and configuration of geographical units that are used, as larger units can mask variation while smaller units may not represent a meaningful neighbourhood.[15,16] Aggregation methods, even when size or total population is similar between methods, can have great influence on results.[17] Seven potential indicators that represent epidemiological (1-4), demographic (5) and social (6-7) measures of primary care health need were identified: (1) the Ambulatory Sensitive Hospitalization (ASH) rate; (2) the crude mortality rate; (3) the incidence rate of selected cancers; (4) the 'Health' domain of the New Zealand Index of Multiple Deprivation (IMD-H); (5) age (% aged ≤ 4 or ≥ 65 years); (6) the New Zealand Index of Socioeconomic Deprivation (NZDep2013); and (7) rates of cigarette smoking among adults. The strengths and weaknesses of each indicator were considered in relation to the above ten criteria. Each indicator was assigned a score out of 10 by JW according to the number of criteria that it met. *Table 6.2* outlines each indicator, a justification for its use, the geographic unit at which it is available, the data source, and the score that each indicator received when assessed against the selection criteria. Although smoking is, strictly speaking, a health-related behavior, rates of smoking are sometimes used as a measure of health status in New Zealand,[18,19] as data at a small area level is freely available through the census, and the poor health outcomes associated with smoking are well known. Furthermore, although ethnic identity is often included as a measure of need in spatial equity analyses, and in New Zealand significant ethnic inequities in health outcomes exist, ethnicity is not a direct indicator of health status or need, as ethnic inequities are produced through material disadvantage.[20] Therefore, ethnicity as a variable was removed from the main analysis, and the distribution of indicators of health need by ethnic identity was examined separately.

Table 6.1 Criteria for selecting health need indicators in a primary care setting

Criteria	**Explanation**
1) Relevant	Indicator should be the most accurate statistic for measuring both the level and extent of health need in a primary care context.
2) Research	There should be sound evidence on key influences and factors affecting outcomes.
3) Disaggregation	Ideally, it should be possible to break the data down by age, sex, socio-economic status, ethnicity, and region, so outcomes can be compared for populations groups.
4) Consistent	Indicator should be defined and measured consistently over time to enable the accurate monitoring of trends.
5) Statistically sound	Indicator uses high quality data and the method used to construct it is statistically robust.
6) Timely	Data should be collected and reported regularly to ensure indicators are providing up to date information.
7) Nationally significant	Indicator reflects progress at a national level and is not confined to particular areas.
8) Internationally comparable	Indicator should be consistent with those used in international research to allow comparisons.
9) Geographical unit	Inidcator data is available at a suitable geographical unit that allows for detailed and meaningful sub-national comparison. The geographical unit should also be consistent with other indicators to allow for comparison or integration.
10) Availability	Indicator data is readily available and accessible to researchers.

Table 6.2 Seven potential health need indicators for spatial equity research on primary care in New Zealand

Indicator	**Components or definition**	**Justification**	**Unit**	**Source**	**Score**
(1) Ambulatory Sensitive Hospitalization (ASH) rate	"Hospitalizations of people less than 75 years old resulting from diseases sensitive to prophylactic or therapeutic interventions that are deliverable in a primary health care setting".[21]	ASH conditions are considered potentially preventable by primary health care interventions. Higher ASH rates suggest unmet need for primary care.[22]	Domicile Code	Ministry of Health	8
(2) Selected cancer rate	Incidence rate of lung, prostate, breast, and colorectal cancer per year, per thousand people.	Primary care plays an important role in the diagnosis and management of cancer.[23]	Domicile Code	Ministry of Health	8
(3) Crude mortality rate	The number of deaths in an area in a year, per thousand people.	Areas with higher levels of mortality are likely to have higher health needs.	Domicile Code	Ministry of Health	8
(4) New Zealand Index of Multiple Deprivation Health domain (IMD-H)	Combination of: Standardized Mortality Ratio, selected infectious disease hospitalizations, selected respiratory disease hospitalizations, Emergency Department (ED) admissions, and selected cancer registrations.	The IMD-H identifies areas with "higher than expected levels of ill health or mortality for the age profile of the population".[24]	Data Zones	University of Auckland[24]	6
(5) Age	Percentage of the population considered 'age dependent' i.e. aged 0-4 or over 65 years old in the 2013 census.	Higher primary care utilization rates for both older and younger age groups.[25,26]	Census Area Unit (AU)	Statistics New Zealand	8

(6) New Zealand Index of Deprivation 2013 (NZDep2013)	Area-level deprivation: 1) Under 65 years old, no internet 2) Receiving a means tested benefit 3) Low income 4) Unemployed 5) No qualifications 6) Does not own home 7) Single parent family 8) Bedroom occupancy threshold 9) No access to a car	Socioeconomic inequities in health outcomes.[27] Includes upstream social determinants of health such as education, housing, and employment.[1]	AU	University of Otago[28]	8
(7) Smoking rate	Percentage of the population aged 15 years or older who are regular cigarette smokers in the 2013 census.	A health-related behavior that is associated with poor health outcomes.	AU	Statistics New Zealand	9

6.2.2 Access to datasets

Data requests were sent to the Ministry of Health for ASH hospitalizations (n = 22,854 hospitalizations compiled for each Area Unit (AU) within the Waikato DHB for the years 2008-2018), total death registrations (n = 10,286 registrations, for the years 2009-2016) and selected cancer registrations (n = 21,496 registrations, for the years 2009-2018). Data on age and rates of smoking (n = 168 AU, for the year 2013) were downloaded from Statistics New Zealand. The IMD-H (n = 511 Data Zones, for the year 2013) and NZDep2013 (n = 168 AU, for the year 2013) were accessed from the University of Auckland and Otago websites respectively.

6.2.3 Unit of analysis

Area Units (AUs, n = 1,911 in New Zealand, n = 168 in Waikato DHB) were selected as the most appropriate geographical unit of analysis. AUs have standard boundaries as defined by Statistics New Zealand and are downloadable from the Statistics New Zealand Geographic Data Service.[29] AUs also allow for a more detailed examination of spatial variation than larger units such as Territorial Authorities, which often include several towns with quite different health and social profiles. While we are aware that with the 2018 census release

Statistics New Zealand has introduced a new small area geography, most health and social data in New Zealand is still only available at the AU level. Although data on rates of cigarette smoking, age, and NZDep2013 are available at a smaller scale (Meshblocks (MB), n= 45,916 in New Zealand, n = 4,532 in Waikato DHB), confidentiality and privacy considerations mean that typically health data is not released at this level. Unfortunately, the IMD-H is only available for 'Data Zones' (DZ, n = 5,958 in New Zealand, n = 511 in Waikato DHB), unique geographical units that were created for the IMD and which do not align to Statistics New Zealand census boundaries. To overcome this issue, DZs were converted to geometric centroids and their associated values were joined to the AU within which the centroid fell. If more than one DZ centroid was contained within an AU, then the AU was assigned the average score of all DZs within it.

6.2.4 Numerators and denominators

For some indicators slightly different numerators and denominators were used as a result of the data provided. For ASH rates the numerator for each AU is the average yearly incidence of all publicly funded hospital discharges with an ICD-10-AM-VI code that is classified as an ASH condition,[30] while the denominator for each AU is the average yearly Estimated Resident Population (ERP) between July 2008 and June 2018. For the selected cancer incidence rate, the numerator is average yearly registrations of lung, prostate, breast, and colorectal cancer, while the denominator is the average yearly ERP between July 2009 and June 2018. The crude mortality rate is based on a numerator of average annual death registrations and denominator of average yearly ERP between July 2009 and June 2016. The smoking rate is based on a numerator of regular cigarette smokers aged 15 years or older in 2013, and a denominator of the population aged 15 years or older in 2013.

6.2.5 Variations in health need by indicator

Differences in the distributions of health need within the Waikato DHB region according to each indicator were examined by creating health need weightings that could be compared and also incorporated into floating-catchment-area (FCA) style accessibility models. Health need weightings were determined using a similar method to McGrail and Humphreys.[31] First, the 'average' level of each indicator was determined for the Waikato DHB region. For instance, the proportion of Waikato DHB residents who are considered likely to have higher age-related health needs (i.e. aged ≤ 4 years or ≥ 65 years old) was 21.7%. A health need weighting, rescaled on a range from 0 to 1, was then applied across the region. AUs with an average or lower level of health need (e.g. 21.7% or fewer residents in high-need age groups) were given a weighting of 0. AUs with a higher than average level of need (e.g. over 21.7% of residents in high-need age groups) were given a weighting that represented the additional health need in the AU, using the following formula:

$$Health\ Need\ Weighting = \frac{\alpha - \beta}{1.0\ - \beta}$$

Where α represents the AU level of health need (e.g. proportion of residents in high-need age groups for a specific AU) and β represents the average level of heath need according to that indicator for the entire Waikato DHB region. This approach to calculating health need weightings was applied to the age indicator as well as rates of ASH, cancer, crude mortality, and smoking. The IMD-H and NZDep2013 already categorize areas into deciles, and therefore a slightly different approach to calculating health need weightings was used. The 10% of AUs with the highest proportion of health outcomes, or socioeconomic deprivation, are assigned to decile 10. Therefore, AUs classified as deciles 6-10 are in the top 50% of places with the highest levels of poor health outcomes and socioeconomic deprivation. Health need weightings can be applied to areas in a similar way to that above. The median decile of IMD-H or NZDep2013 is 5, so any AUs with higher deciles can have health need weightings applied accordingly. An AU with an IMD-H decile of 8 would receive the weighting 0.6, since:

$$Health\ Need\ Weighting = \frac{0.8 - 0.5}{1.0\ - 0.5} = 0.6$$

Weightings were calculated for each health need indicator, for a total of 1,176 values.

6.2.6 Accessibility models

This analysis used an enhanced-2SFCA (E2SFCA) model of spatial accessibility, to examine the spatial equity of GP clinics in the Waikato DHB region. The E2SFCA not only considers supply and demand within a 'catchment area' but also takes distance decay into account.[32]

Data on the location of GP clinics was obtained from the Waikato DHB website,[33] while population data comes from the 2013 census.[34] The health need weightings of each indicator were separately incorporated into the accessibility model by rescaling the scores to a range of (1,2) using:

$$Population\ Weighting\ =\ 1\ +\ [Health\ Need\ Weighting]$$

The population of each AU was then multiplied by the population weighting for that AU to represent that relative health needs in each area. Rescalling the scores in this way follows McGrail and Humphreys' [31] recommendation that the required health needs of a community should *not* be reduced if an indicator score is lower than average. The size of the population in each AU either stays the same, or increases, depending on the relative health need of each AU. This means that in the model of spatial accessibility, communities with lower health needs will have unchanged populations (resulting from a population weighting of 1), while areas with populations that have higher health needs, are recognized as being likely to require greater levels of health resources. The accessibility model was run separately nine times, once for each indicator and once again to calculate an 'unweighted' accessibility score that did not incorporate any health need weighting. The results of the nine different accessibility models were then mapped and analyzed.

6.2.7 Statistical tests

To quantify the degree of similarity between potential indicators, Spearman's correlation coefficients between each of the seven health need indicators were calculated in R,[35] with the Bonferroni adjustment for multiple tests, using the "psych" and "Hmisc" packages.[36,37] Correlations between each indicator and the proportion of Māori and Pacific residents, as well as the proportion of European residents, in each AU were also calculated. Spatial variations in each indicator across the Waikato DHB region were mapped in ArcGIS (ESRI, Redlands, CA, USA). To understand whether high levels of need according to each indicator were clustered in certain areas, Moran's I measure of global spatial autocorrelation and Anselin Local Moran's I, Local Index of Spatial Autocorrelation (LISA) were calculated. To quantify the impact that incorporating health need weightings had on the results of E2SFCA analyses, and establish whether weighted E2SFCA scores were significantly different from unweighted E2SFCA scores, a one-way ANOVA of all accessibility scores was calculated. To establish the degree of similarity between estimates of accessibility under different models, Spearman's correlation coefficients between the results of all weighted and unweighted E2SFCA models were calculated, with the Bonferroni adjustment for multiple tests. Finally, we tested the Inverse Care Law using three common measures of spatial equity[3] including: comparing the Global and local Moran's *I* spatial autocorrelation results for accessibility scores produced by the E2SFCA and levels of population need according to each health need indicator; analyzing the clustering of accessibility scores for populations living in areas of high socioeconomic deprivation, and quantifying the distribution of accessibility scores produced by the E2SFCA with the Gini coefficient, calculated in R using the ACID package.[38] The Gini coefficient is the most common measure of spatial equity, and provides a score between 0 and 1, with 0 representing a perfectly equal distribution of resources and 1 representing a completely unequal distribution.[3]

6.3 Results

6.3.1 Health need indicators

Table 6.3 outlines descriptive statistics for each health need indicator. Several statistically significant Spearman's correlation coefficients between health need indicators were identified (*Table 6.4*). ASH rates and crude mortality rates were found to be significantly and positively correlated with all other indicators, while NZDep2013 was correlated with all indicators except the selected cancer rate. Statistically significant and strong correlations (rs ≥ 0.7) [39] were identified between NZDep2013 and both ASH rates and smoking rates. Age was strongly correlated with both the selected cancer rate and the crude mortality rate.

Table 6.3 Descriptive statistics for health need indicators

Indicator	Mean	SD	Median	Range
ASH rate	.002	.001	.002	.01
Cancer rate	.005	.002	.005	.02
Mortality rate	.007	.005	.005	.02
IMD-H	.52	.31	.52	.90
Age	.22	.08	.20	.67
Area-level deprivation	.62	.28	.70	.90
Smoking rate	.18	.08	.17	.45

Table 6.4 Spearman rank correlations between health need indicators

Indicator	Cancer rate	Mortality rate	IMD-H	Age	Area-level deprivation	Smoking rate
ASH rate	.50**	.63**	.58**	.49**	.74**	.50**
Cancer rate		.67**	.14	.78**	.22	.06
Mortality rate			.34**	.77**	.53**	.31**
IMD-H				.23	.45**	.19*
Age					.33**	.12
Area-level deprivation						.80**

**P*≤0.05 ***P*≤0.01

Statistically significant correlations between area-level proportions of ethnic identity and each indicator except age and selected cancer rate were identified (*Table 6.5*). Indicators were positively correlated with higher proportions of indigenous Māori and Pacific subpopulations at the area-level, and negatively correlated with higher proportions of European residents. A higher proportion of Māori and Pacific residents was strongly correlated with rates of smoking and NZDep2013. With the exception of the crude mortality rate, all indicators in the Waikato DHB region were found to display statistically significant spatial clustering (*Table 6.6*) as were the spatial accessibility scores produced by an unweighted accessibility model (I = .037, P = .011).

Table 6.5 Spearman rank correlations between ethnicity and each health need indicator

Indicator	ASH rate	Cancer rate	Mortality rate	IMD-H	Age	Area-level deprivation	Smoking rate
% Māori or Pacific	.52**	-.01	.27*	.33**	.08	.73**	.72**
% European	-.52**	.14	-.17*	-.43**	.07	-.70**	-.58**

**P*≤0.05 ***P*≤0.01

Table 6.6 Moran's I indicator of spatial clustering for each health need indicator

Indicator	ASH rate	Cancer rate	Mortality rate	IMD-H	Age	Area-level deprivation	Smoking rate
Moran's *I*	.067**	.119**	.012	.193**	.057**	.162**	.254**

**P*≤0.05 ***P*≤0.01

NB: Higher Moran's *I* values indicate greater spatial clustering, suggesting that similar values are located near to each other.

The LISA analysis results are shown in *Figure 6.2.* Dark red represents high-high clusters, which are areas with high need or accessibility surrounded by other high need or access areas. Areas in light red are high-low outliers, which have high needs or high accessibility and are surrounded by areas with low needs or accessibility. Similarly, the dark blue regions represent low-low clusters, while light blue regions are low-high outliers. *Figure 6.2* indicates that health needs vary across the Waikato DHB region, and the clustering of high needs varies depending on the indicator used. However, some areas with clusters of high need across several indicators can be identified. For instance, the Coromandel Peninsular, in the north east of the Waikato DHB region, has clusters of high need across age, cancer, and mortality indicators. Taumarunui, in the southern Waikato region, also has clusters of high need across several indicators, including ASH rates, socioeconomic deprivation, the IMD-H, and smoking. Within Hamilton City, the clustering of high needs varies across neighborhoods, although the western parts of the city do appear to have high levels of ASH rates, smoking, cancer, and the IMD-H. High levels of spatial accessibility are clustered in the Hamilton city and Waipā region. Peripheral areas of the Waikato DHB region, including the Coromandel Peninsular, Taumarunui, and South Waikato have clusters of low spatial accessibility scores.

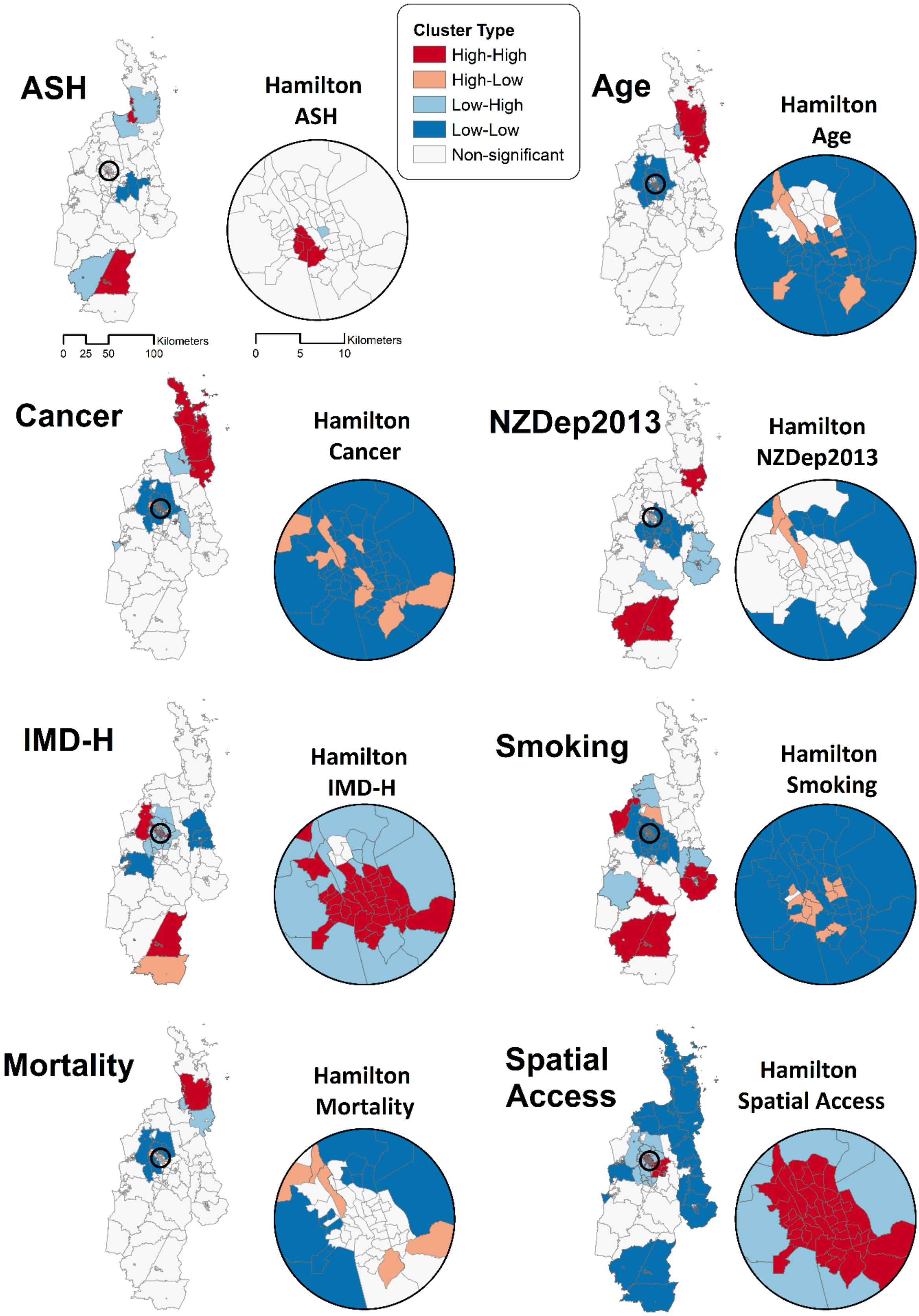

Figure 6.2 Spatial autocorrelation of health need indicators and spatial accessibility in the Waikato DHB region

6.3.2 Accessibility models

The mean accessibility scores produced with 'weighted' E2SFCA analyses were all lower than the 'unweighted' E2SFCA scores, suggesting that the incorporating health need weightings reduces accessibility scores. However, a one-way ANOVA ($F(8, 1485) = 1.57$, $P = .130$) indicated that these were not statistically significant differences. Spearman rank correlations between the accessibility scores produced by incorporating different health need indicator weightings were very strong and significant (all correlations were .98 or above with p-values less than .01) suggesting that no statistically significant difference results are produced by incorporating different health need weightings into spatial equity analyses. *Figure 2* shows the results of the unweighted E2SFCA spatial accessibility index for the Waikato DHB region. Darker areas have low accessibility, while light areas have the best accessibility to GP services.

6.3.3 Spatial equity

Further analysis was carried out to quantify the spatial equity of GP clinics within the Waikato DHB region. A Gini coefficient of .281 suggests that access to GP services is not distributed evenly across the population. Comparing spatial autocorrelation results for accessibility and health need indicators suggests that most areas with high needs do not have correspondingly high access to services. Of the 23 AUs within clusters of high need across three or more indicators, only eight were also in clusters of high accessibility. Within the Waikato DHB region 85 AUs with high levels of socioeconomic deprivation were identified (NZDep2013 decile ≥ 7). Of these, 28 were located in clusters of high access, while a further 37 were located in clusters of low access. These results suggest that access to GP services in the Waikato DHB region is not distributed equally, or according to need, and is therefore inequitable.

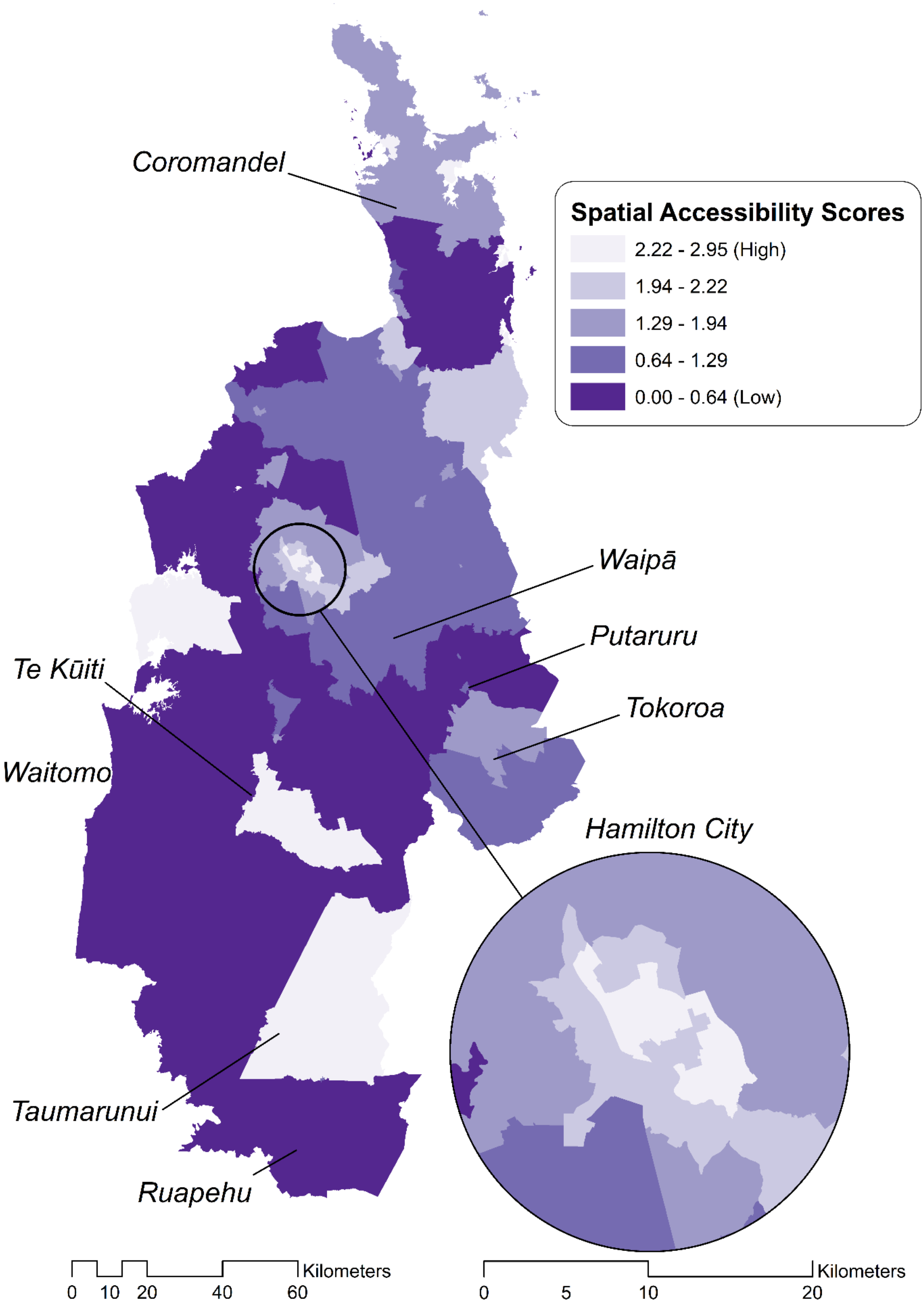

Figure 6.3 Spatial accessibility results of an unweighted E2SFCA model

6.4 Discussion

Our analysis indicates that health needs across the Waikato DHB region vary spatially. Statistically significant clustering was identified for all indicators apart from the crude mortality rate. The pattern of clustering varied for each indicator, supporting evidence that the spatial distribution of health need changes when different indicators are used.[10] However, strong and significant correlations between several indicators suggest that many areas have high or low health need regardless of the specific indicator used. At the neighborhood level, ASH rates and mortality indicators were each significantly correlated with all other indicators of need, and were also correlated with a higher proportion of residents identifying as Māori or Pacific. Neighborhood level socioeconomic deprivation was correlated with all indicators except cancer, and was strongly correlated with ASH rates, smoking and area-level ethnic identity. Previous New Zealand research indicates that increasing levels of socioeconomic deprivation are associated with higher odds ratios of cigarette smoking, avoidable mortality, and mortality from respiratory disease.[40]

Although health needs can be included in FCA accessibility analyses through weightings,[41] our results indicated that this did not significantly impact the final accessibility scores, since weighted E2SFCA results were strongly and significantly correlated with an unweighted E2SFCA. Local demand for services (measured through weighted population size) is only one component of the E2SFCA, which also incorporates the level of service provision and the distance between populations and health care. This supports previous work arguing that catchment size and distance decay function have the greatest impact on spatial accessibility results.[9] Therefore, the spatial equity of GP services was assessed using spatial autocorrelation and the Gini coefficient. Twenty-three AUs were identified as belonging to a cluster of high need across three or more different indicators. Of these, only eight AUs were also located in clusters of high spatial accessibility. *Figure 6.2* indicates that, overall, the pattern of spatial clustering of health need is not matched by appropriately high levels of spatial accessibility, suggesting an inequitable distribution of GP services. A Gini coefficient of .281 suggests that spatial accessibility is uneven and that Hart's Inverse Care Law also applies to GP services in the Waikato DHB region. Previous examples of Hart's Law in New

Zealand include differences in DHB referral expenditure[42] and the distribution of dental services.[43]

None of the seven indicators assessed are 'perfect' for spatial equity research on primary care. Epidemiological indicators (ASH, Cancer, and Mortality rates) each met eight selection criteria, suggesting high potential for their use. However, data access restrictions and potential geocoding and aggregation issues may limit their widespread use. Data extraction costs and delays may present barriers to some researchers. Communication with Ministry of Health Analytical Services revealed a likelihood of geocoding errors in hospitalizations and cancer registration datasets, especially in rural areas where addresses are more difficult to accurately geocode. However, mortality data is considered more accurate as analysists manually geocode addresses that cannot be automatically geocoded. The IMD-H is an alternative source of epidemiological data that is freely available to download without restrictions. However, it is based on the same Ministry of Health datasets (hospitalizations and cancer registrations) that are likely to include some geocoding errors. There has been only one release of the IMD-H so far, meaning that it cannot be used to compare current and past levels of health need, and it is based on older 2013 data that cannot be disaggregated. Furthermore, the geographic unit (DZs) makes incorporating the IMD-H into any analysis or dataset using standard Statistics New Zealand geographical units difficult. Since DZs do not align with AUs, the IMD-H scores could not be calculated for 20 AUs in our analysis, and they had missing values. Conversely, some AUs contained multiple DZs and an average value had to be taken. These issues prevent the IMD-H being used effectively in combination with other datasets and limit its utility. Demographic and social indicators of need based on census data met most of the selection criteria. The main limitations of using age, NZDep2013, and rates of smoking as indicators were the age and relevance of data, as censuses only take place every five years. Furthermore, the age and NZDep2013 indicators cannot be disaggregated. However, the strong correlation between NZDep2013 and ASH rates indicates that socioeconomic deprivation may be an appropriate indicator of health need when epidemiological data is unavailable.

Conceptually, ASH rates are an appropriate need indicator for a primary care context, as they reflect the effectiveness of, and access to, primary care.[22] However, when examining the equity of primary care services, we must consider what a 'pro-equity' distribution of care would look like. Health care services aligned to downstream outcomes such as rates of hospitalization, are responses to individual manifestations of health need. However, they would not address the fundamental drivers of health inequities at a population level – that is, underlying differences in the upstream social determinants of health.[1] While we recognize that health equity can be improved outside of medical intervention by addressing these root causes and the fundamental structure of social hierarchies,[44] distributing health services according to social need may also be an important step towards achieving health equity. In New Zealand, significant socioeconomic and ethnic health inequities in health outcomes have been documented.[4,27] The significant correlation between NZDep2013 and all indicators of health need, except selected cancer rates, indicates that significant socioeconomic health inequities persist in the Waikato DHB region. Furthermore, starkly contrasting associations were identified between health outcomes and the proportion of Māori and Pacific, or European residents in a neighborhood. This highlights the persistence of ethnic health inequities in the Waikato DHB region.

One key pathway through which ethnic health inequities are produced is through differential access to the determinants of health.[4] In New Zealand, Māori are disproportionately affected by and exposed to housing deprivation, a lack of transportation, socioeconomic deprivation, and racism, all of which are associated with poorer health outcomes.[45] Our results indicate that, in the Waikato DHB region, higher levels of neighborhood socioeconomic deprivation were strongly and significantly associated with a higher proportion of Māori or Pacific residents, but negatively associated with the proportion of European residents. Differential access and exposure to the social determinants of health such as education, employment, income, and home ownership (as measured by NZDep2013) is a key driver of inequitable health outcomes in the Waikato DHB region. Furthermore, these factors are more likely to affect Māori and Pacific people, producing ethnic inequities in health. Therefore, action is needed to address the underlying causes of poor health. Ensuring that primary care is distributed more fairly, according to upstream determinants of health, is potentially one way to address persistent health inequities.

The future utility of some indicators may be limited by issues surrounding the 2018 census in New Zealand – which had a much higher than usual non-response rate, especially for particular ethnicities and geographic regions.[46] Statistics New Zealand has attempted to address this undercount by incorporating data on individuals from other sources,[47] however some variables are only collected through the census. For instance, cigarette smoking data cannot be sourced elsewhere. The 2018 Index of Deprivation may also be affected by these issues as components such as ‘home ownership’, ‘bedroom occupancy’, ‘car ownership’, ‘family composition’, and ‘internet connection’ could be impacted as they are based on census data and their quality could also be impacted by low response rates. Another issue with estimating health need in the future relates to the geographical units at which both population and health data is available. Statistics New Zealand have developed a new geographical hierarchy with updated geographic units.[48] From the 2018 census, data will no longer be released at MB or AU level, as these units are being replaced by Statistical area 1 (SA1) with 100-200 residents, and Statistical area 2 (SA2) which contain between 1,000 and 4,000 residents and do not completely align with previous MB or AU boundaries. This may make longitudinal comparison of demographic and social indicators difficult. Furthermore, Ministry of Health data is currently released at the ‘Domicile code’ (AU) level. If this is not updated, the incidence or prevalence rates of health outcomes cannot be calculated accurately at SA1, SA2, or even AU level, as the geographic boundaries for numerator and denominator populations do not align. At the time of writing, population-denominator data published by Statistics New Zealand is no longer available for free download at MB or AU level. These issues highlight the importance of researchers critically appraising the data sources that they intend to use and whether their selected indicators are the most appropriate and reliable for their particular study context.

6.5 Conclusion

This paper outlines a framework for selecting and assessing potential indicators of health need. While rates of smoking scored highest on the selection criteria, epidemiological indicators such as ASH rates are more appropriate measures of direct health need. However, issues of data access, significant correlations between NZDep2013 and other indicators, and consideration towards the role that the social determinants of health have on health outcomes, means that area-level measures of socioeconomic deprivation have the potential for wider use in spatial equity research. We have also shown that health need varies across the Waikato DHB region. While different indicators did produce different weightings and spatial clustering results, strong and significant correlations suggest that many indicators estimate need similarly. This is particularly true for ASH rates and mortality which were correlated with all other potential indicators of need. Our findings indicate that the spatial accessibility results of a E2SFCA analysis were not significantly impacted by incorporating health need weightings. However, a further examination of accessibility scores suggests that services are inequitably distributed and suggests that the Inverse Care Law applies to primary care services in the Waikato DHB region.

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Chapter 7: Article 6 – “We’re trying to heal, you know?” A mixed methods analysis of the spatial equity of general practitioner services in the Waikato DHB region[12]

[12] This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is under review with *New Zealand Population Review*.

Abstract

Inequitable access to health services can cause and exacerbate inequities in health outcomes and should therefore be monitored regularly to ensure that service distributions match population needs. Health service accessibility includes several factors and can be monitored using both quantitative and qualitative methods. We present an exploratory analysis of the spatial equity of general practice services in the Waikato District Health Board region using a mixed methods approach. Geographic Information Systems are used to assess the spatial accessibility of GP services, and in-depth qualitative interviews provide a better understanding of not only *where* inequities exist, but *why* they occur.

7.1 Introduction

Population health inequities are systematic, avoidable, and unfair disparities, caused by different levels of access and exposure to the social determinants of health such as poverty and education (World Health Organization, 2008). To achieve population health equity, disadvantage that is beyond the control of individuals must be eliminated (Marmot, 2005; Woodward & Kawachi, 1998). Health systems, which are known to cause and perpetuate inequities (Marmot & Commission on Social Determinants of Health, 2007), are one social determinant that individuals have little direct control over. Therefore, a critical step towards achieving health equity involves ensuring that health care services are equitable (Dalton et al., 2013). Spatial equity, often thought of as the fair distribution of resources and examined through measures of access, is in turn a key component of equitable health care (Markham & Doran, 2015; Neutens, Schwanen, Witlox, & De Maeyer, 2010; Talen & Anselin, 1998). Since effective primary health care is associated with more equitable population health (Starfield, Shi, & Macinko, 2005), the improved spatial equity of primary health care may advance health equity.

The New Zealand Primary Health Care Strategy (PHCS) (Ministry of Health, 2001) takes a population health perspective towards primary care services, while the refreshed New Zealand Health Strategy includes a shift from treatment to prevention, and a focus on overcoming the inequities in the health system (Ministry of Health, 2016). District Health Boards (DHBs) receive government funding according to the age, sex, ethnicity, and socioeconomic deprivation of each DHB region’s population, to give areas with higher health needs appropriately higher funding (Ministry of Health, 2004). Primary Health Organisations (PHO) are then funded by DHBs to deliver primary care to communities, usually through general practitioner (GP) services. However, New Zealand still has significant and persistent socioeconomic and ethnic health inequities, especially between Māori and non-Māori (Health Quality and Safety Commission, 2019).

The spatial equity of health services is dynamic and should be monitored regularly to ensure that current and future service distributions match population needs. Whitehead, Pearson, Lawrenson, and Atatoa Carr (2018) have outlined a framework for examining the spatial equity and sustainability of GP services. However, health service access and equity is not limited to geography. Penchansky and Thomas (1981) outlined five domains of accessibility, which include non-spatial factors such as ‘accommodation’, ‘affordability’, and ‘acceptability’. Levesque, Harris, and Russell (2013) have more recently expanded upon this and proposed a framework of access that includes five elements (approachability, acceptability, availability and accommodation, affordability, and appropriateness) and also considers the ability of populations to achieve access. Furthermore, it is essential to incorporate qualitative methods into spatial equity analysis in order to better understand not only *where* inequities exist, but to gain insight into *why* they occur. Wakerman and Humphreys (2011) have argued that health services research should be multidisciplinary, and this exploratory paper combines spatial analysis with qualitative in-depth interviews to improve our understanding of GP service equity in the Waikato region.

7.1.1 Setting

The Waikato DHB region is home to around 405,000 people, with approximately 160,000 residing in Hamilton City and the remainder in small towns or rural areas (Statistics New Zealand, 2019a). A greater proportion of the Waikato DHB population identify as Māori (23.9%) compared to the national average (16.2%), and nearly half of children aged under 15 in the Waikato DHB Region identify as Māori (36.9%) or Pacific (8.3%) (Statistics New Zealand, 2019a). The New Zealand Health Survey has found that adults living in the Waikato region have higher levels of obesity, ischaemic heart disease, diabetes, high cholesterol and blood pressure, as well as higher levels of unmet need for primary care (Ministry of Health, 2018). Inequities in these indicators of poor health outcomes are experienced in the Waikato DHB region, particularly for Māori. For instance, half of Māori women in the Waikato DHB region experienced an unmet need for primary care – an odds ratio of 1.3 compared to non-Māori women (Ministry of Health, 2018). GP services in the Waikato DHB region are delivered through three PHOS – Hauraki Primary Health Organisation, the National Hauora Coalition, and the Pinnacle Midlands Health Network. Hauraki PHO and the National Hauora Coalition are kaupapa Māori PHOs that aim to empower wellness and mana in whānau through “mana whānau, whānau ora” (Hauraki Primary Health Organisation, n.d; National Hauora Coalition, n.d). Pinnacle is a network of 85 practices across the Waikato, Taranaki, Lakes, Bay of Plenty, and Tairawhiti DHB regions (Pinnacle Incorporated, n.d). Pinnacle led the development of the Health Care Home – a new model of general practice care adopted by some practices (Pinnacle Incorporated, n.d). Common elements of the Health Care Home model include: capacity for same day appointments; care planning for patients with high needs; the use of technology for phone or email consultations, and web or smartphone-based patient portals; and the more effective use of physical space (Amey, 2018; Cumming, Dunn, Middleton, & O'Loughlin, 2018; Hefford, 2017)

7.2 Methods

7.2.1 Quantitative approach

Geographic Information Systems (GIS) were used to quantitatively assess the spatial equity of GP services. The three steps to spatial equity analysis outlined by Whitehead et al. (2018) involve: (1) defining; (2) estimating; and (3) quantifying spatial equity. Although spatial equity has a range of definitions that vary with context (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019a), it has been referred to as a fair distribution of resources relative to need (Zenk, Tarlov, & Sun, 2006). This recognises that in order to achieve equitable health outcomes, some populations with higher needs may require appropriately higher levels of services (Reid & Robson, 2007). Similarly, there are a range of measures and techniques used to estimate the spatial accessibility of health services (Guagliardo, 2004). The 'Floating Catchment Area' (FCA) group of techniques estimate accessibility by considering service availability relative to population size and the distance between populations and services. FCAs calculate the ratio between the number of services and the size of populations within a defined 'catchment' area and produce an 'accessibility score' for each small area unit within a study area (McGrail & Humphreys, 2009). The main advancement of the Enhanced-2-step-floating-catchment-area method (E2SFCA) is that it incorporates a 'distance decay' function, which recognises that spatial access to services decreases for populations living further from the centre of a GP catchment. The E2SFCA is now considered the default spatial accessibility measure (McGrail, 2012). This paper applied a modified version of the E2SFCA method in ArcGIS (ESRI, Redlands, CA, USA) to estimate accessibility within the Waikato DHB region. Once accessibility has been estimated, the Gini coefficient can be used to quantify equity. The Gini coefficient assesses the distribution of resources (such as income, or in this case 'accessibility') across a population, and provides an equity score between 0 and 1, with 0 representing a perfectly equal distribution and 1 indicating a completely unequal distribution (Jang, An, Yi, & Lee, 2017).

7.2.2 Data

All GP clinics were geocoded based on the physical addresses provided by the Waikato DHB website (Waikato District Health Board, 2019). Area Unit (AU) boundaries were downloaded from Statistics New Zealand (2019b) and linked to 2013 census data, including usually resident population, age group, and ethnicity, in order to represent the distribution of the Waikato DHB region's population. The NZDep2013 index of socioeconomic deprivation (Atkinson, Salmond, & Crampton, 2014) was also linked to AUs. The New Zealand road network was downloaded from Land Information New Zealand (2019) to assist spatial analysis. When analysis was carried out, 2018 census data was unavailable. Although at the time of writing, Statistical Area 2 (SA2) level population data for the 2018 census is available, the 2018 Census External Data Quality Panel (2019, p. 5) has highlighted "operational failures" that resulted in a high level of non-response for the 2018 census. As a result, the External Data Quality Panel has rated the quality of ethnicity data in the 2018 census as 'moderate' and emphasised that at lower levels of geographic scale there is greater uncertainty around both population count and ethnicity data. Furthermore, delays to the release of 2018 census data have meant that a 2018 version of the New Zealand Deprivation Index had not been developed by the time data analysis was performed. Due to these issues of data quality and availability, it was decided that 2013 census data would be used for the purposes of this analysis.

7.2.3 Analytical methods

When estimating the spatial accessibility of GP services we used a recently developed modification of the E2SFCA, which incorporates dynamic catchment sizes which have been defined by patient enrolment data, the VGP-E2SFCA (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2020). Dynamic catchment sizes were used to reflect the distance that patients in urban and rural areas were assumed to be willing to travel to access GP services. Researchers have argued for the incorporation of dynamic catchments to better model accessibility in mixed-urban-rural environments (Luo & Whippo, 2012; McGrail &

Humphreys, 2014). Our decision to use 10km, 20km and 30km catchments for clinics in major urban, small and medium urban, and rural areas respectively, is based on a detailed analysis of patient enrolment records for the Waikato region which is published elsewhere (Whitehead et al., 2020). The Butterworth distance decay function, as used by Langford, Fry, and Higgs (2012) was applied to take into account the reduced spatial accessibility of people living at the outer edge of a catchment compared to those living much closer. We accounted for differences in the level of services available at each clinic by weighting clinics in our model according to the number of GPs working there. While, the Full Time Equivalent hours of each GP and nurse would give a more accurate measure of the availability of appointments for patients, this information was not available for all clinics. The distribution of accessibility scores across the Waikato DHB region was mapped, and differences in accessibility for age, ethnic, and socioeconomic groups was examined. To quantify the overall spatial equity of GP services, the Gini coefficient was calculated in R (R Core Team, 2017) using the ACID package (Sohn, 2016).

7.2.4 Qualitative approach

The qualitative component of this research was based on in-depth interviews. Key stakeholders were initially identified through purposive sampling and contact with appropriate organisations. A snowball method was then used to contact further participants. This method ensured representation of key groups. Potential participants were contacted via email with an interview request, and informed written consent was obtained before the interview. This study received ethical approval from the Human Research Ethics Committee, Faculty of Arts and Social Sciences, University of Waikato – granted 18th May, 2017. Reference: Whitehead FS2017-18. Participants included patient representatives (n=7), general practitioners (n=5), and representatives from Primary Health Organisations (PHO) (n=4) and the Waikato District Health Board (DHB) (n=1). Face-to-face semi-structured interviews lasting approximately 60 minutes were conducted with 17 participants between August and December 2018. Participants were asked a range of questions within the broad theme of GP service equity, including questions around barriers to equity, causes and effects of inequity and potential solutions. The semi-structured nature of interviews gave space for participants to raise their own areas of concern that were not directly addressed by the interview guide (displayed in *Table 7.1* below). These interviews were carried out as part of a larger project that also examined the equity of GP services in the Waikato region, and therefore questions relating to the sustainability of services are also included in the interview schedule. The responses to these questions have been analysed and will be published separately. Audio from all interviews was digitally recorded, transcribed verbatim, de-identified, and imported into NVivo qualitative analysis software (QRS International, 2018). After conducting 17 interviews, saturation was reached with participants repeating common themes, and therefore no further participants were recruited. Interviews and the analysis of qualitative data was carried out by JW, with planning assistance and guidance provided by other contributing authors.

Table 7.1: Interview guide

Key topics relating to equity covered by the interview guide
- How would you define equity? - Are services in the Waikato DHB region equitable? - What factors affect the equity of GP services? - Who is affected by inequitable services? - How could the equity of services be improved? - Which areas have the most or least accessible services?

7.2.5 Analysis and interpretation of data

Through this process of conducting and transcribing interviews JW became familiar with the data corpus, which is phase one of a thematic analysis (Braun & Clarke, 2006). Then, in phase two, an inductive approach was used to generate initial codes from the recurring ideas in the interview transcripts. As suggested by Guest, MacQueen, and Namey (2012), a single codebook with thematic definitions was created iteratively. Codebooks include a list of codes, definitions and examples for each code, and details of when to use it (Guest et al., 2012). In phase three, potential themes were discerned by sorting and grouping codes. These initial themes were reviewed in phase four to ensure that the codes within them were coherent, and that there were clear distinctions between themes. Through this process, higher order themes were discerned, which led to phase five – the definition and naming of themes and an examination of links and connections between concepts. Finally, a more deductive approach has been used in phase six – the development of a narrative and the preparation of this paper – through alignment with key concepts and frameworks in the research literature. An exploratory approach to mapping participants' perceptions of equity and access across the Waikato DHB region was adopted. Participants were asked to highlight, on a map of the region, places that they believed had good or poor access to GP services. The information provided by all 17 participants was amalgamated and has been displayed visually.

7.3 Results

7.3.1 Spatial accessibility

The results of the VGP-E2SFCA analysis indicate that spatial accessibility to GP services varies within the Waikato DHB region. *Figure 7.1* displays the accessibility scores of each AU. Scores were grouped into quintiles from quintile 5 (Q5 - representing AUs with the lowest access scores) to quintile 1 (Q1 - AUs with the highest access scores). *Figure 7.1* indicates that Hamilton City tends to have better spatial accessibility to GP clinics than most rural areas. Sixty-five percent of all AUs with Q1 or Q2 accessibility scores were in Hamilton, while no AUs in Hamilton had low accessibility scores (Q4 or Q5). Hamilton not only has the highest concentration of GP clinics in the region, but also many clinics that have several registered GPs. On the other hand, *Figure 7.1* also reveals that the areas with the lowest spatial accessibility scores tend to be located around the periphery of the Waikato DHB region. For instance, most of the coromandel region, the west coast, and the area surrounding Taumarunui in the southern part of the Waikato DHB region have spatial accessibility scores in Q5.

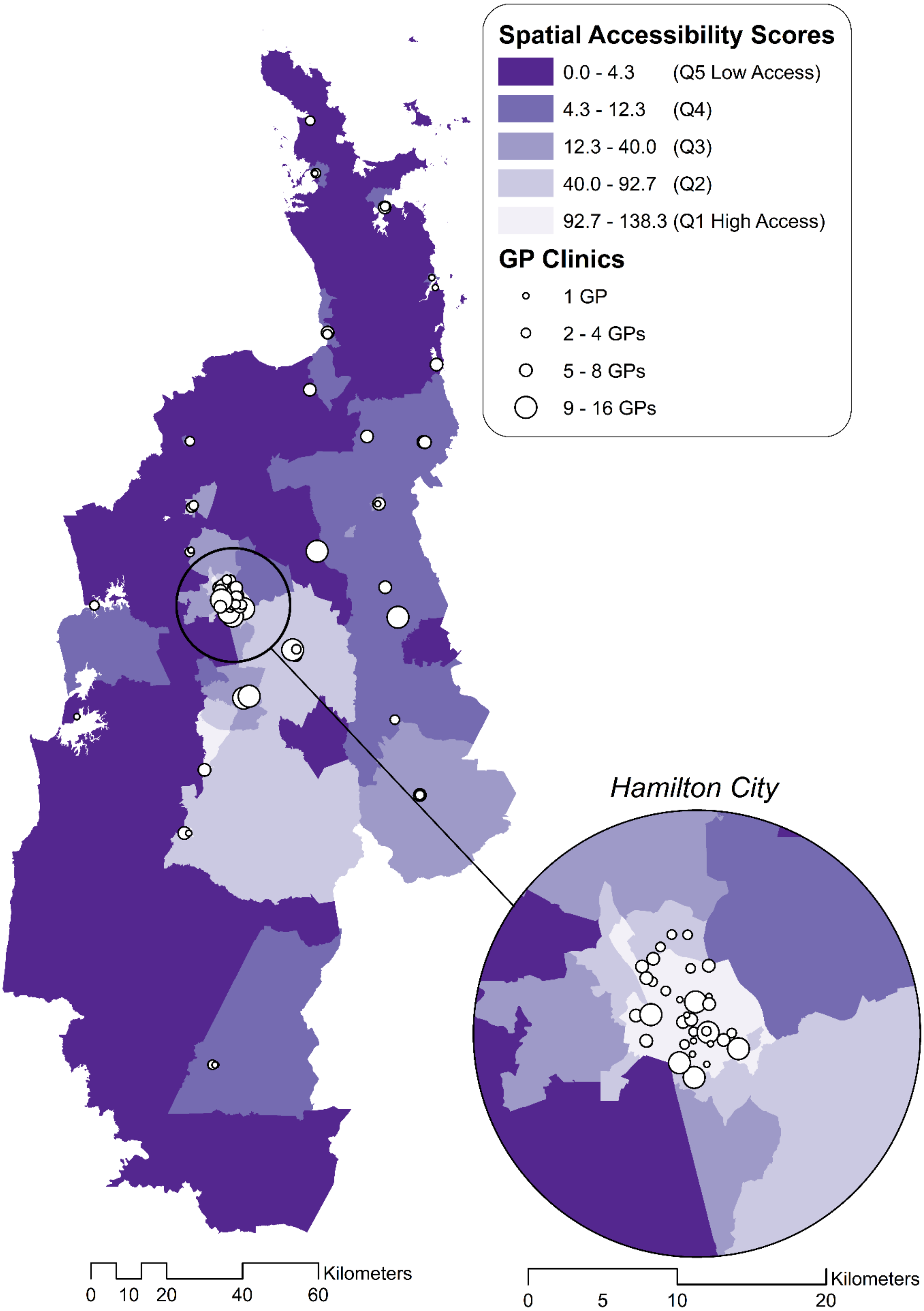

Figure 7.1 Distribution of spatial accessibility scores across the Waikato DHB region

7.3.2 Spatial equity

The Gini coefficient for the distribution of spatial accessibility scores across the Waikato DHB total population was 0.477, suggesting an unequal distribution of GP services. However, it also appears that this distribution is slightly 'positive', with a higher than expected proportion of the population (30.7%) living in areas with high accessibility scores. *Figure 7.2* shows that more than half of the Waikato DHB population reside in areas of high access (Q1 or Q2), while only 14% live in areas of very low accessibility (Q5).

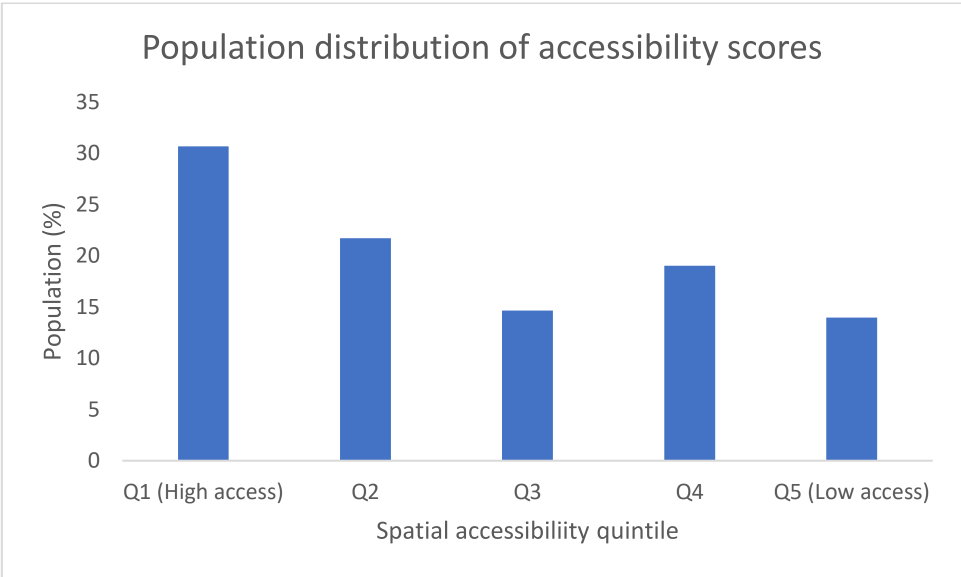

Figure 7.2 Distribution of accessibility scores across the population

Figure 7.3 shows a similar pattern and indicates that all age groups are overrepresented in areas of high accessibility, while only the 'over 65 years' group has a higher than expected population living in areas of lower accessibility (Q4). *Figure 7.4* shows the distribution of accessibility scores by ethnicity. There are high proportions of all ethnic groups living in areas of high accessibility (Q1 and Q2). A particularly high proportion (80%) of Asian residents live in areas of high access, with 52% living in Q1 and 28% living in Q2. While many Europeans live in high access areas, there is also a relatively high proportion living in areas of lower accessibility (Q4). More than half of Māori and Pacific in the Waikato DHB region live in areas of high accessibility (Q1 or Q2), while a low proportion (11% and 7% respectively) live in areas of very low accessibility (Q5). A high proportion of residents of other ethnicities also lived in areas with high spatial accessibility. These results suggest that the ethnic distribution of accessibility scores in the Waikato DHB region follows the same overall trend as the overall Waikato DHB population (as outlined in Figure 7.1), and most residents live in areas of high spatial accessibility.

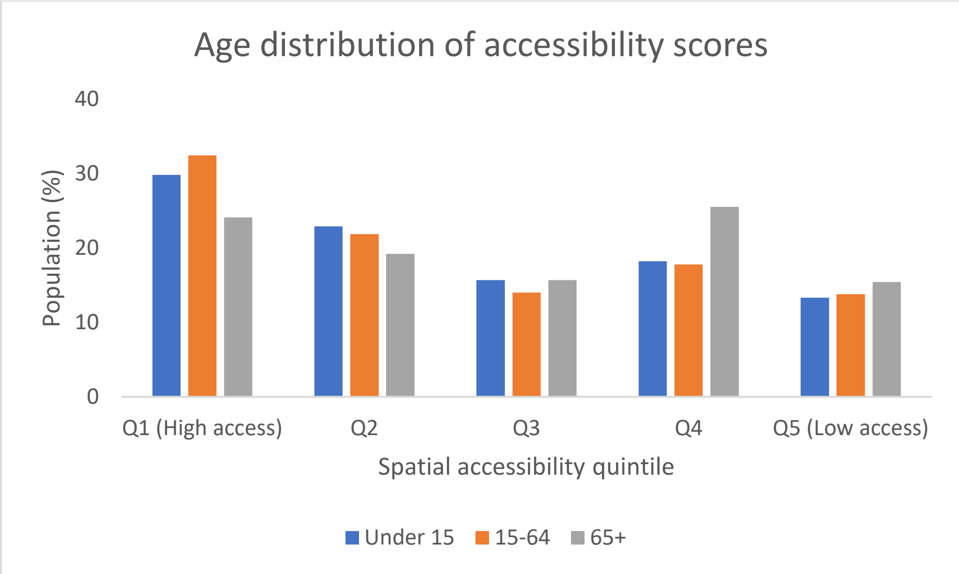

Figure 7.3 Distribution of accessibility scores by age

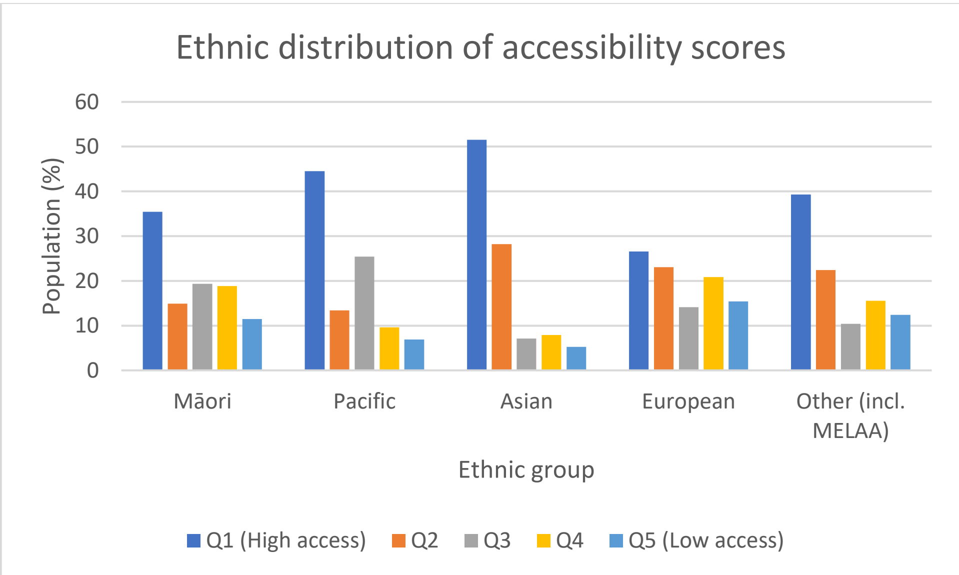

Figure 7.4 Distribution of accessibility scores by ethnicity

Table 7.2 indicates the distribution of accessibility scores for the Waikato DHB population living in areas of high deprivation (NZDep2013 deciles 7-10). *Figure 7.5* indicates that a high proportion of the Waikato DHB population live in areas of high socio-economic deprivation, and that Māori and Pacific populations in particular are over-represented in these areas. *Table 7.2* shows that only a very small proportion (0.26%) of the population face the double-burden of living in areas that are both very highly deprived (NZDep 10) and have very low accessibility (Q5). Furthermore, almost half (49%) of people living in areas of high socioeconomic deprivation (NZDep 7-10) also live in areas of high spatial accessibility (Q1 and Q2). While this may suggest that spatial accessibility is distributed equitably, almost one-third (31.9%) of people living in areas of high socioeconomic deprivation have poor spatial access (Q4 and Q5) to GP services. Furthermore, a large proportion of the total DHB population (17.9%) are affected by both high deprivation and low spatial access to GP services. This is higher than would be expected in an equal distribution and represents over 64,000 residents.

Table 7.2 Area-level deprivation by accessibility

Deprivation	Accessibility	DHB Population (%)	Expected Population (%)
NZDep2013 Decile 7	Q1	4.96%	2.00%
	Q2	0.58%	2.00%
	Q3	0.04%	2.00%
	Q4	2.43%	2.00%
	Q5	1.98%	2.00%
	Total	*10.00%*	*10.00%*
NZDep2013 Decile 8	Q1	7.43%	2.00%
	Q2	0.72%	2.00%
	Q3	4.99%	2.00%
	Q4	4.84%	2.00%
	Q5	1.64%	2.00%
	Total	*19.62%*	*10.00%*
NZDep2013 Decile 9	Q1	7.23%	2.00%
	Q2	0.00%	2.00%
	Q3	2.36%	2.00%
	Q4	2.41%	2.00%
	Q5	0.73%	2.00%
	Total	*12.73%*	*10.00%*
NZDep2013 Decile 10	Q1	5.56%	2.00%
	Q2	0.79%	2.00%
	Q3	3.42%	2.00%
	Q4	3.58%	2.00%
	Q5	0.26%	2.00%
	Total	*13.60%*	*10.00%*

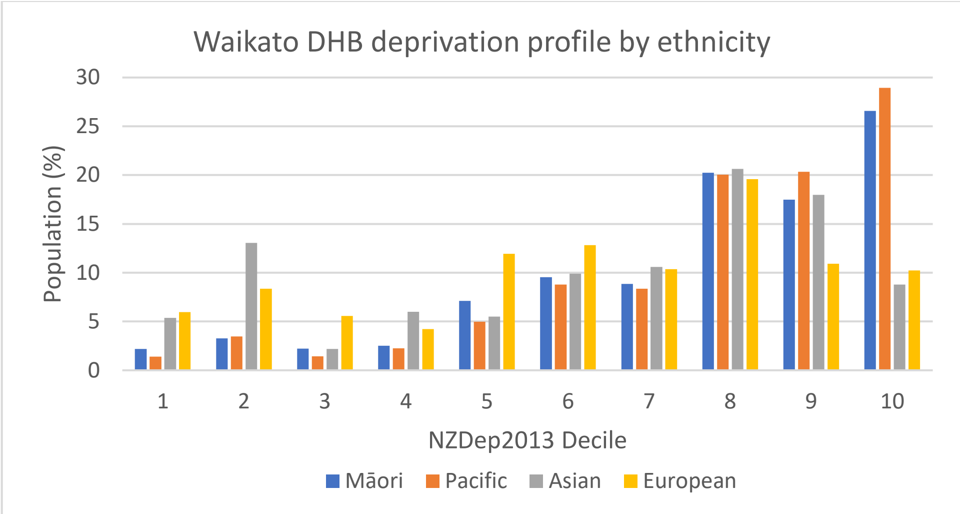

Figure 7.5 Waikato DHB deprivation profile

7.3.3 Qualitative results

Most participants defined equity in terms of a ‘vertical’ needs-based distribution of resources where individuals or populations with higher levels of need received higher levels of resources. This is closely related to a definition of equity that focusses on outcomes. Several participants took an outcome-focused definition of equity, arguing that a social justice approach should be used to ensure that people can achieve the same outcomes of good health and wellbeing regardless of their background. Specifically, participants referred to equity of access and outcomes irrespective of the social position, ethnicity, location, or physical impairment of individuals. These needs-based and outcomes-focussed definitions of equity align with spatial equity definitions outlined in the research literature (Whitehead et al., 2019a). Some participants expanded upon the outcomes-focussed definition to consider equity in terms of the ability for individuals and populations to achieve their full potential in a wider sense, such as the potential for “…good health, good career, good family life, good housing.”. Finally, interviewees also recognised that equity was intertwined with the rights of individuals and populations, and the importance of service quality in achieving equity. All participants viewed GP services in the Waikato region as inequitable. The reasons participants gave were organised into two broad groups: barriers to equitable access, and their structural or systemic causes.

7.3.4 Equity of access

Responses that were coded as access-related were grouped into key themes that aligned with the Levesque et al. (2013) model of access. Levesque et al. (2013) incorporate five dimensions of service accessibility; *approachability*, *acceptability*, *availability and accommodation*, *affordability*, and *appropriateness*. The model includes five corresponding abilities of people to interact with services in order to achieve access. These are the ability to: *perceive the need for care, seek care, reach care, pay for care,* and *engage with health care*. Participant discussions of these interrelated domains, and their relationship to the equity of GP services, are outlined below.

(1) Participants reported that GP services are often not *approachable* as the health system is difficult to navigate and understand, particularly for patients with complex health needs or multi-morbidities. This is then exacerbated by difficulties around the *ability to perceive* the need for health care among some individuals and groups. Different levels of health literacy among some patients meant that they often did not perceive the need for care until conditions had progressed and become serious. On the other hand, participants also discussed a group which they called 'the worried well', who over-utilised health services, often for relatively trivial matters, adding to clinic workloads and taking up appointments that could have been used by those with more serious health issues.

(2) The *acceptability* of services was a key issue. Participants highlighted that mainstream services are aligned with a European view of health, rather than a more holistic Māori approach. Most services lack cultural safety, which presents a significant barrier to access.

> *"We've built [the health service] on the needs of the provider, it's a European model and it isn't responsive to the needs of the population"* – D, Waikato DHB.
>
> "*We have tried, or been made to conform to a mainstream model, and our people continue to be unwell and our people to continue to not thrive as they should"* – A, Patient.

Participants talked about how discrimination results in patients avoiding health services at all costs.

> "*The only time that our people will engage is in ED, when it's literally life or death, and then they get discriminated there...the only way our people will engage is if we make it safe"* – P, Patient.

Participants also expressed a sense frustration with the limitations of 'traditional' GP models of care, and talked about wanting more holistic health care that integrates a wider range of health and social services in order to address the root causes of poor wellbeing, rather than just treating the symptoms. These discussions also included a patient's *ability to seek* care, which was highlighted as another point where inequities in access develop. A lack of services which are seen as culturally safe, exacerbated by a lack of trust in the health system in general mean that many patients delay seeking care. Participants explained that many patients have complex or chaotic lives which often means that accessing health care is not their most immediate priority. Furthermore, the view that the most marginalised members of society are excluded from mainstream services was expressed by several participants.

(3) The *availability and accommodation* of services was also emphasised as a key issue affecting equitable access. Participants highlighted the impacts of workforce shortages (among both GPs and other health professionals) which result in difficulty getting timely appointments. Patients talked about having to wait weeks for an appointment at understaffed practices and highlighted that inflexible opening hours and a lack of afterhours care exacerbates these issues, particularly in isolated areas and with clinics without 'drop-in' or urgent care services. This is also related to a patient's *ability to reach* care. Participants highlighted a lack of available transportation, or high costs associated with transport, as a key barrier to equitable access, particularly in rural areas with very limited public transport. This particularly affects patients with low incomes, as well as the young and elderly who are often reliant on others for transportation. Furthermore, participants emphasised a lack of services designed for people living with disabilities. This lack of accommodation means that some basic aspects of facilities – such as outward opening doors – can act as a fundamental barrier to physically entering a health service.

(4) The *affordability* of GP services was highlighted as a fundamental barrier to equitable access. Participants argued that the cost of appointments was far too high, and that this was

often exacerbated when the cost of prescriptions and accessing afterhours care was considered.

> "*[People] don't want to spend the money. When [my partner] is in the height of his pain and I say go to the doctors he says 'no I don't have enough money to go to the doctors'"* – H, Patient.

This is directly related to a patient's *ability to pay.* Participants highlighted how the lack of affordable GP services, in a context of widespread poverty in many communities means that many patients are unable to pay for health care.

(5) According to Levesque et al. (2013) the *appropriateness* of services concerns their quality in terms of timeliness, the care put into diagnosis and treatment, and fit between services and patient need. Participants discussed how services could be *inappropriate* if they were unable to address patients' wider social, spiritual, environmental, or cultural needs, which are all important components of wellbeing. Patients also highlighted that the quality of care they received from different clinics or different GPs varied greatly. Some patients were willing to travel significant distances to a preferred GP that they knew would be able to meet their particular needs and support access to additional equipment or services that would help them to achieve equitable outcomes. Other patients expressed distress at losing the relationship, continuity, and trust that they had developed with a particular doctor, sometimes over generations.

> *"I struggled when my doctor left. He was my doctor from birth. My Mum's doctor, my Nan's doctor. He just knew me. I didn't even have to say it, I'd just walk in and he'll know. So when he retired I cried because I had a hard time picking a doctor for [my daughter]. A really hard time."* – S, Patient

The *appropriateness* of services aligns with a patient's *ability to engage*. Participants highlighted that this is dependent on patients having a level of empowerment, support, and health literacy, and that this should be developed at the whānau level.

> "*...the first point of contact for people to be well and maintain their wellbeing is whānau, and so whānau capability is a huge thing for me...if I hadn't become savvy about systems, the outcomes for my daughter would be different...so that whole kind*

of literacy space is really important but also building whānau leadership..." – L, Patient

7.3.5 Qualitative mapping

Participants had different views on sub-regional equity, and at times there were contrasting opinions about which places had good or poor access to services. This is likely to reflect the in-depth knowledge and insight that each individual participant has about their local area. However, in general there was agreement that accessibility was much better in Hamilton and the immediately surrounding area, while peripheral rural areas of the region such as Taumarunui, Putaruru and Tokoroa had poor access to GP services. Participants recognised that access to GP services varies across the Waikato DHB region, and that 'place' shapes the opportunities that individuals and communities have to use health services. The number of participants who commented that a place had good or poor access to GP services was counted for each town in the region and has been represented below in *Figure 7.6*. This gives a visual depiction of where interview participants perceived spatial inequities in access to GP services to be located. *Figure 7.6 h*ighlights an understanding among participants that equitable access is variable and dependent on place, as some places have much better access than others. There appears to be significant overlap between the qualitative depiction of accessibility in *Figure 7.6* and the results of the quantitative spatial accessibility model in *Figure 7.1.* Of the AUs that interviewees rated as having 'good' access, 70% were also considered to have high spatial accessibility (Q1 and Q2) according to the VGP-E2SFCA results. The same was true for 68% of AUs that were rated as having 'poor' access by interviewees.

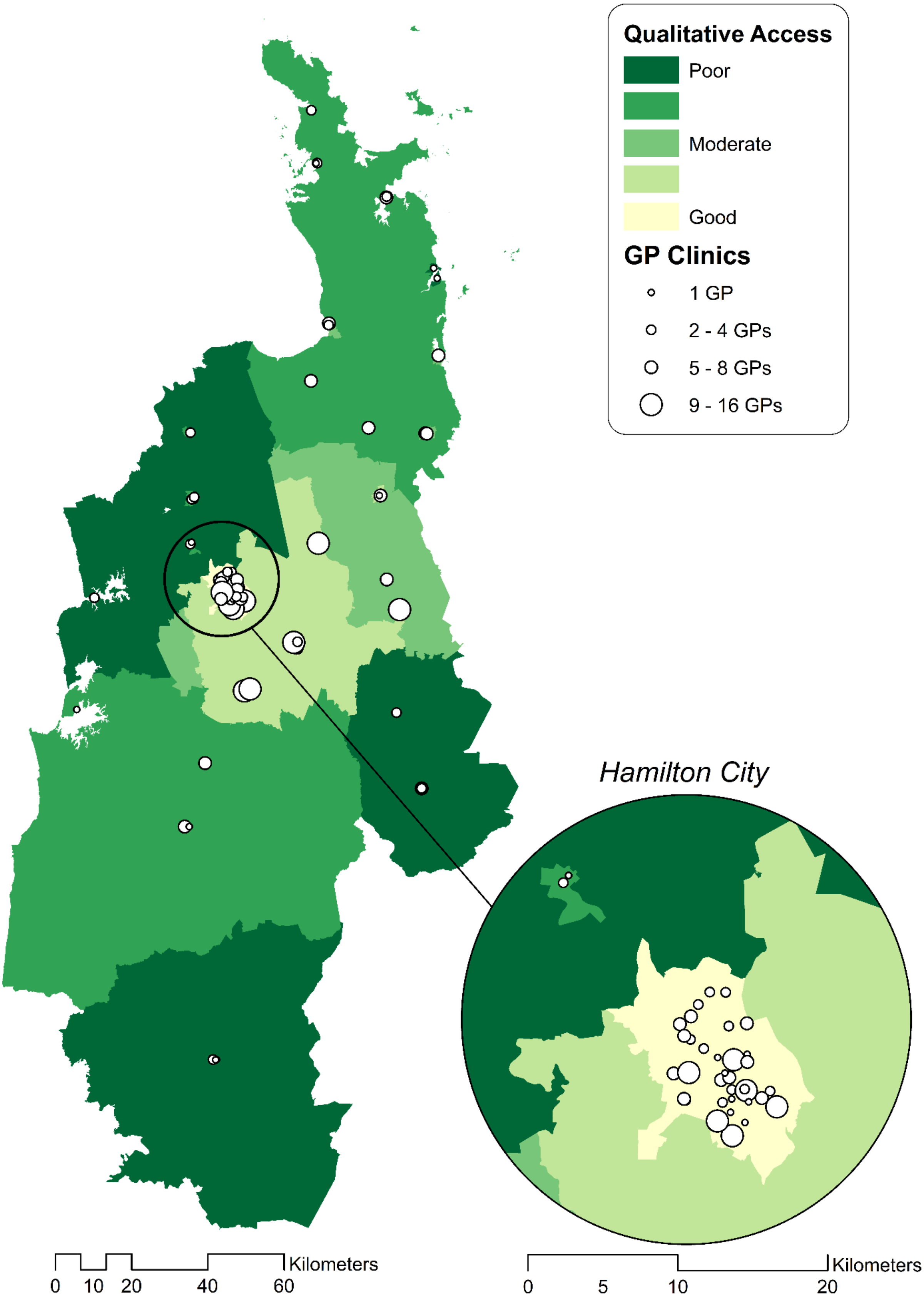

Figure 7.6 Participants perceptions of areas of 'good' and 'poor' access to GP services in the Waikato DHB region

7.3.6 Structural factors

Participants also highlighted how these barriers to equitable access are influenced by structural factors. These aligned with the three main 'system structures' that Kringos, Boerma, Hutchinson, van der Zee, and Groenewegen (2010) highlight in their systematic review of primary health care: governance, economic conditions, and workforce development. Participants emphasised the importance of good governance of health services at all levels, including the Ministry of Health, DHBs, PHOs and at the individual practice level, as a key factor influencing the accessibility of services. The lack of appropriate planning, and the design of services in a provider-centric fashion, rather than to meet the needs of patients was highlighted as a key barrier to equitable access. Furthermore, patients called out a lack of community engagement from governance structures around the design and delivery of services. These act as barriers to the development of service approachability and acceptability. Patients also expressed a strong desire for the better integration of services, with a stronger holistic focus that incorporates the prevention of illness and maintenance of wellbeing. Integration was seen as a particularly pertinent issue in rural areas, where most secondary, tertiary, and specialist services can only be accessed by traveling to Waikato Hospital. A lack of planning and service integration can act as a barrier to the approachability and appropriateness of services.

Participants outlined funding arrangements and business models as key economic factors that affect equity by directly impacting the affordability of GP services. Participants explained the current GP system as a 'public-private' partnership with practices receiving a base-level of public funding, based on their enrolled patient population, which is 'topped up' through co-payments from patients. This arrangement affects service equity. Participants stated that this can result in some practices enrolling high numbers of patients to get higher levels of funding, meaning that patients are more likely to experience longer waiting lists, shorter appointments, and lower quality care.

> *"We're incentivized to take as many patients as we can. It's all mixed up."* – P, GP

Furthermore, if practices are not registered as Very Low Cost Access clinics, they are able to set their own co-payment costs, meaning that the cost of an appointment varies greatly throughout the Waikato region. The type of business model that clinics operate can also affect business decisions, and impact patients. For instance, some doctors noted that under GP-owned models they had more control over how much to charge patients, and in some cases would not charge anything when they knew that patients couldn't afford to pay. On the other hand, participants expressed concern about the increasing corporatisation of health care, suggesting that businesses run purely in the name of profit were unlikely to have patients' best interests at the core of their model, leading to the potential for increased inequities.

Participants also highlighted the link between workforce development and the availability and accommodation of services. Issues around the current GP workforce were discussed. A lack of depth means that in many areas clinics rely or locums or international medical graduates, which impacts on GP continuity for patients. Difficulties recruiting and retaining long-term doctors means that the level of services available can fluctuate. Participants also highlighted the need to better integrate the non-GP health workforce, including pharmacists, nurses, and physician assistants into a health care team. For example, not all appointments need to be with a GP, and therefore other health professionals could meet some of the demand for GP services. Participants also highlighted a lack of professional development opportunities, and that the current medical training system tends to discourage medical students from a career in general practice, contributing to workforce shortages that impact service availability.

Finally, participants outlined the fundamental drivers of health inequity as New Zealand's history of colonisation, and continuing discrimination at systemic, institutional, and interpersonal levels. Participants directly tied the historical injustices of colonisation to current poor health among Māori. Significant land confiscation, violence and oppression resulted in the loss of an economic base and, through the social determinants of health such as poverty, education, and incarceration, has led to present-day health inequities.

> "*The violence that happened across the whole of the Waikato is deeply entrenched in people's history and impacts biochemically on them as well as in terms of what happens with their illness."* – F, GP

Participants argued that colonisation has resulted in Māori being disempowered by the government over many generations. This intentional disempowerment has a significant impact on each of the five 'abilities' of individuals to access care.

> "*Our people are traumatised. There's intergenerational trauma. We're trying to heal, you know?"* – P, Patient

Participants also emphasised that the negative impact of colonisation is reinforced through present-day racism and discrimination which, in the context of health services, directly affects access to appropriate services and treatment.

> "*As a young Māori woman…the service you may receive, as soon as they see you, is not the same as somebody who is similar age, same gender, but could be a different race."* - J, Patient

Participants have described how the historical and ongoing trauma of colonisation and repeated breaches of the Treaty of Waitangi have a direct impact on health, despite Māori being guaranteed rights to protection under Article 3 of the Treaty, including access to the same quality of health and standard of living as Pākehā citizens (Wepa, 2015). Ryks, Simmonds, and Whitehead (2019) have demonstrated that the ongoing impact of colonisation has produced inequities between Māori and non-Māori that exist across key social determinants of health such as housing, transport, socioeconomic deprivation, racism, access to and quality of health care. Furthermore, the Wai 2575 Health Services and Outcomes Kaupapa Inquiry (Waitangi Tribunal, 2019) has found that the primary care system does not adequately address the severe inequities experienced by Māori. Although there has been an increase in Māori service providers, and the Waikato DHB region has four Māori service providers across eight locations (Ministry of Health, 2012), the Wai 2575 inquiry argues that the Crown has not done enough to support Māori to design and deliver primary care services for Māori. Furthermore, the key legislative framework of the primary care system in New Zealand – the New Zealand Public Health and Disability Act (2000) – is not considered to be Treaty-compliant as it does not give full effect to the Treaty of Waitangi or its principles. The direct links that participants drew between colonisation and health inequity supports the research literature outlined above, and highlights the importance of recognising colonisation and self-determination as key determinants of health for indigenous people. In Canada, Greenwood and de Leeuw (2012) have outlined a 'Web of Being' model of the social determinants of indigenous people's health. The inner layer of children, families and communities are impacted by proximal determinants of health such as income, education, and healthy environments. These are surrounded by the intermediate determinants such as health systems, location, cultural ways and justice, while the outer layer consists of distal determinants of health such as self-determination, language, racism, land resources, and poverty. Greenwood and de Leeuw's model recognises the historical and ongoing determinants of health that directly affect indigenous people in Canada, suggesting that improvements to health systems and health outcomes are intrinsically related to indigenous self-determination and empowerment. The Wai 2575 inquiry (Waitangi Tribunal, 2019) has given an interim recommendation that the Crown should explore the concept of a stand-alone Māori primary health authority. Colonisation in Aotearoa New Zealand is also closely linked to capitalism. The systematic dispossession of Māori from their land – and the rights and freedoms associated with it – established the preconditions for capitalism in Aotearoa New Zealand and lay the foundations for persistent inequities between Māori and Pākehā (Wynyard, 2017). In more recent years, neoliberal economic restructuring in Aotearoa New Zealand has led to increasing poverty (Kearns & Barnett, 1992) which marginalises and excludes individuals who are unable to purchase health care (McGregor, 2001). At the same time, market approaches appear to have increased geographic differences in GP availability, resulting in acute shortages in rural areas (Barnett & Barnett, 2004). Kearns and Barnett (1992) argue that the health system in Aotearoa New Zealand has been gradually privatised since the 1950s, leading to the emergence of corporate models of primary care service provision. Capitalism and neoliberalism became influential ideologies in the New Zealand health system in the 1990s (Prince, Kearns, & Craig, 2006) and despite the intentions of the PHCS (Ministry of Health, 2001), primary care in Aotearoa New Zealand is largely based on a privatised business model driven by neoliberal market forces. Colonisation and capitalism have produced inequitable societal conditions, both in terms of the 'abilities' that individuals and populations have to access services, and the impact on the availability and affordability of primary health care services that are user-pays. The research findings discussed above have been synthesised into a model of equitable access to primary health care in the Aotearoa New Zealand context, as displayed in *Figure 7.7*. The model shows that the components of access outlined by Levesque et al. (2013) - approachability, acceptability, availability and accommodation, affordability, and appropriateness - are also key themes in ensuring equitable access to GP services in Aotearoa New Zealand. However, as our participants have highlighted, it is also important to consider the roles that place and health system structures play in shaping inequitable access to health care. Furthermore, these factors are both nested within a wider context, and it is essential to recognise that inequities in both health outcomes and access to services in Aotearoa New Zealand are fundamentally underpinned by colonisation and breaches of the Treaty of Waitangi.

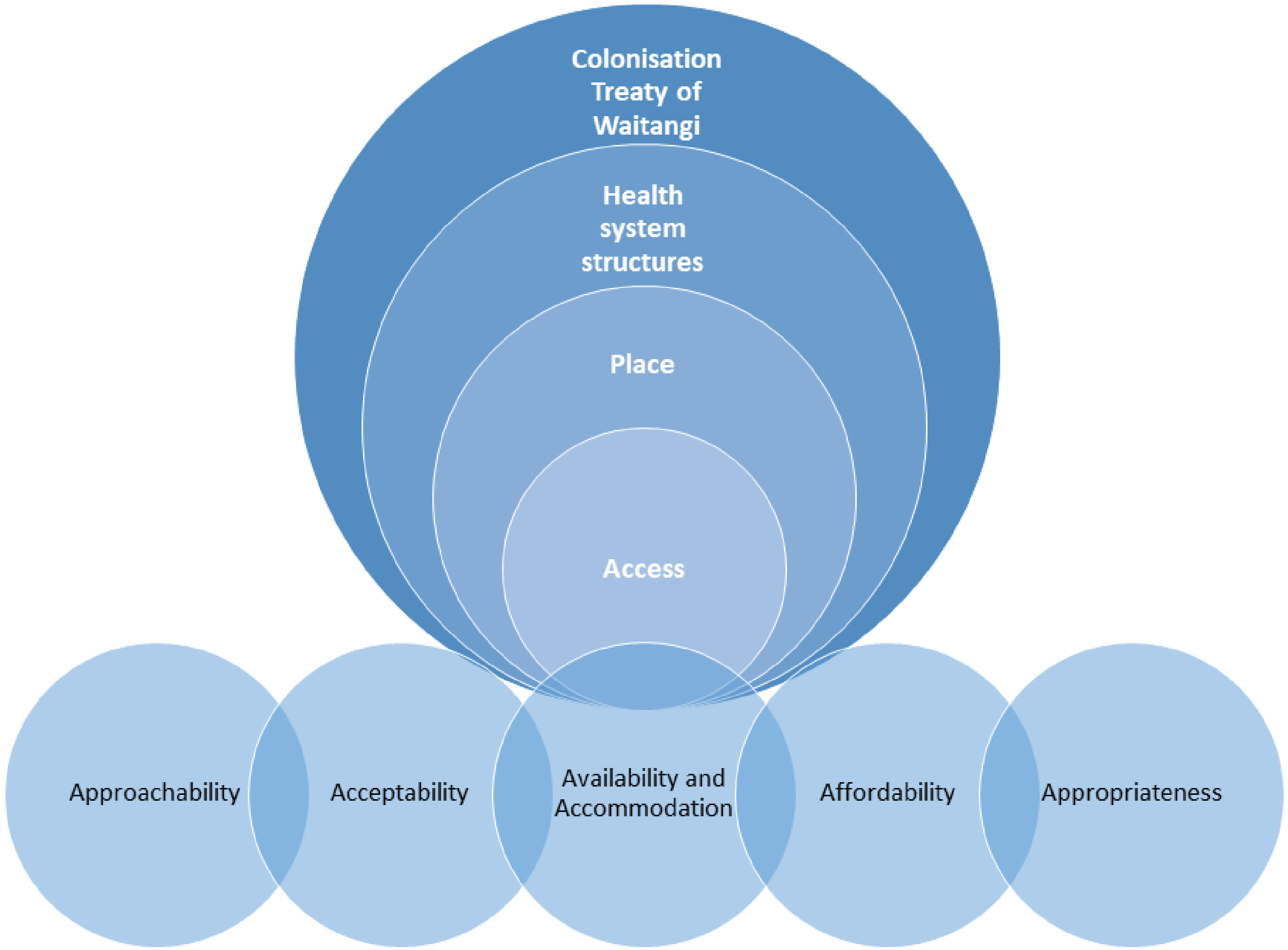

Figure 7.7 A model of equitable access to GP services in Aotearoa New Zealand

7.4 Discussion

Overall, the quantitative findings point to an inequitable distribution of GP services in the Waikato DHB region. The Gini coefficient of 0.477 suggests that access is not shared equally among the population. Although it appears that most residents have good spatial access to services, and there do not appear to be any major differences by age or ethnicity, it is important to recognise that this likely to be influenced by the geographic distribution of the population. Hamilton city accounts for a large proportion of the overall Waikato DHB population, and good access to GP services in the Hamilton area may be masking poor access in rural peripheral areas that have smaller populations. Furthermore, a high proportion of residents of socioeconomically deprived areas reside in Hamilton and therefore also have good spatial access to GP services. However, this is also likely to be masking smaller populations living in small towns and rural areas with high socioeconomic deprivation and poor access to GP services. Importantly, a substantial proportion of people are affected by the double burden of poor spatial access to GP services and high socioeconomic deprivation.

The results of the qualitative component of this research provide important additional insights, and highlight key factors that participants identify as influencing the equity of GP services. The qualitative mapping approach triangulates our quantitative findings and there appears to be significant overlap between the results of a quantitative GIS model of access - based on population size, supply, and the geospatial distribution of services – and the more nuanced qualitative understandings of access among the interviewees. In-depth interviews reinforced the idea that spatial accessibility is only one component of access, supporting the findings of previous research in this area (Panaretto et al., 2017; Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019b). Participants emphasised non-spatial factors that act as barriers to equitable access, particularly the *availability*, *acceptability,* and *affordability* of GP services. Many participants considered the cost of services to be too prohibitive, the focus on European health models unacceptable, and expressed frustration at the difficulty of receiving an appointment with their GP. Several accessibility factors that our participants identified align with the international literature, such as the Levesque et al. (2013) model of patient-centred access. While the HCH model is one response to increase patient-centred care, Cumming et al. (2018) argue that it has potential shortcomings and it is too soon to judge whether it could be a successful model of care in the New Zealand context. For one, Cumming et al. (2018) argue that the HCH model does not directly tackle major equity concerns, especially around the health of Māori and Pacific populations. Furthermore, they suggest that the HCH model is mainly focussed on business efficiency, and it is assumed that giving GPs more time will result in better care for patients and populations with complex needs. Our interviewees also identified factors that influence GP service equity and are unique to the Aotearoa New Zealand context such as the historical and ongoing impact of colonisation and Treaty of Waitangi breaches. Our proposed model of equitable access to GP services therefore highlights the importance of historical and structural factors, as well as the role of place, in shaping individual and community level access to GP services. Landscapes of health and place are dynamically and reciprocally developed through the activities of health care provision which impacts health services, the health of population groups, and the vitality of places (Kearns, 1993; Kearns & Joseph, 1997). Kearns (1993) argues that health services are a key institutional component of places. However, the restructuring and re-orienting of health services towards free-market principles since the 1980s have often limited the provision of rural services to very basic levels (Joseph & Chalmers, 1996). Furthermore, Pomeroy (2019) has outlined how the inequitable development of rural New Zealand has systematically disadvantaged Māori populations, while Came, Herbert, and McCreanor (2019) argue that a fundamental barrier to achieving health equity is colonial health policy designed for 'all' New Zealanders. The colonial health infrastructure and policies which replaced indigenous systems of health have been ineffective at addressing the systemic inequities produced through colonisation (Came et al., 2019; Waitangi Tribunal, 2019). Therefore, in order to achieve equity, health policy and health services need to effectively engage with *te Tiriti o Waitangi* obligations (Came et al., 2019).

This paper has taken an exploratory approach to investigating health care equity using mixed methods. This has highlighted areas of weakness in a purely quantitative approach, and areas for future improvement. For instance, the VGP-E2SFCA model used in this paper did not consider the availability of appointments at each clinic, the type of service being provided, or the cost of an appointment, despite *availability*, *acceptability* and *affordability* being emphasised by participants as key components of equitable access. The *ability* of populations to access services was also assumed to be equal across the region. Although practice level databases exist that include the availability and type of appointments and PHOs have data on staff FTE hours for each clinic, this data was not made available for this research project. Future research could aim to better incorporate these aspects of accessibility into a GIS model. Furthermore, the use of GP numbers as a proxy measure of GP and nurse FTE hours represents a potential underestimate of service availability in our GIS model. Many primary care nurses are highly qualified, hold their own appointments, and manage the population health components of general practice such as screening, leading to increased capacity.

The qualitative component of this research is not without its limitations either. While our original sample was designed to include a diverse range of interviewees, the snowball approach to identify additional participants may have limited the final sample. Interviewees may have recommended contacts with similar world-views meaning that thematic saturation might have been reached earlier than if another methodology was used – such as randomly selecting service providers and cold calling them to request interviews. However, overall, incorporating the perspectives of patients, GPs and health service providers into this research has led to the development of a much more intricate and nuanced understanding of GP service delivery in the Waikato region.

To our knowledge, this type of mixed-methods analysis of health service accessibility is unique. Previous research in the New Zealand context has tended to take approaches that are either quantitative (see Pearce, Witten, Hiscock, and Blakely (2006) for their examination of access to health related resources) or qualitative (see Lawton, Makowharemahihi, Cram, Robson, and Ngata (2016) for their examination of barriers to accessing contraception among Māori teenage mothers). This has meant that quantitative studies of access to health services have tended to overlook the social and historical contexts within which the use of services takes place, and the underlying structural factors that shape opportunities to access health care are concealed.

7.5 Conclusion

This exploratory research has provided new insights into the equity of GP services in the Waikato DHB region and has highlighted particular areas that have poor spatial accessibility. Although it is unclear whether these results can be generalised to other parts of Aotearoa New Zealand, the research approach could be replicated and applied to other study regions. There is clear potential for the results to inform the Ministry of Health and DHBs in their decision making around delivering more equitable primary health services. Our proposed model of equitable access expands upon previous theoretical frameworks of accessibility, is tailored to the Aotearoa New Zealand context, and incorporates key drivers of health service equity. This paper has shown how a mixed methods approach can be used to gain a deeper understanding of health care equity at a regional level and can answer questions of not only *where* inequities occur, but also *why* they have been and continue to be produced.

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Chapter 8: Article 7 – The sustainability of General Practitioner services: a mixed methods investigation of policy scenarios in the Waikato District Health Board region of New Zealand[13]

[13] This work, co-authored with Assistant Professor Amber L. Pearson, Professor Ross Lawrenson, and Associate Professor Polly Atatoa Carr, is ready for submission to the *Journal of Mixed Methods Research*.

Abstract

Introduction: Most literature on the factors that affect the sustainability of primary health services describe an Australian or North American context. Little is known about the specific factors that affect General Practitioner (GP) service sustainability in New Zealand, and even less is known about sub-national contexts. To our knowledge there are no studies that quantify the impact of projected changes to workforce supply and population demand on the future spatial accessibility of services, describe variations in sustainability at a sub-national level, and simulate policy scenarios to improve equity. Spatial accessibility is defined as the number of services available and the geographic separation between populations and services.

Method: A mixed methods approach to examining the sustainability of GP services in the Waikato District Health Board (DHB) region was developed. Quantitative Geographic Information Systems (GIS) techniques were used to model and estimate sustainability. GP workforce and population projections under six policy scenarios are used to examine likely changes in sustainability from 2013 to 2043. In-depth qualitative interviews with 17 key informants provided narrative confirmation. A thematic analysis of interview transcripts identified key themes and factors that affect the sustainability of GP services in the Waikato DHB region. This mixed methods approach allows for the triangulation of results to develop a deeper understanding of not just where services are likely to be unsustainable, but the reasons *why* this occurs, and which policy settings may be the most effective at improving sustainability and equity.

Results: Average levels of spatial accessibility are projected to increase from 2013 baseline levels. However, areas that already have high accessibility at baseline are expected to see the largest improvements in accessibility, while areas with poor access to services at baseline are projected to have very minor increases in accessibility, increasing spatial inequities. Places with higher health needs, a large proportion of residents aged 0-4 years or over 65 years, and a large proportion of Indigenous Māori residents are not projected to have substantially increased access to GP services. A simulated policy scenario where GPs are incentivised to work in areas of high socioeconomic deprivation resulted in the highest projected spatial accessibility scores, but also the highest Gini coefficient. A policy scenario

encouraging GPs to work in areas of high age-related health need resulted in the most equal distribution of spatial accessibility, but also lower levels of spatial accessibility. A policy scenario targeting spatial inequities produced the largest short-term increase in spatial equity as well as long-term improvement and could be considered the most sustainable scenario. The four key themes representing dimensions of sustainability identified by participants were: Economic, Professional, Organisational, and Social. Novel components that were identified as relevant to the Waikato DHB (and likely wider New Zealand) context which emerged from interviews include: unique health care business models in New Zealand's public-private-partnership and how these impact the economic dimension; the importance of a broader range of factors in the professional dimension, such as working conditions; recognition that different models of care can improve the sustainability of the organisational dimension; importance of whanaungatanga [relationships developed through shared experiences and working together which provide people with a sense of belonging] to the social dimension.

Conclusion: GP services in the Waikato DHB are unlikely to be sustainable in the long-term given the workforce and demographic trends in the region. Improved access to GP services is likely to benefit areas that already have the best access, undermine the viability of rural clinics, and exacerbate and entrench current spatial inequities. Our modelling of potential policy settings indicates that in order to achieve significant improvements, action to improve GP service sustainability and equity needs to focus on more than just workforce supply and population demand. We have identified several factors such as ownership models, working conditions, models of care and whanaungatanga which can be addressed to improve the sustainability of GP services.

8.1 Introduction

Ensuring the sustainability of primary care services is an important challenge for health systems (Wakerman & Humphreys, 2013). New Zealand has a growing, ageing population that is living longer (Spoonley, 2016) and is expected to result in increased demand for health services, including primary care (Murdoch, 2010). The New Zealand Ministry of Health (2004) predicts that by 2051, government spending on health may rise from 6.2% to 9.2% of GDP, with the share of spending consumed by older people rising from 40% to 63%. Structural ageing, where populations are made up of higher proportions of older people, is an inevitable force that will affect most regions of New Zealand (Jackson, 2016). In some areas this structural ageing will likely lead to population decline as growth through natural increase comes to an end (Jackson, 2016). Most primary care in New Zealand is delivered through general practices. General practitioners (GP) are the first point of contact that most patients have with the New Zealand health system. However, much of the GP workforce is ageing and nearing retirement (The Royal New Zealand College of General Practitioners, 2019) suggesting that supply may not be able to match future demand for services. Furthermore, some areas are likely to be more deeply affected by demographic changes than others (Jackson, 2016), suggesting that some GP services may be unsustainable, and that inequities in access may increase in the future. While the level of population demand for services, and the size of the health workforce are important, international research suggests that there are other key aspects that affect the sustainability of primary care services such as GP clinics. Commonly described threats to sustainability documented in the international literature include: an increasing demand for health services in economically constrained situations; geographic isolation, particularly in rural areas; government policies; and management structures (Buykx et al., 2012; Humphreys, Wakerman, & Wells, 2006; Humphreys et al., 2008; London, 2002; Murdoch, 2010; Schoo, Lawn, & Carson, 2016; Wakerman, 2009; Wakerman & Humphreys, 2011). Key enablers of sustainable services are generally recognised as clear governance structures, and supportive communities and policy conditions at the environmental level (Buykx et al., 2012; Wakerman & Humphreys, 2011). These in turn impact on the four sustainability dimensions which Humphreys et al. (2006) describe as underpinning rural GP viability in the Australian context: economic factors, professional factors, organisational factors, and social factors. Much of the literature on the sustainability of primary care services describes an Australian or North American context, with fewer studies focussing on New Zealand (see Brunton, 2017; London, 2002; Murdoch, 2010; Rees, Crampton, Gauld, & MacDonell, 2018; Ross & Kenrick, 2011). Therefore, relatively little is known about the unique factors affecting GP service sustainability in New Zealand, and even less is known about sustainability at a sub-national level. To address these gaps in the research literature this paper focuses on the Waikato District Health Board (DHB) region in the North Island of New Zealand. We carry out a mixed-methods analysis that will quantify the sustainability of GP services, and identify the key factors and processes that influence the sustainability of GP services in the Waikato DHB region using interviews with key stakeholders.

Our quantitative framework for assessing the sustainability of health services (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2018), involves: (1) defining sustainability; (2) estimating current and future levels of access and need; and (3) quantifying the sustainability of services. Although there is no consensus on the definition of sustainability (Blanchet & Girois, 2013), it usually considers the ability to provide ongoing services (Humphreys et al., 2006), and ongoing access to quality, cost-efficient care in a changing environment (Buykx et al., 2012). However, the spatial equity of services – that is, whether their distribution is fair and aligns with population need (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019a) – must also be considered. In this context, sustainability can be examined by considering whether a fair distribution of services is likely to be maintained or improved over time (Whitehead et al., 2018). The supply of an adequate and competent health workforce is a key driver of inequitable access to health care, and an important component of sustainable services. Current and future levels of access to GP services can be estimated using a range of measures and techniques (Guagliardo, 2004). The 'Floating Catchment Area' (FCA) group of techniques estimate accessibility by considering service availability relative to population size and the distance between populations and services. FCAs calculate the ratio between the number of services and the size of populations within a defined 'catchment' area and produce an 'accessibility score' for each small area unit within a study area (McGrail & Humphreys, 2009). The Enhanced-2-step-floating-catchment-area method (E2SFCA) incorporates distance decay and is now considered the default spatial accessibility measure (Luo & Qi, 2009; McGrail, 2012), although various improvements such as incorporating variable catchment sizes (Luo & Whippo, 2012; McGrail & Humphreys, 2014; Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2020) have been developed. Population projections can be incorporated into FCA approaches to estimate future levels of spatial accessibility and health need. The sustainability of GP services over time can then be quantified using several statistical techniques such as ANOVA, the Gini coefficient, and spatial autocorrelation (Whitehead et al., 2019a). For instance, Hara, Kunisawa, Sasaki, and Imanaka (2018a) identified a decline in the equity of Japan's geographical distribution of physicians by comparing Gini coefficients between 2002 and 2014. This approach could be adapted to estimate future changes in spatial equity. In New Zealand it is important that the impact of potential changes to the sustainability of services on Indigenous Māori are examined to monitor structural discrimination and ensure that health services in New Zealand meet their Treaty of Waitangi commitment to protect Māori health (Whitehead et al., 2018). Wakerman and Humphreys (2011, p. 121) have argued that "health systems research requires a multi-method approach, both qualitative and quantitative". To our knowledge there have been no qualitative studies of GP sustainability published in New Zealand, nor has a framework of GP sustainability for the New Zealand context been produced. Carrying out interviews with key informants and performing a qualitative analysis of GP service sustainability allows for both the triangulation of results, and the development of a deeper understanding of not just where services are likely to be unsustainable, but the reasons *why* this occurs.

8.2 Methods

8.2.1 Ethics

This study received ethical approval from the Human Research Ethics Committee, Faculty of Arts and Social Sciences, University of Waikato – granted 18th May 2017. Reference: Whitehead FS2017-18.

8.2.2 Study design

This study is a mixed-methods analysis that uses both quantitative GIS techniques and a qualitative analysis of interviews with key informants. The quantitative and qualitative methodologies are outlined below in detail.

8.2.3 Quantitative approach

Geographic Information Systems (GIS) were used to quantitatively assess the sustainability of GP services using models of spatial accessibility and statistical techniques.

8.2.4 Data

All GP clinics were geocoded based on the physical addresses obtained from the Waikato DHB (2019). The number of GPs working in each clinic was obtained from Primary Health Organisation (PHO) datasets and websites (Hauraki Primary Health Organisation, (n.d); Pinnacle Incorporated, (n.d)). Historical GP workforce data was obtained from the Medical Council of New Zealand (n.d). Area Unit (AU) boundaries were downloaded from Statistics New Zealand (2019) so that 2013 census data could be linked to sub-national population projections for the Waikato DHB region using the *Area unit population projections, by age and sex, 2013(base)-2043 update* dataset (Statistics New Zealand, 2020). TA boundaries were also downloaded from Statistics New Zealand (2019) and linked to sub-national ethnic population projection data (Statistics New Zealand, 2017). 'Medium' level projections - which assume medium levels of fertility, mortality, and net migration - were used for each time-point. The *Area unit population projections* dataset also included the projected size of each age group, allowing the proportion of residents aged 0-4 years or 65 years and older to be estimated at each time-point for all AUs. The New Zealand Index of Deprivation (NZDep2013) (Atkinson, Salmond, & Crampton, 2014) was downloaded from the University of Otago. The New Zealand road network was downloaded from Land Information New Zealand (2019) to assist with spatial analysis.

8.2.5 Spatial accessibility

Spatial accessibility highlights the geographic separation between populations and services, and the number of services available to populations (Guagliardo, 2004). When estimating the spatial accessibility of GP services we used the VGP-E2SFCA - a recently developed modification of the E2SFCA, which incorporates dynamic catchment sizes that were defined by patient enrolment data (Whitehead et al., 2020). Dynamic catchment sizes reflect the distance that patients in urban and rural areas were assumed to be willing to travel to access GP services. Researchers have argued for the incorporation of dynamic catchments to better model accessibility in mixed-urban-rural environments (Luo & Whippo, 2012; McGrail & Humphreys, 2014). Our decision to use 10km, 20km and 30km catchments for clinics in major urban, small and medium urban, and rural areas respectively, is based on a detailed analysis of patient enrolment records for the Waikato region which is published elsewhere (Whitehead et al., 2020). The Butterworth distance decay function, as used by Langford, Fry, and Higgs (2012) was applied to take into account the reduced spatial accessibility of people living at the outer edge of a catchment. We accounted for differences in the level of services available at each clinic by weighting clinics in our model according to the number of GPs working there. Higher scores indicate higher accessibility (range 92.7 – 138.3 under 2013 baseline settings).

8.2.6 Policy scenarios to improve equity and sustainability

We developed six separate scenarios to estimate how future changes to the Waikato DHB resident population, and GP workforce may impact the short- and long-term sustainability and equity of GP services. The recently released Health and Disability System Review (2020) recommends that DHBs take a more proactive role in planning primary care services to improve accessibility, effectiveness, and health equity. The review calls for services to be planned on a locality basis, taking a population health perspective based on detailed population needs analyses to achieve equitable outcomes. Therefore, four of the six scenarios involved DHB incentives for new GPs to work in areas considered to have higher health needs. Under Scenario 1 it was assumed that while the DHB resident population would increase as projected by Statistics New Zealand, the total number and distribution of the GP workforce would not change. Scenario 1 implies that the number of new medical graduates and overseas doctors entering general practice does not exceed the number of current GPs who will retire. In Scenario 2, we assumed that under 'market conditions' the number and distribution of GPs in the Waikato DHB region would continue to increase at the same rate as the years 2001-2011. Annual GP workforce data between 2001 and 2011 was sourced from the Medical Council of New Zealand (n.d) and used to estimate the future distribution of GPs throughout the Waikato DHB region. The average yearly increase in the number of GPs working within Hamilton city and for the Waikato DHB as a whole was calculated. This annual rate of workforce increase was then used to project the number of GPs in Hamilton city, and the DHB region as a whole for the years 2028, 2033, 2038 and

2043. In Scenario 3, we simulated the impact of the Waikato DHB providing GPs with incentives to work in areas with high health need or poor access to GP services. Four separate hypothetical initiatives were tested. In Scenario 3A, we simulated that GPs would be incentivised to work in areas of high socioeconomic deprivation. We therefore increased the GP workforce by an additional 20% above Scenario 2 for clinics located in areas in the highest quintile of deprivation according to NZDep2013 (n=71). The number of GPs in clinics not meeting the criteria for incentives was reduced so that the total number of GPs across the Waikato DHB region was the same as Scenario 2 at each time-point. This step was applied for all scenarios. In Scenario 3B, we simulated that GPs would be incentivised to work in areas with a proportion of Māori or Pacific residents that is higher than average for the Waikato DHB region (>26.1%), and therefore increased the GP workforce by an additional 20% above Scenario 2 for all clinics located in these areas (n=36). Under Scenario 3C, we simulated that GPs would be incentivised to work in areas with a proportion of residents aged 0-4 or 65 and older that is higher than average for the Waikato DHB region (>21.7%), and therefore increased the GP workforce by an additional 20% above Scenario 2 for all clinics located in these areas (n=51). Finally, under Scenario 3D, we simulated that in order to reduce spatial inequities the Waikato DHB may incentivise GPs to work in areas with poor spatial access to GP services from 2028. We therefore identified GP clinics located in the lowest accessibility quintile in 2013 (under Scenario 1) and increased the GP workforce by and additional 20% above Scenario 2 (n=27). The VGP-E2SFCA model was run five times for each scenario, once each using data for the: 2013 usually resident population; and the 2028, 2033, 2038, and 2043 projected populations from Statistics New Zealand (2020). The distribution of accessibility scores across the Waikato DHB region was mapped for each model.

8.2.7 Health need

The spatial distribution of health need was considered separately from the distribution of spatial accessibility. When considering the sustainability of GP services, the most readily available data on potential future health needs is the age of residents. Those aged 0-4 years and over 65 years have higher levels of service utilisation (Amey, 2018; Cumming, Stillman, Liang, Poland, & Hannis, 2010; Ministry of Health, 2004), and such data is readily available through Statistics New Zealand subnational population projections at the AU level. The projected future distribution of population health need was therefore estimated using Statistics New Zealand age-specific population projections. The proportion of residents aged 0-4 years or aged 65 years or older in each AU was calculated. The percentage point change in the proportion of the 'age dependent' population between the 2013 baseline and each time-point was then calculated.

8.2.8 Spatial equity

To examine the spatial equity of GP services at each time-point, the population weighted Gini coefficient of each accessibility score was calculated in R (R Core Team, 2017) using the ACID package (Sohn, 2016). The Gini coefficient assesses the distribution of resources (such as income, or in this case 'accessibility') across a population, and provides an equity score between 0 and 1, with 0 representing a perfectly equal distribution and 1 indicating a completely unequal distribution (Jang, An, Yi, & Lee, 2017).

8.2.9 Statistical tests

To establish whether future spatial accessibility scores, as estimated by the VGP-E2SFCA, are projected to be significantly different from 2013 baseline scores, a repeated-measures one-way ANOVA of all accessibility scores, followed by paired samples t-tests with the Bonferroni adjustment were calculated in R (R Core Team, 2017) using the "ez" package (Lawrence, 2016). Statistical significance was defined as $p<0.01$. A repeated-measures one-way ANOVA and adjusted paired samples t-tests were also used to determine whether there was a statistically significant difference in the accessibility scores produced by each of the six scenarios. To identify whether statistically significant clustering of spatial accessibility scores, or health need (as estimated by age) occurred in 2013, or was projected to occur in 2038 or 2043, the Global Moran's *I* measure of spatial autocorrelation was calculated in Arc GIS v10.7.1 (ESRI, 2018). Global Moran's *I* quantifies the degree of spatial clustering or dispersion, and determines whether it is statistically significant (Scott & Janikas, 2010). Anselin's local Moran's *I* was also calculated to map the locations of clusters of high and low access or need, as well as spatial outliers.

8.2.10 Qualitative approach

The qualitative component of this research was based on semi-structured interviews, and interview data was analysed according to the six phases to thematic analysis as outlined by Braun and Clarke (2006).

8.2.11 Data collection

Key stakeholders were initially identified through purposive sampling and contact with appropriate organisations involved in primary care provision in the Waikato DHB region (e.g., the Waikato DHB, PHOs, GP clinics, and consumer representatives). A total of 10 respondents agreed to participate and then the snowball method was used to contact further participants (n= 7). This method ensured representation of important groups regarding GP sustainability. Potential participants were contacted via email with an interview request, and informed written consent was obtained before the interview. Participants included patient representatives (n=7), general practitioners (n=5), representatives from PHOs (n=4), and the Waikato DHB (n=1). Face-to-face semi-structured interviews lasting approximately 60 minutes each were conducted with these 17 participants between August and December 2018 in locations convenient to the participants. Participants were asked a range of questions within the broad themes of GP service sustainability, including questions around barriers to achieving sustainability, causes and effects of unsustainable services, and potential solutions (see *Table 8.1*).

Table 8.1: Interview guide

Key topics relating to sustainability covered by the interview guide
- Are services in the Waikato DHB region sustainable? - What factors affect the sustainability of GP services? - How can the sustainability of services be improved? - Which areas have the most or least sustainable services? - How do ownership, funding and care models relate to sustainability? - What is an ideal population to GP ratio?

The semi-structured nature of interviews gave space for participants to raise their own areas of concern that were not directly addressed by the interview guide. These interviews were carried out as part of a larger project that also examined the equity of GP services in the Waikato region, and therefore questions relating to the equity of services were also included in the interview guide. Audio from all interviews was digitally recorded, transcribed verbatim, de-identified, and imported into NVivo qualitative analysis software (QRS International, 2018). After conducting 17 interviews, saturation was reached with participants repeating common themes, and therefore no further participants were recruited. Interviews and the analysis of qualitative data was carried out by the lead author, with planning assistance and guidance provided by other contributing authors.

8.2.12 Data analysis and interpretation

Through this process of conducting and transcribing interviews the lead author became familiar with the data corpus, which is phase one of a thematic analysis (Braun & Clarke, 2006). Then, in phase two, an inductive approach was used to generate initial codes from the recurring ideas in the interview transcripts. As suggested by Guest, MacQueen, and Namey (2012), a single codebook with thematic definitions was created iteratively. Codebooks include a list of codes, definitions and examples for each code, and details of when to use it (Guest et al., 2012). In phase three, potential themes were discerned by sorting and grouping codes. These initial themes were reviewed in phase four to ensure that the codes within them were coherent, and that there were clear distinctions between themes. Through this process, higher order themes were discerned, which led to phase five – the definition and naming of themes and an examination of links and connections between concepts. Finally, a more deductive approach was used in phase six to align qualitative findings with key concepts and frameworks in the research literature. This synthesis provided the narrative presented in this paper.

8.3 Results

8.3.1 Quantitative results

The 2013 baseline spatial accessibility scores in *Figure 8.1* were sorted into quintiles with the darkest areas representing the 20% of AUs in the Waikato DHB region with the lowest GP service accessibility, and the lightest areas representing the 20% of areas with the highest accessibility scores. Most places with high levels of access to GP services are located in Hamilton city, while the peripheral rural areas of the Waikato DHB region tend to have lower accessibility scores. The projected spatial accessibility scores calculated under Scenario 2 for each future point in the study period – from 2028 through to 2043 – are displayed in *Figure 8.2*. While most areas are projected to have unchanged accessibility scores, the areas surrounding Hamilton city, Waipā district and Te Kūiti are projected to have increased spatial accessibility, especially by 2043. Overall, under all scenarios except Scenario 1, the average accessibility scores are projected to increase at each time-point between 2013 and 2043, as indicated in *Table 8.2*. The projected increase in accessibility scores over time for scenarios 2 and 3A- 3D is statistically significant. For Scenario 2 a one-way repeated measures ANOVA indicated that there were statistically significant differences between the five different spatial accessibility scores calculated for the years 2013 to 2043 ($F(4, 660) = 152.15$, $p<0.001$). Paired samples t-tests with the Bonferroni adjustment revealed statistically significant differences between all possible pairs of accessibility scores calculated for the years 2013 to 2043. The same pattern of statistically significant differences in accessibility across time-points was repeated for all scenarios. However, as indicated by *Figure 8.2*, many AUs remained in the lowest quintile of accessibility across all time-points.

A repeated measures ANOVA and paired samples t-tests with the Bonferroni correction were also carried at each time-point (years 2028 – 2043) to compare the spatial accessibility scores produced by each simulated scenario. For the year 2028 a statistically significant difference in scores across the scenarios was noted ($F(5,825) = 111.13$, $p< 0.001$, n2 = 0.016). Scenario 1 had significantly lower spatial accessibility scores than all other scenarios. Projected spatial accessibility under Scenario 2 was significantly higher than under Scenarios 3C and 3D, but not statistically significantly different from Scenarios 3A or 3B. The difference between Scenarios 3B and 3C was also statistically significant. The same pattern of statistically significant results was also repeated for the years 2033, 2038, and 2043, however, the difference in spatial accessibility between Scenarios 3B and 3C was only marginally significant for the years 2033 - 2043 ($p<0.05$).

Figure 8.3 represents projected levels of spatial accessibility in 2043 under the four DHB incentive policy scenarios. Apart from the western Waikato region, which has improved access under Scenario 3B, the spatial distribution of accessibility scores is relatively similar under each of the scenarios. Furthermore, none of the four policy scenarios had a substantial impact on the Gini coefficients calculated for each year of projected spatial accessibility. In some cases (3A and 3B) they actually had the effect of slightly increasing projected spatial inequities compared to the default scenarios (1 & 2). By 2043, Scenario 3A produced the highest average accessibility score, however it also resulted in the highest Gini coefficient. Furthermore, spatial accessibility under 3A was not significantly higher than Scenario 2. Scenario 3C produced the lowest Gini coefficient of all scenarios tested, but also had the lowest average accessibility score (aside from Scenario 1). While sustainability improved under all scenarios (except Scenario 1), Scenario 3D produced the largest short-term increase in spatial equity as well as long-term improvement and could be considered the most sustainable scenario.

Table 8.2. Average accessibility scores and Gini coefficients for each time-point in the study period, and each scenario

Scenario	Year	2013	2028	2033	2038	2043
1 – No change to workforce numbers or distribution	Average accessibility	44.8	34.8	33.5	32.5	31.7
	Gini coefficient	0.477	0.459	0.454	0.449	0.443
2 – Linear increase in GP numbers	Average accessibility		52.7	62.6	74.9	90.1
	Gini coefficient		0.458	0.453	0.448	0.443
3A – Incentive to work in NZDep2013 Q5	Average accessibility		53.7	63.9	76.3	91.9
	Gini coefficient		0.470	0.465	0.460	0.455
3B – Incentive to work in Māori & Pacific communities	Average accessibility		52.0	61.8	74.0	89.1
	Gini coefficient		0.466	0.461	0.456	0.451
3C – Incentive to work in areas of age-based need	Average accessibility		48.9	58.3	69.7	84.0
	Gini coefficient		0.457	0.452	0.447	0.442
3D – Incentive to work in areas with poor spatial access	Average accessibility		51.6	61.3	73.3	88.2
	Gini coefficient		0.442	0.454	0.448	0.443

NB: Higher average spatial accessibility scores indicate that the average level of spatial access across all AUs in the Waikato DHB region has increased. Higher Gini coefficients indicate that the distribution of spatial accessibility across the Waikato DHB population is more unequal.

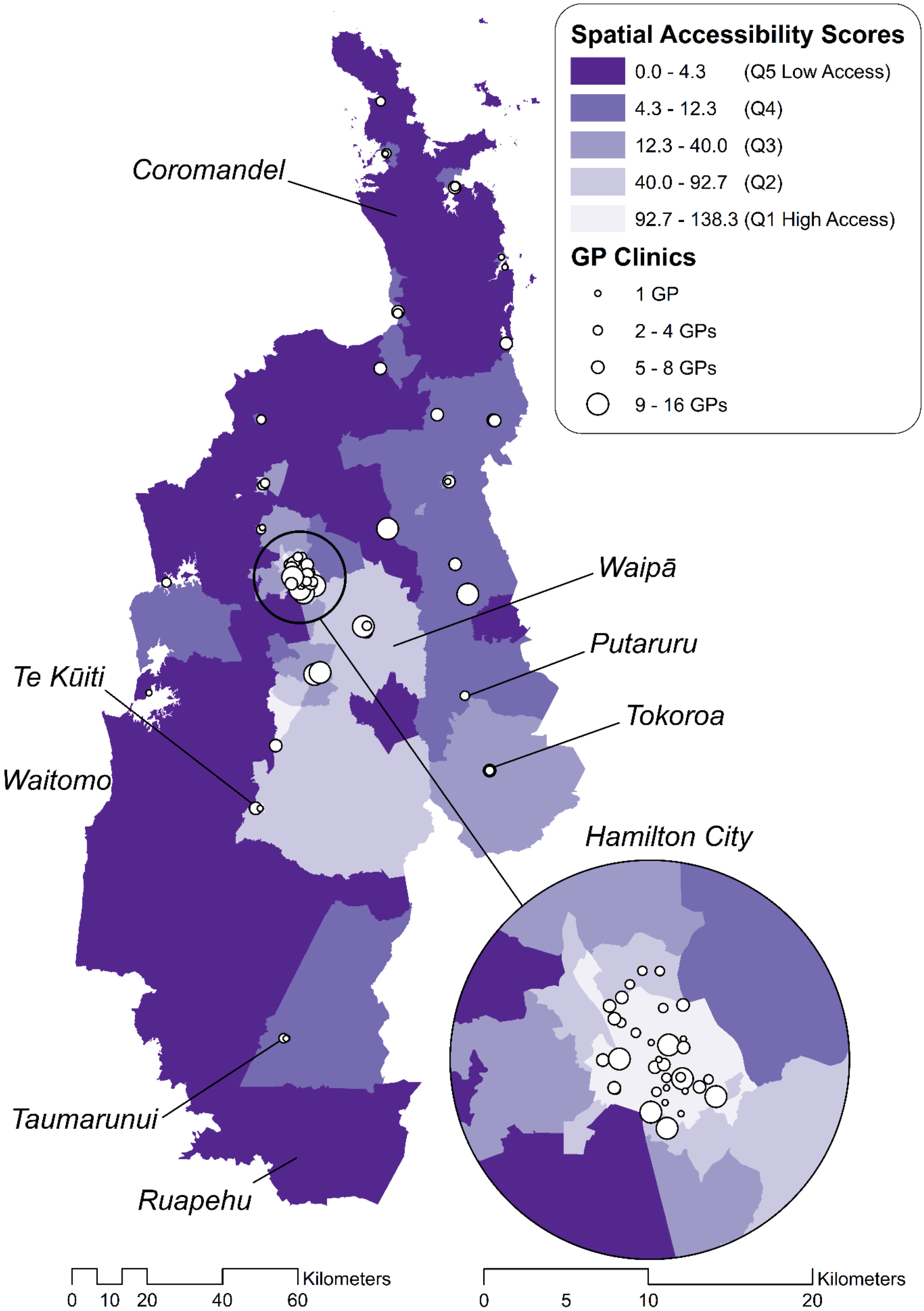

Figure 8.1. The spatial accessibility of GP services in the Waikato DHB region, 2013 baseline levels.

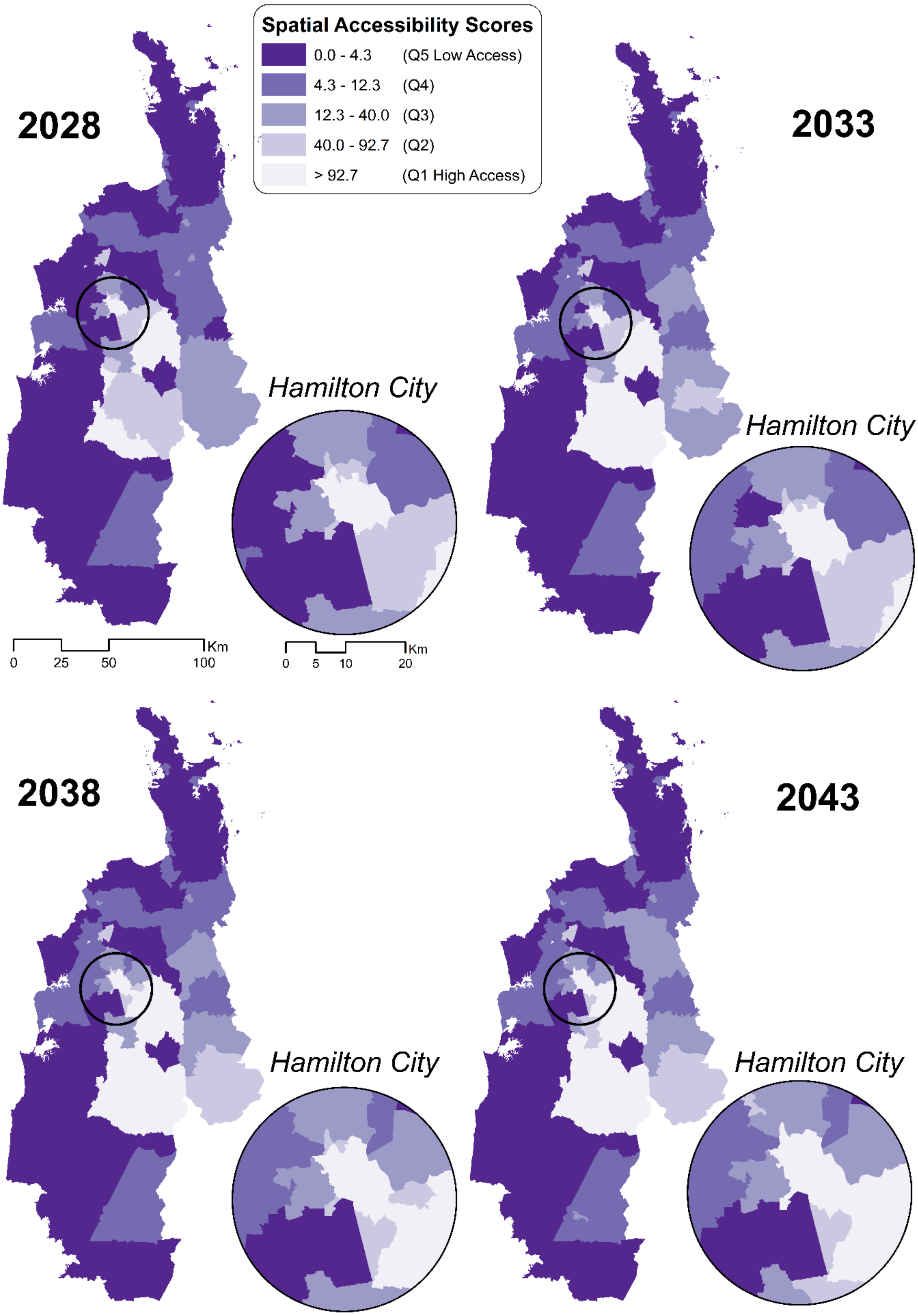

Figure 8.2. The projected spatial accessibility of GP services in the Waiakto DHB region for 2028, 2033, 2038 and 2043 under Scenario 2

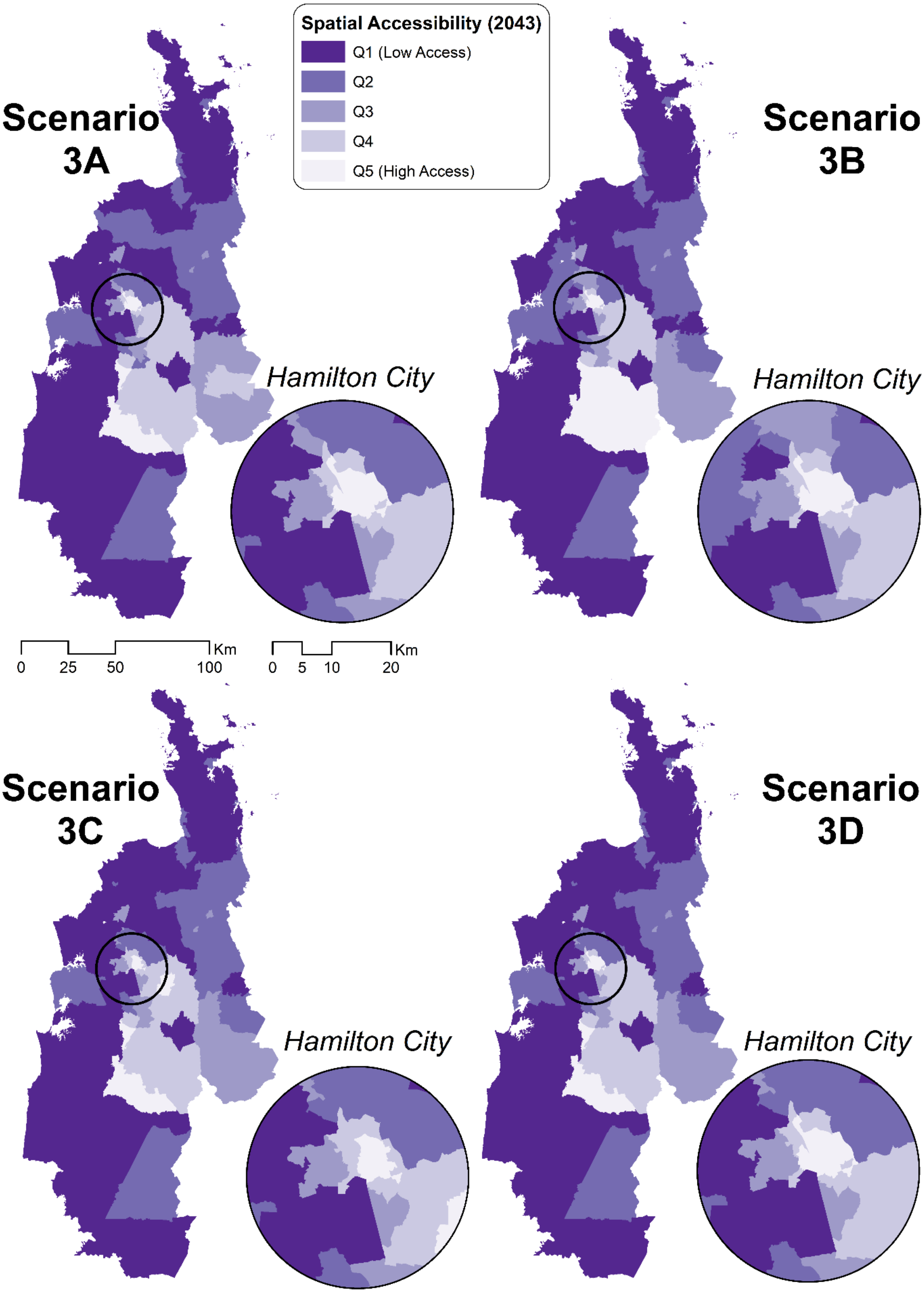

Figure 8.3 Projected spatial accessibility in 2043 under four simulated scenarios of DHB incentives

Since ethnic and general subnational population projections are only available until 2038 and 2043 respectively, the remainder of the quantitative analysis in this paper focuses on these two time-points.

Figure 8.4 represents the projected change in accessibility scores since 2013 for the years 2038 and 2043 under Scenario 2. The largest increases in spatial accessibility are in the Te Kūiti and Waipā areas south of Hamilton, as well as Hamilton city itself. Under Scenario 2, accessibility is projected to increase between 2013 and 2043, as is the equality of the distribution of access since the Gini coefficient moving closer to zero during this period. However, this result should be interpreted with caution. Despite average accessibility being projected to double between 2013 and 2043, the Gini coefficient only decreases by 0.034 (or 7.1%). Furthermore, the areas expected to have the greatest increase in spatial accessibility are the same places with the highest accessibility scores at the 2013 baseline.

The projected future distribution of population health need, as estimated by the proportion of residents aged 0-4 years and 65 years or older, is displayed in *Figure 8.5.* By 2043 the largest increases in the proportion of the 'age dependent' population is projected to occur in two main locations – the southern part of the Hauraki-Coromandel region, and the rural area surrounding Taumarunui and Ruapehu district in the north-eastern and south-western parts of the Waikato DHB respectively. Moran's *I* test of global spatial autocorrelation identified statistically significant spatial clustering of values in the projected accessibility scores (Scenario 2) and proportion of age-dependent population in both 2038 and 2043, as indicated in *Table 8.3.* Anselin's local Moran's I measure of local level spatial autocorrelation was calculated for each projected measure, and results are displayed in *Figure 8.6.* In both 2038 and 2043 high levels of spatial accessibility are expected to be clustered around Hamilton city, Waipā district and Te Kūiti, while low spatial accessibility scores are expected to be clustered in peripheral areas of the Waikato DHB region, such as the Coromandel, Taumarunui/Ruapehu, and both eastern and western parts of the region. On the other hand, high levels of health need are projected to be clustered in the southern Coromandel and the rural area between Putaruru and Tokoroa. These results displayed in *Figure 8.6* suggest that projected clusters of spatial accessibility and health need are likely to reflect Hart's (1971) inverse care law, as the areas with clusters of the highest health needs are also expected to have low spatial accessibility to GP services.

Table 8.3: Moran's I indicator of spatial clustering for projected accessibility scores (under Scenario 2) and age in 2038 and 2043

Projected measure	Spatial Access 2038	Spatial Access 2043	Age 2038	Age 2043
Moran's *I*	0.601**	0.951**	0.349**	0.335**

*p≤0.05   **p≤0.01

NB: Higher Moran's *I* indicates greater spatial clustering, suggesting that similar values are located near to each other.

Figure 8.7 displays the proportion of the population in each Territorial Authority (TA) which is projected to identify as Māori between 2013 and 2038. This indicates that by 2038, more than 50% of the residents of Waitomo and Ruapehu Districts, in the southwest of the Waikato DHB region, are projected to identify as Māori. *Figures 8.2, 8.3 and 8.4* indicate that by 2038 these areas are likely to be in the bottom quintile of spatial accessibility scores, are likely to have only had small increases in spatial accessibility since 2013, and are likely to have had a 10-20 percentage point increase in the proportion of the population aged under 5 years or over 65 years. This suggest that regions with a higher proportion of Māori residents are likely to have increased population demand for GP services, while the level of supply is unlikely to substantially increase.

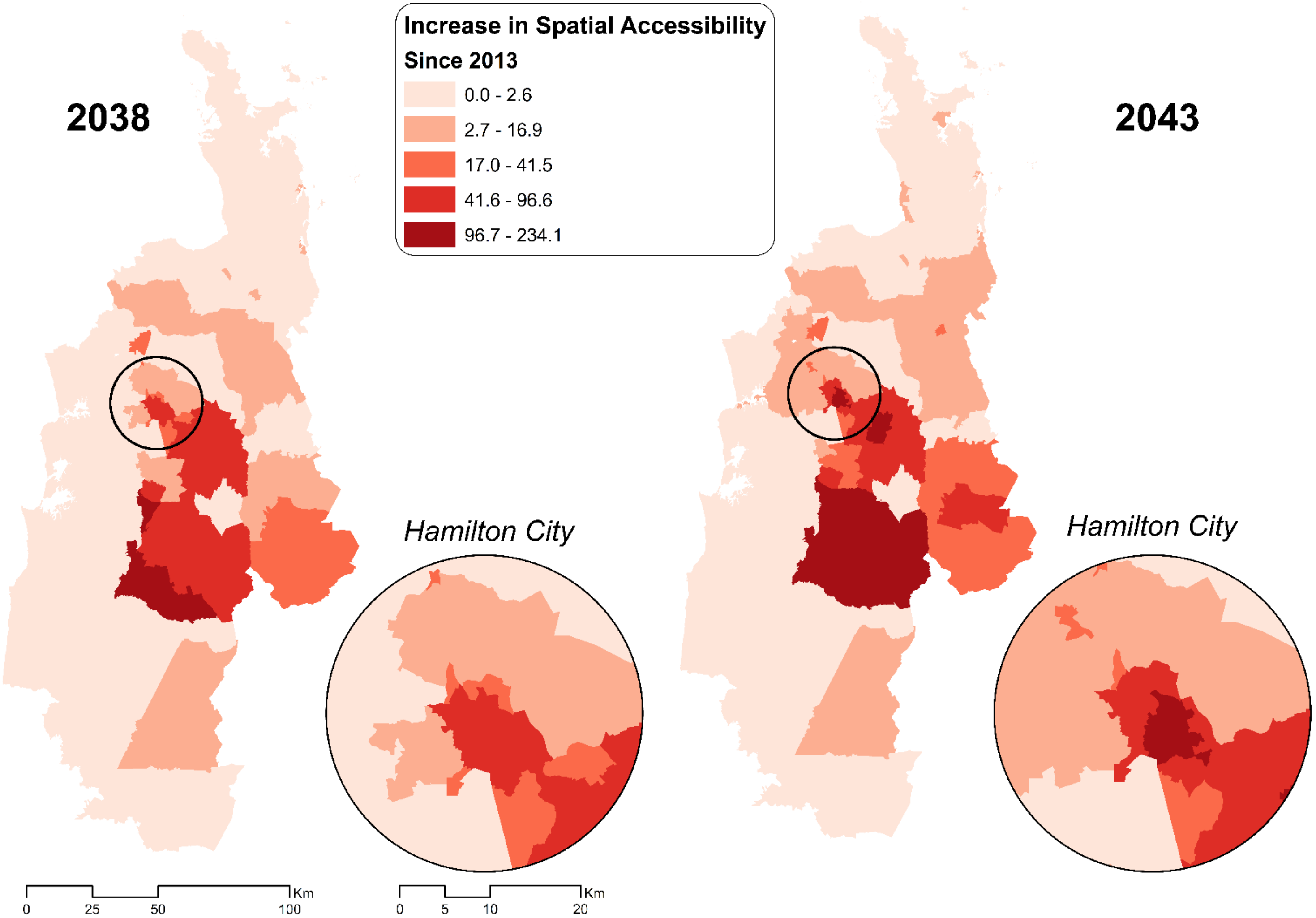

Figure 8.4 Changes in the spatial accessibility of GP services in the Waikato DHB region from 2013 baseline levels to projected 2038 and 2043 levels under Scenario 2

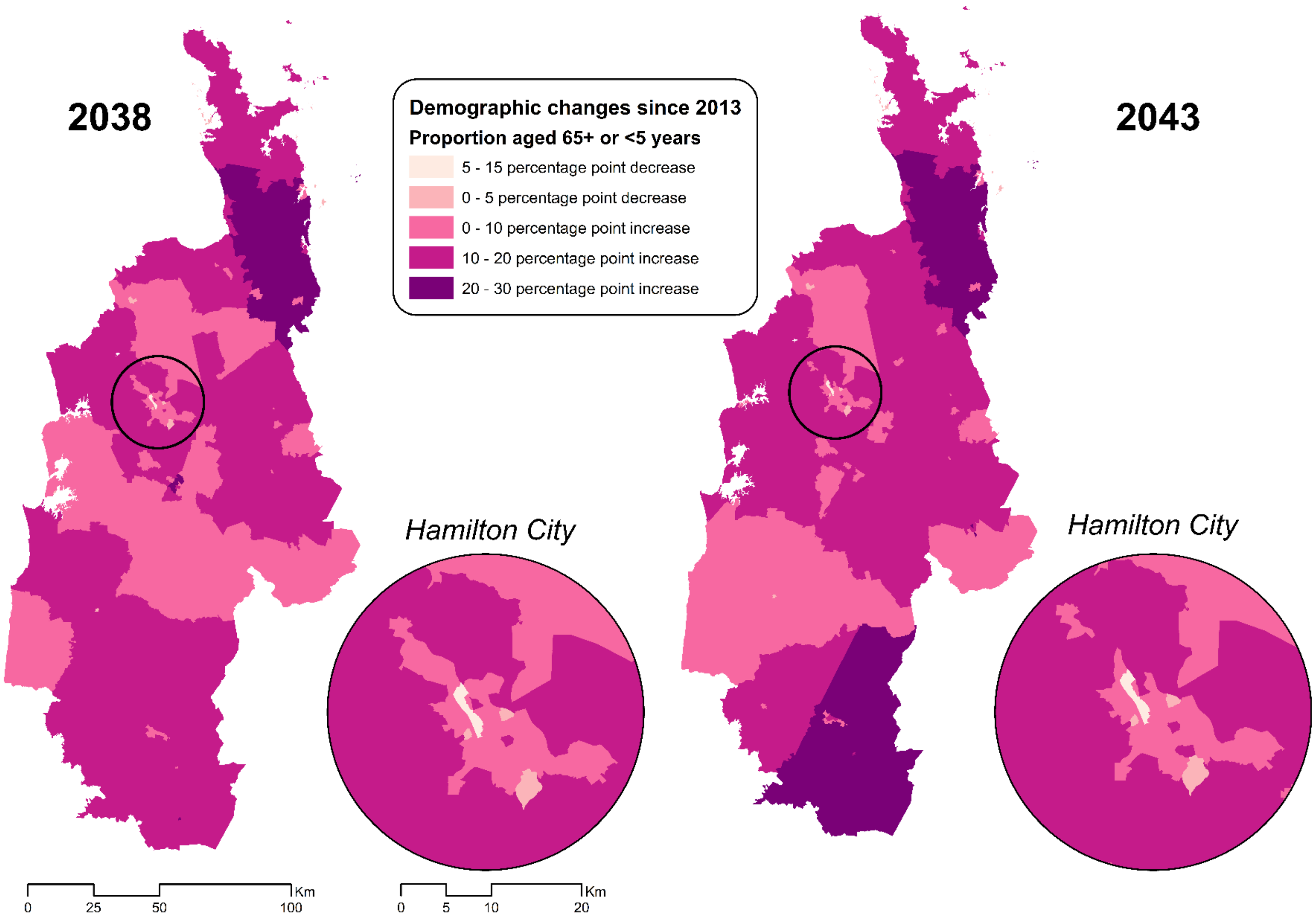

Figure 8.5. Projected demographic changes in the Waikato DHB region. The percentage point change from the 2013 baseline in the proportion of residents aged 0-4 years or 65 years and older

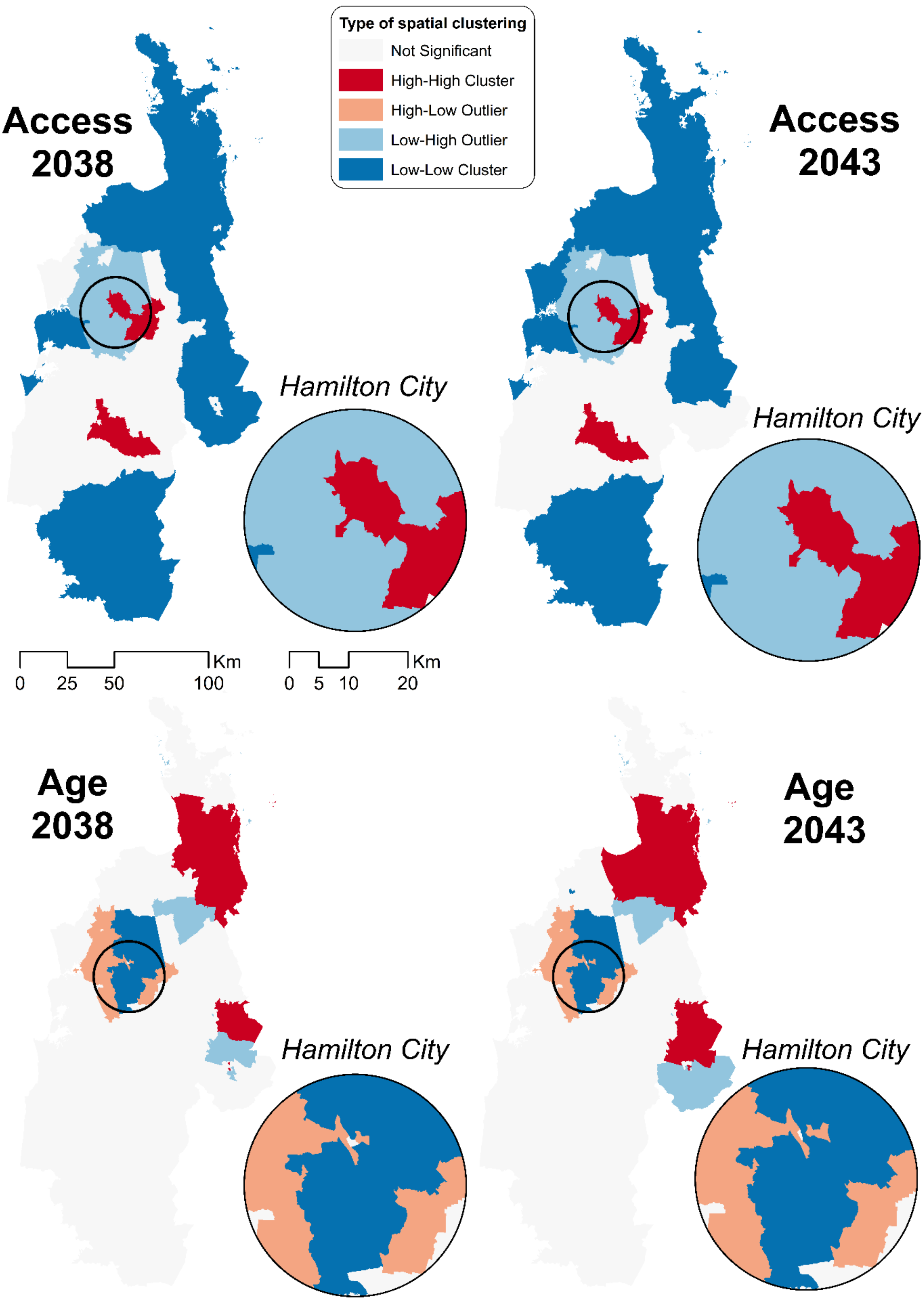

Figure 8.6 The projected spatial clustering of access and age in the Waikato DHB regionin 2038 and 2043

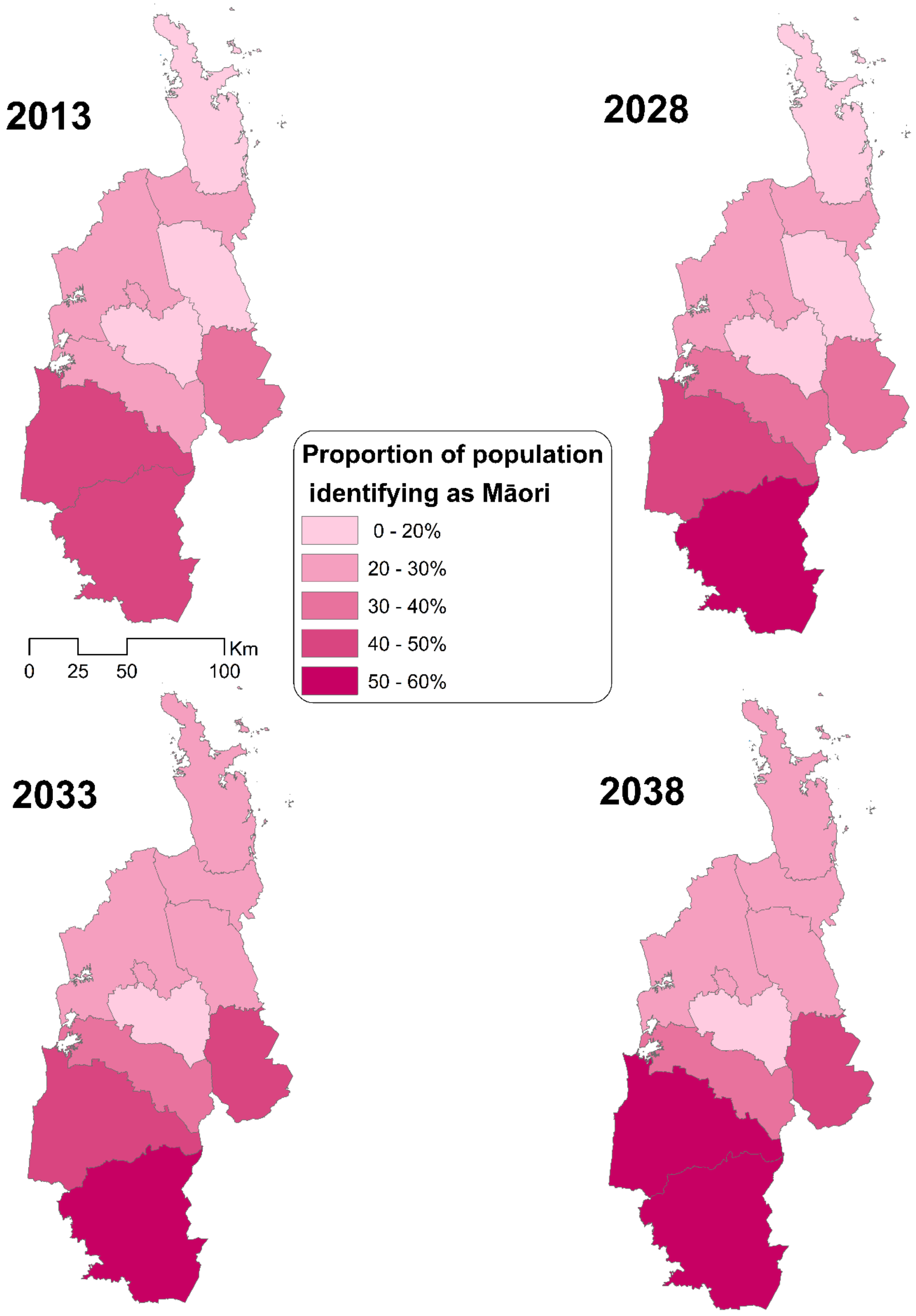

Figure 8.7 The proportion of each Territorial Authority population in the Waikato DHB that is projected to identify as Māori

8.3.2 Qualitative results

Although participants expressed uncertainty about what the future of primary care might look like, they indicated that, in their current format, GP services in the Waikato DHB region were unsustainable. Four overarching themes surrounding GP sustainability were discerned from the interview transcripts: professional, economic, organisational, and social. These themes align with dimensions of GP sustainability outlined by Humphreys et al. (2006). Key themes, sub themes and their components, as well as overarching macro structures and local health landscapes are outlined in the framework depicted in *Figure 8.8,* and discussed in detail below.

8.3.4 Professional theme

"Look it all comes down to workforce and we've been very poor at planning" – H, PHO

Interviewees highlighted workforce issues in the professional domain as a primary cause of poor sustainability. These were grouped into three sub-themes. First, participants described issues around the GP workforce, in particular the challenges of GP retirement, recruitment, and the training of the future GP workforce. The most significant issue identified by participants was around the current, ageing, GP workforce, of whom a large proportion are likely to retire in the near future. Current workforce shortages are likely to be exacerbated and participants identified that the number of medical trainees choosing to become GPs has been decreasing over time.

"There's not enough people coming in at the bottom to deal with people leaving at the top" - P, GP

Participants identified training as an area to improve the future sustainability of GP services. While an increased number of training places would likely lead to a higher number of medical graduates working as GPs, participants also stressed the importance of getting the 'right kinds of people' to become GPs. Most interviewees agreed that training people, from different backgrounds, with links to different towns in the Waikato region would strengthen the workforce in many places where recruitment and retention have been difficult. Improving the mentorship of medical students and recent graduates, as well as ongoing workforce development were also highlighted as routes to improve workforce sustainability.

"it's key to look at growing the workforce from within the community itself" – J, GP

There was also recognition of the importance of the wider health workforce, including nurses, kaiāwhina, pharmacists, and health care assistants, in supporting the sustainability of GP services. Participants highlighted that with changing models of care, nurses in particular are able to take on more complex tasks as part of their scope of practice, and that this can increase the efficiency and sustainability of 'health teams' working within GP clinics. Many participants suggested that, in the future, 'health teams' in a single practice might consist of one GP, three nurse practitioners and several nurses.

The broader working conditions of GP and other health workers within GP services were widely discussed and identified by participants as a key factor in the sustainability of the GP workforce. These conditions were noted as important in both attracting new medical graduates, and retaining the current workforce. Three main aspects of working conditions were identified: (1) financial aspects, such as differences between GP and specialist salaries, and the lack of a hierarchical scale in general practice – meaning that recent graduates and experienced doctors are paid the same; (2) the scope of practice, including increasing expectations from patients, the burden of afterhours commitments and administrative work; and (3) supportive environments, including the importance of good relationships with co-workers and professional development opportunities.

"Part of sustainability is knowing that you can work collegially with people so that makes your day to day job less difficult" – P, GP

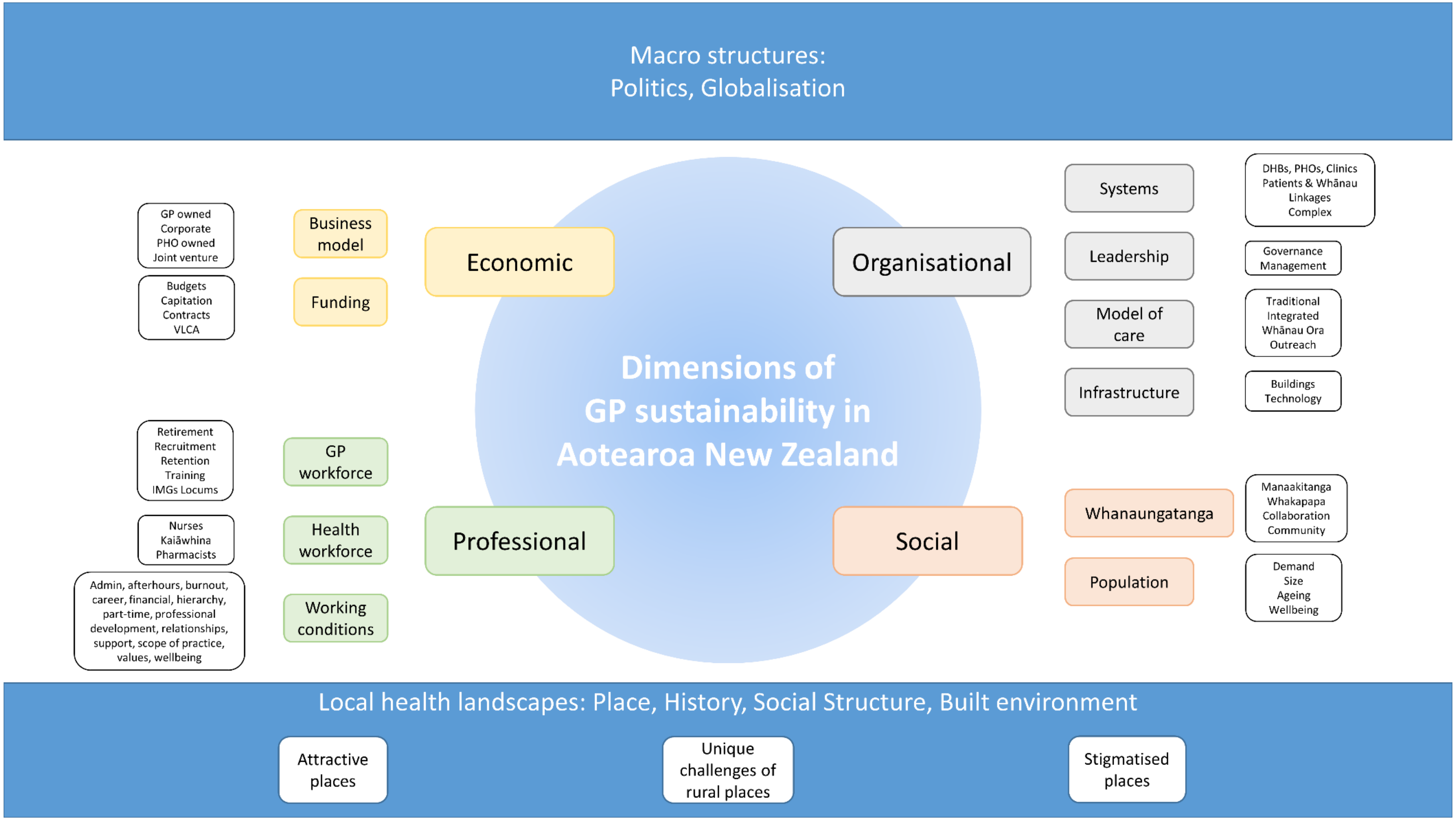

Figure 8.8 Dimensions of GP sustainability in New Zealand discussed by interview participants

NB: whanaungatanga refers to relationships developed through shared experiences and working together which provide people with a sense of belonging; Whānau is extended family; Manaakitanga is hospitality, kindness, generosity, support – the process of showing respect, generosity and care for others; whakapapa refers to genealogy, lineage, or descent; Kaiāwhina are a non-regulated health workforce that empower health consumers using a holistic strengths-based approach in a wide range of roles.

8.3.5 Economic theme

The business models and funding arrangements of GP services were identified by participants as key economic aspects that influence sustainability. Participants discussed four main types of business models. Several participants suggested that the 'traditional' GP-owner-operator business model was not likely to be sustainable in the long-term. Several factors were highlighted as weaknesses of the GP-owned business model, including:

- High costs of buying into practices for young GPs
- Changing attitudes to full time work – with an increasingly part-time and sessional workforce
- Difficulty running a profitable model for small populations
- Challenges for retiring GPs wanting to sell their businesses.

However, others argued that there would always be some interest in GP-ownership and that this model would never cease to exist entirely. Increased engagement in and long-term commitment to communities, higher motivation to improve business practices, and larger potential profits for owners were identified as strengths of GP-ownership. Some participants also suggested that while GP-owned practices were still privately run for profit, this was preferable to corporate business models. Many interviewees expressed concern about the *"corporatisation wave occurring across general practice in New Zealand" (J, PHO),* suggesting that their motivations for becoming involved in the delivery of health care were profit-driven and that this could come at the expense of patients' health and wellbeing. It was also noted that, while corporate entities were purchasing many practices in New Zealand, this tended to be concentrated in urban centres and they had shown very little interest in buying rural practices – possibly because of the smaller profits to be made. One participant even suggested that *"you can't do health on a corporate basis in a rural community, you just can't" (W, GP)*. However, some interviewees did note that corporate ownership could mean the more efficient and effective management of practices at scale, and shared infrastructure, which could lead to improved sustainability. PHO-owned business models were discussed by participants as an alternative business model. Non-profit organisations such as PHOs that share management and infrastructure, at scale, can improve sustainability – particularly for smaller practices that might not be financially viable alone. Interviewees suggested that this business model could also work when there was nobody willing to buy a practice, but salaried staff could be found.

Finally, participants outlined joint ventures – or shared GP ownership – as another business model. It was suggested that this model could be more attractive for young doctors, as the start-up costs were not as large as buying a whole practice outright, and the practice didn't need to be sold when a GP was ready to retire. Furthermore, joint owners could all have a say in how the practice was run and could also draw a share of the profits while they are working there.

Participants also discussed four main issues with funding arrangements that impact the sustainability of GP services: budgets, capitation, funding contracts, and Very Low Cost Access (VLCA) funding. Interviewees discussed the challenges of DHBs working with a limited budget from the Ministry of Health to deliver both essential hospital-based services, and invest in community health promotion and prevention through primary care services. This tension was highlighted as a reason for the underinvestment in primary care, which was also described as inevitably leading to increased demand for hospital services, and therefore threatening the sustainability of the health system as a whole.

> *"we all know that general practice or primary care gets the crumbs after the hospitals have sucked up the majority of it. So it needs to be turned on its head" – H, PHO*

While participants recognised that capitation-based funding had played an important role in developing the current primary care system, several sustainability risks were identified. Participants suggested that capitation funding limited the sustainability of services in places with small populations. Importantly, participants also argued that funding by capitation could decrease the quality of services, as it meant that clinics were incentivised to enrol as many patients as possible. Unscrupulous clinics could provide minimal services with large waiting lists and be funded at the same level. While individual practices might make a profit, the health of patients would suffer, and demand would need to be met by other parts of the health system – often through hospitalisations for preventable conditions. Participants also discussed how funding contracts could impact upon the sustainability of services. Interviewees argued that competitive contracts for services disrupted the ability for PHOs to plan systematically. Others suggested that funding contracts could drive the way that services were delivered, as most contracts were predicated on a GP-patient relationship, and failed to adequately recognise the critical role of nurses and other health workers. It was argued that, therefore, funding contracts needed to be more flexible to improve sustainability as the model of care that GP services use changes to meet patient demand. Some participants argued that contracts for 24/7 care could damage the sustainability of rural clinics, as it places increased pressure on staff, especially since rural funding has not increased for several years. Furthermore, it was argued that the poor funding and level of recognition of community-driven solutions is a threat to sustainability. This undervalues the contribution of communities to improved health services, and risks excluding them from planning processes. Participants discussed how the targeting of VLCA funding to clinics rather than patients created challenges for both low-income patients and clinics that were not eligible for VLCA funding but still served low-income patients.

8.3.6 Organisational theme

Within the organisational theme, participants discussed several topics including: models of care; systems; infrastructure; and leadership.

Models of care were described as an important factor influencing the sustainability of GP services. Many participants indicated that the traditional, GP-led model of care, predicated on a one-to-one relationship between GPs and patients, was difficult to sustain as the scope of general practice was widens and younger GPs are less likely to find this style of working attractive. Participants indicated that more integrated models of care were likely to improve the sustainability of GP services. Integrated models, that offered a range of services and utilised the skills of nurse practitioners, support nurses, health care assistants, clinical pharmacists, kaiāwhina, mental health and social workers were also highlighted as a better way to improve the health of communities. It was suggested that patients also expected a range of different interactions with their primary care services, including telephone consultations, email communication, group meetings and so on, rather than being limited to traditional face-to-face consultations with GPs. Participants also highlighted the importance of Whānau Ora style services that take a much wider, holistic view of health and wellbeing and support individuals and whānau to become well, while building their capability and leadership skills. It was argued that an expansion of these services would be a significant step forward, albeit an expensive one. However, participants argued that investing in preventative, early intervention approaches would have a significant impact on the sustainability of GP and primary care services by improving population health and wellbeing, leading to decreased demand for services. Finally, participants also suggested that in some cases, when communities were too small to support a service of their own, outreach models of care were important ways to serve populations in need.

Interviewees talked about how systems can influence the sustainability of GP services. Tensions between the objectives and processes of the DHB, PHOs and individual clinics within the Waikato region were highlighted as a barrier to sustainability. While collaboration has the potential to improve sustainability through joined-up and systematic planning, the fragmentation of the primary care system meant that organisations were often competing for funding rather than working together. Furthermore, the lack of linkages between different levels of the primary care system, and between primary, secondary, and tertiary care decreased accessibility for patients and the long-term sustainability of primary care. For instance, one participant argued that the closure of small rural hospitals has increased demand for local primary care services, forcing patients to travel further to centralised services. Participants also suggested that while the issues affecting populations with high health needs were so complex and systemic that primary care could not solve them alone, patients and whānau should be better included in the planning process to develop patient and whānau centred systems. Finally, participants highlighted an overall lack of systems thinking and planning as a risk to sustainability, as the best actions from a systems sustainability perspective were noted to not always be the cheapest, most efficient, or most profitable for individual clinicians or organisations to take. This discussion recognised one of the fundamental tensions in New Zealand's public-private-partnership system of GP services, where the values of capitalist neoliberalism and the state-based provision of services do not always align.

Infrastructure was discussed by participants as both an enabler of and a constraint upon service sustainability. Physical buildings were identified as a constraint on sustainability when poor planning for future population growth meant that practices were too small, and the physical infrastructure for services could not be increased to meet population demand.

The high costs of building ownership were seen to act as a barrier for younger GPs wanting to own practices, and also meant that many clinics were dependent on their landlords. Participants also highlighted the fact that much of the capital investment in GP services is privately owned – the IT systems, the buildings, and staff – and that these decisions are not made by the private system. This again highlighted the tensions in the public-private partnership around GP services that are often privately run for profit, but are also partially funded with public money. The growth of technology in GP services was also identified as a key factor in future sustainability. While participants outlined the positive aspects of technology filling gaps through telehealth, and the potential for tech-driven diagnostics and precision healthcare in the future, there was wide recognition of the limitations of technology. Rural areas in particular were described as particularly limited in the use of technological health care delivery systems due to poor quality, and unstable internet access. Stakeholders also described that many populations and clinicians were not yet willing or able to embrace technology.

A lack of leadership and coordination in primary care was highlighted by participants as a risk to sustainability. While participants argued that many communities were proactive in identifying workforce shortages and acting to support their own community members to become health professionals, or advocate for improved services in their areas, they also noted that community and whānau are generally excluded from planning and decision-making processes. Furthermore, a system-wide approach and primary care leadership are lacking, resulting in an ad hoc approach which means some communities have very sustainable services, while others could be without services altogether if one GP decided to retire.

8.3.7 Social theme

Participants portrayed whanaungatanga and populations as key social factors that act as a crosscutting domain of sustainability. Many interviewees described relationship building and reciprocity as essential components of any sustainable health service, but argued that whanaungatanga is particularly important for general practice. The relationship between clinicians and patients not only attracts doctors to specialise in general practice, but is key to the long-term success and sustainability of clinics. Building trust with patients was highlighted as a key factor in enabling patients to seek health care when needed, and become empowered in managing their own health. Māori GPs highlighted the importance of the terms and the meaning of whanaungatanga, manaakitanga and making patients feel valued as an indispensable part of their practice and identity.

"…as a Māori doctor being able to provide that which is just a part of our own culture, which is being mutually respectful to one another – Manaakitanga" – J, GP

The importance of whakapapa was also described as a key factor in attracting Māori doctors, nurses, and other health professionals to work outside of the main urban centres. Participants described the choice of returning to their hometowns to work for the benefit of their community and help to achieve community aspirations of good health. The relationships between different components of the primary care system were also an important determinant of sustainability. While respectful relationships between GPs, Clinics, PHOs, and the DHB could facilitate sustainability, dysfunctional relationships were described as a significant barrier. Participants suggested that there should be more incentives to collaborate across organisations. GPs argued that being able to rely on colleagues improved service sustainability as workloads could be shared and services could become more efficient. Interviewees also highlighted the importance of relationships in training and career development, and suggested that good mentorship could strengthen the future workforce.

Patient representatives suggested that they wanted GPs and nurses to be more involved in their community and help to build relationships and networks between patients so that they could support each other in their wellness journeys. The relationship between services and the community was described as having both a positive and negative influence on sustainability. On the positive side, many communities were leading efforts to improve the sustainability of their health services and encouraged workforce development from within the community. Having strong collective aspirations and a drive for solutions, as well as a community plan were seen as important drivers of sustainability. Furthermore, a supportive community was seen as having an important influence on the wellbeing and job satisfaction of GPs who would then be more likely to stay in their role for longer, improving the health of the community and service sustainability. Several participants identified the reciprocal role between the health and wellbeing of patients and doctors, and the sustainability of services.

"*…doctors often stress out, they burn themselves out, they either leave practicing or move on to other places…and GPs that are under pressure means that patients don't get looked after well…but in terms of sustainability it's making sure that the [GPs] we've got now are well looked after"* – J, Patient

"*[we need to] …help support the collective drive and dream for the community – which is always wellness in any form"* – J, GP

On the negative side, it was recognised that many communities were limited in what they could do to support practices and encourage the sustainability of services. Communities were described as facing a wide range of challenges, from housing and education to employment, and as often excluded from higher level planning processes. Communities that are not empowered find it very difficult to effectively influence change and advocate for themselves in GP services.

Demographic changes at a population level were also identified as a key element of GP service sustainability. Participants expected the demand for GP services to increase in the future as a result of increased population size, ageing, changes to the ethnic composition of the Waikato region's population, and higher expectations from patients around the type and quality of care they receive.

"Demand's always going to increase. The demand for primary care is going to go exponential, like it already is" – L, Patient

Participants recognised that both growing and shrinking populations pose a challenge to sustainability. Larger populations require a larger health workforce, while running a GP service for small, isolated towns may not be economically viable. It was also argued that demand for services is likely to increase as populations age and that this will pose a significant challenge to sustainability since much of the GP workforce is also ageing and approaching retirement. Interviewees also suggested that the projected increase in the Waikato region's Māori and Pacific population would lead to an increased demand for services, even in areas where the total population may decline. Participants proposed that demographic changes were likely to not only affect sustainability but also the equity of services. Many places projected to have declining total populations, and potentially face reductions in services, were also likely to have a higher proportion of elderly, young children, and Māori. Markham and Doran (2015) argue that while 'bureaucratic' decision making in health care is purported to be non-biased and based on improving efficiency, the end result is often still ethnic-based inequities in service access. Participants recognised the association between inequitable services and poor sustainability and highlighted the importance of improving the sustainability of services by increasing equity. Increasing and improving services for Māori and Pacific patients, and in areas of high need, through more holistic, wellbeing focused, preventative care was seen as an important way to improve equity and sustainability. Doing so was described as improving overall population wellbeing and health equity, decreasing demand, and improving sustainability.

8.3.8 Structural factors that influence the sustainability of GP services

All four dimensions of sustainability are influenced by both macro-level structures, such as politics and globalisation, and micro-level local health landscapes which consider the importance of place, history, social structure, and the built environment. The influence of politics on the sustainability of health services, and rural primary care in particular, is well documented in the research literature (Buykx et al., 2012; Humphreys et al., 2008; Loh et al., 2015; London, 2002; Murdoch, 2010; Rees et al., 2018; Schoo et al., 2016; Wakerman & Humphreys, 2011). Interview participants also discussed how dimensions of sustainability are affected by politics. Frustration was expressed about the 'sweeping changes' to strategic direction and funding priorities that can occur when governments change, which makes building a stable and sustainable health system difficult.

"Literally overnight you couldn't use the words 'health inequalities' in certain documents anymore.' – P, GP

Fundamentally, interviewees argued that the size of the overall health budget is a political decision which in turn determines the overall level of funding for the health system and consequentially local primary care services. The political ideology of the government plays a key role in whether more money is spent on primary health care, or whether funding is cut for so-called 'non-essential' services. Participants argued that these decisions were not always based on what was best for the health system and patients, but rather what gave politicians the greatest chance of being re-elected. Participants also argued that changes to funding arrangements could have unintended consequences. For instance, free, or reduced-fee GP visits are aimed at improving accessibility for low income and vulnerable populations. However, this may result in increased service utilisation, which without appropriate support for the health workforce could make burnout more likely and reduce workforce sustainability. Participants highlighted the underlying tension in the public-private partnership that defines GP services. Most GP clinics are privately run, with capital such as buildings, IT systems, and medical equipment being privately owned, and patients almost always being charged a co-payment fee. On the other hand, capitation payments represent financial support from the government. However, the government, and DHBs have limited influence in determining what kinds of GP services are provided where, and the distribution and delivery of primary care services is often left to be determined by market forces. Furthermore, while participants recognised the importance of a strong relationship between the government, health organisations, services, and iwi, it was argued that building these relationships was difficult, took time and could be affected by the prevailing political climate.

Participants discussed the growing influence of international organisations providing corporate-style healthcare overseas and in New Zealand, highlighting that processes of globalisation can impact the sustainability of GP services. Interviewees suggested that technological innovations such as telehealth, and app-based healthcare services can increase patient choice and accessibility. However, unless such advancements are adopted by GP services, they could be a direct threat to the sustainability of traditional models of care. Furthermore, the globalisation of the health workforce is another potential threat to sustainability. Participants suggested that medical graduates from New Zealand may be attracted overseas to earn higher wages in Australia and the UK, exacerbating current workforce shortages. Conversely, International Medical Graduates (IMGs) who have been trained overseas often practice in hard-to-staff rural areas, often making important long-term contributions to health services in these areas. However, interviewees emphasised that new IMGs can require high levels of community support, and that patients may need additional time to form trusting relationships with IMGs. These issues were described as additional challenges, particularly if IMGs do not stay in communities long-term.

Participants alluded to the importance of local health landscapes. These are places where the complex layers of history, social structure and the built environment come together (Kearns & Moon, 2002). Participants discussed how the attractiveness of some places, the stigma associated with others, and the unique challenges of rural places can all impact the sustainability of GP services. The lifestyle opportunities and natural beauty afforded by some places within the Waikato DHB region were identified as attractive features for GPs and the health workforce, despite other limitations such as isolation and population size. Attractive places were seen as more likely to have sustainable GP services as they did not experience workforce shortages and were likely to continue being seen as a desirable working environment. In contrast, interviewees acknowledged that unattractive places tended to exacerbate other challenges to sustainability, as it was more difficult to recruit the health workforce.

"[They] are never going to struggle because it provides a good lifestyle option, and attractive place." - S, GP

"People don't want to live in those places…why would you?" – P, GP

However, participants also argued that place-based-stigma can exacerbate sustainability challenges. External perceptions of certain communities were highlighted as an additional barrier to attracting the health workforce.

"No one wants to come [here], you know? There's been an unfair reputation placed on us and that's through the media and certain activities that have happened here previously…it seems to overshadow the other 97% of just awesomeness that we have here" – A, Patient

While some rural locations were considered desirable and others unattractive, many participants described the unique challenges to sustainability that rural places face. Geographical isolation has an impact on all four domains of sustainability: infrastructure such as medical technology and high-quality internet is often insufficient; small, isolated populations often living in areas of high socioeconomic deprivation can create a challenging social and economic environment; geographic isolation limits opportunities for collegial support and collaboration, increasing the burden of responsibility on rural GPs.

"Gnarly stuff happens here, and there's no nurses, there's no paramedics, nothing. You're it. So that's not sustainable" – F, GP.

Interviewees also described the important role that history plays in influencing the health and wellbeing of populations, which in turn affects the sustainability of services. Colonisation systematically and intentionally disempowered Māori across the Waikato region, through violence, land confiscation and cultural alienation. Participants explained how this history of violence and oppression is embodied in current health outcomes and inequities, and results in intergenerational disempowerment. Participants suggested that, without addressing these fundamental causes of poor health, through holistic, preventative, wellbeing-based primary healthcare, inequities will persist and demand for services will remain high. Interviewees also argued that clinicians should be aware of and responsive to both the current and historical social contexts of the places they work in. Providing services that are culturally safe and empower individuals and whānau to become leaders of their own health journeys will enhance equity and sustainability. The improved wellbeing of patients with chronic health issues, and the wider community, will not only increase health equity but also sustainability as the pressure on GP services declines.

8.4 Discussion

8.4.1 Key findings

Several key findings emerge from this mixed-methods investigation of GP service sustainability in the Waikato region. The results of our geospatial quantitative analysis suggest that the current configuration of GP services is not sustainable in the long-term. Apart from under Scenario 1, average levels of spatial accessibility were projected to increase at each time-point in the study period. However, improved access is strongly focussed in Hamilton city and the Waipā and Te Kūiti areas - places that are already in the top two quintiles of spatial accessibility. While the equality of the distribution of GP services was also projected to slightly increase under all scenarios except 3B, this result should be interpreted cautiously. Although the Gini coefficient can indicate that a distribution of accessibility is likely to become more equal, it does not specify how that increased equality might be achieved or who will benefit from the projected distribution of resources. *Figure 8.3* displays changes in spatial accessibility scores from 2013 baseline to the projected 2038 and 2043 levels under Scenario 2, and indicates that increases in spatial accessibility for parts of Hamilton city and Waipā are projected to be between 37 and 234 times higher than peripheral parts of the Waikato DHB region, which *Figure 8.2* shows currently has poor spatial accessibility. Hamilton city and the Waipā area have relatively large populations, and therefore increased accessibility in these areas will lead to improved access to GP services for a significant proportion of the population, which means that the Gini coefficient will reduce. However, this ignores the fact that the areas with the best access to services at baseline are projected to benefit the most from changes to the levels of population demand and health workforce supply, while areas with the worst access to GP clinics will see little to no improvement in their access. Failing to address this distribution risks entrenching and exacerbating current inequities. Furthermore, our analysis suggest that future services are not likely to be spatially equitable given the projected distributions of health need. Statistically significant clustering of projected accessibility scores and health needs were not aligned spatially. Additionally, regions that are projected to have a high proportion of Māori residents were also expected to have low spatial accessibility and an increase in the proportion of the population aged under 5 years or over 65 years. In theory, initiatives from national government, DHBs, or PHOs could be used to target workforce increases in specific areas. The impact of four simulated scenarios was tested. While targeted workforce growth of 20% for selected clinics would improve access for some populations and regions, the overall results suggest that, compared to a 'default' or market-led situation (Scenario 2), they would not have a statistically significant impact on projected spatial accessibility scores. Most AUs also remained in the same spatial accessibility quintile under all four simulated scenarios. Moreover, the impact on spatial equity for the entire Waikato DHB region would be minimal, with only minor reductions in the Gini coefficient under all scenarios. These results suggest that other initiatives, such as more drastic workforce increases, the adoption of new models of care, or the addition of new primary health clinics in underserved areas is needed to address issues of ongoing spatial equity and sustainability. Therefore, our quantitative analysis suggests that GP services in the Waikato DHB region are not sustainable. Our analysis builds upon the work of Hara, Kunisawa, Sasaki, and Imanaka (2018b), who examined the projected future physician workforce in Japan. While they found that geographic inequities in physician distribution were likely to increase, their approach did not include any analysis of spatial accessibility.

The qualitative component of our analysis outlined the key dimensions and factors related to the sustainability of GP services in the Waikato as discussed by our research participants, and provides important context to the GIS analyses. Our qualitative data confirms that that factors outlined in the Australian and US research literature such as increasing population demand, workforce supply and retention, government policy, funding, infrastructure, organisation, rurality, and community factors (Buykx et al., 2012; Humphreys et al., 2006; Humphreys et al., 2008; Hunsaker & Kantayya, 2010) are also important components of GP service sustainability in the Waikato context. Our novel sustainability framework expands upon previous research by identifying additional factors that are important for the Waikato context, and are also likely to be important in other mixed-urban-rural regions of New Zealand. While our framework has similarities with the four dimensions of rural GP viability outlined by Humphreys et al. (2006), there are some important differences. Within the economic dimension, our framework has a specific focus on the impact of different ownership models on the sustainability of GP services. This recognises the context of primary health care delivery in New Zealand, and recognises that there are multiple ways of navigating the 'public-private-partnership' to ensure the economic viability of GP services. Different ownership models may also be more sustainable in particular contexts, as practices in small, communities face different economic pressures than those in urban centres. Within the professional domain, our framework includes a broader range of factors than the description of Humphreys et al. (2006) who primarily focus on the number of GPs. Our framework also includes the increasing influence of the non-GP health workforce, and working conditions. Including these factors in the professional domain of our framework shifts attention to the importance of creating positive and supportive working environments, as well as improved integration of the wider health workforce. Within the organisational domain the Humphreys et al. (2006) model is limited to practice level infrastructure. Our framework also considers organisational factors from the system linkages between DHBs, PHOs, clinics and individual GPs, as well as leadership factors. Our framework also recognises that different models of care can impact the sustainability of GP services by both making effective use of the limited number of health professionals, and improving the health and wellbeing of populations to decrease the level of demand for health services. In the social dimension Humphreys et al. (2006) recognise the importance of community services, facilities, and the attractiveness of places (e.g. educational opportunities, commercial and cultural facilities). However, our framework also emphasises the importance of relationships as a key aspect of sustainability. This includes the importance of reciprocal relationships with community, also recognised by Farmer, Prior, and Taylor (2012) regarding the health services contribution to the sustainability of rural communities. The sustainability framework described here also includes the importance of both intra- and interdisciplinary professional collaboration within the health system, which are key to developing effective and patient-centred health care (Schoo et al., 2016). Schoo et al. (2016) also argue that social capital and social relations are critical to effective rural health services, and suggest that health professionals can play a greater role in fostering community connections and developing social capital, leading to improved equity and sustainability of health services. Furthermore, our framework recognises the importance of population characteristics, such as the population size and level of demand for services, as a key driver of sustainability. We also recognise that macro structures and higher-level forces such as politics and globalisation influence power structures and economic conditions, and can either enhance or constrain the possibilities for sustainable health services. For instance, our participants highlighted the importance of politics in influencing the kinds of health policies that are developed around primary health care and GP service delivery. Wakerman et al. (2019) also recognise the importance of policies in ensuring the sustainability of the Australian rural health workforce. In particular, they argue that policies should: encourage collaboration across sectors to ensure a fit-for-purpose workforce; fund equitably; prioritise indigenous training and employment, mandate culturally safe work environments, and facilitate transition to community control; and provide opportunities for flexible working conditions. In terms of environmental characteristics, our framework expands on Humphreys et al. (2006) to consider not only location and attractiveness, but recognise that history, social structure, stigma and built environments come together in health care landscapes (Kearns & Moon, 2002) that impact the sustainability of services differently in different places. This is an important addition, since “places are not bounded geographical units, abritrarily created and independent of social order. Rather they are ‘meeting’ places of networks of interdependent local, national and global forces” (Pawson & Scott, 1992, p. 375). In order to understand the sustainability of health services, we must recognise the underlying unequal development of New Zealand’s rural communities, which (Pomeroy, 2019) argues has continued from colonisation through to the cementing of structural inequalities with neo-liberalisation in the 1980s. Rural towns have always been vulnerable to global pressures, and the erosion of state welfare support has had a direct impact on employment, economic opportunities, and the viability of many small towns (Pomeroy, 2019). The importance of place for sustainability is supported by recent literature, including: an analysis indicating the association between rural workforce supply and place-based factors such as coastal location, population size, an older and more educated population, and higher house prices; and a scoping review of the influence of place-based social processes in the retention of rural health workforce identifies rurality, social connection and integration, and community participation as key themes (Cosgrave, Malatzky, & Gillespie, 2019; McGrail et al., 2017). The findings of this research support Wakerman and Humphreys’ (2011, p. 121) assertion that “addressing workforce shortages alone without addressing other inter-related health system components is unlikely to improve [sustainability]”.

8.4.2 Limitations

The quantitative approach to GP sustainability in this paper is a novel application of the E2SFCA, and to our knowledge the first of its kind. However, it is important to interpret these results with caution as they are driven by projected changes to population size and linear increases in GP supply, and are also based on several assumptions. Firstly, it is assumed that the availability of services is appropriately represented by the number of GPs working in each clinic. While the full-time equivalent hours of each clinician, and the availability of nurses would give a more accurate measure of each clinic’s capacity to provide appointments with patients, this information was not available for all clinics. Secondly, it is assumed that the spatial distribution of GP clinics will remain the same, and the number of GPs will continue to increase at the same average yearly rate as the decade from 2001-2011. Estimating the future workforce distribution using this method assumes that places that have high numbers of GPs will increase more than those with low numbers. Although this may not happen, the decision was made to follow this approach as there is no publicly available spatial data at a sub-national level on either the retirement intentions of current GPs, or the career intentions of current medical students. At a national scale, research from The Royal New Zealand College of General Practitioners (2015) suggests that a significant proportion of current GPs are intending to retire – and that this is likely to disproportionately affect rural areas of New Zealand where GPs tend to be older. Analysis of New Zealand medical student career intentions by Seleq et al. (2019) indicates that general practice is the preferred specialty of only 20.7% of current students, which is insufficient interest to meet future workforce needs. Data analysed by The New Zealand Medical Schools Outcome Database Steering Group (2019) also indicates that 86% of medical students indicate a preference for working in a major city (population >100,000) or regional centre (population 25,000-100,000), with only 4.9% planning to work in small communities of less than 10,000 residents. Furthermore, the demographic changes and challenges of population ageing that affect New Zealand as a whole are also likely to impact on the health workforce. In Australia, it has been suggested that demographic changes will result in a smaller workforce overall, with fewer new graduates entering the workforce (Wakerman & Humphreys, 2013). These changes may represent more important and significant fluctuations in the GP workforce over time in the future. Therefore, our projected GP distribution could be an overestimation of the level of medical services available in the future, particularly for rural areas and small communities that are most likely to undergo structural ageing and appear to be the least attractive locations for medical students. The assumptions in our GIS model mean that results should be interpreted carefully. For example, increases in spatial accessibility in Hamilton city and Waipā are driven by a projected increase in the GP workforce in these areas that is larger than projected population growth. Increased accessibility in Te Kūiti however, is a due to a projected increase in the GP workforce combined with a projected decrease in population. In reality this situation is unlikely. Towns with small and declining populations are often unable to attract a health workforce as they are seen as economically unviable locations to practice in (Humphreys et al., 2006). Although it is more likely that Te Kūiti would see a reduction in the availability of GP services in the future, this has not been reflected in the GIS modelling and is a limitation of the data used in our approach.

Thirdly, our GIS model assumes a 'traditional' model of care, whereby GPs are the main health professional that patients interact with in primary care. This does not account for the increasing role of nurses, nurse practitioners, pharmacists, or kaiāwhina and other health professionals. A greater integration of these non-GP health professionals means that fewer GPs are needed in each clinic as patient care can be more effectively shared among a health care team. This integrated care team was found to be an important feature of sustainable GP services in our qualitative data. Due to a lack of available quantitative data, the implications of any potential increase in non-GP health workforce has not been incorporated into the GIS model, which may therefore underestimate accessibility in some areas. Thirdly, we have assumed accuracy of the Statistics New Zealand's medium level population projections from the 2013 census baseline and out to 2038. It is difficult to estimate the impact of unexpected international events such as increased climate change related migration from the Pacific, Brexit related migration from the UK, or the impact of a global infectious disease pandemic such as Covid-19, and these specific variables are unlikely to have been included in Statistics New Zealand 2013-base projections. However, the data used in this analysis is the most up to date available. Future research could be carried out with Statistics New Zealand population projections based on 2018 census data, which are yet to be released. A fourth limitation is that our GIS model of spatial accessibility did not include non-spatial aspects of access or sustainability. After-hours availability, Kaupapa Māori services, and the cost of appointments have been shown to be important factors in patient enrolment in GP services (Whitehead, Pearson, Lawrenson, & Atatoa Carr, 2019b), and their importance was reinforced by our participants' comments. Finally, it should also be noted that our analysis of spatial equity is based on a single indicator of health need – the proportion of residents aged either under 5 years old or 65 and older. Statistics New Zealand population projections include age group projections, therefore we were able to readily incorporate estimates of future health need into our GIS models of accessibility without additional analysis. Although examining a different health need indicator may have produced different results, our previous work on health need indicators for the Waikato DHB region (see Chapter 6) suggests that many indicators of need are strongly correlated. Age (proportion of residents aged 0-4 and 65+ years) was found to be strongly correlated with the rate of selected cancer and mortality, and was moderately correlated with rates of ambulatory sensitive hospitalisations and area level socioeconomic deprivation. Despite these limitations, this analysis is an important first step in attempting to quantify GP services at a sub-national scale. It also provides evidence of the likely future accessibility of services, and when interpreted alongside a detailed qualitative analysis could contribute to the improved equity and sustainability of GP services.

Other limitations relate to when the qualitative interviews were conducted, and national and international changes that have since taken place. For instance, interviews were conducted before government changes to funding arrangements in December 2018 which gave Community Services Card holders the same low fees as patients enrolled in VLCA clinics. At this stage it is unclear whether this initiative has improved access to GP appointments for low income New Zealanders. Another limitation is that the interviews were conducted before the COVID-19 pandemic occurred. During New Zealand's level 4 lockdown, most face-to-face primary care consultations were transferred to telehealth appointments in order to meet social distancing requirements. At this stage it is unclear whether the impact of COVID-19 has increased the use of telehealth services among GP clinics and patients. While increased use of and familiarity with telehealth has the potential to improve the long-term sustainability of primary health care, it may negatively impact health equity. Low income patients may be unable to afford high-quality internet connections, and rural communities are often unable to connect to fibre broadband infrastructure.

8.5 Conclusion

Our mixed-methods analysis indicates that GP services in the Waikato DHB region are not sustainable in the long-term, and while overall access to services is projected to improve, this will not be equitably distributed. These findings suggest that national initiatives to achieve health equity and honour Treaty of Waitangi commitments to protecting Māori health are likely to be hindered by ongoing spatial inequities in service delivery. We have also outlined four key dimensions of GP sustainability in the Waikato context, which we believe are broadly applicable to New Zealand. Novel components of our sustainability framework include: the importance of whanaungatanga to the social domain; the essential role that working conditions play in the professional domain; the importance of different models of care to the organisational domain; and the role that business models have in navigating New Zealand's public-private-partnership for the economic domain of sustainability. The mixed methods approach used in this research has allowed us to triangulate results from both quantitative GIS and qualitative interview analyses. Therefore, this research provides a deeper understanding of not just where services are likely to be unsustainable, but the reasons *why* this occurs. This research moves discussions of sustainability beyond solely considering levels of workforce supply and population demand. It also outlines important opportunities for service providers, PHOs, DHBs and policy makers to provide interventions that could improve sustainability. To our knowledge this work is the first of its kind in the New Zealand context and is an important first step to developing a deeper understanding of how the sustainability of GP services can be improved, at a sub-national level, in an equitable manner. Future research should aim to improve the equity of access to health care while ensuring that services are sustainable.

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Chapter 9: Discussion and conclusions

This thesis research has made a number of important methodological contributions and advancements to the fields of spatial equity and sustainability of health services. This thesis examined general practitioner (GP) services in the Waikato District Health Board (DHB) region of New Zealand, and aimed to identify not only *where* inequities exist, but *why* they occur and *how* they could be overcome. To address the overall aims of this research and associated sub questions, a mixed methods approach was used that combined quantitative geospatial techniques with a qualitative analysis of in-depth, semi-structured interviews. This chapter will discuss the: main research findings; methodological contributions; additional strengths; limitations; research implications; challenges and opportunities in spatial equity and sustainability research; and future research directions. Finally, a conclusion is provided.

9.1 Summary of findings and research contributions

In Chapter 2 a conceptual framework was outlined which described how the spatial equity and sustainability of health services can be assessed. This framework has been used to guide this body of research. Chapter 2 adapted and expanded upon the framework of spatial equity analysis for public transportation developed by Mortazavi and Akbarzadeh (2017). The three key steps in examining the spatial equity and sustainability of health services are to define, estimate and quantify spatial equity and sustainability. This framework provides a structure for examining the spatial equity and sustainability of GP services in a context where multiple definitions and measures of these concepts are used in the literature at different scales. Spatial equity and sustainability research was defined in Chapter 2 as "assessing whether the distribution of services is fair relative to population need, whether spatial equity is likely to be maintained over time, and how the distribution of GP services affects social groups differently". As there is no clear consensus on exactly how spatial equity should be defined and measured (Kunzmann, 1998; Neutens, 2015), it was determined that a systematic review was needed in order to reach a definition (Chapter 3).

Chapter 3 provided a detailed systematic review (n=75 studies) and summary of the range of definitions and measures of spatial equity used in the research literature. Four themes of definition were identified, with the most common type of definition being a "need-based distribution of resources". Within this theme, papers referred to either horizontal or vertical equity. Vertical equity represents service distributions that are unequal, but populations with higher needs receive appropriately higher resourcing (S. I. Wang & Yaung, 2013). Horizontal equity argues equal needs should be treated equally, and often assumes that need is equal across a population (Peacock, Devlin, & McGee, 1999). Within health services research vertical equity investigations using upstream measures of health need are more appropriate, since "…different resourcing is needed in order that different groups enjoy equitable health outcomes" (Reid & Robson, 2007, p. 4). The Gini coefficient was identified as the most common measure of spatial equity overall. However, this measure does have limitations as health systems with low Gini coefficients (indicating higher equality) may not actually improve health equity, as unfair differences in health outcomes are likely to be maintained. Spatial autocorrelation techniques were identified as the most common spatial equity measure among studies with a 'need-based' definition.

Chapters 4, 5 and 6 addressed the second step of applying the conceptual framework by estimating spatial equity and sustainability through measures of access. This provided evidence of current levels of service accessibility and the distribution of health needs in the Waikato DHB region. These chapters also contributed to the development of a GIS model to assess the spatial equity and sustainability of GP services in the New Zealand context. In Chapter 4, a geospatial analysis of patient enrolment data from Hauraki Primary Health Organisation (PHO) revealed that the majority of patients did not enrol with the GP services closest to their home address. This result echoes the findings of Panaretto et al. (2017) in Australia, Lewis and Longley (2012) in the U.K, and previous survey-based research by Hays, Kearns, and Moran (1990) in Gisborne, New Zealand. It also suggests that 'closest-facility' measures of accessibility are based on flawed assumptions about patient travel behaviour and therefore other methods of estimating access such as floating-catchment-area (FCA) approaches should be used. Furthermore, several contextual, clinic-level, and individual-level factors were identified as influencing enrolment patterns. For instance, urban residents, people living in areas of low deprivation, patients enrolled with Māori service providers, and non-European patients were more likely to bypass the GP clinic closest to their residential address.

Although FCA methods address the weaknesses of 'closest facility' measures of access, 'traditional' FCA approaches such as the 2SFCA method still have limitations such as: arbitrarily defined catchment sizes (Allan, 2014); static catchments (McGrail, 2012); and the poor integration of health need indicators (McGrail & Humphreys, 2009). In Chapter 5 the Hauraki PHO patient enrolment dataset was used again to define appropriate catchment sizes for the Waikato DHB region and examine the claim that dynamic catchments are more appropriate that fixed catchments in 2SFCA analyses (Luo & Whippo, 2012; McGrail & Humphreys, 2014). Dynamic catchments were defined at a smaller spatial scale than previous work (see Goodman et al., 2003; Mazumdar et al., 2014) through a detailed sensitivity analysis of patient enrolments, revealing that the average catchment sizes of rural, small town, and urban GP clinics varied significantly. The incorporation of variable data-driven catchments recognised that patient travel patterns change with rurality and helped to overcome issues with assessing spatial accessibility on the fringe of major urban areas (McGrail, 2012). The VGP-E2SFCA improved spatial accessibility results in a mixed urban-rural context at a regional (DHB area) scale that is relevant for health policy.

There is no clear, single indicator of health need for spatial equity research on primary health care internationally or in New Zealand. The World Health Organisation's (2018) list of 'core' health indicators includes 100 indicators, and papers included in Chapter 3's systematic review used a range of measures of health need. Furthermore, Kephart and Asada (2009) found that the magnitude and direction of spatial inequities varied according to the health need indicator used. Therefore, in Chapter 6, seven potential indicators of health need in a New Zealand primary care setting were evaluated and mapped for the Waikato DHB region. Strong and statistically significant correlations between several indicators were identified. Area-level socioeconomic deprivation, often used as an indicator of upstream determinants of health, was correlated with Ambulatory Sensitive Hospitalisation rates, smoking, mortality, the health domain of the Index of Multiple Deprivation, and age (0-4 years and 65+ years). Significant clusters of high health need were identified, and some sub-regions such as the Coromandel Peninsula, Taumarunui, and the western part of Hamilton city had clusters across several health need indicators. It was also determined that including health need weightings into FCA models of accessibility had a negligible impact on results, and that doing so may mask differences in health need that are an essential consideration in spatial equity investigations.

Chapters 7 and 8 expanded upon the key findings from previous chapters in a detailed mixed-methods investigation into the spatial equity and sustainability of GP services. The framework, definitions and measures identified in Chapters 2 and 3 provided a structure for the investigation, while the geospatial analyses carried out in Chapters 4, 5, and 6 informed the approach taken to estimate the current and future spatial equity of GP services. Although Arranz-López, Soria-Lara, and Pueyo-Campos (2019) recently investigated the spatial equity of urban retail accessibility using both GIS and qualitative interviews, spatial equity and sustainability research tends to be exclusively quantitative. Chapters 7 and 8 therefore addressed this gap in the literature and built upon previous chapters by incorporating a qualitative approach to develop a deeper understanding of how and why spatial inequity and poor sustainability has developed in the Waikato DHB region.

Chapter 7 expanded on previous analysis of primary health care accessibility in rural Otago (Bagheri, Benwell, & Holt, 2008) by using an improved version of the 2SFCA method (the VGP-E2SFCA), and by quantifying spatial inequity. Access to GP clinics varied within the Waikato DHB region with a Gini coefficient of 0.477 confirming that spatial accessibility is not distributed evenly. The findings aligned with previous New Zealand research which indicates that geographic access to health services is high for the majority of populations living in areas of high socioeconomic deprivation (Bagheri et al., 2008; Bagheri, Holt, & Benwell, 2009; Pearce, Witten, Hiscock, & Blakely, 2006). However, almost one-third of people in the Waikato DHB region who lived in areas of high socioeconomic deprivation faced the double-burden of poor spatial access to GP services as well as poor socioeconomic circumstances. Additional barriers to equitable primary care access for patients were then identified through qualitative interviews and included the approachability, acceptability, availability and accommodation, affordability, and appropriateness of services. These barriers aligned with and confirmed the relevance of previously proposed international models of health care access in the New Zealand context (Levesque, Harris, & Russell, 2013; Penchansky & Thomas, 1981). However, participants provided additional examples specifically relevant to primary care access in the New Zealand context. They also identified important structural factors that have shaped the inequitable distribution of GP services, including those within health systems (such as governance, economic conditions, and workforce development) and the impact of colonisation and ongoing discrimination against Māori that have contributed to present day health inequities. When the quantitative and qualitative results of Chapter 7 were considered together it was clear that spatial barriers are compounded by non-spatial factors at both the individual and structural levels. Rather than a pro-equity needs-based distribution, GP services in the Waikato DHB region are an example of the Inverse Care Law (Hart, 1971). The spatially inequitable geographic distribution of GP services in the Waikato DHB region is unlikely to lead to health equity.

Chapter 8 used historical workforce data from the Medical Council of New Zealand (n.d) and population projections from Statistics New Zealand (2017a) to estimate the likely future distribution of spatial accessibility under six simulated scenarios. Projected changes in the Gini coefficient and estimated future clusters of high health needs suggested that GP services in the Waikato DHB region are unlikely to be sustainable in the long-term under a 'market-led' scenario. Spatial accessibility was identified as likely to increase the most in areas that already have the best access to GP clinics. Targeted incentives to address the inequitable distribution of the GP workforce were found to be unlikely to result in a significantly different pattern of spatial accessibility in the long-term. This is likely to undermine the viability of rural clinics and entrench current inequities. Although the quantitative GIS component of Chapter 8 focused on distributions of population demand and workforce supply, the qualitative component identified wider dimensions of GP service sustainability which fit into economic, professional, organisational, and social domains. The manifestation of these four domains into local-level sustainability is shaped by local health landscapes. This work expanded on both retrospective (Hara, Kunisawa, Sasaki, & Imanaka, 2018a) and future focussed (Hara, Kunisawa, Sasaki, & Imanaka, 2018b) quantitative examinations of changes in the spatial equity of health workforce distributions by directly incorporating measures of spatial accessibility at a local scale. It also provided an account of key sustainability elements in a New Zealand context which differ from those outlined in the international literature (Humphreys, Wakerman, & Wells, 2006; Wakerman & Humphreys, 2011).

Additionally, when considered in its entirety, this thesis provided evidence for the role that the inequitable provision of health care services plays in the development or persistence of health inequities in New Zealand. The most pervasive health inequities in New Zealand are ethnic inequities which are produced by three main pathways (Reid & Robson, 2007):

1) Differential access to the determinants of health
2) Differential access to health services
3) Differences in the quality of care received.

It is well documented that Māori are disproportionately affected by and exposed to many determinants of health including housing deprivation, a lack of transportation, socioeconomic deprivation, and racism (Ryks, Simmonds, & Whitehead, 2019). These determinants are correspondingly associated with higher rates of infectious disease such as rheumatic fever and respiratory infections (Ministry of Health, 2014), transport-related barriers to health service access (Ministry of Health, 2016), a lower chance of cancer survival (Robson, Cormack, & Purdie, 2010), and higher experiences of racial discrimination which is associated with poorer self-rated health and higher levels of psychological distress (Harris, Cormack, & Stanley, 2013). This thesis research has focussed on the second pathway to inequities, and in particular the spatial component of differential access to services. As discussed above, GP services in the Waikato DHB region were found to be spatially inequitable, with an overall Gini coefficient of 0.477 and clusters of high health need located in areas with low GP service accessibility. Furthermore, the distribution of services did not meet the needs of Māori or Pacific residents who were more likely than European New Zealanders to bypass the GP clinic closest to their home. These higher rates of bypass suggest that culturally appropriate, acceptable, and affordable services are not as readily available, or conveniently located for Māori and Pacific populations as they are for Pākehā. This thesis research has also reconfirmed that spatial accessibility is not the only barrier to accessing healthcare, particularly for Māori (Jansen, Bacal, & Buetow, 2011; Levesque et al., 2013; Penchansky & Thomas, 1981; Ryks et al., 2019), and interviews with key informants in this thesis research reinforced the importance of acceptable, appropriate, affordable, and approachable GP services.

9.2 Methodological contributions

This thesis has made a number of important contributions to research on the spatial equity and sustainability of health services both in New Zealand and internationally. These contributions include advancements in GIS methods, a novel mixed methods approach to spatial equity, sustainability, and primary care research. The main original contributions were:

First, the highly detailed geo-spatial analysis of PHO patient enrolment data was performed to test the key assumption of 'closest-facility' GIS measures of accessibility - that people use their closest GP service. Results indicated that the majority of patients did not enrol with the GP clinic closest to their home. Rates of GP bypass were higher in urban areas and among Māori, Pacific and Asian residents. These findings suggest that, despite more than a decade of New Zealand research using closest-facility measures (see Bagheri, Benwell, & Holt, 2005; Bagheri et al., 2009; Brabyn & Barnett, 2004; Pearce, Witten, & Bartie, 2006; Poole, 2016), there are key weaknesses with the approach (Yang, Goerge, & Mullner, 2006).

Second, to overcome the weaknesses of closest-facility approaches, this thesis expanded on previous research applying the 2SFCA to rural Otago primary health care services (Bagheri et al., 2008) by developing enhanced geospatial methods for New Zealand health services research. This involved the first comprehensive attempt to define GP catchments in the New Zealand context. A novel approach was developed for defining catchments using patient enrolment data. Catchment thresholds were tested through a detailed sensitivity analysis, and generalised catchment sizes proposed for major, medium, and small urban areas, as well as rural parts of the Waikato DHB region. This defined appropriate catchment sizes in a mixed-urban-rural New Zealand context for the first time - providing empirical evidence that the size of catchments in urban, small town, and rural areas do indeed vary. This has also made a significant contribution to the ongoing debate about what constitutes appropriate catchment sizes, which Allan (2014) argues cannot be settled without real-world data.

Third, this thesis developed and comprehensively tested a novel spatial accessibility measure, the Variable-GP-Enhanced-2-Step-Floating-Catchment-Area (VGP-E2SFCA) which used data-defined dynamic catchments determined from the 'perspective' of GP clinics. Since the original 2SFCA was developed (Luo & Wang, 2003) there have been a multitude of modifications and advancements, such as the enhanced-2SFCA (Luo & Qi, 2009) which incorporates distance decay, and the inclusion of dynamic catchment sizes (Luo & Whippo, 2012; McGrail & Humphreys, 2014). However, dynamic catchment sizes have not been universally adopted. The novel VGP-E2SFCA was compared and contrasted with an alternative Variable-Population-E2SFCA (VPOP-E2SFCA), and the 'traditional' E2SFCA. Results indicated that the VGP-E2SFCA produced a more appropriate pattern of spatial accessibility than the alternative methods. This was the first application of FCA measures to an entire New Zealand DHB region, and included several methodological improvements on previous 2SFCA analysis of New Zealand health services (Bagheri et al., 2008). It was also the first international application of data-defined GP catchments.

Fourth, this thesis advanced the identification, measurement, and testing of indicators of health need for spatial equity research in the New Zealand primary care context. Seven potential indicators of health need were identified through the systematic literature review of spatial equity studies in Chapter 3, and the World Health Organisation (2018) list of core indicators, and then mapped for the Waikato DHB region. Socio-economic deprivation was identified as a useful and readily available area-level indicator of health need that is significantly correlated with five of the six other indicators. The impact of incorporating indicator-based health need weightings into the VGP-E2SFCA was also tested and found to have no statistically significant impact on the spatial accessibility results produced. This was the first New Zealand study to investigate potential indicators of health needs for spatial equity research in a primary care context, and the first study to assess the impact of health needs weightings on FCA results.

Fifth, this thesis carried out the first quantification of the spatial equity of health services in the New Zealand context. The distribution of spatial accessibility scores in the Waikato DHB region was analysed using the GINI index, and a demographic analysis examined the distribution of spatial accessibility among population groups organised by age, ethnicity, and socioeconomic deprivation. Although other New Zealand studies have investigated the spatial accessibility of primary health care services (Bagheri et al., 2005; Brabyn & Barnett, 2004), and examined how accessibility relates to socioeconomic deprivation (Bagheri et al., 2008; Bagheri et al., 2009; Pearce, Witten, Hiscock, et al., 2006) this was the first study that directly quantified the spatial *equity* of GP clinics in New Zealand.

Sixth, this thesis developed a quantified assessment of GP service sustainability using population and workforce projections. Projected changes in the spatial equity of GP services were quantified by incorporating population and workforce projections into the VGP-E2SFCA. Spatial accessibility results were calculated for each year where population projections were available from Statistics New Zealand, and the Gini index was used to quantify projected changes in spatial equity. Age-specific population projections were examined, and Local Indicators of Spatial Autocorrelation were used to determine whether future levels of spatial accessibility were likely to align with health needs. This was the first New Zealand study to quantify the sustainability of GP services using GIS techniques with population projections and health workforce data. Internationally, this work has built upon research by Hara et al. (2018b) who projected the future geographic distribution and equity of physicians in Japan, but did not examine the implications of this on the spatial accessibility of health services.

Seventh, this thesis explored a mixed methods approach to examining the spatial equity and sustainability of GP services. This involved developing a synthesis of previously outlined GIS approaches to quantifying spatial equity and sustainability, with the views of key informants through the thematic analysis of in-depth interviews. The participants involved in this research were: Māori, Pacific, Asian and European; young and old; male and female; and represented patients, GPs, practice owners, PHOs, and the Waikato DHB. The recruitment of new participants was only suspended when thematic saturation was reached, and the small sample size allowed for a semi-structured interview format which produced detailed and in-depth transcripts that are were of high analytic value. This work signified a further methodological advancement for the fields of spatial equity, sustainability, and primary care research, which Poole (2016) notes rarely include mixed methods GIS approaches, with the few available studies focussing on incorporating geospatial technologies into health care delivery. There is also very little mixed methods research on spatial equity, aside from investigations of access to parks in New York City (Maroko, Maantay, Sohler, Grady, & Arno, 2009) and retail access in Zaragoza, Spain (Arranz-López et al., 2019). The mixed methods approach to health services research in this thesis appears to be novel, both in New Zealand and internationally. Furthermore, the conceptual models of spatial equity and sustainability, which were developed through this qualitative analysis, are in themselves a key contribution to research methodologies on New Zealand primary care services.

Eighth, this thesis constructed a novel conceptual framework for assessing the spatial equity and sustainability of GP services. This framework outlined key steps and considerations for undertaking research into the spatial equity and sustainability of health services, and provides a template for further research in this area.

Taken together, these methodological contributions advance understandings in the field of spatial equity and sustainability research and represent an original contribution to knowledge.

9.3 Summary of additional strengths

Despite the limitations outlined below, there are a number of key strengths underpinning this research. The spatial accessibility of GP services in the Waikato DHB region was estimated using a novel method that was comprehensively developed and tested at each stage of its development. First, the assumptions of commonly used closest facility measures of accessibility were shown to be inappropriate for the mixed urban-rural Waikato DHB context. An alternative measure of spatial accessibility was developed through a comprehensive sensitivity analysis of data-defined GP catchment sizes and the approach to assessing spatial equity was clarified through the rigorous assessment and testing of health needs indicators. The novel VGP-E2SFCA was then used as the basis of a spatial equity and sustainability analysis for GP services. The definitions and measures of spatial equity used were identified through a detailed systematic review of the spatial equity research literature, and a novel approach to quantifying the sustainability of services using population and workforce projections was developed. This comprehensive quantitative analysis was then triangulated with a detailed qualitative analysis of key informant interviews, providing a richer and more detailed insight into spatial equity and sustainability in the Waikato DHB region which could not have been achieved with a quantitative analysis alone. Furthermore, by limiting the scope of this research to the Waikato DHB region, a much more detailed sub-regional analysis was achieved. A common frustration of many national level reports is that while differences between the health systems or outcomes of different DHBs are often compared, there is little analysis of these inequities within DHB regions. The local-level approach of this research thesis focused on differences in both health needs and the accessibility of GP services *within* the Waikato DHB region, highlighting the importance of sub-regional analyses.

9.4 Summary of limitations

Despite the important contributions to knowledge and methodological improvements outlined above, this research thesis is not without its limitations. One limitation is that the patient enrolment data used in Chapters 3 and 4 did not include all enrolled patients in the study region, as Pinnacle PHO declined to share their data for this research. Furthermore, 17 of the Hauraki PHO GP clinics were designated as Very Low Cost Access services, meaning that the socio-demographic profile of this enrolled patient dataset differed from that of the Waikato DHB population as a whole. The Hauraki PHO dataset included a higher proportion of Māori, Pacifc and Asian residents, as well as people living in areas of high socioeconomic deprivation. However, the patient enrolment data provided by Hauraki PHO included more than 135,000 patients living in small towns, rural, and urban parts of the Waikato DHB region and included areas of both high and low socioeconomic deprivation.

Another limitation is that the population data from Statistics New Zealand that was used in this research thesis is derived from the 2013 census. Although these data are now seven years old, there are several reasons why it was favoured above 2018 census data. Firstly, the Statistical Standard for Geographical Areas changed between the 2013 and 2018 censuses (Statistics New Zealand, 2017b). From 2018, data were no longer released at the meshblock or AU level, with these geographic units being replaced by the Statistical Area 1 (SA1) and Statistical Area 2 (SA2) geographies respectively. The change was particularly significant for this research, which relied on integrating population and health outcome data at the same spatial scale. At the time of writing, the smallest geographical unit at which the Ministry of Health provides health outcome data is the 'Domicile code' (AU) level. This means that studies examining the incidence or prevalence rates of health outcomes, such as the analysis of health need indicators in Chapter 6, could not be calculated accurately at SA1 or SA2 level, as the geographic boundaries for numerator and denominator populations did not align. Furthermore, Statistics New Zealand have not yet released population projections at SA1 or SA2 level, meaning that the sustainability assessment in Chapter 8 is only feasible with AU level population data, therefore limiting analysis to data derived from the 2013 census. Secondly, several issues with the 2018 Census have been highlighted elsewhere, including: a large undercount and non-response rate which is particularly biased towards certain geographical areas and populations – particularly Māori and Pacific residents (Kukutai & Cormack, 2018); the use of administrative data to 'fill the gaps' in the census, meaning that it's overall quality has been reduced; and significant delays in the release of 2018 census data (2018 Census External Data Quality Panel, 2020). Therefore, although 2013 census data is relatively old, it was the most accurate and up-to-date data available at the time, and was used in 2019 by the Ministry of Health to calculate population based funding levels for DHBs (Bennett, 2019, 19th February).

While, this thesis has shown that there are a range of important factors which influence the sustainability of GP services, the quantitative modelling of sustainability was necessarily limited by the availability of quality data at a suitable spatial scale. It should therefore be recognised that this modelling represents one aspect of sustainability.

Although the VGP-E2SFCA method developed in this thesis has made substantial advancements on the closest-facility and 2SFCA approaches previously used in New Zealand spatial accessibility research, the following limitations to the method must be recognised: locations outside catchments are still considered to have 'zero' accessibility; and the VGP-E2SFCA does not account for the 'border crossings' of patients who may use local GP services despite residing outside the Waikato DHB region or vice versa. Furthermore, the assumptions of the 2SFCA as outlined by McGrail (2012) also apply to the VGP-E2SFCA, for instance:

1) GP clinics are assumed to be appropriately represented by their geocoded address, which does not account for clinics offering outreach services
2) Populations are represented through their address-weighted Area Unit centroid.

While the use of road network distances rather than travel times to define catchment sizes may also be seen as a limitation, this is not necessarily the case. Estimates of travel time assume that individuals have access to a private vehicle, and that traffic and road conditions are amenable to access. Distance is a more appropriate representation of the geographical barriers that many people face to accessing GP services, especially children, older people, and others who are unable to drive themselves to GP clinics.

It is also important to recognise that the spatial accessibility results in this thesis did not represent access in its more holistic sense. Most quantitative measures of access, including FCA approaches, privilege the geographical component of accessibility. At their core, these measures are based on the relationship between three key factors: population size, service availability, and the distance between populations and services. While the VGP-E2SFCA approach was a significant advancement on the closest facility measures previously used in New Zealand research, the limitations of this focus on spatial accessibility must be recognised. For instance, FCA approaches are based on assumptions that:

- All individuals are aware of the location and availability of health services
- All services are culturally safe, appropriate, and acceptable to all population groups
- Clinics have open books, are currently accepting patients, do not have waiting lists, and that opening hours are convenient for patients
- All individuals have the ability to overcome distance and cost barriers
- All clinics provide the same level and quality of services.

Another limitation is that the wider ‘activity spaces’ of individuals were unable to be considered in the geospatial analyses. Kwan (2018) argues that it is often inappropriate to assume that people’s residential neighbourhoods are the most important areas of environmental exposure and service access. People travel each day for work, education, and recreational activities, and this is not necessarily represented by analysis of residential administrative units. While an individuals’ AU of residence indicates their local neighbourhood, they are not limited to that space, and many people may find it more convenient to access GP services that are close to their work or school. Individual activity spaces were unable to be accounted for in either the geospatial analysis of patient enrolment records (Chapter 3) or the analyses of spatial equity and sustainability (Chapters 7 and 8 respectively).

The scope and scale of this project was limited to the Waikato DHB region, and for some chapters was limited to a Waikato DHB subpopulation. This means that while a detailed local analysis was able to be performed, the results are not necessarily generalisable to the rest of New Zealand. This is particularly true for the quantitative results which focussed on *where* spatial inequities and poor sustainability occurred within the Waikato DHB region.

However, the methods developed are generalisable. Further, the results of the qualitative component of this research are also likely to be generalisable, as many of the same issues discussed by interview participants are relevant for other parts of the country, and internationally.

9.5 Research implications

As previously outlined, this research thesis has made important contributions to the field of spatial equity, sustainability and health services research, including: the development of a conceptual framework to guide future research; the first systematic review of spatial equity definitions and measures; advances to geospatial analysis techniques; and the development of New Zealand specific conceptual models of equitable access and GP service sustainability. While it is important to continue advancing academic knowledge and debate, the research methods and findings in this thesis are also of importance to health service providers and policy makers.

This thesis identified key factors that affect the equity and sustainability of GP services, and provided evidence that could help the Ministry of Health, DHBs, and PHOs to focus their efforts to address health inequities. One level of intervention identified by the Ministry of Health (2002) to address this need is through ensuring the equitable distribution of health services and the removal of barriers to accessing health care. Chapter 7 outlined a method for assessing the spatial equity of GP services at a DHB level. This approach could be adapted to other regions, or expanded to the national level and potentially also include other health services such as mental health or maternity care services. This research is timely, as although the urgent need to address health inequities in New Zealand is longstanding, the Ministry of Health (2018a) notes that the current Government has provided a pro-equity mandate, implying that now is the ideal time to act to *eliminate* inequities in health. Chapter 8 highlighted a novel method for quantifying the sustainability of health services, which also ensures that equity remains central to sustainability planning. This approach used health workforce data and population projections and could also be applied nationally or to other DHB regions.

Many of the novel methods developed in this thesis could be used by health service providers, or the Ministry of Health to improve the equitable delivery, and sustainability, of health services. The geospatial methods developed in Chapters 4 and 5 could be used by PHOs and DHBs to gain a better understanding of how patients enrol and interact with primary care services. Chapter 4 drew attention to the fact that the clinic located closest to peoples' homes is often not their preferred service. The importance of Māori Service Providers and clinics offering after hours care were also reinforced, and the enrolment patterns for these services suggested that patients should be able to choose between a range of locally available services that appropriately meet the health care needs and expectations of communities. Chapter 5 described how GP catchment areas could be defined. This information could be used by individual clinics to identify patients that do not live locally and may have very different needs in terms of appointment times or prescription collection. Furthermore, the recent Health and Disability System Review (2020) recommended that 'Tier 1' services such as primary care should be designed with a population health focus and that prevention and outreach services should be strengthened. Clinics, PHOs, and DHBs could use the methods described in Chapter 5 to identify which communities are being served by each clinic. This may not always align with the areas that clinics *think* they serve, and could encourage clinics and PHOs to take a more active role in health promotion within their specific communities. The GIS methods and geospatial evidence in Chapters 6, 7 and 8 can make important contributions to the planning and delivery of a wide range of health services at a range of scales. Chapter 6 outlined a method of examining the distribution of health needs, while the spatial equity and sustainability methods in Chapters 7 and 8 and could be used by DHBs or the Ministry of Health to more efficiently allocate services regionally or nationally and identify opportunities to improve the availability and accessibility of services for areas and communities with high health needs.

This research also highlighted non-spatial opportunities to improve the equity and sustainability of GP services. The qualitative components of Chapters 7 and 8 identified the multi-faceted nature of equity and sustainability. Chapter 7 emphasised the importance of addressing both the proximal and structural causes of inequitable access. Proximal factors included high out-of-pocket costs, Euro-centric health models, restricted operating hours, and a lack of patient-centred care. The underlying structural causes of inequitable health services and outcomes included the historical and ongoing impact of colonisation and Treaty of Waitangi breaches. The proposed model of equitable access to GP services in Chapter 7 outlined the interaction of these factors in shaping individual and community level access to GP services, and could provide a useful framework for improving equitable access to health services. While the Ministry of Health (2018b) and The Royal New Zealand College of General Practitioners (2019) recognise that the health workforce is an essential component of sustainable health services, Chapter 8 highlighted other social, professional, economic and organisational factors that play an important role in GP service sustainability. The novel model of GP sustainability dimensions may also provide a useful framework for individual GP clinics, PHOs, DHBs and the Ministry of Health and help to identify potential areas for action that could improve the sustainability of services.

9.6 Challenges and opportunities in spatial equity and sustainability research

The equity of health service provision has long been an important and widely recognised issue (Hart, 1971). Furthermore, the sustainability of health services is not only essential from a health sector perspective, but often also underpins the vitality and sustainability of many communities (Farmer, Prior, & Taylor, 2012). While a mixed methods approach combining GIS and qualitative interviews can make important contributions to the understanding of the spatial equity and sustainability of health services such as GP clinics, several challenges remain. Shah, Milosavljevic, and Bath (2017) argue that estimations of spatial accessibility depend on three key factors, which can affect results considerably:

1) The quality of input data
2) The geographic unit of analysis
3) The accessibility measure used.

The availability and quality of secondary data at an appropriate geographic unit has been a considerable challenge this research faced, and will continue to affect future research. Gaining access to high quality GP workforce data proved to be particularly difficult. The Medical Council of New Zealand (n.d) has produced national GP workforce statistics at the Territorial Authority level. However, this data has not been released below DHB level since 2011. Although Health Workforce New Zealand appears to be doing important GIS work in this area, they have also been constrained by what they are ‘able’ to share at a local, or practice level. The most accurate and up-to-date GP workforce and patient enrolment data is held by PHOs. However, access to this differs according to the researcher-PHO relationship and the data-sharing policies of each organisation. Data on health outcomes at the AU level is available through several Ministry of Health datasets such as the National Minimum Dataset (hospital events) and the New Zealand Cancer Registry. However, data held by PHOs includes much more detailed information about the entire enrolled patient population (many of whom have never been hospitalised) and is therefore more useful in understanding and modelling community health needs that can be addressed by primary care. As previously outlined, data from the 2018 census is of reduced quality (2018 Census External Data Quality Panel, 2020) and the new small area geographical units for census population data do not currently align with other secondary data sources. These issues of data access, quality, and spatial scale may make it difficult to apply some of the methods and techniques developed in this thesis to a national level analysis. However, most of the quantitative analysis has been carried out with open-source data, meaning that there is potential to replicate this work for other regions or at a national scale.

There are a wide range of spatial accessibility measures that could be used for analyses of spatial equity and sustainability, and the choice of measure has a substantial impact on results (Shah et al., 2017). Guagliardo (2004) outlined several measures, from population-to-provider ratios to travel time impedance, in his review of methods and highlighted the 2SFCA as a recent development in the field. Several advancements to the 2SFCA have since been made, including the incorporation of distance decay (Luo & Qi, 2009), the exploration of variable catchments (Luo & Whippo, 2012; McGrail & Humphreys, 2014), and the development of other alternative floating catchment measures (Delamater, 2013; Langford, Higgs, & Fry, 2016; Wan, Zou, & Sternberg, 2012). Recently, Chen and Jia (2019) compared 24 different 2SFCA-style measures, finding that the most significant impact on spatial accessibility results was due to the choice of catchment size and distance decay function in each model. Although this thesis outlined a method for defining data-driven catchments, patient enrolment data is not readily available to all researchers and debate around FCA measures is likely to persist (Allan, 2014; Chen & Jia, 2019). Challenges also remain around how best to combine spatial and non-spatial measures of access and health needs. McGrail and Humphreys (2009) integrated health needs into their index of rural access through population weightings. However, as shown in Chapter 6, this approach produced negligible differences in spatial accessibility results and risks masking the considerable health needs of some communities. Chapter 7 took an approach more similar to that of Bagheri et al. (2008) by considering how high levels of health need and poor access to health services interact for some populations.

Furthermore, although health service accessibility has been conceptualised across spatial and non-spatial domains, and can include potential and realised access, most GIS research remains focussed on potential spatial access (Guagliardo, 2004; Levesque et al., 2013; Penchansky & Thomas, 1981). For instance, the accessibility model used in Chapter 7 did not incorporate the importance of non-spatial factors by not distinguishing between mainstream clinics and Māori Service Providers. The results were therefore based on an assumption that Māori patients are always willing and able to use mainstream GP clinics. Although the analysis in Chapter 4 suggested that the majority of Māori patients using Hauraki PHO services were enrolled with mainstream GP clinics, the results also indicated that patients often bypass closer services to enrol with clinics run by Māori Service Providers. Therefore, the apparently low proportion of Māori patients using Māori Service Provider clinics may be due to a lack of availability and access to these primary health services – with only 11 clinics in the Waikato DHB region run by Māori Service Providers.

Mixed method approaches, such as those used in this thesis, offer an opportunity for more comprehensive conceptualisations and investigations of spatial accessibility, equity, and sustainability. Interviews with participants in Chapter 7 revealed that community demand for kaupapa Māori services is so high that many patients are unable to enrol with Māori Service Providers or receive timely access to services. There was also a widespread recognition that *all* GP services needed to more effectively and appropriately meet the needs of Māori. Te Tiriti o Waitangi promises Māori ōriteitanga (equity) with non-Māori, and the Declaration on the Rights of Indigenous Peoples guarantees health equity for all Indigenous peoples (Came, Herbert, & McCreanor, 2019; Wyeth, Derrett, Hokowhitu, Hall, & Langley, 2010). This rights-based definition of equity was not documented in the international spatial equity literature that was reviewed in Chapter 3, and highlights the importance of effectively engaging with Indigenous people and perspectives (Moon & Kearns, 2019). In order to overcome current and historical inequities, the right that Māori have to not only access the same level of mainstream services as other populations, but equitably higher levels of resourcing and opportunities to access kaupapa Māori services (Reid & Robson, 2007) must be realised. Kaupapa Māori services are one way through which Māori can express tino rangatiratanga in the health system (Berghan et al., 2017) and are an important way to overcome the shortcomings of government health services provided to Māori (Waitangi Tribunal, 2019).

The effective translation of research findings into action is another challenge. Monitoring the equity and sustainability of health services is important (Commission on the Social Determinants of Health, 2008), but it is only the first step in a process to achieve long-term health equity. The mixed methods approach in this research highlighted the structural factors that produce ongoing spatial inequities in access and sustainability. While GIS is a powerful tool in public health and health services research (F. Wang, 2020), the key challenge is often translating research into policy action to improve the spatial equity and sustainability of health services, and address upstream causes of health inequities (Commission on the Social Determinants of Health, 2008; Humphreys & Wakerman, 2018). The Health and Disability System Review (2020) has recently provided several recommendations that could be adopted to improve the equity of the New Zealand Health System. Alongside an increased focus on population health, which is argued should be a driver of the health system, recommendations relating to primary care services include:

- That services should reflect local populations and needs
- That DHBs should be required to develop five-year strategic plans that include locality plans and are based on detailed population needs analysis
- That a networked approach to primary care services should be adopted with a greater focus on improving the accessibility and effectiveness of services
- That DHBs should commit to providing culturally safe services including kaupapa Māori options
- That equity and prevention should be priorities for future funding
- and that resources should be directed to where they are needed most.

These recommendations recognise the importance of a primary care system where resources are distributed according to a ‘vertical needs-based’ definition of spatial equity.

They also highlight the importance of designing and delivering services that are based on the needs of local populations and ensuring that culturally safe and acceptable services are available. Additionally, these recommendations outlined in the Health and Disability System Review acknowledge the value of detailed population analysis at the local level, and community engagement, to inform the design and delivery of primary health services. The techniques and methods developed in this thesis could be used as an essential part of these planning processes.

9.7 Future research

In order to further examine the spatial equity and sustainability of GP services, and the underlying causes of poor sustainability and inequity, further research replicating and validating the novel methods developed in this thesis is necessary. For example, applying the approach to quantifying spatial equity and sustainability to other DHB regions, New Zealand as a whole, and internationally would help to validate the appropriateness of this approach in other contexts. In the New Zealand context population data, health workforce information, and health outcome data could be used to expand the analysis of spatial equity, sustainability and the distribution of health needs to a national level and improve our understanding of the delivery of primary health services. The novel geospatial methods developed in this thesis could also be adapted and applied to other health services and used to examine the spatial equity and sustainability of maternity care, mental health services, secondary and tertiary hospital services, or allied health services for instance. Furthermore, PHO patient enrolment data from other DHB regions could be used to validate the results of Chapters 3 and 4, and determine whether similar enrolment patterns persist, and whether the proposed catchment sizes are appropriate in other contexts. The analysis of patient enrolment records could also be extended to examine how patients with specific health conditions interact with services, or examine whether health need has an impact on enrolment patterns. Ministry of Health or PHO enrolment data could also be examined in greater detail to identify geographic areas with high levels of specific conditions (see Bagheri, Wangdi, Cherbuin, & Anstey, 2018 for an example in the Australian context), or the distribution of health needs for specific age or ethnic population groups. This could help to inform the ideal location for specific health services or interventions.

Issues with unsuitable definitions of rurality for health research in New Zealand have previously been outlined (Fearnley, Lawrenson, & Nixon, 2016). The analysis of urban-rural differences in this thesis relied on the 2018 Statistical Standard for Geographical Areas (Statistics New Zealand, 2017b), which is a limited classification of rurality based on population size and density alone. Statistics New Zealand are currently developing and updated Urban Influence Classification (UIC) which will better recognise the functional interactions between rural land and urban centres (Statistics New Zealand, 2020). Work is also underway to produce an appropriate Geographic Classification for Health (GCH) research and policy purposes. Previous work using an experimental classification of rurality (Ministry of Health, 2012) identified higher rates of cancer among Māori living in small rural towns that were masked by generic rurality classifications. Once the UIC and GCH have been developed, an important research focus will be examining rural and urban differences in indicators of health need, and the spatial equity and sustainability of a range of health services.

Future spatial accessibility research should take the mixed-methods findings from Chapter 7 and aim to develop a more holistic quantification of access. As previously discussed, most GIS measures of access privilege distance and geography at the expense of other aspects of accessibility. Future work should examine how key non-spatial components of access – including attributes such as Māori service provider status, after hours availability, cost of services, and the quality of care available in clinics – can be incorporated into a GIS model. Future research should also examine alternative 'health need' indicators that better align with Māori and Pacific understandings of health and wellbeing. An example of a first step in this work is the use of Sir Mason Durie's (1999) Te Pae Mahutonga framework of Māori health promotion and both geospatial data and official statistics to develop community indicators of Waiora, Oranga, Toiora, and Mauriora (Ryks, Kilgour, Whitehead, & Rarere, 2018). These measures could also be used within a spatial equity framework to identify the strengths of particular communities, and investigate whether the distribution of kaupapa Māori or Pacific health services aligns with community needs.

Health systems and their services are only one route through which health inequities are produced, and differential access to the social determinants of health, including employment, education, and healthy living and working conditions are a major driver of inequitable health outcomes (Commission on the Social Determinants of Health, 2008; Ministry of Health, 2002; Reid & Robson, 2007). A detailed investigation of how other geographically located determinants of health interact with health systems to impact health equity and sustainability is an important extension of this thesis research. For example, schools in socioeconomically deprived areas of New Zealand have been found to have higher concentrations of fast food outlets (Pearce, Blakely, Witten, & Bartie, 2007), and the density of fast food outlets around schools has increased significantly over time (Day, Pearce, & Pearson, 2015). Furthermore, health-promoting infrastructure may be inequitably distributed (Smith et al., 2017). Pearce, Witten, and Bartie (2006) examined access to 16 health related resources in New Zealand using closest facility measures. However, future research should use the methods and techniques developed in this thesis to examine whether the spatial inequities in the built and food environment are associated with inequities in access to health services and health need – potentially representing a triple burden of spatial inequity. In terms of sustainability, McGrail et al. (2017) investigated the relationship between levels of primary care workforce supply and both community and environmental amenities in rural American and Australian towns. Their approach could be adapted to the NZ context and expanded to identify built and natural environment factors that may be associated with inequities in health service access and outcomes.

The third pathway through which inequities are produced is through differences in the quality of care received (Reid & Robson, 2007). The analysis in this thesis has not attempted to estimate or incorporate the quality of care provided. Future research could incorporate several potential indicators of quality of care, such as: average consultation length; the gender and ethnicity balance of GPs in a practice; and the quantity and quality of facilities available (Crampton et al., 2004). The monitoring of patient health status, treatment processes and outcomes could also inform whether services are providing high quality primary care (Gribben, Coster, Pringle, & Simon, 2002). Racism is increasingly recognised as a key determinant of health (Harris et al., 2006b) and the presence of both interpersonal and institutional racism in the health system increases health inequities (Harris et al., 2006a). A systematic literature review and meta-analysis of the impact of racism on health service utilisation indicates that experience of racism is associated with delaying treatment (or not getting care at all), and more negative experiences of health services (Ben, Cormack, Harris, & Paradies, 2017). Therefore, future spatial equity and sustainability research should also aim to incorporate racism, discrimination, and the quality of care provided as important non-spatial components of equitable health care.

9.8 Conclusion

This thesis was the first study to extensively investigate the spatial equity and sustainability of GP services in New Zealand using both quantitative GIS and qualitative methods. It also included the description of a novel framework to guide spatial equity and sustainability research, the first systematic literature review of spatial equity definitions and measures, and the development of novel geospatial methods for examining both realised and potential accessibility. The overall results of this research showed that GP services in the Waikato DHB region are neither spatially equitable nor sustainable in the long-term, and that this is driven by multiple factors. Spatial accessibility was found to vary within the Waikato DHB region, and disadvantage populations in peripheral rural areas. Differences in the key components of access to GP services, including the approachability, acceptability, availability and accommodation, affordability, and appropriateness of services were also recognised as proximal causes of spatial inequities. Furthermore, these were identified as being fundamentally driven by structural factors including the upstream social determinants of health and the ongoing impact of colonisation. The GIS analysis of sustainability indicated that spatial accessibility is likely to increase the most for areas that already have good geographic access to GP services, potentially entrenching health inequities. The sustainability of GP services is not only shaped by pressures on workforce capacity and demographic shifts to population demand for services. Rather, a broader range of economic, professional, organisational, and social factors are also influential. This research highlighted the importance of continually striving to address the limitations of standard methods used in spatial accessibility research, and to develop approaches for effectively assessing the spatial equity and sustainability of health services. This research has strengthened current international and national evidence that health services and resources are not distributed equitably or sustainably, and has highlighted the importance of addressing the upstream determinants of health and structural factors that produce and sustain health inequities.

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Appendix – Co-authorship forms

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Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wāhanga Ratonga Mātauranga Ākonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

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Chapter 2: Article 1 – Framework for examining the spatial equity and sustainability of general practitioner services

Whitehead, J., Pearson, L.A., Lawrenson, R. & Ataboa-Carr, P. (2018). Framework for examining the spatial equity and sustainability of general practitioner services. *The Australian Journal of Rural Health, 26*, 336-341.

Nature of contribution by PhD candidate	Literature review, design and planning of framework, writing of article, creation of figures/maps, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

Name	Nature of Contribution
Amber L. Pearson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
Ross Lawrenson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
Polly Atatoa Carr	Assistance in planning stage, feedback and suggestions on draft article, help with reviewer feedback of 1st submission

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Jesse Whitehead		29/07/2020
Amber L. Pearson		24/07/2020
Ross Lawrenson		27/06/2020
Polly Atatoa Carr		29/07/2020

July 2015

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WAIKATO

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Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
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Chapter 3: Article 2 – How can the spatial equity of health services be defined and measured? A systematic review of spatial equity definitions and methods

Whitehead, J., Pearson, A. L., Lawrenson, R., & Atatoa-Carr, P. (2019). How can the spatial equity of health services be defined and measured? A systematic review of spatial equity definitions and methods. *Journal of Health Services Research & Policy, 24*(4), 270-278.

Nature of contribution by PhD candidate	Design of systematic review, database search, data compilation and analysis, writing of article, creation of figures and tables, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

Name	Nature of Contribution
Amber L. Pearson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
Ross Lawrenson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
Polly Atatoa Carr	Assistance in planning stage, feedback and suggestions on draft article, help with reviewer feedback of 1st submission

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Chapter 4: Article 3 – Spatial equity and realised access to healthcare – a geospatial analysis of general practitioner enrolments in Waikato, New Zealand

Whitehead, J., Pearson, A. L., Lawrenson, R., & Atatoa-Carr, P. (2019). Spatial equity and realised access to healthcare-a geospatial analysis of general practitioner enrolments in Waikato, New Zealand. *Rural and remote health, 19*(4), 5349.

Nature of contribution by PhD candidate	Accessing PHO dataset, data cleaning and analysis, running statistical tests, literature review, writing of article, creation of maps, figures, and tables, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

Name	Nature of Contribution
Amber L. Pearson	Feedback and suggestions on draft article, suggestions for data analysis, and help with reviewer feedback of 1st submission
Ross Lawrenson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
Polly Atatoa Carr	Assistence in planning stage and gaining access to database, feedback and suggestions on draft article, help with reviewer feedback of 1st submission

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Amber L. Pearson	[signature]	24/07/2020
Ross Lawrenson	[signature]	29/06/2020
Polly Atatoa Carr	P. A Carr	29/07/2020

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Chapter 5: Article 4 – Defining general practitioner and population catchments for spatial equity studies using patient enrolment data in Waikato, New Zealand Whitehead, J., Pearson, A. L., Lawrenson, R., & Atatoa-Carr, P. (2020). Defining general practitioner and population catchments for spatial equity studies using patient enrolment data in Waikato, New Zealand. *Applied Geography, 115*, 102137. https://doi.org/10.1016/j.apgeog.2019.102137.	
Nature of contribution by PhD candidate	Accessing PHO dataset, data cleaning and analysis, sensitivity analysis, development and testing of accessibility model, literature review, writing of article, creation of maps, figures, and tables, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

Name	Nature of Contribution
Amber L. Pearson	Feedback and suggestions on draft article, suggestions for data analysis, and help with reviewer feedback of 1st submission
Ross Lawrenson	Feedback and suggestions on draft article, help with reviewer feedback of 1st submission
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Chapter 6: Article 5 – Selecting health need indicators for spatial equity analysis in the New Zealand primary care context

At the second stage of review with the *Journal of Rural Health*

Nature of contribution by PhD candidate	Accessing datasets, data cleaning and analysis, statistical testing, development and testing of accessibility model, literature review, writing of article, creation of maps, figures, and tables, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

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Chapter 7: Article 6 – "We're trying to heal, you know?" A mixed methods analysis of the spatial equity of general practitioner services in the Waikato DHB region

Ready for submission to *Journal of Mixed Methods Research*

Nature of contribution by PhD candidate	Accessing datasets, data cleaning and analysis, statistical testing, development and testing of accessibility model, designing interview questions, contacting and interviewing participants, interview transcription, thematic analysis, literature review, writing of article, creation of maps, figures, and tables, submission and review of article
Extent of contribution by PhD candidate (%)	90%

CO-AUTHORS

Name	Nature of Contribution
Amber L. Pearson	Feedback and suggestions on draft article, suggestions for data analysis statistical testing and map design.
Ross Lawrenson	Assistance with design of interview guide and contacting potential interview participants. Suggestions for workforce data sources. Feedback and suggestions on draft article.
Polly Atatoa Carr	Assistance with design of interview guide and contacting potential interview participants. Assistance in planning stage, feedback and suggestions on draft article.

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Polly Atatoa Carr	P. Atatoa Carr	29/07/2020

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Chapter 8: Article 7 – The sustainability of General Practitioner services: a mixed methods investigation of policy scenarios in the Waikato District Health Board region of New Zealand

Ready for submission to *Journal of Mixed Methods Research*

Nature of contribution by PhD candidate	Accessing datasets, data cleaning and analysis, statistical testing, development and testing of accessibility model, designing interview questions, contacting and interviewing participants, interview transcription, thematic analysis, literature review, writing of article, creation of maps, figures, and tables, submission and review of article
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