Treatment and survival of Asian women diagnosed with breast cancer in New Zealand

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Abstract

Purpose: This study aims to examine the differences in characteristics, treatment and survival between Asian and European women diagnosed in stage I-III breast cancer in New Zealand.

Methods: The studied population included European women and Asian women diagnosed with stage I-III breast cancer between June 2000 and May 2013 identified from the combined Waikato and Auckland Breast Cancer Registers. Characteristics and treatment were compared between Asian and European women. Kaplan-Meier method was used to examine the survival difference. Cox proportional hazards model was used to estimate the hazard ratio (HR) of mortality.

Results: The studied cohort included 8608 European and 949 Asian women. Asian women were younger, had less comorbidities and were less likely to be obese than European women. Asian women were more likely to have grade 3, larger and HER2+ breast cancers. Asian women were more likely to receive mastectomy, less likely to have reconstruction after mastectomy, less likely to have chemotherapy, and less likely to be treated with trastuzumab if HER2+ and had better adherence to endocrine therapy (adjusted odds ratio: 1.54; 95% CI: 1.22-1.93). Asian women had better cancer-specific and all-cause survival than European women. The adjusted HR of cancer-specific mortality and all-cause mortality was 0.64 (95% CI: 0.49-0.82) and 0.68 (95% CI: 0.55-0.84).

Conclusions: Asian women are more likely to have high grade, larger and HER2+ breast cancers than European women. In spite of this, they had better breast cancer outcomes. Possible explanations include: the differences in adherence to endocrine therapy, age, BMI and comorbidities.

Key words: Asian women; Breast cancer; Adherence to endocrine therapy; Survival; Ethnic disparity

Introduction

Breast cancer is the most frequently diagnosed cancer in women, impacting 2.1 million women each year around the world in 2018, and is also the commonest cause of cancer death for women.[1, 2] Diversity in cancer characteristics, treatment and survival between different ethnic groups has been well documented.[3-9] Compared to European, Hispanic and Asian women in the US, African American women have the highest risk of having triple negative breast cancer that is associated with a poor outcome.[4] Japanese and Filipino women were found to be less likely to receive breast conserving surgery than white women.[3] Asian women are more likely to have human epidermal growth factor receptor 2 positive (HER2+) than European (10.9% vs 7.0%).[4] African American women have worse breast cancer-specific survival and Asian women have better survival than European women.[4, 5]

European, Māori, Pacific and Asian are the four main ethnic groups in New Zealand. It has been demonstrated that Māori and Pacific women were more likely to be diagnosed with advanced breast cancer, have disadvantages in access to treatment and have poorer survival compared to European women.[6-15] Breast cancer in Asian women has rarely been studied in New Zealand, but the above studies suggested that Asian women in New Zealand may have better outcomes that the other groups.

In New Zealand, Asian ethnicity account for 11.8% (471,708) of the population in 2013, increasing from 9.2% (354,552) in 2006.[16] The Asian ethnic group is getting older, with a median age of 28.6 years in 2006 and a median age of 30.6 years in 2013.[16] The health needs of Asian are changing with the increasing population and the aging problem. This study aims to examine the differences in characteristics, treatment and survival between Asian and European women diagnosed in stage I-III breast cancer in New Zealand.

Methods

The studied population included European women and Asian women diagnosed with stage I-III breast cancer between June 2000 and May 2013 identified from the combined Waikato and Auckland Breast Cancer Registers.[17] The registers' data includes: 1) patient characteristics: age, ethnicity and BMI (body mass index); 2) tumour information: diagnosis date, cancer stage, cancer grade, tumour size and biomarkers including estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (HER2), and 3) information on treatment: surgery (including breast conserving surgery (BCS) and mastectomy), chemotherapy, trastuzumab, endocrine therapy and radiation therapy. Ethnicity was self-identified as part of the registers

consent process. The classification of New Zealand European women and Asian women followed the Ethnicity New Zealand Standard Classification (2005 V2.0.0).[18]

Information on comorbidities has been obtained by reviewing linked data from the National Minimum dataset (NMDS) by National Health Index number (NHI) and categorising patients using the C3 comorbidity index: [19, 20] 1) less or equal to zero, 2) greater than zero but less or equal to one, and 3) greater than one. BMI were grouped into <18.5 (underweight), 18.5~25 (normal), 25~30 (overweight) and ≥30 (obese). In this study, HER2+ was defined as FISH amplified or IHC 3+ according to the 2013 American Society of Clinical Oncology (ASCO) guideline.[21] Recommended in the 2001 St. Gallen Consensus, ER+ or PR+ was assessed as IHC positive (1+).[22] Based on the status of the three biomarkers ER, PR and HER2, five cancer subtype groups were categorised including Luminal A, Luminal B HER2-, Luminal B HER2+, HER2+ non-luminal and triple negative.[9, 23] Patient and tumour characteristics were compared between Asian and European women. Chi-square test was used to examine the differences between the two ethnic groups.

The PHARMS dataset contains claim and payment information from pharmacists for subsidised dispensings. Adherence to endocrine therapy was investigated in patients diagnosed in 2005-13, because 2005 was the first year that over 80% of pharmaceutical dispensing records reported NHI in the PHARMS dataset. The quality of PHARMS data has improved and in 2010 NHI was provided for approximately 97% of pharmaceutical dispensing.[24] An adherence index/medication possession ratio (MPR) for each woman was calculated by dividing the number of days covered by endocrine therapy with the number of days for up to 5 years unless censored by death or the conclusion of the study (31 December 2014). A MPR of 80% or more was considered to be high/optimal level of adherence.[25-27] Stepwise logistic regression model was used to estimate the odds ratio of treatment and adherence to endocrine therapy between the two groups.

Patient outcomes include breast cancer-specific survival and all-cause survival. These mortality data were derived from the New Zealand National Mortality Collection. For all-cause survival analyses, patients without a documented record of death were considered to be censored on the last updated date for Mortality Collection which was 31 December 2014. For cancer-specific analyses, deaths from other causes were censored on the date of death. Kaplan-Meier method was used to examine the survival between Asian and European women, as well as the survival between Asian subgroups (Chinese, Southeast Asian, Indian and other Asian). We used Cox proportional hazards model to estimate the hazard ratio (HR) of breast cancer-specific mortality and all-cause mortality between Asian and European women after adjustment for characteristics and treatments. All data analyses were performed in IBM SPSS statistics 25 (New York, United States).

Results

The studied cohort included 8608 European women and 949 Asian women (317 Chinese, 225 Indian, 94 Southeast Asian and 313 other Asian). The number of Asian women diagnosed with stage I-III breast cancer has been increasing rapidly, from 148 in 2000-03 to 331 in 2010-13 (Table 1). Asian women who were diagnosed with stage I-III breast cancer were generally younger (average age: 53 years vs 60 years) and had less comorbidities than European women. Compared to 78.7% of European women, 86.7% of Asian women had no severe comorbidities. BMI data was only available in 28.0% of patients. Among those with BMI information, 30.2% of European were obese (BMI≥30) compared to 15.4% of Asian women. A higher proportion of Asian women were diagnosed with grade 3 breast cancer than European women (36.6% vs 27.3%), as well as HER2+ breast cancer (16.0% vs 11.8%). The tumour size for Asian women was larger than that for European women.

Asian women were more likely to receive mastectomy rather than BCS compared to European women (Table 2). The odds ratio of Asian women having BCS compared to European was 0.63 (95% confidence interval (CI): 0.54-0.74) after adjustment for age, year, register, screen detection, public/private treatment, cancer stage, grade, tumour size and subtype. Among the 532 Asian women diagnosed with T1 breast cancer, 41.0% (218) had mastectomy and 59.0% (314) had BCS. The respective percentage was 28.5% and 70.7% for European women diagnosed with T1 breast cancer. Asian women were also less likely to have reconstruction after mastectomy (adjusted odds ratio: 0.34), less likely to have chemotherapy (adjusted odds ratio: 0.73), and less likely to be treated with trastuzumab if tested HER2+ (adjusted odds ratio: 0.43). Use of radiotherapy and endocrine therapy for ER/PR positive cancer were similar between the two ethnic groups. Asian women had better adherence to endocrine therapy with an adjusted odds ratio of 1.54 (95% CI: 1.22-1.93, p-value<0.001).

Asian women had better breast-cancer specific survival and all-cause survival than European women (Figure 1 and 2). The crude HR of breast-cancer mortality for Asian women compared to European women was 0.60 (95% CI: 0.47-0.78), and the crude HR of all-cause mortality was 0.66 (95% CI: 0.53-0.81). The respective HR was 0.64 (95% CI: 0.49-0.82) and 0.68 (95% CI: 0.55-0.84) after adjustment for characteristics and treatments (Table 3). Better breast cancer-specific survival and all-cause survival were associated with fewer comorbidities, younger age, diagnosed in recent years, earlier cancer stage, lower cancer grade, smaller tumour size, less aggressive subtypes, having surgery, chemotherapy, radiotherapy and good adherence to endocrine therapy. The Kaplan-Meier method showed that Chinese, Indian and other Asian women had similar breast cancer-specific survival, but Southeast Asian women had worse survival than other Asian subgroups (Figure 3. log-rank test p-value =0.016). The adjusted hazard ratio of breast cancer-specific mortality for Southeast Asian women compared to other Asian subgroups was 2.90 (95% CI: 1.42-5.51).

Discussion

This study shows that Asian women with stage I-III breast cancer have better survival than European women. This is consistent with two American studies [4, 5] demonstrating a lower HR of mortality in Asian women compared to European women. However, in these two studies, the Asian group includes Pacific islanders who were found to have the worst survival of breast cancer compared to other ethnic groups in New Zealand.[28, 29] If Pacific women were not included in the Asian group, the HR of death in Asian women would likely have been even lower. Among the Asian subgroups, Southeast Asian women had the worst survival, as found in another American study compared to Chinese and Japanese.[30] However, the numbers of Asian subgroups were small, therefore the Asian subgroup findings were prone to great uncertainty. The definition of Southeast Asian [30-32] was different in other studies, and therefore the comparison with other studies is difficult. In New Zealand, Southeast Asian includes Filipino, Cambodian, Vietnamese, Indonesian, etc,[18] but Filipino and Vietnamese were not included in the Southeast Asian group in some American studies.[32]

Ten percent of Asian women diagnosed with breast cancer were 70 years or older compared to 24.6% of European women. This is a reflection in the make-up of the Asian and European populations in New Zealand. Five percent of Asian women in New Zealand are 70 years or older compared to 14% of European women.[33]

Asian women have shown better survival from breast cancer, in spite of the fact that they are more likely to be diagnosed with HER2+ breast cancer – a factor that is associated with worse outcomes.[11] Sixteen percent of Asian women had HER2+ breast cancer compared to 11.8% of European women. This has also been found in other studies, but the proportions of HER2+ breast cancers were slightly different.[4, 32, 34] The reported percentages of HER2+ breast cancer ranged from 20.6% to 36% for Asian women and 16.8% to 19% for European women.[4, 32, 34]

The better breast cancer outcome in Asian women was partly due to the better adherence to endocrine therapy (odds ratio: 1.54). In the Cox proportional hazards model, high adherence to endocrine therapy was associated with a decreased risk of breast cancer-specific mortality and all-cause mortality (respective hazard ratio: 0.41, 0.57). Previous studies have also shown that sub-optimal adherence to adjuvant endocrine therapy increased the risk of breast cancer recurrence and mortality.[27, 35, 36]

Fewer comorbidities and younger age have a significant impact on both breast cancer-specific and all cause survival. Compared to European women, Asian women were younger and were less

likely to have comorbidities.[37, 38] Comorbidities in patients with breast cancer can lead to dose reduction in chemotherapy and radiotherapy,[37, 38] and consistent underdosing of chemotherapy, and dose reductions in radiation therapy limit treatment efficacy and disease outcome.[37-39]

In Seneviratne's paper,[15] the survival difference between Māori women and European diagnosed with breast cancer disappeared after adjustment for patient characteristics and treatment, but the HR in our study did not change substantially after adjustment. That means there are some unknown factors contributing to the survival difference between Asian and European women. The breast cancer outcome in Asian women may be also associated with their health status and life style. The available BMI data show that Asian women were half as likely to be obese compared to European women (15.4% vs 30.2%). This is consistent with the data reported in the New Zealand Health Survey 2017/18: 15.1% of Asian and 30.7% of New Zealand European were obese.[40] Obesity is associated with a higher risk of developing breast cancer, especially in postmenopausal women, and with worse disease outcome for women of all ages.[38] Exercise and weight loss can reduce breast cancer risk and improve outcomes.[38]

The New Zealand Health Survey 2017/18 also showed that only 6.5% of Asian people are hazardous drinkers but 21.2% of European are hazardous drinkers. Alcohol consumption has an adverse impact on survival for women with breast cancer. Drinking ≥ 6 g/d of alcohol compared with no drinking after a breast cancer diagnosis increase risk of breast cancer recurrence (HR, 1.35; 95% CI, 1.00 to 1.83), especially among postmenopausal (HR, 1.51; 95% CI, 1.05 to 2.19) and overweight/obese women (HR, 1.60; 95% CI, 1.08 to 2.38).[41]

The difference in diet between Asian and European women may have an impact on the incidence and outcome of breast cancer. An American study found that low intake of meat/starches and high intake of legumes is associated with a reduced risk of breast cancer in Asian Americans.[42] A meta-analysis also show that a Mediterranean diet including fresh produce, whole grains, and legumes, as well as some healthful fats and fish, can reduce the risk of breast cancer.[43]

The strength of this study is that it comprises a relatively large population based database with comprehensive data on patient characteristics, patient treatment as well as outcomes. One weakness is that we do not have good data on BMI, exercise, drinking and diet that may explain the survival difference between Asian and New Zealand European women. Therefore, we used the New Zealand Health Survey data for discussion of possible explanations. It has been found that survival after breast cancer is different between immigrant Asian women and locally born Asian women.[44, 45] The Breast Cancer Registers do not record immigrant status and therefore we

cannot compare the survival between immigrant Asian women and New Zealand born Asian women.

Conclusion

Asian women are more likely to have high grade, larger and HER2+ breast cancers than New Zealand European women. In spite of this, they had better breast cancer outcomes. Possible explanations include: the differences in adherence to endocrine therapy, age, BMI and comorbidities.

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Compliance with ethical standards

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References

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A: **Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries**. *CA: a cancer journal for clinicians* 2018, **68**(6):394-424.
2. **Breast cancer** [https://www.who.int/cancer/prevention/diagnosis-screening/breast-cancer/en/]
3. Gelber RP, McCarthy EP, Davis JW, Seto TB: **Ethnic disparities in breast cancer management among Asian Americans and Pacific Islanders**. *Annals of surgical oncology* 2006, **13**(7):977-984.
4. Warner ET, Tamimi RM, Hughes ME, Ottesen RA, Wong Y-N, Edge SB, Theriault RL, Blayney DW, Niland JC, Winer EP *et al*: **Racial and Ethnic Differences in Breast Cancer Survival: Mediating Effect of Tumor Characteristics and Sociodemographic and Treatment Factors**. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2015, **33**(20):2254-2261.
5. Curtis E, Quale C, Haggstrom D, Smith-Bindman R: **Racial and ethnic differences in breast cancer survival: how much is explained by screening, tumor severity, biology, treatment, comorbidities, and demographics?** *Cancer* 2008, **112**(1):171-180.
6. Brown C, Lao C, Lawrenson R, Tin Tin S, Schaaf M, Kidd J, Allan-Moetaua A, Herman J, Raamsroop R, Campbell I *et al*: **Characteristics of and differences between Pasifika women and New Zealand European women diagnosed with breast cancer in New Zealand**. *The New Zealand medical journal* 2017, **130**(1467):50-61.
7. Tin Tin S, Elwood JM, Brown C, Sarfati D, Campbell I, Scott N, Ramsaroop R, Seneviratne S, Harvey V, Lawrenson R: **Ethnic disparities in breast cancer survival in New Zealand: which factors contribute?** *BMC Cancer* 2018, **18**:58.
8. Lawrenson R, Seneviratne S, Scott N, Peni T, Brown C, Campbell I: **Breast cancer inequities between Maori and non-Maori women in Aotearoa/New Zealand**. *European journal of cancer care* 2016, **25**(2):225-230.
9. Lawrenson R, Lao C, Campbell I, Harvey V, Seneviratne S, Edwards M, Elwood M, Scott N, Kidd J, Sarfati D *et al*: **Treatment and survival disparities by ethnicity in New Zealand women with stage I-III breast cancer tumour subtypes**. *Cancer causes & control : CCC* 2017, **28**(12):1417-1427.
10. Seneviratne S, Campbell I, Scott N, Shirley R, Lawrenson R: **Impact of mammographic screening on ethnic and socioeconomic inequities in breast cancer stage at diagnosis and survival in New Zealand: a cohort study**. *BMC Public Health* 2015, **15**(1):46.
11. Lawrenson R, Lao C, Campbell I, Harvey V, Seneviratne S, Elwood M, Sarfati D, Kuper-Hommel M: **The impact of different tumour subtypes on management and survival of New Zealand women with Stage I-III breast cancer**. *The New Zealand medical journal* 2018, **131**(1475):51-60.
12. Seneviratne S, Lawrenson R, Scott N, Kim B, Shirley R, Campbell I: **Breast cancer biology and ethnic disparities in breast cancer mortality in New Zealand: A cohort study**. *PLoS ONE* 2015, **10**(4).
13. Seneviratne S, Scott N, Lawrenson R, Campbell I: **Ethnic, socio-demographic and socio-economic differences in surgical treatment of breast cancer in New Zealand**. *ANZ Journal of Surgery* 2015.
14. Seneviratne S, Lawrenson R, Harvey V, Ramsaroop R, Elwood M, Scott N, Sarfati D, Campbell I: **Stage of breast cancer at diagnosis in New Zealand: Impacts of socio-**

demographic factors, breast cancer screening and biology. *BMC Cancer* 2016, **16**(1).
15. Seneviratne S, Campbell I, Scott N, Shirley R, Peni T, Lawrenson R: **Ethnic differences in breast cancer survival in New Zealand: contributions of differences in screening, treatment, tumor biology, demographics and comorbidities**. *Cancer Causes and Control* 2015, **26**(12):1813-1824.
16. Statistics New Zealand: **2013 Census QuickStats about culture and identity**. In. Wellington, New Zealand; 2014.
17. Seneviratne S, Campbell I, Scott N, Shirley R, Peni T, Lawrenson R: **Accuracy and completeness of the New Zealand Cancer Registry for staging of invasive breast cancer**. *Cancer Epidemiology* 2014, **38**(5):638-644.
18. **Ethnicity New Zealand Standard Classification 2005 V2.0.0** [http://aria.stats.govt.nz/aria/#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/l36xYpbxsRh7IW1p]
19. Tin ST, Elwood JM, Lawrenson R, Campbell I, Harvey V, Seneviratne S: **Differences in breast cancer survival between public and private care in New Zealand: Which factors contribute?** *PLoS ONE* 2016, **11**(4).
20. Sarfati D, Gurney J, Stanley J, Salmond C, Crampton P, Dennett E, Koea J, Pearce N: **Cancer-specific administrative data-based comorbidity indices provided valid alternative to Charlson and National Cancer Institute Indices**. *Journal of Clinical Epidemiology* 2014, **67**(5):586-595.
21. Wolff AC, Hammond ME, Hicks DG, Dowsett M, McShane LM, Allison KH, Allred DC, Bartlett JM, Bilous M, Fitzgibbons P *et al*: **Recommendations for human epidermal growth factor receptor 2 testing in breast cancer: American Society of Clinical Oncology/College of American Pathologists clinical practice guideline update**. *J Clin Oncol* 2013, **31**(31):3997-4013.
22. Thuerlimann B: **International consensus meeting on the treatment of primary breast cancer 2001, St. Gallen, Switzerland**. *Breast cancer (Tokyo, Japan)* 2001, **8**(4):294-297.
23. Lawrenson R, Lao C, Campbell I, Harvey V, Seneviratne S, Elwood M, Sarfati D, Kuper-Hommel M: **The impact of different tumour subtypes on management and survival of New Zealand women with Stage I–III breast cancer**. *New Zealand Medical Journal* 2018, **131(1475)**:51-60.
24. **Pharmaceutical Collection** [https://www.health.govt.nz/nz-health-statistics/national-collections-and-surveys/collections/pharmaceutical-collection]
25. McCowan C, Shearer J, Donnan PT, Dewar JA, Crilly M, Thompson AM, Fahey TP: **Cohort study examining tamoxifen adherence and its relationship to mortality in women with breast cancer**. *Br J Cancer* 2008, **99**(11):1763-1768.
26. Hershman DL, Shao T, Kushi LH, Buono D, Tsai WY, Fehrenbacher L, Kwan M, Gomez SL, Neugut AI: **Early discontinuation and non-adherence to adjuvant hormonal therapy are associated with increased mortality in women with breast cancer**. *Breast Cancer Res Treat* 2011, **126**(2):529-537.
27. Seneviratne S, Campbell I, Scott N, Kuper-Hommel M, Kim B, Pillai A, Lawrenson R: **Adherence to adjuvant endocrine therapy: Is it a factor for ethnic differences in breast cancer outcomes in New Zealand?** *Breast* 2015, **24**(1):62-67.
28. Campbell I, Scott N, Seneviratne S, Kollias J, Walters D, Taylor C, Roder D: **Breast cancer characteristics and survival differences between Maori, Pacific and other New zealand women included in the quality audit program of breast surgeons of Australia and New Zealand**. *Asian Pacific Journal of Cancer Prevention* 2015, **16**(6):2465-2472.

29. Campbell ID, Scott N, Seneviratne S, Kollias J, Walters D, Taylor C, Webster F, Zorbas H, Roder DM: **Breast cancer survival in New Zealand women**. *ANZ Journal of Surgery* 2015, **85**(7-8):546-552.
30. Parikh-Patel A, Mills PK, Jain RV: **Breast cancer survival among South Asian women in California (United States)**. *Cancer causes & control : CCC* 2006, **17**(3):267-272.
31. dos Santos Silva I, Mangtani P, De Stavola BL, Bell J, Quinn M, Mayer D: **Survival from breast cancer among South Asian and non-South Asian women resident in South East England**. *Br J Cancer* 2003, **89**(3):508-512.
32. Telli ML, Chang ET, Kurian AW, Keegan THM, McClure LA, Lichtensztajn D, Ford JM, Gomez SL: **Asian ethnicity and breast cancer subtypes: a study from the California Cancer Registry**. *Breast cancer research and treatment* 2011, **127**(2):471-478.
33. **Subnational population estimates tables.** [http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7512]
34. Parise C, Caggiano V: **Breast Cancer Mortality among Asian-American Women in California: Variation according to Ethnicity and Tumor Subtype**. *J Breast Cancer* 2016, **19**(2):112-121.
35. Hershman DL, Shao T, Kushi LH, Buono D, Tsai WY, Fehrenbacher L, Kwan M, Gomez SL, Neugut AI: **Early discontinuation and non-adherence to adjuvant hormonal therapy are associated with increased mortality in women with breast cancer**. *Breast Cancer Research and Treatment* 2011, **126**(2):529-537.
36. McCowan C, Shearer J, Donnan PT, Dewar JA, Crilly M, Thompson AM, Fahey TP: **Cohort study examining tamoxifen adherence and its relationship to mortality in women with breast cancer**. *British Journal of Cancer* 2008, **99**(11):1763-1768.
37. Edwards MJ, Campbell ID, Lawrenson RA, Kuper-Hommel MJ: **Influence of comorbidity on chemotherapy use for early breast cancer: systematic review and meta-analysis**. *Breast Cancer Res Treat* 2017, **165**(1):17-39.
38. Picon-Ruiz M, Morata-Tarifa C, Valle-Goffin JJ, Friedman ER, Slingerland JM: **Obesity and adverse breast cancer risk and outcome: Mechanistic insights and strategies for intervention**. *CA: a cancer journal for clinicians* 2017, **67**(5):378-397.
39. Lyman GH: **Weight-based chemotherapy dosing in obese patients with cancer: back to the future**. *Journal of oncology practice* 2012, **8**(4):e62-64.
40. Ministry of Health: **Tier 1 statistics 2017/18: New Zealand Health Survey.** In. Wellington, New Zealand; 2018.
41. Kwan ML, Kushi LH, Weltzien E, Tam EK, Castillo A, Sweeney C, Caan BJ: **Alcohol consumption and breast cancer recurrence and survival among women with early-stage breast cancer: the life after cancer epidemiology study**. *J Clin Oncol* 2010, **28**(29):4410-4416.
42. Tseng C-C, Stanczyk FZ, Pike MC, Yu MC, Wu AH: **Dietary patterns and breast cancer risk in Asian American women**. *The American Journal of Clinical Nutrition* 2009, **89**(4):1145-1154.
43. Li Y, Hu BQ, Wu XJ, Qi XW, Jiang J, Cui X, Zhang F, Yang XH: **Adherence to mediterranean diet and the risk of breast cancer: A meta-analysis**. *Translational Cancer Research* 2018, **7**(5):1290-1297.
44. Gomez SL, Clarke CA, Shema SJ, Chang ET, Keegan THM, Glaser SL: **Disparities in breast cancer survival among Asian women by ethnicity and immigrant status: a population-based study**. *Am J Public Health* 2010, **100**(5):861-869.

45. Pineda MD, White E, Kristal AR, Taylor V: **Asian breast cancer survival in the US: a comparison between Asian immigrants, US-born Asian Americans and Caucasians**. *International journal of epidemiology* 2001, **30**(5):976-982.

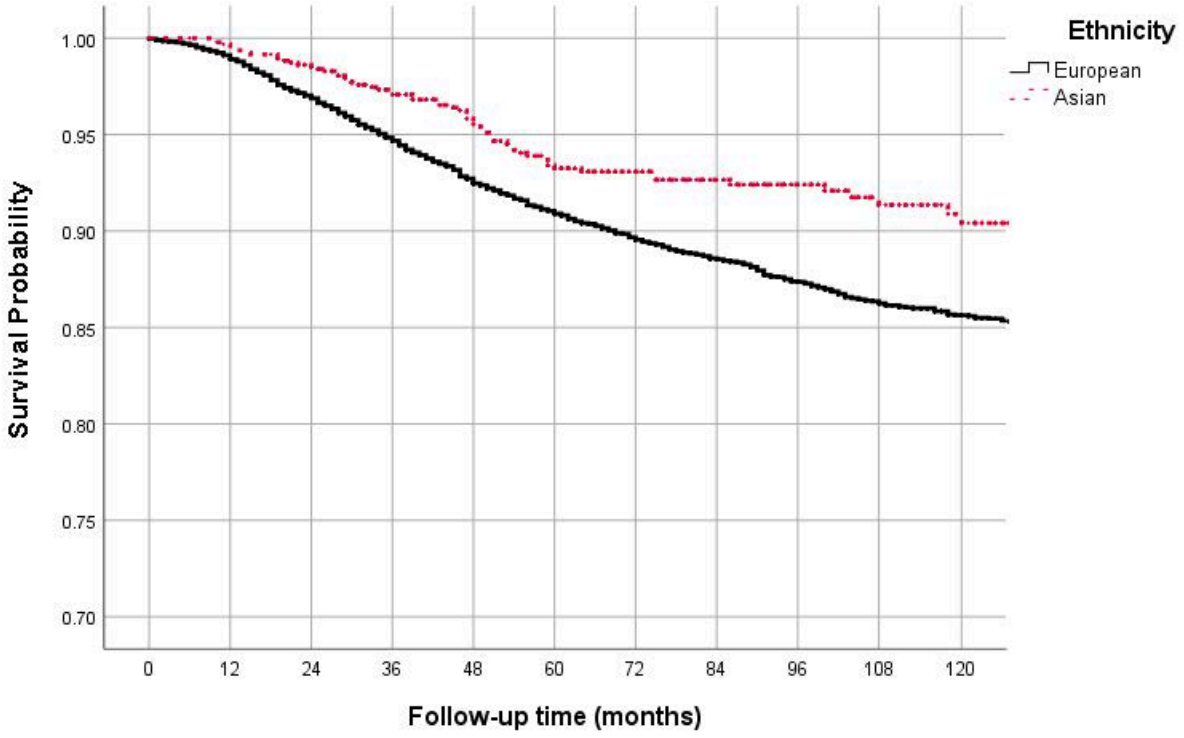
Table 1. Characteristics of NZ European women and Asian women diagnosed with stage I-III breast cancer

Characteristics	NZ European		Asian		Total		P-value (Chi-square test)
Year of diagnosis							
2000-2003	2191	25.5%	148	15.6%	2339	24.5%	<0.001
2004-2006	1878	21.8%	196	20.7%	2074	21.7%	
2007-2009	2033	23.6%	274	28.9%	2307	24.1%	
2010-2013	2506	29.1%	331	34.9%	2837	29.7%	
Comorbidity C3 score							
≤0	6775	78.7%	823	86.7%	7598	79.5%	<0.001
>0&≤1	680	7.9%	60	6.3%	740	7.7%	
>1&≤2	479	5.6%	28	3.0%	507	5.3%	
>2	674	7.8%	38	4.0%	712	7.5%	
Age							
<40	483	5.6%	90	9.5%	573	6.0%	<0.001
40-49	1655	19.2%	339	35.7%	1994	20.9%	
50-59	2247	26.1%	284	29.9%	2531	26.5%	
60-69	2101	24.4%	141	14.9%	2242	23.5%	
70-79	1183	13.7%	71	7.5%	1254	13.1%	
80+	939	10.9%	24	2.5%	963	10.1%	
BMI							
<18.5	30	1.2%	4	1.5%	34	1.3%	<0.001
18.5~25	844	34.9%	135	51.9%	979	36.5%	
25~30	816	33.7%	81	31.2%	897	33.5%	
≥30	730	30.2%	40	15.4%	770	28.7%	
Unknown	6188		689		6877		
Mode of detection							
Not screen detected	5113	59.4%	590	62.2%	5703	59.7%	0.098
Screen detected	3495	40.6%	359	37.8%	3854	40.3%	
Node positivity							
No	4935	61.9%	585	63.7%	5520	62.1%	0.298
Yes	3038	38.1%	334	36.3%	3372	37.9%	
Unknown	635		30		665		
Cancer stage							
I	4019	46.7%	439	46.3%	4458	46.6%	0.919
II	3298	38.3%	370	39.0%	3668	38.4%	
III	1291	15.0%	140	14.8%	1431	15.0%	
Grade							
1	2148	26.1%	200	21.7%	2348	25.6%	<0.001
2	3843	46.6%	385	41.8%	4228	46.1%	
3	2253	27.3%	337	36.6%	2590	28.3%	
Unknown	364		27		391		
Tumour size (mm)							
0-10	4979	60.0%	532	56.8%	5511	59.7%	0.044
>20	2877	34.7%	338	36.1%	3215	34.8%	
>50	445	5.4%	66	7.1%	511	5.5%	
Unknown	307		13		320		
Biomarker subtype							
Luminal A	3819	46.3%	440	47.7%	4259	46.5%	<0.001
Luminal B HER2-	859	10.4%	101	11.0%	960	10.5%	
Luminal B HER2+	600	7.3%	83	9.0%	683	7.5%	
HER2+ non-Luminal	369	4.5%	65	7.0%	434	4.7%	
Triple Negative	852	10.3%	106	11.5%	958	10.5%	
Unknown	2109		154		2263		
Total	**8608**		**949**		**9557**		

Table 2. Treatment difference between European and Asian women with breast cancer

Treatment	European		Asian		Adjusted OR	95% CI	p-value
Surgery							
BCS	4683	54.4%	417	43.9%	0.63[†]	0.54-0.74	<0.001
Mastectomy	3577	41.6%	521	54.9%			
No primary surgery	348	4.0%	11	1.2%			
Reconstruction after mastectomy							
No	2696	75.4%	437	83.9%			
Yes	881	24.6%	84	16.1%	0.34	0.26-0.44	<0.001
Radiotherapy after BCS							
No	777	16.6%	77	18.5%			
Yes	3906	83.4%	340	81.5%	0.81	0.62-1.07	0.140
Chemotherapy							
No	5561	64.6%	529	55.7%			
Yes	3047	35.4%	420	44.3%	0.73	0.60-0.89	0.002
Trastuzumab for HER2+ women							
No	410	42.1%	54	36.5%			
Yes	564	57.9%	94	63.5%	0.43	0.27-0.69	<0.001
Endocrine therapy for ER/PR+ women							
No	1783	25.8%	177	23.9%			
Yes	5152	74.2%	564	76.1%	1.06	0.86-1.31	0.602
Adherence to Endocrine therapy in 2005-13							
Low adherence (MPR<80%)	1275	34.7%	132	30.6%			
High adherence (MPR≥80%)	2114	65.3%	256	69.4%	1.54	1.22-1.93	<0.001

[†] Adjusted ratio of having BCS compared to mastectomy



Number at risk	Follow-up time (Months)										
	0	12	24	36	48	60	72	84	96	108	120
European	8608	8453	7860	6868	5927	5133	4411	3706	3097	2525	2001
Asian	949	942	888	758	669	567	468	380	314	237	191

Figure 1. Breast cancer-specific survival between European and Asian women with breast cancer

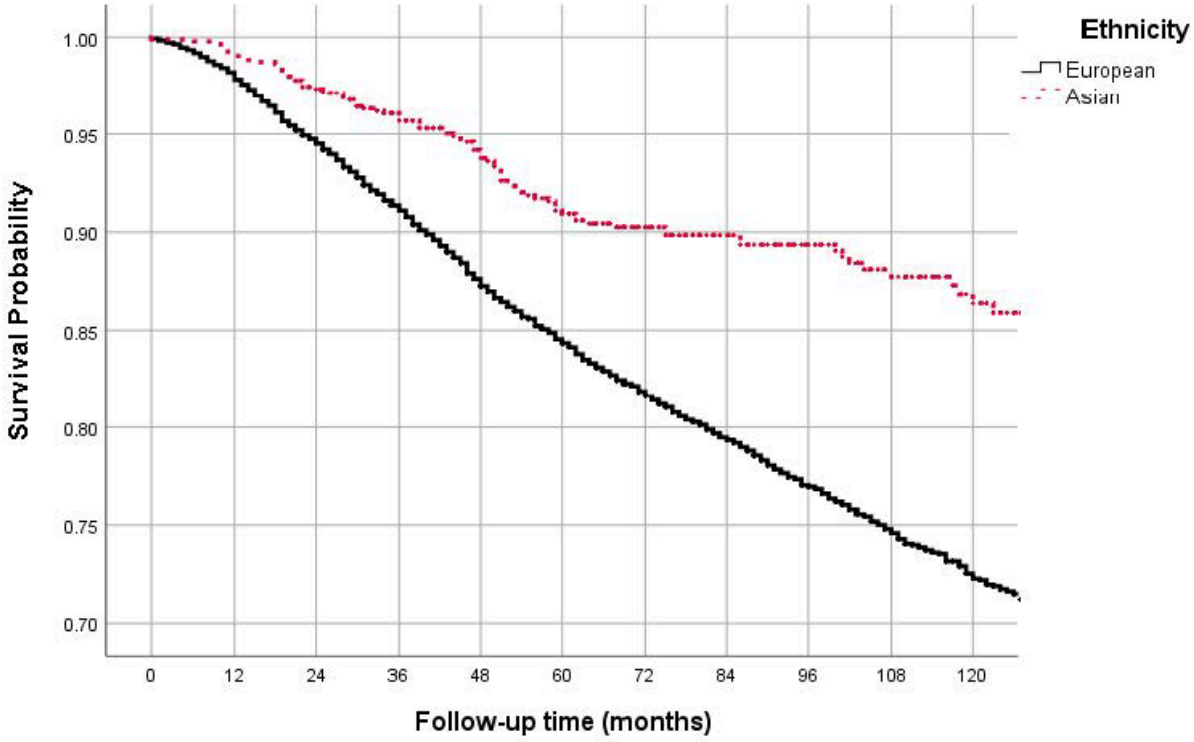


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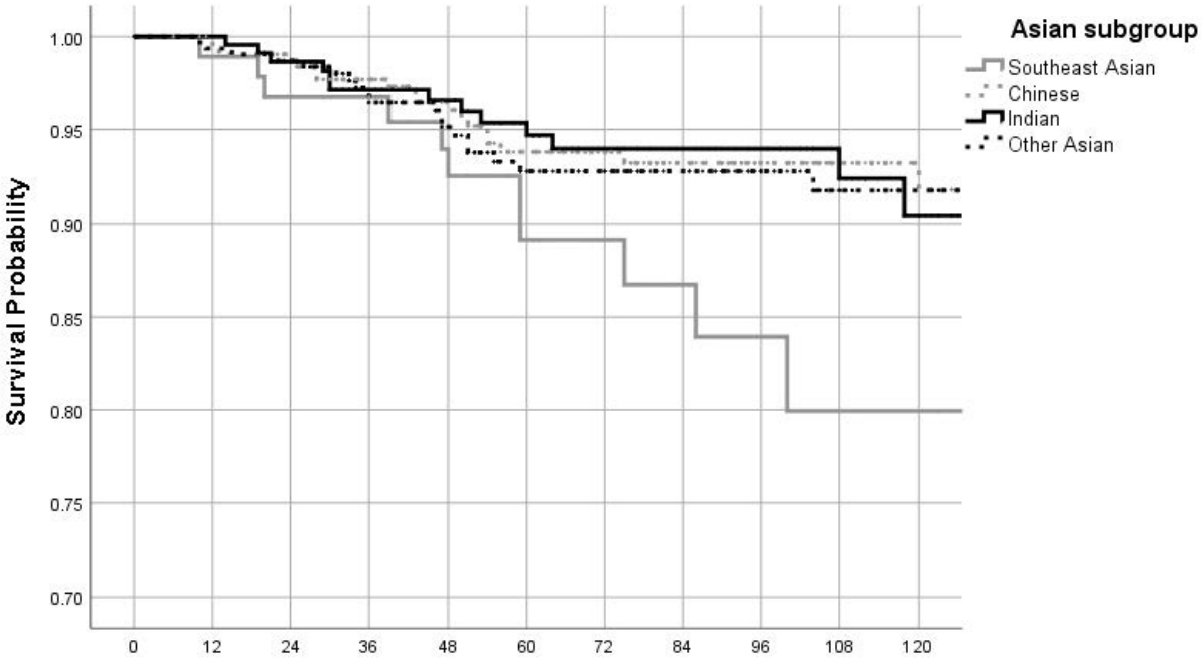
Figure 2. All cause survival between European and Asian women with breast cancer



Number at risk	Follow-up time (Months)										
	0	12	24	36	48	60	72	84	96	108	120
Chinese	317	315	298	258	226	193	165	132	107	81	65
Indian	225	225	211	180	164	145	112	92	78	59	45
Other Asian	313	310	295	245	214	178	152	124	107	77	64
Southeast Asian	94	92	84	75	65	51	39	32	22	20	17

Figure 3. Breast cancer-specific survival between the Asian subgroups

Table 3. Hazard ratios of breast cancer-specific mortality and all-cause mortality

Factors[†]	Breast cancer-specific mortality		All-cause mortality	
	Hazard ratio (95% CI)	p-value	Hazard ratio (95% CI)	p-value
Age (continuous)	1.01 (1.00-1.01)	0.041	1.04 (1.04-1.05)	<0.001
Year at diagnosis (continuous)	0.90 (0.88-0.93)	<0.001	0.96 (0.94-0.98)	<0.001
C3 comorbidity score				
≤0	Ref		Ref	
>0 & ≤1	1.21 (0.95-1.54)	0.117	1.30 (1.10-1.53)	0.002
>1	1.25 (1.02-1.53)	0.035	1.86 (1.65-2.10)	<0.001
Ethnicity				
European	Ref		Ref	
Asian	0.64 (0.49-0.82)	<0.001	0.68 (0.55-0.84)	<0.001
Cancer stage				
I	Ref		Ref	
II	2.25 (1.82-2.77)	<0.001	1.47 (1.29-1.68)	<0.001
III	5.57 (4.35-7.12)	<0.001	3.31 (2.78-3.95)	<0.001
Grade				
1	Ref		Ref	
2	3.49 (2.44-5.01)	<0.001	1.34 (1.15-1.56)	<0.001
3	6.38 (4.42-9.23)	<0.001	1.99 (1.68-2.35)	<0.001
Tumour size (mm, continuous)	1.01 (1.01-1.01)	<0.001	1.01 (1.01-1.01)	<0.001
Subtype				
Luminal A	Ref		Ref	
Luminal B HER2-	2.20 (1.75-2.76)	<0.001	1.59 (1.35-1.89)	<0.001
Luminal B HER2+	1.48 (1.13-1.93)	0.004	1.20 (0.97-1.48)	0.094
HER2+ non-luminal	2.13 (1.54-2.95)	<0.001	1.40 (1.09-1.79)	0.009
Triple negative	2.53 (1.90-3.35)	<0.001	1.65 (1.35-2.01)	<0.001
Surgery				
Breast conserving surgery	Ref		Ref	
Mastectomy	1.28 (1.08-1.52)	0.004	1.10 (0.97-1.25)	0.120
No primary surgery	5.49 (3.11-9.68)	<0.001	3.43 (2.47-4.76)	<0.001
Radiotherapy				
No	Ref		Ref	
Yes	0.77 (0.65-0.92)	0.003	0.66 (0.58-0.75)	<0.001
Chemotherapy				
No	Ref		Ref	
Yes	0.76 (0.63-0.92)	0.005	1.02 (0.88-1.18)	0.784
Endocrine therapy				
No	Ref		Ref	
Yes	1.03 (0.83-1.27)	0.797	0.92 (0.800-1.05)	0.205
Adherence to endocrine therapy				
Low adherence (MPR<80%)	Ref		Ref	
High adherence (MPR≥80%)	0.41 (0.31-0.53)	<0.001	0.57 (0.47-0.68)	<0.001

[†] Trastuzumab was not included in the model because of the small number of patients receiving trastuzumab.