Ethnic differences in time to surgery for women with early stage breast cancer in Aotearoa/New Zealand: a population-based study

Leah Boyle,[a,*] Ross Lawrenson,[b,c] Maxine Ronald,[d] Ian Campbell,[e] Vili Nosa,[f] and Sandar Tin Tin[a,g]

[a]Cancer Epidemiology Unit, Oxford Population Health, The University of Oxford, United Kingdom
[b]University of Waikato, Hamilton, New Zealand
[c]Waikato District Health Board, Hamilton, New Zealand
[d]Department of General Surgery, Whangarei Hospital, New Zealand
[e]Department of Surgery, Faculty of Health Sciences, University of Auckland, New Zealand
[f]Faculty of Medical and Health Sciences, University of Auckland, New Zealand
[g]Epidemiology and Biostatistics, School of Population Health, University of Auckland, New Zealand

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Summary

Background This study evaluates whether there are ethnic differences in time to surgery in women with early-stage (1–3a) breast cancer in four NZ urban regions between 2000 and 2020 pre- and post- Faster Cancer Treatment (FCT) implementation, which was introduced to address inequities in cancer outcomes.

Methods This retrospective analysis used *Te Rēhita Mate Ūtaetae* (Breast Cancer Foundation National Register), a prospectively maintained database of breast cancers from 2000 to 2020. Women with stage 3b, 3c, metastatic or bilateral cancers were excluded. Logistic regression models evaluated ethnic differences in time to surgery (≤31/>31 days as per FCT plan) with sequential adjustment for potential contributing factors (demographic, mode of diagnosis, tumour, treatment facility type and treatment). Subgroup analyses by pre- and post-FCT implementation date were undertaken.

Findings Of the 16,365 women included, 74.1% were NZ European (NZE), 10.2% were Māori, 6.1% were Pacific, and 9.2% were Asian. Wāhine Māori (Māori women) and Pacific women were more likely to experience delays in surgery >31 days, compared to NZE (maximally adjusted OR: 1.18; 95% CI:1.05, 1.33 and OR:1.42; 95% CI:1.22, 1.65, respectively)–deprivation and treatment facility type contributed most to this. Wāhine Māori experienced delay in the public system only. The associations did not differ between the pre- and post- FCT periods.

Interpretation Ethnic inequities exist with respect to time to surgery for women with early-stage breast cancer and these differences persist after FCT implementation.

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Keywords: Breast cancer; Surgery; Delay; Inequities; Ethnicity

Introduction

In Aotearoa/New Zealand (NZ), breast cancer affects one in nine women, with an age-standardized rate of 93.0 per 100,000 person-years which is markedly higher than the average rate of 55.9 per 100,000 person-years in other countries with high human development index.[1–3] Over time, survival from breast cancer has improved in NZ; however, there are significant ethnic inequities which require urgent public health focus,[3–5] disproportionately affecting Māori (Indigenous people) and Pacific (immigrants or descendants of immigrants from Pacific islands) people, who comprise 16% and 8% of the NZ population respectively.[6]

Causes of inequity in cancer care and outcomes are complex, encompassing a range of demographic, tumour and health system factors,[4,7] as well as the

*Corresponding author. Cancer Epidemiology Unit, Oxford Population Health, Richard Doll Building, Oxford OX3 7LF, United Kingdom.
E-mail address: leahimogenboyle@gmail.com (L. Boyle).

Research in context

Evidence before this study

Surgery is most often the primary treatment for early stage (1–3a) breast cancer.

Wāhine Māori and Pacific women with breast cancer experience almost two-fold greater mortality compared to non-Māori non-Pacific women. Treatment delay is one factor affecting survival for breast cancer. Prior research among breast cancers diagnosed between 2005 and 2010 in the Waikato region of New Zealand (NZ) demonstrated ethnic inequities in time to surgery, disproportionately affecting wāhine Māori (Māori women) and Pacific women, who experienced significantly longer delays (37 and 43 days respectively) to surgery, compared to NZ European (NZE) women (30 days).

Added value of this study

In July 2012, the NZ government introduced the Faster Cancer Treatment (FCT) plan, stating that *all* people irrespective of ethnicity and other socio-demographic factors should receive their first cancer treatment within 31-days from date of decision to treat. There have been no studies evaluating the associations between ethnicity and time to breast cancer surgery since FCT implementation, or in other regions of NZ. Our study demonstrates that ethnic inequities persist in time to surgery, with longer delays experienced by wāhine Māori and Pacific women, compared to NZE women, and that there has been no improvement since FCT implementation.

Implications of all the available evidence

NZ faces significant inequities in breast cancer outcomes, disproportionately affecting wāhine Māori and Pacific women. Inequities in time to surgery continue despite FCT implementation, further efforts are needed to achieve equitable cancer care in NZ.

impact of colonisation in NZ.[8,9] Specifically for breast cancer, deprivation and late stage at diagnosis have been identified as the key contributors to the survival disadvantage experienced by wāhine Māori and Pacific women when compared to NZ European (NZE) women, ultimately reflecting the downstream consequences of colonisation.[4,9]

Timely access to high-quality cancer treatment influences breast cancer survival.[10] The primary treatment for early-stage (1–3a) breast cancer is usually surgery; an earlier study demonstrated that in the Waikato region of NZ, among cancers diagnosed from 2005 to 2010, wāhine Māori (Māori women) and Pacific women had significantly longer delays at 37 and 43 days respectively to surgery, compared to NZE women at 30 days.[10] This may in part be because Wāhine Māori are more likely to receive care in the public sector compared to NZE women.[11] Māori patients also reported experiences of interpersonal racism and discrimination within the NZ healthcare system.[12,13]

In July 2012, the NZ Ministry of Health (MOH) introduced the Faster Cancer Treatment (FCT) plan to facilitate equal and timely access to high-quality cancer care for *all* New Zealanders, irrespective of their ethnicity or other sociodemographic factors. This plan introduced the 31-day indicator which defined 31-days as the maximum acceptable delay from date of decision to treat to first cancer treatment.[14] To our knowledge, there have been no national studies evaluating the associations between ethnicity and time to breast cancer surgery in NZ since FCT implementation.

This study therefore assessed whether there were ethnic differences in women with early-stage (1–3a) breast cancer, from 2000 to 2020 in time to surgery and whether these associations differed pre- and post- FCT implementation, using the data from *Te Rēhita Mate Ūtaetae* (Breast Cancer Foundation National Register) which captures all breast cancers in four urban regions of NZ comprising two-thirds of the country's population and representative of 63% of national breast cancer cases.[3]

Methods

Study design and data sources

This retrospective study used the data from *Te Rēhita Mate Ūtaetae* (The Breast Cancer Foundation National Register), a prospectively maintained database which records all primary breast cancer diagnoses in four large tertiary centres in NZ—Auckland, Waikato, Christchurch, and Wellington from 2000 to 2020.[3] This register has a less than 1% withdrawal rate and is representative of 99% of eligible cancer cases and is shown to be more comprehensive than national databases.[3,15]

Study population

A total of 34,742 women with breast cancer between 1 June 2000 and 31 December 2020 were recorded in the database. This study included 16,365 women (biological sex female) who were diagnosed with histologically confirmed early-stage (1–3a) primary invasive breast cancer, and received surgery as their initial cancer treatment. Note that, surgery is the primary treatment for early invasive breast cancer as it aims to eradicate the primary tumour and any associated local extension, aiming to obtain local disease control.[16] Women with bilateral or multi-focal cancer, stage 3 b or 3c, or metastases were excluded as these women do not typically have surgery as an initial treatment as neoadjuvant

therapy is often required.[3,16] Consistent with prior research, women undergoing neoadjuvant therapy were excluded, as this would delay time to surgery[3] (Fig. 1).

Variables of interest

The exposure of interest was ethnicity categorised as NZE, Māori, Asian or Pacific. Ethnicity in *Te Rēhita Mate Ūtaetae* is sourced from the MOH through linkage with individual National Health Identifier numbers. The register allows for up to three ethnicities to be selected.[3] As per the NZ MOH 'HISO 10001:2017 Ethnicity Data Protocol', patients with more than one recorded ethnicity were allocated to a single ethnic group in order of priority: Māori, Pacific, Asian, and European/other.[17] 'Other' ethnicity comprises 1.5% of patients in the register and was excluded from this analysis, as this represents a number of ethnicities therefore interpretation of results would be limited and this is also in alignment with prior *Te Rēhita Mate Ūtaetae* analyses of ethnicity-based outcomes.[3]

The primary study outcome was time in days from date of diagnosis to date of surgery. The date of diagnosis in the registry corresponds to date of the diagnostic procedure, and this was used as a proxy for 'date of decision to treat' as used in the FCT guidelines. A threshold of 31 days was used as the limit for the longest acceptable delay in keeping with the FCT indicator set by the NZ MOH and time to surgery was categorised as a binary variable accordingly (≤31/> 31 days).[14] An additional 90-day threshold was also used. This is associated with a significant survival disadvantage and used in similar literature providing a means for comparison.[10]

Other variables for analysis which may contribute to the associations between ethnicity and time to surgery were selected *a priori* based on prior literature (Fig. 2).[4,5,7,10,11] These were: 1) demographic factors—age (<45 years, ≥45 to ≤ 69 years (screening age), >69 years), region, area of residence (rural, urban, unknown), NZ deprivation index (1, least deprived to 10, most deprived, in quintiles), 2) mode of diagnosis (screened, symptomatic), 3) tumour factors—TNM stage (1—3a), grade (low, intermediate, high, unknown), histology (ductal, lobular, mixed, other, unknown), oestrogen and progesterone receptor status (ER+/PR+, ER+/PR–, PR–/ER+, PR–/ER–unknown), and human epidermal growth factor receptor 2 (HER2) status, 4) treatment facility (public/private) and 5) treatment factors –locoregional therapy (BCS + RT, BCS no RT, mastectomy) and systemic therapy (see Supplementary Table S1 for detail on variable categorization—note that, 'unknown' was used for missing covariates which ensured the sample size remained in building the multivariate model).

Statistical analyses

Descriptive analyses summarize the data by ethnicity and differences across the four ethnic groups were assessed using chi-square (χ^2) tests. Days to surgery were presented as median (interquartile range IQR) due to right skew. Supplementary Table S2 displays descriptive statistics for excluded women not undergoing surgery.

Using NZE as the reference group, multivariate logistic regression models were built to obtain odds ratios (OR) with 95% confidence intervals (CI) for the associations between ethnicity and time to surgery >31 days. Models were also built using the 90- day threshold. The models were adjusted in a step-wise fashion with a forward approach, in five domains, to build a total of five models for each outcome. Model one included adjustment for demographic factors, model two additionally included adjustment for mode of diagnosis, model three included adjustment for tumour factors, model four included adjustment for treatment facility, and then the maximally adjusted model, model five, included adjustment for treatment factors. For the primary outcome, the mediating role of each of the five domains was determined by the percentage reduction in the β coefficient after inclusion of each domain in the model using the approach described previously: $100 \times (\beta_{crude}-\beta_{adjusted})/\beta_{crude}$.[4,18] The 95% CI relating to each percentage attenuation was estimated using a non-parametric bootstrapping method with 1000 re-samplings with replacement.

Subgroup analyses by date of diagnosis (pre-FCT/post-FCT) based on the FCT implementation date (July 2012), treatment facility type (public/private) and mode of diagnosis (screened/symptomatic) were undertaken. The pre-FCT/post-FCT subgroup was restricted to women treated in the public care sector consistent with MOH guidelines[14] (this excluded 5736 women treated in private and 247 with unknown recorded for treatment facility type). We also fitted separate logistic regression models for each NZ deprivation index quintile, by treatment facility type (public/private), excluding those (n = 587) with unknown record for NZ deprivation index. χ^2 for heterogeneity were obtained to determine whether the risk estimates from these subgroup analyses were different. Sensitivity analysis was undertaken with comorbidity added to the models, using the Charlson Comorbidity Index (CCI) by restricting the sample to the 4052 women with a CCI recorded. CCI is a validated index which measures the presence of up to 19 comorbidities and weights them according to their associated mortality risk to obtain a score, categorized as: 0, 1–2, 3–4, >5.[19] A *p*–value of 0.05 was considered statistically significant. Data was analysed in Stata MP version 17.0 and SAS version 9.4.

Ethics

This study was approved by the Central Health and Disability Ethics Committee (Ref: 19/CEN/4).

Role of the finding source

This study was funded by: Dunedin Basic Medical Sciences Course Trust (Richard Stewart scholarship) (LB),

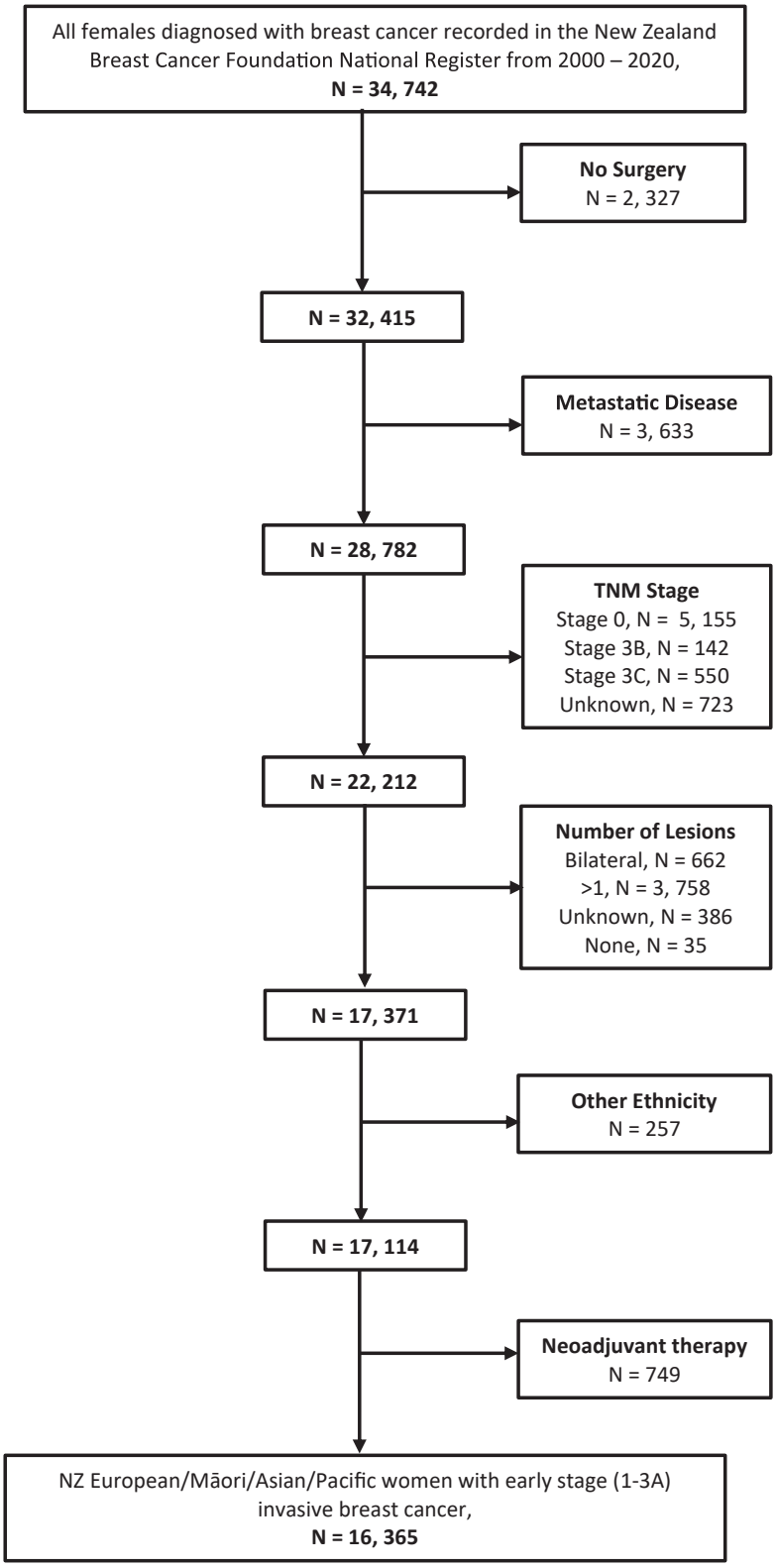

Fig. 1: Sample restriction flowchart.

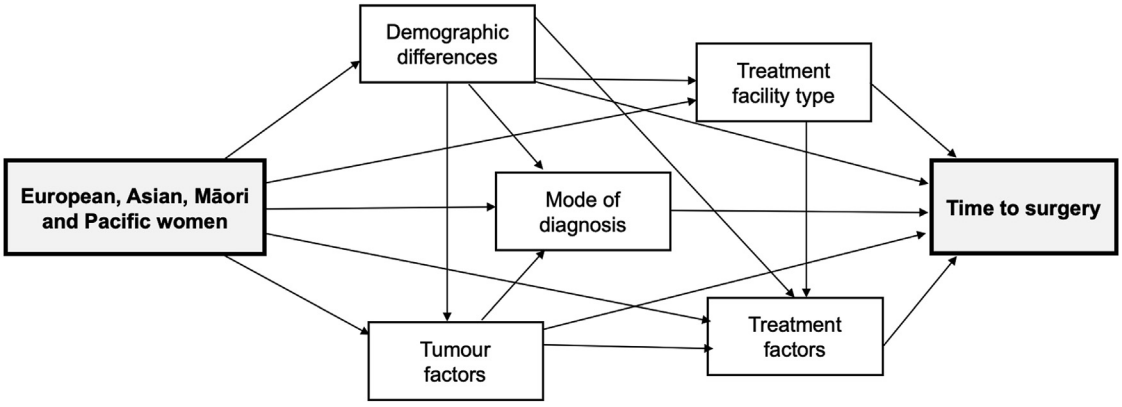

Fig. 2: Conceptual framework displaying potential contributing factors on the ethnicity–time to surgery association for women with breast cancer in New Zealand.

Royal Australasian College of Surgeons (Hugh Johnston Travel Grant) (LB), Oxford Population Health (post-Master of Science research assistant position) (LB), HRC and Girdlers' UK fellowship (Ref: 19/031) (STT), and Sir Charles Hercus Health Research Fellowship (Ref: 23/051) (STT).

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Results

Participant characteristics

Of the 16,365 women included, 74.8% were NZE, 9.2% were Asian, 9.9% were Māori and 6.1% were Pacific (Table 1). Most were in the screening age group (≥45 to ≤ 69 years; 71.2%). Asian and Pacific ethnicities had the greatest proportion of younger women <45 years with breast cancer (19.2% and 15.4% respectively). Wāhine Māori and Pacific women were more likely to live in deprived areas, with 34.0% and 46.0% living in decile 9–10 areas respectively (compared to 8.4% of NZE women). They were more likely to have a later stage at diagnosis with the greatest proportion of stage 2 b cancers (13.5% and 16.0% respectively for wāhine Māori and Pacific women, compared to 11.4% among NZE) and 3a cancers (7.1% and 9.6% respectively, compared to 5.2% among NZE). Regarding treatment, wāhine Māori and Pacific women were markedly less likely to receive treatment in a private facility (12.5% and 9.3% respectively), compared to NZE (40.5%) and Asian (31.8%) women.

Time to surgery

The overall median time to surgery was 28 (Interquartile Range: 22) days. 58.2% of women underwent surgery within 31 days of diagnosis, 98.4% received surgery within 90 days.

When compared with NZE women, Wāhine Māori and Pacific women were more likely to experience delays from diagnosis to surgery beyond 31 days (OR 1.99, 95% CI: 1.79, 2.21, and OR 2.24, 95% CI: 1.96, 2.25 respectively) (Table 2). Maximally adjusted models for all five domains resulted in significant attenuation of ORs, by 75.4% (95% CI: 65.4%, 86.5%) to 1.18 (95% CI: 1.05, 1.33) for wāhine Māori and by 56.8% (95% CI: 45.8%, 65.4%) to 1.42 (95% CI: 1.22,1.65) for Pacific women. The main contributors to this attenuation were deprivation and treatment facility type, but even after addition of all factors to the model, both wāhine Māori and Pacific women were still more likely to experience delay from diagnosis to surgery beyond 31-days. There were no statistically significant results for Asian women, compared to NZE women.

Supplementary Table S3 displays the associations for all the covariates included in the maximally adjusted models. Notably, the OR for delay beyond 31-days for women in the public system, compared to the private system, was 6.72 (95% CI: 6.16, 7.33). In addition, women from the most deprived areas (NZDep 9–10) were 30% (OR 1.30, 95% CI: 1.15, 1.48) more likely to experience delay beyond 31-days, compared to women from the least deprived areas (NZDep 1–2). Regarding tumour factors, the odds of delay beyond 31 days reduced with higher tumour grade (OR 0.82, 95% CI: 0.73–0.92 for grade 3 compared to grade 1 tumours).

The multivariate models for 90- day threshold is displayed in Supplementary Table S4. The final multivariate model shows that compared to NZE, wāhine Māori experienced no significant delay beyond 90-days (OR 1.21, 95% CI: 0.81, 1.81), whereas Pacific women still experienced significant delay beyond 90-days (OR 3.14, 95% CI: 2.15, 4.59).

Subgroup analysis by Faster Cancer Treatment implementation

When stratified by date of diagnosis, pre- and post- FCT implementation, in the public care sector, the odds of

Characteristic, n (%)	Total (n = 16,365)	NZ European (n = 12,242)	Māori (n = 1625)	Asian (n = 1502)	Pacific (n = 996)
Age (years)					
<45	1727 (10.6)	1080 (8.8)	206 (12.7)	288 (19.2)	153 (15.4)
≥45 to ≤69	11,660 (71.2)	8543 (69.8)	1282 (78.9)	1081 (72.0)	754 (75.7)
>69	2978 (18.2)	2619 (21.4)	137 (8.4)	133 (8.9)	89 (8.9)
Region					
Auckland	9604 (58.7)	6669 (54.5)	865 (53.2)	1236 (82.3)	834 (83.7)
Waikato	2643 (16.2)	2088 (17.1)	446 (27.5)	65 (4.3)	44 (4.4)
Christchurch	2258 (13.8)	2031 (16.6)	119 (7.3)	86 (5.7)	22 (2.2)
Wellington	1860 (11.4)	1454 (11.9)	195 (12.0)	115 (7.7)	96 (9.6)
NZ deprivation index					
1–2 (least deprived)	3673 (22.4)	3141 (25.7)	144 (8.8)	325 (21.6)	63 (6.3)
3–4	3454 (21.1)	2802 (22.9)	187 (11.5)	379 (25.2)	86 (8.6)
5–6	3333 (20.4)	2641 (21.6)	260 (16.0)	317 (21.1)	115 (11.6)
7–8	3073 (18.8)	2164 (17.7)	425 (26.2)	255 (17.0)	229 (23.0)
9–10 (most deprived)	2245 (13.7)	1027 (8.4)	553 (34.0)	206 (13.7)	459 (46.0)
Unknown	587 (3.6)	467 (3.8)	56 (3.5)	20 (1.3)	44 (4.4)
Area of residence					
Urban	14,149 (86.5)	10,396 (84.9)	1369 (84.2)	1445 (96.2)	939 (94.3)
Rural	1634 (10.0)	1384 (11.3)	200 (12.3)	37 (2.5)	13 (1.3)
Unknown	582 (3.5)	462 (3.8)	56 (3.5)	20 (1.3)	44 (4.4)
Mode of diagnosis					
Screen-detected	8338 (51.0)	6309 (51.5)	858 (52.8)	673 (44.8)	498 (50.0)
Symptomatic	8027 (49.0)	5933 (48.5)	767 (47.2)	829 (55.2)	498 (50.0)
TNM stage					
1a	8.980 (54.9)	6967 (55.9)	816 (50.2)	782 (52.0)	415 (41.7)
1b	485 (3.0)	374 (3.1)	49 (3.0)	39 (2.6)	23 (2.3)
2a	4180 (25.5)	3028 (24.7)	426 (26.2)	423 (28.2)	303 (30.4)
2b	1791 (11.4)	1238 (10.1)	219 (13.5)	175 (11.7)	159 (16.0)
3a	929 (5.7)	635 (5.2)	115 (7.1)	83 (5.5)	96 (9.6)
Cancer grade					
Low	4313 (26.4)	3322 (27.1)	412 (25.4)	3783 (24.8)	206 (24.8)
Intermediate	7610 (46.5)	5695 (46.5)	813 (50.0)	640 (42.6)	462 (46.4)
High	4300 (26.3)	3129 (25.6)	381 (23.5)	471 (31.4)	471 (31.3)
Unknown	142 (0.9)	96 (0.8)	19 (0.8)	18 (1.2)	9 (0.9)
Histology					
Ductal	13,095 (80.0)	9701 (79.2)	1328 (81.7)	1262 (84.0)	804 (80.7)
Lobular	1632 (10.0)	1328 (10.9)	143 (8.8)	86 (5.7)	75 (7.5)
Mixed	445 (2.7)	318 (2.6)	49 (3.0)	47 (3.1)	31 (3.1)
Other	1044 (6.4)	792 (6.5)	86 (5.3)	93 (5.9)	73 (7.3)
Unknown	149 (0.9)	103 (0.8)	19 (1.2)	14 (0.9)	13 (1.3)
Receptors					
ER+/PR+	9277 (56.7)	6829 (56.6)	880 (54.2)	847 (56.4)	621 (62.4)
ER+/PR−	1446 (8.8)	1136 (9.3)	99 (6.1)	159 (10.6)	52 (5.2)
ER−/PR+	128 (0.8)	95 (0.8)	11 (0.7)	18 (1.2)	4 (0.4)
ER−/PR−	1928 (11.8)	1447 (11.8)	158 (9.7)	287 (12.5)	136 (13.6)
Unknown	3586 (21.9)	2635 (21.5)	477 (29.4)	291 (19.4)	183 (18.4)
HER					
Negative	12,498 (76.4)	9339 (76.3)	1250 (76.9)	1191 (79.3)	718 (72.9)
Equivocal	43 (0.3)	36 (0.3)	2 (0.1)	3 (0.2)	2 (0.2)
Positive	1889 (11.5)	1303 (10.6)	221 (13.6)	193 (12.9)	172 (17.3)
Unknown	1935 (11.8)	1564 (12.8)	152 (9.4)	115 (7.7)	104 (10.4)
Treatment facility					
Public	10,382 (63.4)	7077 (57.8)	1412 (86.9)	994 (66.2)	899 (90.3)
Private	5736 (35.1)	4962 (40.5)	203 (12.5)	478 (31.8)	93 (9.3)
Unknown	247 (1.5)	203 (1.7)	10 (0.6)	30 (2.0)	4 (0.4)

(Table 1 continues on next page)

Characteristic, n (%)	Total (n = 16,365)	NZ European (n = 12,242)	Māori (n = 1625)	Asian (n = 1502)	Pacific (n = 996)
(Continued from previous page)					
Locoregional treatment					
BCS + RT	8632 (52.8)	6632 (54.2)	868 (53.4)	676 (45.0)	456 (45.8)
BCS no RT	1366 (8.4)	1034 (8.5)	136 (8.4)	101 (6.7)	95 (9.5)
Mastectomy	5504 (33.6)	3849 (31.4)	565 (34.8)	677 (45.1)	413 (41.5)
Unknown	863 (5.3)	727 (5.9)	56 (3.5)	48 (3.2)	32 (3.2)
Systemic therapy					
Yes	11,561 (70.6)	8447 (69.0)	1246 (76.7)	1121 (74.6)	747 (75.0)
No	4804 (29.4)	3795 (31.0)	379 (23.3)	381 (25.4)	249 (25.0)

Ethnic differences for all characteristics statistically significant with $p < 0.001$ in χ^2 tests. Abbreviations used in the table–TNM—Tumour Node Metastasis Stage, ER—Oestrogen Receptor, PR—Progesterone Receptor, HER—Human Epidermal Growth Factor Receptor, BCS—Breast Conserving Surgery, RT—Radiotherapy.

Table 1: **Baseline demographic, tumour and treatment characteristics by ethnicity.**

delay >31 days, were not significantly reduced after FCT implementation for any ethnicity compared to NZE (Māori OR: 1.07; 95% CI: 0.90, 1.27, Asian OR 0.91; 95% CI: 0.76, 1.09 and Pacific OR: 1.30; 95% CI 1.06, 1.61). Deprivation remained a key contributor post-FCT implementation to delay in time to surgery, for Pacific women while both region and deprivation were key contributors for wāhine Māori (Table 3).

Subgroup analysis by treatment facility type

Almost two-thirds (63.9%) of women received surgery in the public system. In maximally adjusted models, wāhine Māori were more likely to experience delay beyond 31-days when compared to NZE in the public system (OR: 1.19; 95% CI: 1.05, 1.35) but not in the private system (OR: 0.96; 95% CI: 0.63, 1.45), with deprivation representing a key contributor in the public system (Table 4).

Model	Additional variables in model[a]	NZ European (n = 12,242)	Māori (n = 1625)		Asian (n = 1502)		Pacific (n = 996)	
		Reference	OR (95% CI)	% attenuation (95% CI)[b]	OR (95% CI)	% attenuation (95% CI)[b]	OR (95% CI)	% attenuation (95% CI)[b]
Unadjusted		1.00	1.99 (1.79, 2.21)		1.11 (1.00, 1.24)		2.24 (1.96, 2.55)	
1. Unadjusted + Demographics	Age	1.00	2.09 (1.88, 2.33)		1.21 (1.08, 1.35)		2.39 (2.09, 2.73)	
	Region	1.00	2.03 (1.83, 2.26)		1.36 (1.22, 1.52)		2.72 (2.37, 3.11)	
	NZ Dep Index	1.00	1.72 (1.54, 1.91)		1.31 (1.17, 1.47)		2.13 (1.85, 2.46)	
	Area of residence	1.00	1.72 (1.54, 1.92)	21.1 (16.6, 26.1)	1.31 (1.17, 1.47)	−150.5 (−544.0, −81.6)	2.13 (1.85, 2.45)	6.0 (1.1, 11.0)
2. Model 1 + Mode of diagnosis	Mode of diagnosis	1.00	1.74 (1.56, 1.95)	19.2 (14.8, 24.1)	1.35 (1.21, 1.52)	−182.1 (−663.3, −97.9)	2.18 (1.89, 2.51)	3.4 (−1.5, 8.5)
3. Model 2 + Tumour factors	Stage	1.00	1.74 (1.56, 1.95)		1.36 (1.21, 1.52)		2.18 (1.89, 2.51)	
	Grade	1.00	1.73 (1.55, 1.94)		1.36 (1.22, 1.53)		2.19 (1.90, 2.53)	
	Histology	1.00	1.75 (1.56, 1.95)		1.38 (1.23, 1.55)		2.21 (1.92, 2.55)	
	ER/PR	1.00	1.74 (1.55, 1.94)		1.36 (1.21, 1.52)		2.17 (1.88, 2.50)	
	HER2	1.00	1.72 (1.53, 1.92)	21.6 (17.2, 27.5)	1.33 (1.19, 1.49)	−165.1 (−617.2, −88.5)	2.15 (1.86, 2.48)	5.2 (−1.1, 9.9)
4. Model 3 + Treatment facility	Treatment facility	1.00	1.20 (1.07, 1.35)	73.6 (63.8, 84.3)	1.10 (0.97, 1.25)	8.4 (−38.1, 84.7)	1.43 (1.23, 1.66)	55.5 (44.9, 63.6)
5. Model 4 + Treatment factors	Locoregional	1.00	1.18 (1.05, 1.33)		1.05 (0.93, 1.19)		1.41 (1.21, 1.64)	
	Systemic	1.00	1.18 (1.05, 1.33)	75.4 (65.4, 86.5)	1.06 (0.94, 1.21)	42.6 (−2.9, 186.1)	1.42 (1.22, 1.65)	56.8 (45.8, 65.4)

Abbreviations used in the table—OR—Odds Ratio, CI—Confidence Interval, NZ Dep Index–New Zealand Deprivation Index, ER—Oestrogen Receptor, PR—Progesterone Receptor, HER2—Human Epidermal Growth Factor Receptor. [a]Variables are categorized as follows: age; <45 years, ≥45 to ≤69 years (women eligible for BSA) and >69 years, region; Auckland, Waikato, Christchurch, Wellington, NZ Dep Index; decile 1- least deprived to decile 10—most deprived, area of residence; rural or urban, mode of diagnosis; screened or symptomatic, stage; using AJCC 7th edition TNM staging, grade; 1—low to 3—high, histology; ductal, lobular, mixed, other, ER/PR; ER+/PR+, ER+/PR−, ER−/PR+, ER−/PR−, unknown, HER; negative, equivocal, positive, unknown, treatment facility; public or private, radiotherapy; radiotherapy or no radiotherapy, systemic; systemic treatment (chemotherapy, hormone therapy or biologics) or no systemic treatment. [b]Percent attenuation compared to unadjusted model = 100 × (βcrude-βadjusted)/βcrude with 95% bootstrap confidence interval.

Table 2: **Multivariate logistic regression models for odds of time to surgery >31 days versus ≤31 days by ethnicity.**

Model	Additional variables in model[b,c]	Pre—FCT[a] (n = 4135) OR (95% CI)				Post—FCT[a] (n = 6247) OR (95% CI)			
		NZ European (n = 2851)	Māori (n = 595)	Asian (n = 362)	Pacific (n = 327)	NZ European (n = 4226)	Māori (n = 817)	Asian (n = 632)	Pacific (n = 572)
Unadjusted		1.00	1.42 (1.18, 1.70)	0.94 (0.75, 1.17)	1.25 (0.99, 1.57)	1.00	1.22 (1.04, 1.43)	0.88 (0.73, 1.03)	1.35 (1.12, 1.62)
1. Unadjusted + Demographics	Age	1.00	1.41 (1.17, 1.69)	0.99 (0.79, 1.23)	1.27 (1.01, 1.61)	1.00	1.23 (1.05, 1.45)	0.91 (0.77, 1.09)	1.37 (1.14, 1.65)
	Region	1.00	1.36 (1.13, 1.64)	1.03 (0.82, 1.29)	1.32 (1.04, 1.67)	1.00	1.15 (0.98, 1.35)	0.90 (0.76, 1.08)	1.38 (1.14, 1.68)
	NZ Dep Index	1.00	1.28 (1.06, 1.54)	1.03 (0.82, 1.29)	1.20 (0.94, 1.53)	1.00	1.09 (0.92, 1.29)	0.89 (0.75, 1.07)	1.27 (1.04, 2.15)
2. Model 1 + Mode of diagnosis	Mode of diagnosis	1.00	1.30 (1.08, 1.57)	1.07 (0.85, 1.35)	1.24 (0.97, 1.58)	1.00	1.10 (1.15, 1.47)	0.91 (0.76, 1.09)	1.28 (1.05, 1.58)
3. Model 2 + Tumour factors	Stage	1.00	1.31 (1.08, 1.58)	1.08 (0.86, 1.35)	1.26 (0.98, 1.61)	1.00	1.11 (0.93, 1.30)	0.91 (0.76, 1.09)	1.30 (1.06, 1.59)
	Grade	1.00	1.31 (1.08, 1.57)	1.09 (0.87, 1.38)	1.26 (0.99, 1.62)	1.00	1.10 (0.93, 1.30)	0.91 (0.76, 1.09)	1.30 (1.06, 1.60)
	Histology	1.00	1.31 (1.08, 1.59)	1.10 (0.87, 1.39)	1.28 (0.99, 1.64)	1.00	1.10 (0.92, 1.30)	0.93 (0.78, 1.11)	1.31 (1.06, 1.60)
	ER/PR	1.00	1.31 (1.08, 1.58)	1.09 (0.87, 1.37)	1.28 (1.00, 1.65)	1.00	1.08 (0.91, 1.28)	0.93 (0.78, 1.12)	1.31 (1.06, 1.61)
	HER	1.00	1.30 (1.07, 1.57)	1.08 (0.85, 1.36)	1.28 (0.99, 1.65)	1.00	1.10 (0.91, 1.28)	0.93 (0.80, 1.12)	1.31 (1.07, 1.61)
4. Model 3 + Treatment factors	Locoregional	1.00	1.29 (1.06, 1.56)	1.03 (0.81, 1.30)	1.26 (0.98, 1.62)	1.00	1.07 (0.90, 1.27)	0.91 (0.76, 1.10)	1.30 (1.06, 1.61)
	Systemic	1.00	1.30 (1.07, 1.57)	1.04 (0.82, 1.31)	1.27 (0.99, 1.63)	1.00	1.07 (0.90, 1.27)	0.91 (0.76, 1.09)	1.30 (1.06, 1.61)

Abbreviations used in the table—FCT—Faster Cancer Treatment, OR—Odds Ratio, CI—Confidence Interval, NZ Dep Index-New Zealand Deprivation Index, ER—Oestrogen Receptor, PR—Progesterone Receptor, HER—Human Epidermal Growth Factor Receptor. [a]31 day Faster Cancer Treatment indicators implemented July 2012 by the Ministry of Health, pre- and post FCT includes patients diagnosed before/after this date respectively. [b]Variables are categorized as follows: age; <45 years, ≥45 to ≤69 years (women eligible for BSA) and >69 years, region; Auckland, Waikato, Christchurch, Wellington, NZ Dep Index; decile 1- least deprived to decile 10—most deprived, area of residence; rural or urban, mode of diagnosis; screened or symptomatic, stage; using AJCC 7th edition TNM staging, grade; 1—low to 3—high, histology; ductal, lobular, mixed, other, ER/PR; ER+/PR+, ER+/PR−, ER−/PR+, ER−/PR−, unknown, HER; negative, equivocal, positive, unknown, treatment facility; public or private, locoregional treatment; BCS + RT, BCS, mastectomy + RT, mastectomy, systemic; systemic treatment (chemotherapy, hormone therapy or biologics) or no systemic treatment. [c]Area of residence was omitted due to collinearity.

Table 3: **Subgroup analysis for odds of time to surgery >31 days versus ≤31 days by ethnicity before and after implementation of Faster Cancer Treatment (FCT) targets in public care.**

Model	Additional variables in model[a]	Public care (n = 10,382) OR (95% CI)				Private care (n = 5736) OR (95% CI)			
		NZ European (n = 7077)	Māori (n = 1412)	Asian (n = 994)	Pacific (n = 899)	NZ European (n = 4962)	Māori (n = 203)	Asian (n = 478)	Pacific (n = 93)
Unadjusted		1.00	1.29 (1.14, 1.45)	0.92 (0.80, 1.05)	1.33 (1.15, 1.53)	1.00	1.98 (1.78, 2.20)	1.11 (1.00, 1.24)	2.23 (1.00, 1.24)
1. Unadjusted + Demographics	Age	1.00	1.30 (1.15, 1.46)	0.97 (0.84, 1.11)	1.36 (1.17, 1.57)	1.00	1.00 (0.67, 1.48)	1.16 (0.90, 1.50)	1.75 (1.07, 2.88)
	Region	1.00	1.26 (1.12, 1.42)	1.00 (0.88, 1.16)	1.42 (1.23, 1.65)	1.00	0.94 (0.63, 1.41)	1.38 (1.06, 1.79)	1.92 (1.16, 3.20)
	NZ Dep Index	1.00	1.19 (1.05, 1.35)	0.99 (0.86, 1.14)	1.30 (1.12, 1.52)	1.00	0.93 (0.62, 1.40)	1.37 (1.06, 1.78)	1.91 (1.15, 3.19)
	Area of residence	1.00	1.19 (1.05, 1.35)	0.98 (0.85, 1.13)	1.30 (1.11, 1.51)	1.00	0.94 (0.63, 1.41)	1.36 (1.04, 1.76)	1.89 (1.13, 3.16)
2. Model 1 + Mode of diagnosis	Mode of diagnosis	1.00	1.21 (1.07, 1.37)	1.00 (0.88, 1.16)	1.32 (1.13, 1.54)	1.00	0.95 (0.63, 1.43)	1.44 (1.11, 1.87)	1.99 (1.19, 3.33)
3. Model 2 + Tumour factors	Stage	1.00	1.22 (1.07, 1.38)	1.01 (0.88, 1.16)	1.33 (1.14, 1.56)	1.00	0.94 (0.63, 1.42)	1.44 (1.10, 1.87)	2.00 (1.19, 3.34)
	Grade	1.00	1.21 (1.06, 1.37)	1.02 (0.88, 1.17)	1.34 (1.15, 1.57)	1.00	0.94 (0.63, 1.42)	1.45 (1.11, 1.89)	2.02 (1.21, 3.40)
	Histology	1.00	1.21 (1.07, 1.37)	1.03 (0.90, 1.19)	1.35 (1.15, 1.58)	1.00	0.96 (0.64, 1.44)	1.48 (1.14, 1.93)	2.04 (1.21, 3.43)
	ER/PR	1.00	1.21 (1.07, 1.37)	1.02 (0.89, 1.18)	1.34 (1.15, 1.57)	1.00	0.98 (0.65, 1.48)	1.45 (1.11, 1.90)	2.02 (1.20, 3.39)
	HER	1.00	1.21 (1.06, 1.37)	1.01 (0.88, 1.17)	1.35 (1.15, 1.58)	1.00	0.96 (0.64, 1.45)	1.42 (1.09, 1.85)	1.93 (1.15, 3.24)
5. Model 3 + Treatment factors	Locoregional	1.00	1.19 (1.05, 1.35)	0.98 (0.85, 1.12)	1.33 (1.14, 1.56)	1.00	0.95 (0.63, 1.45)	1.26 (0.96, 1.66)	1.81 (1.07, 3.06)
	Systemic	1.00	1.19 (1.05, 1.35)	0.99 (0.86, 1.14)	1.34 (1.14, 1.57)	1.00	0.96 (0.63, 1.45)	1.28 (0.97, 1.68)	1.79 (1.06, 3.03)

Abbreviations used in the table—OR—Odds Ratio, CI—Confidence Interval, NZ Dep Index-New Zealand Deprivation Index, ER—Oestrogen Receptor, PR—Progesterone Receptor, HER—Human Epidermal Growth Factor Receptor. [a]Variables are categorized as follows: age; <45 years, ≥45 to ≤69 years (women eligible for BSA) and >69 years, region; Auckland, Waikato, Christchurch, Wellington, NZ Dep Index; decile 1- least deprived to decile 10—most deprived, area of residence; rural or urban, mode of diagnosis; screened or symptomatic, stage; using AJCC 7th edition TNM staging, grade; 1—low to 3—high, histology; ductal, lobular, mixed, other, ER/PR; ER+/PR+, ER+/PR−, ER−/PR+, ER−/PR−, unknown, HER; negative, equivocal, positive, unknown, radiotherapy; radiotherapy or no radiotherapy, systemic; systemic treatment (chemotherapy, hormone therapy or biologics) or no systemic treatment.

Table 4: **Subgroup analysis for odds of time to surgery >31 days versus ≤31 days by ethnicity in public and private treatment facility.**

Pacific women were more likely to experience delay beyond 31-days in both treatment facility types, whereas Asian did not experience increased odds of delay in either. χ^2 for heterogeneity was not significant for any ethnicity. In the public system, increasing deprivation further disadvantaged Pacific women who were more likely to experience delay beyond 31-days, when from more deprived areas (NZDep Index quintiles 7–8 and 9–10) compared to NZE women from the same quintiles (Supplementary Table S5).

Subgroup analysis by mode of diagnosis

Approximately half (50.1%) of women were diagnosed by screening. There was a significant delay beyond 31 days for screened Pacific women, compared to screened NZE (OR: 2.12; 95% CI: 1.68, 2.68), but this association was not significant in the non-screened women (OR: 1.00; 95% CI: 0.81, 1.24) ($\chi^2 = 21.66$, $p < 0.001$). There were no significant differences for Māori or Asian women. Deprivation and facility type were key contributors in both groups (Supplementary Table S6).

Sensitivity analysis

CCI was recorded for 4052 women. 70.8% had a score of 0, 25.5% a score of 1–2, 2.4% a score of 3–4 and, 1.4% a score ≥5. Inclusion of CCI in the model did not significantly alter the OR for either outcome for any ethnicity compared to NZE (Supplementary Table S7).

Discussion

In this study involving women diagnosed with early-stage breast cancer in NZ between 2000 and 2020, only 58% received surgery within 31-days. Wāhine Māori and Pacific women experienced longer delays to surgery compared to NZE women, which was contributed by deprivation and treatment facility type. Māori experienced significant delay in the public system but not in the private system, whereas Pacific women experienced delays in both systems. There was no significant improvement in time to surgery for any ethnic group compared to NZE, when comparing the pre- and post- FCT implementation periods.

Our finding that only 58% of women had surgery for breast cancer within 31-days, falls well below the NZ national recording in December 2022 of 88% (all cancer types), and also well below the UK recording in April 2021 of 94% (all cancer types).[20,21] Separating the target by breast cancer stream and ethnicity, and including all women in four regional centres, this study reveals the need for additional efforts to achieve this target for women with breast cancer.

The FCT plan aims for timely treatment regardless of ethnicity or socioeconomic status, however we observed ethnic inequities as reported previously[10] and identified deprivation as a key contributor even post- FCT implementation.[14,20] Wāhine Māori and Pacific women were overrepresented in the most deprived quintile, consistent with census data.[22] Previous research has associated deprivation with reduced healthcare access, diagnostic delay, and reduced survival in NZ women with breast cancer.[4,23,24] Another study, however, demonstrates that breast cancer survival does not vary by deprivation index for wāhine Māori, but reducing deprivation confers a survival benefit for NZE women.[25] Therefore reducing deprivation may address some of the differences in timeliness of care, however it is important to acknowledge the impact of the healthcare system on causing health inequities and solutions must put in processes and systems which mitigate this effect.

We identified treatment facility type as another potential cause for delay in surgery. As reported previously,[11] wāhine Māori and Pacific women were underrepresented in receiving care in the private facility, where adequate resourcing facilitates more timely treatment. Of concern, in our subgroup analyses, wāhine Māori experienced delay in the public system only, suggesting that the public sector is not meeting the needs of Indigenous women in NZ. The better outcomes in the private division of the NZ healthcare system highlight what could be achieved in NZ with adequate resourcing and improved access to care and should motivate policy makers to increase resources in public as a potential solution to the delay in surgery we demonstrated for wāhine Māori and Pacific women.

Given that delay in time to surgery persisted for wāhine Māori and Pacific women after adjustment for all available covariates, other factors such as comorbidities, requirement for additional investigations, anaesthetic input and patient preference as well as broader systemic factors such as discrimination or institutional racism may contribute to further delay and inequity. Comorbidities have been associated with surgical delay,[10] and institutional racism has been shown to impact healthcare experience of Māori and Pacific people.[12,13]

While we could not identify all causes, our findings underscore the need to improve the timeliness and equitability of NZ breast cancer care pathways. Some strategies are underway; for example, in 2023, the 'equity adjustor score' was piloted in Auckland, which considers five new factors not currently assessed in the current 'Clinical Priority Assessment Criteria' score in prioritizing surgical waitlists: clinical priority, time on the waitlist, ethnicity, deprivation, and rurality.[26] This is the first time that an ethnicity lens has been applied to surgical waitlists in NZ. As ethnic differences in time to surgery were largely driven by deprivation in this study, this tool, including both ethnicity and deprivation, may represent a step in the right direction. Additional solutions include increased funding into Māori and Pacific cancer care coordinators, linked in with community health providers such as Māori health providers and primary care, to facilitate timely and culturally appropriate cancer care.

Strengths and limitations

To our knowledge, this study is the first to examine ethnic differences in time to surgery for women with early-stage breast cancer, across four large urban regions in NZ from 2000 to 2020; prior studies did not capture this timeframe, nor study all four regions. National reporting of the 31-day indicator does not reflect all breast cancer cases in NZ—it excludes screened cancer, or women coded without a high suspicion of cancer (up to 70% of breast cancer cases).[3] Our study included these women, and covered the pre- and post-FCT implementation periods. Data from *Te Rēhita Mate Ūtaetae* facilitated a comprehensive analysis; it contains more detail on tumour and treatment factors compared to other national databases.[15] Use of the MOH ethnicity data protocol maximized minority group representation, though there was slight underrepresentation of wāhine Māori.[17] We studied the Asian ethnicity who are the least reported in NZ studies.[3]

Study limitations must be considered. We have limited information on comorbidities (recorded for 26%). On average wāhine Māori and Pacific women experience greater comorbidity, and comorbidity may cause surgical delay given the need for further investigation and specialist input. However, our sensitivity analysis with adjustment for CCI did not significantly change the results. Secondly, date of diagnosis was used as a proxy for 'date of decision to treat' as used in the FCT guidelines. This leads to overestimation of time to surgery as it can take between 1 and 2 weeks for diagnostic results to be communicated to patients and treatment decisions to commence; however, it is crucial to assume that even moderate delays could contribute to poorer outcomes.[10] Importantly the influence of this would not differ by ethnicity. Deprivation, a key contributing factor is measured at area-level with the NZDep Index. Additionally, the register is limited to four urban centres, and it is possible these differences may be greater in rural areas due to resourcing and other sociodemographic factors; for example, more Māori live rurally than non-Māori. Finally, while we identified key contributors to ethnic differences in time to surgery, such as deprivation and treatment facility type, we have not captured ethnic differences in the cumulative effect of multiple barriers on time to surgery. Importantly, this study could not measure the potential for unmeasurable factors such as discrimination or institutional racism which are shown to impact healthcare experience and could therefore contribute to delay to treatment.[12,13]

Conclusion

Two in five women in NZ with early-stage breast cancer did not receive treatment within 31-days, despite introduction of this target in 2012. Wāhine Māori and Pacific women represent underserved ethnic groups with delays in surgery compared to NZE, mainly contributed to by deprivation and treatment facility type. Our findings underscore the need for the timeliness and equitability of treatment for breast cancer, with particular focus on the public healthcare system.

Contributors

LB and STT conceptualized and developed the research proposal. STT obtained access to the database. LB designed the methodology with supervision from STT and RL. LB undertook the background literature review and formal data analyses under supervision from STT and RL. LB, STT and RL interpreted the data. LB wrote the original manuscript and generated the tables and figures. STT, RL, MR, IC and VN contributed to the final manuscript. All authors reviewed and edited the final manuscript.

Data sharing statement

The datasets analysed during the current study are not publicly available to protect privacy and confidentiality. Data requests for de-identified data can be made online through Te Rēhita Mate Ūtaetae (The NZ Breast Cancer Foundation National Register).

Declaration of interests

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101091.

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