

# Breast cancer costs in New Zealand's public health system

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## ABSTRACT

**AIM:** This study aims to estimate the mean costs of breast cancer in New Zealand's public health system.

**METHOD:** This study included women diagnosed with invasive breast cancer between 1 July 2010 and 30 June 2018 who received services in public hospitals. These patients were identified from the National Breast Cancer Register or the New Zealand Cancer Registry and linked with the Pharmaceutical Collection, National Minimum Dataset, National Non-Admitted Patient Collection and Mortality Collection.

**RESULTS:** 22,948 breast cancer patients were included. The mean public health cost of breast cancer was NZ\$44,954 per patient for the period of three months preceding and five years following cancer diagnosis, with the treatment phase accounting for 70% of the cost and the follow-up phase accounting for the remaining 30%. During the treatment phase, surgery costs accounted for the biggest proportion (35%) of the total cost, followed by immunotherapy costs (18%), radiotherapy costs (17%) and costs of diagnostic test, scan and biopsy (16%). The costs decreased substantially with age, from \$69,121 for women younger than 45 years old to \$23,805 for those aged 80 or over.

**CONCLUSIONS:** The costs of breast cancer in New Zealand's public health system are substantial and have been increasing. However, outcomes of breast cancer have been improving. The results of this study can be used as a baseline of actual costs for comparing the costs of introducing new diagnosis and treatment modalities in the future.

Breast cancer is the most common cancer in New Zealand women and its incidence has been increasing steadily: from 2,799 cases in 2009 to 3,572 in 2018 (a 28% increase).<sup>1</sup> In contrast, mortality from breast cancer (in terms of both the number of deaths and the mortality rates) is declining in New Zealand,<sup>2</sup> with 80% of breast cancer patients now surviving for more than 10 years.<sup>3</sup> New Zealand has introduced and funded new treatments, such as trastuzumab, lapatinib, pertuzumab and ado-trastuzumab emtansine, fulvestrant, Palbociclib and zoledronic acid for adjuvant therapy.<sup>4</sup> Diagnostic tools have also been implemented in recent years, including breast MRI, PET-CT (for small number of patients applying well-defined criteria) and CT imaging for metastatic disease (initially three monthly, but now two monthly). The increasing incidence of breast cancer and advancements in diagnostics and therapeutic options have led

to greater economic burden to the healthcare system.<sup>5,6</sup>

As reported in a 2008 Ministry of Health report, *The Price of Cancer*, breast cancer was the most expensive cancer to treat in New Zealand, with breast cancer diagnosis and treatments accounting for 15% of the total costs of cancer.<sup>7</sup> The report demonstrated that breast cancer cost the New Zealand healthcare system \$76.8 million per year.<sup>7</sup> The very few studies on the economic burden of cancer in New Zealand<sup>7,8</sup> have focused on economic burden of all cancers in New Zealand, but with data collected a decade ago. Due to the rise in the number of patients diagnosed with breast cancer and evolving diagnostic and therapeutic options, the costs of breast cancer are changing. In order to guide future healthcare planning, an up-to-date and detailed report on the costs of breast cancer is needed.

By linking National Breast Cancer Register data with the national administrative datasets, this study aims to (1) estimate the mean costs of breast cancer in New Zealand's public health system, (2) calculate the proportion of different cost components in total costs and (3) examine the mean costs of breast cancer by age group.

## Methods

### Data sources

We identified women from the National Breast Cancer Register (NBCR) and the New Zealand Cancer Registry (NZCR) who were diagnosed with breast cancer between 1 July 2010 and 30 June 2018 and included only those who received healthcare services in public hospitals. We linked the eligible breast cancer cases with the Pharmaceutical Collection (PHARMS, which includes all publicly funded pharmaceuticals prescribed in both public and private hospitals), National Minimum Dataset (NMDS, which includes all publicly funded inpatient records), National Non-Admitted Patients Collection (NNAPC, which includes all publicly funded outpatient records), the Mortality Collection (MORT, coded mortality information) and death certificates (uncoded mortality information). The datasets were linked using National Health Index (NHI) numbers, which are unique identifiers for people using publicly funded health and disability services in New Zealand.

### Cancer care pathway

We divided the cancer care pathway into two phases: (1) the treatment phase (TP, three months preceding and 12 months following diagnosis of breast cancer) and (2) the follow-up phase (second to fifth year following diagnosis). We further broke down the follow-up phase into the second (FU2), third (FU3), fourth (FU4) and fifth (FU5) years. We considered the date of death or the latest date of service (31 December 2019) available in the NNAPC, NMDS and PHARMS as the censor date (whichever was earlier). The estimation of costs for each phase only included patients who had follow-up time for that phase. For calculating the total cost of all phases combined, we only included patients who had follow-up time for all phases (ie, those who were still alive and not censored within five years post diagnosis).

### Cost estimation and analysis

The cost estimation was from the perspective of the Ministry of Health and only included public medical costs, which were the costs of public outpatient services, of public inpatient services and of funded pharmaceuticals (prescribed by either public or private hospitals). Our clinical advisors (RL, MKH and IC) checked the definitions of purchase unit codes for outpatient services (in NNAPC), the definitions of surgery codes for inpatient services (in NMDS) and pharmaceuticals, and this study only included the inpatient, outpatient and pharmaceutical records that were relevant to breast cancer. Costs of diagnostic services such as radiology and pathology, and costs of treatment response assessment tools, were also included in the inpatient or outpatient costs. For pharmaceuticals, only relevant endocrine therapy, chemotherapy and therapies targeted at human epidermal growth factor receptor 2 (HER2) were included. Other medications, such as pain killers, were not included, because we could not identify whether these medications were breast cancer related; including all these medications would overestimate the costs. All cost estimations were based on 2019/2020 New Zealand dollars (NZ\$).

Outpatient costs were estimated by multiplying the number of relevant outpatient visits recorded in the NNAPC with the unit cost of outpatient visits. The unit costs for the outpatient visits were based on district health board (DHB)-contracted purchase unit prices. Inpatient costs were estimated by multiplying the accumulated cost weights for all relevant events with the purchase unit price as set by the National Pricing Programme. The Ministry of Health calculates the cost weights, which provides resource utilisation information, for each diagnosis-related group (DRG) code using the weighted inlier equivalent separation (WIES) method and sets a purchase unit price for each year. The 2019/2020 cost-weight unit price was NZ\$5,216.21.<sup>9</sup> The costs of publicly funded pharmaceuticals were estimated by multiplying the quantity of the pharmaceuticals dispensed by the unit prices for each pharmaceutical that appears in the Pharmaceutical Schedule.<sup>10</sup>

We estimated the mean of breast cancer in the public healthcare system during the treatment phase and the follow-up phase and described the proportions of different cost components in total costs. The mean costs of breast cancer during different phases were also compared by age group (<45, 45–59, 60–69, 70–79 and 80+ years) after stratification of the cancer cases by cancer stage (stage I, stage II, stage III and stage IV). The difference in costs by age group were examined by Kruskal–Wallis test. The proportions of cost components in total costs by age group were also explored.

## Results

Between 1 July 2010 and 30 June 2018, 25,085 women were diagnosed with invasive breast cancer in New Zealand (Figure 1). We excluded 2,137 patients who did not have any treatment records in public hospitals. A total of 22,948 breast cancer patients received services in public hospitals. The number of patients in each phase decreased year by year because some patient died or censored. There were 13,312 patients with five-years follow-up time post diagnosis who were included in the cost estimation for FU5. The mean public health costs of breast cancer were \$44,954 per patient (Table 1) for the TP–FU5. Over 70% of the costs were in the TP (\$31,599), 14% in the FU2 (\$6,181), 7% in the FU3 (\$3,008), 6% in the FU4 (\$2,721) and 5% in the FU5 (\$2,364). The mean costs decreased with age. The costs for the TP–FU5 were from \$69,121 for women under 45 years old to \$23,805 for women aged 80 years or older ( $p$ -value<0.05 by Kruskal–Wallis test).

The proportion of each cost component varied in different phases (Figure 2). Surgery costs accounted for 35% of the total costs in the TP but only 22% in the FU2. In contrast, the immunotherapy costs comprised only 18% of the total costs in the TP and 47% in the FU2. Of the immunotherapy costs, 98% were trastuzumab costs in the TP and 95% in the FU2. During the TP, 16% of the breast cancer costs were for diagnostic test, scan or biopsy; 17% were for radiotherapy, 4% for medical oncology outpatient visit, 7% for chemotherapy (including delivery costs) and less than 1% for endocrine therapy.

Table 2 shows the mean public healthcare costs of breast cancer by age group and

stratified by cancer stage. The mean costs of breast cancer decreased with age in all cancer stages, and the differences were significant in all subgroup costs ( $p$ -value<0.05 by Kruskal–Wallis test).

For stage I disease, the mean costs of the TP–FU5 were from \$53,841 for women aged under 45 years to \$22,816 for women aged 80 years or older; for stage II disease, the mean costs were from \$57,905 for women aged under 45 years to \$26,818 for women aged 80 years or older; for stage III disease, the mean costs were from \$79,592 for women aged under 45 years to \$27,536 for women aged 80 years or older; and for metastatic cancers, the costs were from \$167,935 for women aged under 45 years to \$27,902 for women aged 80 years or older.

The mean costs in different phases followed the same pattern. For example, during the TP for metastatic breast cancer, the mean costs decreased from \$53,985 for those aged under 45 years to \$13,757 for those aged 80 years or older.

The proportion of each cost component in different phases also varied by age group (Table 3). During the TP, the percentage of surgery costs and the percentage of costs of diagnostic test, scan or biopsy both increased with age, from 30% and 9% for women aged under 45 years to 57% and 22% for those aged 80 years or older. On the contrary, during the TP, the percentage of immunotherapy costs, the percentage of chemotherapy costs and the percentage of costs for medical oncology visits all decreased with age, from 27%, 11% and 6% for women aged under 45 years to 3%, 1% and 1% for those aged 80 years or older. During the TP, the percentage of radiotherapy costs increased from 14% for women aged under 45 years to 19% for women aged 60–69 years, and then decreased to 13% for those aged 80 years or older. During the FU2–FU5, the proportion of costs of chemotherapy all decreased with age, but the proportion of other cost components fluctuated.

## Discussion

The number of new breast cancer cases has been increasing steadily in New Zealand.<sup>1</sup> The economic burden of breast cancer is also expected to be rising.<sup>7,11</sup>

Figure 1: Data cleaning flow chart.

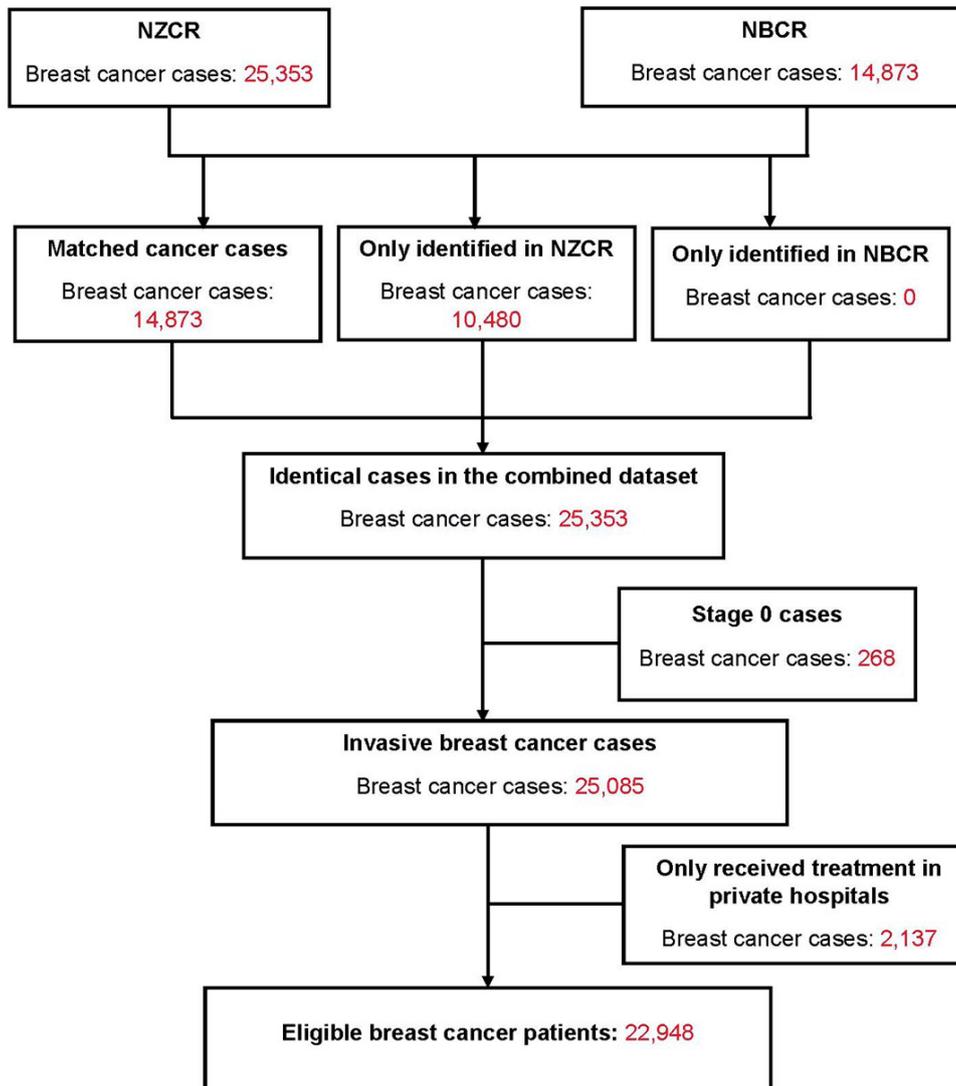


Table 1: Mean public health costs of breast cancer for eligible patients.

Phases	TP	FU2	FU3	FU4	FU5	All phases
Number of patients	22,948	22,204	19,918	16,527	13,312	13,312
Overall mean costs	\$31,599	\$6,181	\$3,008	\$2,721	\$2,364	\$44,954
<b>Mean costs by age group</b>						
<45 years	\$44,189	\$2,822	\$5,705	\$5,866	\$4,268	\$69,121
45–59 years	\$35,268	\$7,245	\$3,434	\$2,790	\$2,434	\$49,021
60–69 years	\$29,801	\$4,340	\$1,972	\$1,900	\$1,935	\$38,638
70–79 years	\$25,297	\$4,030	\$2,383	\$2,321	\$1,841	\$34,019
80+ years	\$16,925	\$1,976	\$1,667	\$1,145	\$1,281	\$23,805

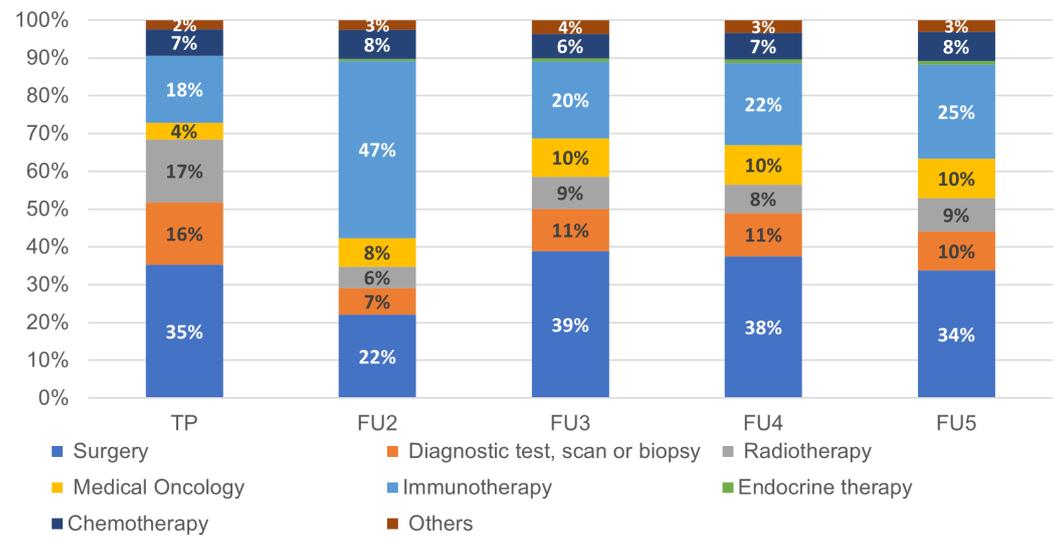
Evolving diagnostic and therapeutic options will also increase the costs of breast cancer. The results of this study can be used as a baseline of actual costs for comparing the costs of introducing new diagnosis and treatment modalities in the future. For example, the results from this study can be used to examine the financial impact of introducing genomic testing in early breast cancer by comparing the costs of chemotherapy before (from this study) and after introducing genomic testing.<sup>12</sup>

Using data for patients diagnosed in 2003–2008, the 2008 Ministry of Health report *The Price of Cancer* showed that the diagnostic and treatment costs for breast cancer were \$28,074 per patient from one year prior to diagnosis and five years post diagnosis.<sup>7</sup> In comparison, our study, based on data of patients diagnosed in 2010–2018, found that these costs of breast cancer have increased by 61% to \$45,150. This increase can be partly attributed to newly funded pharmaceuticals that have become available during this period, including trastuzumab. From July 2007, PHARMAC agreed to fund trastuzumab for nine weeks for HER2 positive stage I–III breast cancer,<sup>13</sup> and from 1 July 2010 trastuzumab has been funded for up to 12 months for early-stage disease.<sup>14</sup> Publicly funded breast reconstruction has also been increasingly used in New Zealand,

which would have increased the costs of breast cancer. However, breast conserving surgery is being used more and more commonly, and the use of breast reconstruction will be affected.<sup>15</sup> Though the costs of breast cancer have been increasing over time, the outcome of breast cancer has been improving.<sup>3</sup> Trastuzumab improved the breast cancer-specific survival for women diagnosed with HER2-positive disease by over 40%.<sup>16</sup>

Most of the costs of breast cancer were in the TP, which is in line with the findings of an Australian study.<sup>17</sup> This is because most of the treatments occur during the TP. In July 2012, the New Zealand healthcare system introduced faster cancer treatment indicators, including a 62-day indicator: patients referred urgently with a high suspicion of cancer receive their first treatment (or other management) within 62 days of the referral being received by the hospital.<sup>18</sup> The costs of breast cancer in our study are driven predominantly by costs of surgery, diagnostic test and immunotherapy. In contrast to the TP, the proportion of the costs for immunotherapy are the highest in the FU2. This might be because surgeries are typically performed in the first year after diagnosis, but the expensive HER2-targeted therapy trastuzumab (funded for 12 months) is still used into FU2.

**Figure 2:** Proportion of each cost component in different phases.



**Table 2:** Mean public health costs of breast cancer by age group stratified by cancer stage.

Age group	TP	FU2	FU3	FU4	FU5	All years
<b>Stage I</b>						
<45	\$34,423	\$7,992	\$2,706	\$2,947	\$3,625	\$53,841
45–59	\$28,687	\$4,324	\$1,838	\$1,574	\$1,891	\$36,922
60–69	\$26,074	\$2,671	\$1,294	\$1,116	\$1,333	\$32,064
70–79	\$22,229	\$2,113	\$1,084	\$1,438	\$998	\$26,794
80+	\$18,554	\$1,272	\$960	\$984	\$1,212	\$22,816
<b>Stage II</b>						
<45	\$41,744	\$9,906	\$3,941	\$3,159	\$1,972	\$57,905
45–59	\$35,214	\$6,473	\$2,626	\$2,284	\$1,926	\$47,269
60–69	\$30,423	\$4,101	\$1,422	\$1,519	\$1,331	\$37,791
70–79	\$26,166	\$3,787	\$2,369	\$2,391	\$2,306	\$35,712
80+	\$20,881	\$1,343	\$1,235	\$1,331	\$1,515	\$26,818
<b>Stage III</b>						
<45	\$49,407	\$15,716	\$6,450	\$7,427	\$4,896	\$79,592
45–59	\$42,893	\$10,745	\$4,676	\$4,405	\$3,484	\$65,213
60–69	\$38,277	\$7,313	\$3,147	\$2,865	\$2,913	\$52,725
70–79	\$30,843	\$4,802	\$3,467	\$3,806	\$1,923	\$43,021
80+	\$22,145	\$3,093	\$3,038	\$1,339	\$1,843	\$27,536
<b>Stage IV</b>						
<45	\$53,985	\$30,360	\$30,726	\$30,371	\$21,265	\$167,935
45–59	\$40,814	\$25,555	\$19,202	\$16,245	\$12,689	\$98,527
60–69	\$29,312	\$17,729	\$19,302	\$21,300	\$17,483	\$102,292
70–79	\$24,764	\$14,276	\$12,445	\$6,677	\$9,051	\$53,348
80+	\$13,757	\$4,471	\$3,826	\$2,137	\$3,751	\$27,902

**Table 3:** Proportion of each cost component in different phases by age group.

Cost components	<45 years	45–59 years	60–69 years	70–79 years	80+ years
<b>TP</b>					
Surgery	30%	34%	35%	39%	57%
Diagnostic test, scan or biopsy	9%	15%	20%	20%	22%
Radiotherapy	14%	17%	19%	18%	13%
Medical oncology	6%	5%	4%	3%	1%
Immunotherapy	27%	19%	15%	13%	3%
Chemotherapy	11%	8%	5%	4%	1%
Endocrine therapy	0%	0%	0%	0%	0%
Others	3%	2%	2%	3%	3%
<b>FU2</b>					
Surgery	24%	22%	18%	22%	39%
Diagnostic test, scan or biopsy	5%	7%	8%	11%	17%
Radiotherapy	5%	5%	6%	8%	12%
Medical oncology	7%	7%	8%	9%	8%
Immunotherapy	49%	49%	48%	40%	13%
Chemotherapy	8%	8%	8%	7%	3%
Endocrine therapy	0%	0%	1%	1%	2%
Others	2%	2%	3%	3%	6%
<b>FU3</b>					
Surgery	41%	43%	30%	29%	42%
Diagnostic test, scan or biopsy	8%	11%	14%	11%	16%
Radiotherapy	6%	8%	11%	10%	12%
Medical oncology	10%	10%	12%	11%	6%
Immunotherapy	24%	18%	20%	27%	14%
Chemotherapy	8%	6%	6%	6%	3%
Endocrine therapy	0%	1%	1%	1%	2%
Others	2%	3%	5%	4%	5%

**Table 3:** Proportion of each cost component in different phases by age group (continued).

Cost components	<45 years	45–59 years	60–69 years	70–79 years	80+ years
<b>FU4</b>					
Surgery	44%	40%	27%	31%	33%
Diagnostic test, scan or biopsy	7%	11%	16%	14%	15%
Radiotherapy	6%	7%	9%	8%	14%
Medical oncology	9%	11%	11%	10%	7%
Immunotherapy	24%	20%	23%	25%	20%
Chemotherapy	8%	7%	7%	6%	4%
Endocrine therapy	0%	1%	1%	1%	2%
Others	2%	4%	4%	4%	4%
<b>FU5</b>					
Surgery	35%	34%	32%	28%	44%
Diagnostic test, scan or biopsy	7%	10%	12%	10%	22%
Radiotherapy	7%	9%	10%	9%	9%
Medical oncology	11%	11%	10%	11%	5%
Immunotherapy	29%	23%	24%	30%	14%
Chemotherapy	9%	8%	8%	7%	3%
Endocrine therapy	0%	1%	1%	1%	2%
Others	3%	3%	3%	3%	2%

Costs of breast cancer decreased with age. This is likely due to the fact that young women are more likely to have advanced breast cancer and more likely to receive more treatments than older women.<sup>19</sup> The low chemotherapy and HER2-targeted therapy costs for older women (80+ years) is due to the fact that older women are less likely to receive chemotherapy and HER2-targeted therapies and there being fewer lines of treatment for advanced disease.<sup>20</sup> Increasing age was significantly associated with decreasing use of surgery, adjuvant radiotherapy, endocrine therapy and chemotherapy, even after adjustment for stage and level of co-morbidity.<sup>20</sup>

One of the strengths of this study is that, by combining the NBCR data with the NZCR, PHARMS, NMDS, NNAPC, MORT datasets and death certificates, we had comprehensive data on all breast cancer patients. Our clinical advisors helped us to identify the cancer-related events and therefore the estimated costs were more relevant to breast cancer. One of the limitations of this study is that, in order to calculate the pharmaceutical costs, we used the unit costs of drugs available in the Pharmaceutical Schedule. Using these unit costs might have led to an overestimation of the costs of

cancer, because we did not know whether there were any confidential rebates for these drugs.<sup>21</sup> Another limitation is that we have only included endocrine therapy, chemotherapy and HER2-targeted therapy; including any other drugs would have caused underestimation of the total costs. Other drugs that might have been used for breast cancer (eg, pain killers and bisphosphonates) were not included in the cost estimation because we could not identify whether these drugs were used for breast cancer or other diseases (eg, arthritis and osteoporosis). The costs of complications of public chemotherapy, chemotherapy-induced short-term mortality and iatrogenic complication were not included in this study.

## Conclusions

The costs of breast cancer in New Zealand's public health system are substantial and have been increasing. However, the outcomes of breast cancer have been improving. The results of this study can be used as a baseline of actual costs for comparing the costs of introducing new diagnosis and treatment modalities in the future.

**Competing interests:**

Nil.

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