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Original article

Impact of the age expansion of breast screening on screening uptake and screening outcomes among older women in BreastScreen western

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ABSTRACT

Objectives: To assess the impact of age expansion of screening (EOS) of the target age group from 50 to 69 to 50–74 in Australia, which began mid-2013, by examining screening uptake and outcomes of older women, and by identifying factors associated with continuing screening after reaching the age of 75 years.

Methods: Retrospective study using data from women aged 65+ who attended BreastScreen Western Australia between 2010 and 2017 for free mammograms. Screening uptake and screening outcomes were calculated for the periods before (2010–2012) and after (2015–2017) the age EOS to women aged 70–74. Logistic regression was used to identify variables associated with continuing screening after reaching age 75 years, while controlling for possible confounding variables.

Results: Age EOS increased screening uptake amongst women aged 70–74 b y 36% and amongst women ≥75 years by 3% while screening uptake in women aged 65-69 decreased by 3%. Rate of invasive screened-detected cancers significantly decreased among women aged 70–74 from 11.4/1000 screens before to 8.1/1000 screens after age EOS. Likelihood of continuing screening into age ≥75 years was higher in women who had a personal history or a family history of breast cancer, or used hormone replacement therapy within six months of screening. Women who were born outside Australia were less likely to continue screening after reaching age 75 years.

Conclusions: Our study found that age EOS to women aged 70–74 was effective in increasing screening uptake in this age-group but was accompanied by a moderate increase in screening uptake amongst women ≥75 years via self-referral for whom potential benefit of screening may be limited.

1. Introduction

The value of a population-based mammography screening program in the detection of early breast cancer is well established, but its benefit for older women's health remains unclear. Consensus has been reached that screening for breast cancer with mammography reduces breast cancer mortality, especially for women aged 50–69 years [1]. However, the evidence on the benefits of mammography screening in women aged ≥70 years is mixed and is mostly form observational studies, and experts are divided as to the balance of benefit and harm of continuing to screen women older than 69 years [2,3]. The expected major benefit of screening older women is a reduction in breast cancer mortality, and the major harm is over-diagnosis of breast cancers that may not become clinically apparent during the woman's lifetime in the absence of screening and in the context of competing causes of death in older age-groups [4].

The current target age range of population breast screening programs varies among countries. In New Zealand [5] the target age-group for biennial breast screening is 45–69 years, while in Norway it is 50–69 years [6] and in the Netherlands 50–75 years [7]. Australia's screening programme (BreastScreen Australia, BSA) offers free biennial screening to women aged 40 and older. Up till June 30, 2013, women aged 50–69 years had been specifically targeted, and women aged 70 years or older were able to access

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Abbreviation

Breast Screen Australia (BSA)
Western Australia (WA)
Expansion of screening (EOS)

screening through self-referral, but were not actively recruited. In July 2013, BSA extended the target age group from 50–69 years to 50–74 years following national recommendations from the BSA program 2009 evaluation report (recommendation 2 [8]). To support this age expansion of screening (EOS), several social marketing campaigns were implemented to encourage older women (70–74 years) to participate in the BSA program.

In Australia, women aged ≥75 years can have a free screening mammogram through self-referral, but they are not actively invited by the program [8]. Mammography screening uptake in BSA was reported to be 7.6% in women aged ≥75 years in 2016–17 [9]. This low screening uptake might be in part due to preference to discontinue screening in later years, however, there is some evidence that this may be due to lack of awareness of the availability of self-referral and how to access the program [10,11]. Furthermore, there is limited knowledge of what drives some women to continue screening after reaching the upper age limit of screening recommendation of 74 years.

There are no published data on whether and how the age EOS targeting women 70–74 years have impacted screening in older women in Australia. To address this knowledge gap, we undertook an evaluation in the BreastScreen Western Australia (WA) program to (i) examine changes in screening uptake in women aged 65–69, 70–74 and ≥ 75 years before and after implementation of age EOS; (ii) report screening outcomes in women aged 65–69, 70–74 and ≥ 75, before and after implementation of age EOS; and (iii) identify factors associated with continuing to screen after reaching the upper age limit of 75 years. Evidence from this study would be relevant to cancer screening policy, as it would quantify the outcomes of extending screening to 74 years and could identify consequences for screening in women above the target age (≥75) who potentially do not benefit from screening.

2. Methods

2.1. Study population and program

A retrospective study was performed using data sourced from BreastScreen WA which is a fully accredited part of the BSA Program that started in 1990. BreastScreen WA is a population-based screening program that currently provides free screening mammograms to Western Australian women aged ≥40 years and specifically targets women aged 50–74 years. Women who attend for screening undergo bilateral two-view mammography, which is read independently by two radiologists. If there is disagreement between the two radiologists then the final recommendation is based on review by an experienced third reader. We included data for women aged 65 and older who participated in BreastScreen WA between July 1, 2010 to June 30, 2017, focusing on two time periods: consecutive screens before (1st July 2010–June 30, 2012) and consecutive screens after (July 1, 2015–June 30, 2017) implementation of the extension of invitations to screen women aged 70–74 (Appendix 1). Women who were not WA residents were excluded from the analysis.

Women participating in BreastScreen WA give written permission for use of their data for quality assurance, monitoring, evaluation and research purposes. The Governance, Evidence, Knowledge & Outcomes (GEKO) Research Ethics Committee approved the study (No 29158).

2.2. Demographic and screening data

During each screening examination, women are routinely asked to complete a self-reported questionnaire which includes questions on age at time of screening, country of birth, language spoken at home, residential address, family history of breast cancer, indigenous status, breast symptoms, use of hormone replacement therapy (HRT) during the last six months, and personal history of breast cancer. Family history was defined as having at least one first degree relative affected with breast cancer. The definition of breast symptoms included breast lump, nipple discharge (blood-stained or clear), and other concerning sensation of breast change. We used self-reported country of birth to group women to Australian born and overseas-born. Postcodes of residence were used to derive statistic Socio-Economic index for Areas Index (SEFIA) of Relative Socioeconomic Disadvantage [12] and the accessibility/remoteness index of Australia (ARIA +) score for 2016 [13]. The ARIA index was grouped into those residing in major cities, inner regional areas, outer regional areas, remote areas and very remote areas.

A screen-detected cancer (invasive or in situ) was defined as a cancer diagnosed by the program at the scheduled screen. As part of the program's accreditation process, BreastScreen WA collects data on interval cancers by linking with the population-based WA Cancer Registry. The Cancer Registry receives cancer notification under a legal mandate from hospitals and laboratories for all cancers except for non-melanoma skin cancers. In addition, women self-report interval cancers to the program, and treating surgeons also provide notification to the program. An invasive interval breast cancer was defined as new primary cancer of the breast diagnosed after completion of a negative screening episode and before the next scheduled screen, within 24 months from the date of the previous screen (or within 12 months for high-risk women eligible for annual screening). Breast cancers diagnosed in women who presented with symptoms at early re-screen were counted as interval cancers if the symptom was in the same breast as the subsequently diagnosed cancer. Furthermore, invasive cancers detected through BreastScreen WA at early review performed at six months or more from the date of screening were counted as interval cancers. Recall rates, the proportion of women recalled for further assessment based on an abnormal screening mammogram, were also calculated.

2.3. Definition of continuing screening after the age of 74 years

A binary outcome variable was created to indicate whether a woman had a mammogram after the age of 74 (screened at or before age 74 only = 0; screened before and after the age of 74 = 1) during our study period 2010–2017. The woman's last mammogram before age 75 was used as the index event. Women who did not screen after the age of 74 years because they died or did not yet reach age 75 years at June 30, 2017 were excluded from this analysis. Women who did not have screening episodes before the age of 75 in our data were also excluded from this outcome.

2.4. Statistical analysis

Descriptive statistics were used to describe screening uptake and screening events that were examined during the study period. Screening uptake is measured over two years to align with the 2-year recommended screening interval. If a woman had been screened more than once in a 2-year period, then only the last

screening episode was counted. Screening uptake was calculated for the age-groups 65–69, 70–74, and ≥75 years, and stratified by indigenous status, socioeconomic status, remoteness, main language spoken at home, and country of birth. Due to the implementation of the age EOS in 2013, the period between July 2012–June 2015 was considered as the transition period (Appendix 1). The estimated resident population of WA from the census in 2011 [14] and 2016 [15] were used as the denominator to calculate screening uptake before and after the expansion, respectively.

Screen-detected and interval cancer rates per 1000 screens and the percentage of screens recalled to assessment (% recall), were calculated and were stratified by age-group and period (before/after age EOS). We also calculated the percentage of screens with family history of breast cancer, personal history of breast cancer, HRT used during the last six months and breast symptoms. Exact 95% confidence intervals were calculated.

Logistic regression was performed to identify the likelihood of continuing screening after reaching ≥75 years, and the possible independent effect of demographic and risk variables collected by the study. Statistical significance was determined when two-tailed p values were <0.05. All analyses were performed using Stata Version 15.1 (Stata 15.1, StataCorp, and College Station, USA).

3. Results

3.1. Screening uptake

A total of 40,246 and 69,211 women aged ≥65 years participated in the BreastScreen WA program before and after the age EOS period, respectively. Screening uptake was highest among women aged 65–69, followed by women aged 70–75 and ≥ 75 years respectively. Screening uptake by women aged 65–69 years slightly decreased, while for women aged ≥75 screening uptake increased, after the expansion period. For women aged 70–74 years, screening uptake increased from 22% before the expansion period to 58% after the expansion period, with an absolute percentage change of 36% (Table 1).

After the age EOS period, screening uptake increased amongst women aged 65–69 years with those living in the highest quintile of socioeconomic status, major cities, inner regional and remote areas while decreased in all other categories of demographic factors examined. Screening uptake increased in women aged 70–74 year after age EOS, and this increase was seen across all the demographic subgroups. Similarly, screening uptake amongst women aged ≥75 years also increased after the EOS across all demographic factors except for women living in very remote areas where 4% decrease was observed (Table 2).

3.2. Screening outcomes

A total of 43,108 screens were performed among 40,246 women aged ≥65 years before the age EOS and a total of 75,081 screens were performed among 69,211 women aged ≥65 years after the age EOS. A higher percentage of screens from women aged 65–69 years and ≥75 years with a personal history was observed after the age EOS period. A significantly higher percentage of screens from women aged 70–74 who are at higher risk of developing breast cancer was observed before the age EOS. The percentage of screens from women aged 70–74 years with a family history and breast symptoms decreased after the age EOS. The percentage of screens with self-reported HRT during the last six months decreased after the age EOS for women aged 65–69 years and 70–74 years. Women aged ≥75 years had higher percentages of screens with a personal or family history of breast cancer as compared to women in the other age groups (Table 3).

Recall for assessment in women aged 65–69 years significantly increased after the age EOS. The rate of invasive screened-detected cancers significantly decreased among women aged 70–74 from 11.4 per 1000 (95%; 9.3–14.0) before age EOS to 8.1 per 1000 (95%; 7.1–9.3) screens after age EOS period. However, the rate was not significantly different when stratified by high-risk, showing that the higher rate of invasive screened-detected cancers before age EOS is attributable to the higher prevalence of high-risk screens. Women aged ≥75 years had a significantly higher rate of screened-detected cancers than women aged 65–69 after the age EOS period (Table 3).

3.3. Factors associated with continuing screening after the reaching age of 74 years

Restricting the study cohort to include the last screening event before the age of 75 for women who had the opportunity to screen at age ≥75 years resulted in 17,111 screens to be analysed. Women who screened at the age of ≥75 years were more likely to report: family history of breast cancer (OR = 1.71; 95% CI 1.58–1.85), personal history of breast cancer (OR = 2.30; 95% CI 2.02–2.63), and use of HRT during the last six months (OR = 1.36; 95% CI 1.22–1.52). Women born overseas (OR = 0.87; 95% CI 0.81–0.94) were less likely to screen after the age of 74. Women living in regional and remote areas were significantly more likely to screen after the age of 74 in comparison to women who lived in major cities. No significant difference was observed for social-economic status, indigenous status or language spoken at home (Table 4).

4. Discussion

This study examined the impact of the age expansion of Australia's population breast screening program to women aged 70–74 years (mid-2013), by examining screening uptake and outcomes before and after the age EOS across older age-groups in BreastScreen WA. We found age EOS to women aged 70–74 was effective in increasing participation by 36%. The rate of screen-detected cancers was significantly lower after the age EOS in women aged 70–74. We also found a moderate increase in

Table 1
Screening uptake before and after the age expansion of screening in BreastScreen WA[a] by age group.

Age group	2010–2012 (Before the age expansion of screening)			2015–2017 (After the age expansion of screening)			Absolute percentage change (%)
	No. Women Breastscreen WA (N = 40,246)[c]	No. WA Population 2011 (N = 147,414)[b]	Screening uptake (%)	No. Women Breastscreen WA (N = 69,211)[c]	No. WA Population 2016 (N = 183,729)[b]	Screening uptake (%)	
65–69	27,844	42,757	65%	36,721	58,854	62%	−3%
70–74	7492	33,944	22%	24,466	42,054	58%	36%
≥75	4910	70,713	7%	8024	82,821	10%	3%

[a] Expansion of screening refers to extending active invitation to women aged 70–74 years.
[b] The denominator data was extracted from the Australian Bureau of Statistics.
[c] Only the last screening episode was counted for woman who had been screened more than once in a 24-month period.

Table 2
Screening uptake before and after age expansion of screening in Breastscreen WA by specific demographic factors and stratified by age group.[c]

	2010–2012 (Before the age expansion of screening)			2015–2017 (After the age expansion of screening)			Absolute percentage change (%)[d]
	No. women Breastscreen WA (N = 40,246)[b]	No. WA Population 2011 (N = 147,414)[a]	Screening uptake (%)[d]	No. women Breastscreen WA (N = 69,211)[b]	No. WA Population 2016 (N = 183,729)[a]	Screening uptake (%)[d]	
65–69 years							
Socioeconomic status							
1st quintile (lowest)	2157	4033	53%	2543	5707	45%	−9%
2nd quintile	5777	8431	69%	7408	11,926	62%	−6%
3rd quintile	6351	10,336	61%	8498	14,953	57%	−5%
4th quintile	5764	7809	74%	7888	12,559	63%	−11%
5th quintile (highest)	7757	11,983	65%	10,351	13,532	76%	12%
Remoteness Area							
Major cities	22,051	32,598	68%	28,637	44,969	64%	−4%
Inner Regional	2800	4481	62%	3901	6451	60%	−2%
Outer Regional	2048	3797	54%	3061	5140	60%	6%
Remote	615	1204	51%	740	1321	56%	5%
Very remote	294	508	58%	350	798	44%	−14%
Indigenous status							
Indigenous	249	531	47%	303	795	38%	−4%
Non-indigenous	27,595	42,236	65%	36,418	58,059	63%	−2%
Country of birth							
Australia	15,655	22,604	69%	20,527	30,160	68%	−1%
Overseas	12,189	20,153	60%	16,194	28,694	56%	−4%
Language spoken at home							
English	24,251	37,689	64%	31,617	50,708	62%	−2%
Other	3593	50,67	71%	5104	8145	63%	−8%
70–74 years							
Socioeconomic status							
1st quintile (lowest)	580	3408	17%	1761	4309	41%	24%
2nd quintile	1779	7062	25%	5137	9125	56%	31%
3rd quintile	1741	8338	21%	5736	10,733	53%	33%
4th quintile	1474	6316	23%	5136	8385	61%	38%
5th quintile (highest)	1908	8762	22%	6677	9421	71%	49%
Remoteness Area							
Major cities	1761	26,315	21%	19,132	32,294	59%	38%
Inner Regional	5137	3474	22%	2551	4435	58%	35%
Outer Regional	5736	3009	26%	2058	3844	54%	28%
Remote	5136	815	25%	492	905	54%	29%
Very remote	6677	278	32%	214	492	43%	12%
Indigenous status							
Indigenous	72	347	21%	164	463	35%	15%
Non-indigenous	7420	33,598	22%	24,302	41,591	58%	36%
Country of birth							
Australia	4533	17,550	26%	13,857	21,241	65%	39%
Overseas	2959	16,394	18%	10,609	20,813	51%	33%
Language spoken at home							
English	6645	29,196	23%	21,354	36,802	58%	35%
Others	847	4748	18%	3112	5252	59%	41%
≥75 years							
Socioeconomic status							
1st quintile (lowest)	436	7002	6%	683	8768	8%	2%
2nd quintile	1159	14,994	8%	1891	18,377	10%	3%
3rd quintile	1148	16,076	7%	1905	19,987	10%	2%
4th quintile	922	13,215	7%	1584	16,321	10%	3%
5th quintile (highest)	1242	19,365	6%	1954	19,309	10%	4%
Remoteness area							
Major cities	3622	57,007	6%	5804	66,317	9%	2%
Inner Regional	489	6291	8%	885	7644	12%	4%
Outer Regional	578	5624	10%	1010	6827	15%	5%
Remote	163	14,03	12%	254	1435	18%	6%
Very remote	55	358	15%	64	540	12%	−4%
Indigenous status							
Indigenous	41	455	9%	50	558	9%	0%
Non-indigenous	4869	70,237	7%	7974	82,263	10%	3%
Country of birth							
Australia	3195	36,709	9%	5033	40,845	12%	4%
Overseas	1715	34,004	5%	2991	41,976	7%	2%
Language spoken at home							
English	4339	60,108	7%	7116	70,323	10%	3%
Others	571	10,605	5%	908	12,498	7%	2%

[a] The denominator data used for 2010–2012 and 2015–2017 were extracted from the Australian Bureau of Statistics for 2011 and 2016 census respectively.
[b] Only the last screening episode was counted for woman who has been screened more than once in a 24-month period.
[c] Expansion of screening refers to extending active invitation to women aged 70–74 years. Numbers may not add up due to missing data.
[d] Percentages are rounded to the nearst wholenumber.

screening uptake after EOS by women aged ≥75 years while a slight decrease in was observed for women aged 65–69. Women who continued screening beyond 74 years were more likely to report a personal history of breast cancer, a family history of breast cancer, use of HRT during the prior six months, and being born in Australia than women who did not continue screening.

The expansion of screening from 69 to 74 increased screening uptake among women aged 70–74 compared to when the service was available to these women through self-referral. However, the uptake was still lower than women aged 65–69 (62%) but was almost similar to the overall crude participation rate of 56% in WA [9]. The 58% screening uptake of women aged 70–74 years observed in our study is similar to other screening programmes which also invite women aged 70–74, for example, Canada, has reported 58% of women in that age-group accepting an invitation to screening [16]. Age EOS increased screening among women aged 70–74; however, this increase was not equal across demographic factors. Women living in areas of higher socioeconomic status or major cities had the highest increase in screening uptake compared to other women. Women born in Australia showed more increase in screening uptake than women born in other countries.

The rate of invasive screened-detected cancers significantly decreased among women aged 70–74 after the age EOS period. This decrease is likely explained by the higher percentages of screens presented with risk factors among self-referred screeners (26.4% had family history of breast cancer, 11.0% used HRT, 1.2% presented with breast symptoms) as compared to invited screeners (22.3% had family history, 8.0% used HRT, 0.7% with breast symptoms). Our finding of cancer detection rate was roughly similar to a study in Italy that found self-referred screeners had a higher detection rate compared to the general population of women who were invited to screening (10 vs 7.5 per 1000 screens) [17]. A study in the UK found the rate of screen-detected invasive cancers was higher in women who were self-referred and aged 70–74 (12 per 1000 screens) compared to women aged 65–70 who were invited (9 per 1000 screens) [18], which might be also attributed to age difference.

Our study found that screening uptake in women beyond the recommended upper age for population screening (≥75 years) moderately increased by 3% following the age EOS. This raises a concern given that older women might not benefit from breast screening because they have a higher likelihood of dying from other causes [19]. This increase might also be in part attributed to the improvement in access to breast screening services over the years We also identified that women at higher risk of developing breast cancer (such as those with personal or family history of breast cancer) were more likely to continue screening after reaching the upper age limit of 74 years. Personal history of breast cancer has been consistently associated with better participation in screening [20,21]. A study in Australia found women with a previous diagnosis of breast cancer were significantly more likely to rescreen

Table 3
Breast cancer risk factors, recall for assessment, and cancer detection and interval cancer rates, before and after age expansion of screening in Breastscreen WA services[a], stratified by age group.

	65–69 years		70–74 years		≥75 years	
	2010–2012 (Before the age expansionof screening) No. Screens = 29,764	2015–2017 (After the age expansion of screening) No. Screens = 39,886	2010–2012 (Before age expansion of screening) No. Screens = 8043	2015–2017 (After the age expansion) No. Screens = 26,432	2010–2012 (Before the age expansion of screening) No. Screens = 5301	2015–2017 (After the age expansion of screening) No. Screens = 8763
Personal history (%; 95 CI)	5.2 (4.9–5.4)	6.9 (6.6–7.1)	9.7 (9.0–10.3)	8.9 (8.6–9.3)	14.9 (14.0–15.9)	18.5 (17.7–19.3)
Family history of breast cancer (%; 95% CI)	21.2 (20.7–21.6)	21.7 (21.3–22.1)	26.4 (25.4–27.4)	22.3 (22.1–23.1)	28.8 (27.6–30.0)	29.6 (28.7–30.6)
Breast symptoms (%; 95 CI)	0.6 (0.5–0.7)	0.6 (0.5–0.7)	1.2 (0.9–1.4)	0.7 (0.6–0.8)	1.0 (0.8–1.4)	0.9 (0.7–1.1)
HRT used during the last six months (%; 95 CI)	11.6 (11.3–12.0)	9.9 (9.6–10.2)	11.0 (10.2–11.5)	8.4 (8.1–8.8)	7.5 (6.8–8.2)	7.1 (6.5–7.6)
High risk[b] for developing breast cancer (%; 95 CI)	34.4 (34.2–35.2)	35.0 (34.5–35.5)	41.8 (40.8–42.9)	36.2 (35.6–36.8)	45.5 (44.2–46.6)	47.6 (46.6–48.7)
Recall for assessment (%; 95 CI)	2.3 (2.1–2.5)	3.1 (2.9–3.2)	3.2 (2.8–3.6)	3.2 (3.0–3.4)	3.2 (2.7–3.7)	3.7 (3.3–4.1)
Invasive screen-detected cancer, (per 1000 screens; 95 CI)	6.6 (5.7–7.5)	6.5 (5.8–7.4)	11.4 (9.3–14.0)	8.1 (7.1–9.3)	9.4 (7.2–12.4)	11.4 (9.3–13.9)
Invasive screen-detected cancer, (per 1000 screens; 95 CI) for high risk[b]	8.0 (6.5–10.0)	8.6 (7.2–10.3)	14.9 (11.3–19.5)	10.8 (8.9–13.0)	10.8 (7.4–15.7)	14.1 (11.0–18.2)
Invasive screen-detected cancer, (per 1000 screens; 95 CI) for no risk[b]	5.8 (4.8–6.9)	5.4 (4.6–6.4)	9.0 (6.6–12.1)	6.6 (5.5–8.0)	8.3 (5.6–12.3)	8.9 (6.6–12.1)
In situ screen detected cancer, (per 1000 screens; 95 CI)	1.6 (1.2–2.1)	1.6 (1.3–2.1)	2.4 (1.5–3.7)	2.0 (1.5–2.7)	2.6 (1.6–4.4)	1.3 (0.7–2.2)
Invasive screen detected cancer ≤15 mm, (per 1000 screens; 95 CI)	4.2 (3.6–5.0)	3.9 (3.3–4.6)	7.5 (5.8–9.6)	5.1 (4.4–6.1)	5.5 (3.8–7.8)	6.4 (4.9–8.3)
Invasive screen detected cancer>15 mm, (per 1000 screens; 95 CI)	2.3 (1.8–2.9)	2.6 (2.2–3.2)	4.0 (2.8–5.6)	3.0 (2.4–3.7)	4.0 (2.6–6.0)	5.0 (3.7–6.7)
Invasive interval cancer, (per 1000 screens; 95 CI)	1.8 (1.4–2.4)	1.7 (1.3–2.2)	2.5 (1.6–3.8)	2.2 (1.8–2.9)	1.7 (0.8–3.2)	1.5 (0.9–2.5)

[a] Expansion of screening refers to extending active invitation to women aged 70–74 years.
[b] 'High risk' refers to screens where at least one of these risk factors was recorded: family history of breast cancer; a personal history of breast cancer; presented with breast symptoms; or used HRT during the last six months (otherwise screens were considered 'no-risk' where none of the above factors was recorded).

Table 4
Adjusted odds ratios (aOR) and 95% confidence intervals (CI) estimating the associations between screening after reaching the upper age limit of ≥75 years in screening recommendations (yes/no) and demographic/screening factors, 2010–2017.

Variable	No. of Women who did not continue screening (N = 11,279)	No. of women who did continue screening (N = 5832)	Adjusted odds ratio (aOR)[a]	95% confidence interval (CI)
Social-economic status				
1st quintile (lowest)	860	464	Ref	Ref
2nd quintile	2465	1319	0.94	(0.82–1.08)
3rd quintile	2506	1392	1.00	(0.87–1.15)
4th quintile	2371	1153	0.95	(0.83–1.09)
5th quintile (highest)	3077	1504	0.97	(0.85–1.11)
Remoteness area				
Major cities	9023	4312	Ref	Ref
Inner Regional	1048	659	1.28	(1.15–1.43)
Outer Regional	904	656	1.49	(1.33–1.67)
Remote	202	156	1.56	(1.25–1.92)
Very remote	101	50	1.15	(0.80–1.66)
Indigenous status				
Non-indigenous	11,196	5793	Ref	Ref
Indigenous	83	39	0.77	(0.51–1.16)
Country of birth				
Australia	6355	3587	Ref	Ref
Overseas	4924	2245	0.87	(0.81–0.94)
Language spoken at home				
English	9675	5175	Ref	Ref
Other	1604	658	0.91	(0.82–1.01)
Personal history of breast cancer				
No	10,807	5925	Ref	Ref
Yes	472	537	2.30	(2.02–2.63)
Family history of breast cancer				
No	9329	4271	Ref	Ref
Yes	1950	1561	1.71	(1.58–1.85)
HRT during the last six months				
No	10,329	5227	Ref	Ref
Yes	950	605	1.36	(1.22–1.52)

[a] Odds ratios are adjusted for all variables listed in the table.

compared to women with no history of breast cancer (OR = 1.78; 95% 1.62–1.93) [21]. Previous studies have also shown women with (versus without) a family history of breast cancer were more likely to adhere to breast cancer screening guidelines [22,23]. Participation in mammography screening tends to be higher among women who had ever used HRT as compared to non-users (adjusted prevalence ratio (aPR) = 1.05, 95% CI 1.02–1.07) [24].

Even though screening uptake by non-Australian born women increased in 70–74 year olds age group after age EOS (from 18% to 51%) it was still lower than Australian-born women (from 26% to 65%), and this pattern was also observed in the other age-groups (65–69; and ≥75). This observation is similar to another Australian study that found women aged 50–69 from non-English speaking backgrounds were more likely not to attend for second round screening (relative risk ranged between 1.18 and 1.77) [25]. A systematic review showed migrant women participate in mammographic screening less frequently than non-migrant women (64.1% vs. 81.8%) [26]. Furthermore, non-Australian-born women were significantly less likely to attend screening through self-referral after age 74 than Australian-born after controlling for other variables. This indicates that migrant women might be unaware of the availability of self-referral service or that they are more compliant with the recommendations.

Regional residents were more likely to continue screening after reaching the upper age of 74 as compared to women living in the major cities. This finding is consistent with national data showing that screening uptake for women aged 50–74 are highest among women living in regional areas and inner regional areas at 57% and 57%, respectively followed by women living in major cities at 53% [9]. Interestingly, women living in remote areas of Western Australia were more likely to attend screening after the age of 74 than women living in major cities. A potential explanation is that these women often have no local access to diagnostic services and the only option to receive a mammogram is through the program's mobile unit's biennial visit or alternate travel to the city. The inconvenience and costs associated with travel maybe drive older women in remote areas to use the self-referral service.

To the authors' knowledge, this is the largest and only study in Australia examining the impact of age EOS to women aged 70–74 years. This study was based on state-wide screening program that invites all women aged between 50 and 74 to screen and was not limited to a selected cohort of women. However, the study was limited to the information collected by the screening program, and it was not possible to obtain additional data of potential relevance, such as lifestyle and reproductive factors which have been found to be associated with participation in screening [24,27]. We also did not have data on the characteristics of screen-detected cancers. In addition, whilst the population-based government funded program is the largest mammographic screening service in WA, we are not able to capture data on women who have their mammography at private imaging clinics.

In conclusion, the expansion of screening to women aged 70–74 has significantly increased screening uptake in this age-group based on this BreastScreen WA evaluation. This was however accompanied by a modest increase in screening uptake among women aged over 74 years via self-referral, and these tended to be women at higher risk of breast cancer, as well as women living in regional and remote areas. Future research is needed to identify the benefits and harms of offering screening via self-referral to women aged ≥75, given that potential benefit in these older groups might

not be realised. In addition, research is required to quantify if services provided to the older cohort (≥75 years), who take up significant resources within the program, could be better directed to relatively younger women with greater potential to benefit from screening as measured by the reduction of mortality and years of life lost.

Authors' contribution

SE, NH, NH, EM, LW conceived the research questions and designed the study. SE analysed and interpreted the data under the supervision of HL, EM, and NH. All authors significantly contributed to the interpretation of the results, drafting and revising the manuscript and approving the final manuscript.

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Ethical approval

The Governance, Evidence, Knowledge & Outcomes (GEKO) Research Ethics Committee approved the study (No 29158).

Declaration of competing interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.breast.2021.02.006.

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