



History of screening by BreastScreen New South Wales of women with invasive breast cancer

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ABSTRACT

Background: The principal target age for Australian BreastScreen services was 50–69 years in 1991–2013 and 50–74 years from 2014. History of BreastScreen NSW screening participation of NSW women diagnosed with breast cancer in 2005–2014 was examined using linked BreastScreen and Cancer Registry data.

Methods: Differences in BreastScreen participation were investigated by sociodemographic and tumour characteristics, and diagnostic period, using the Pearson Chi-square test, or Fisher's Exact test when numbers were small, and by multivariate logistic regression.

Results: At breast cancer diagnosis, a history of BreastScreen participation varied by age from 23 % for 40–49 years to 68 % for 50–59 years, 72 % for 70–74 years and 78 % for 60–69 years. Among women experiencing breast cancer at age 50–69 years, 60 % had participated in BreastScreen < 24 months of diagnosis. Higher odds of BreastScreen participation applied to residents of inner regional and remote compared with major city areas and for women with localized compared with more distant cancer spread. BreastScreen participation was lower in Indigenous than non-Indigenous women. Differences in participation existed by country of birth and residential location, but they were not pronounced.

Conclusion: The history of BreastScreen NSW participation of 60 % < 24 months for women aged 50–69 years at breast-cancer diagnosis is less than the 70 % target for biennial screening coverage at a population level, but this target has never been reached by an Australian jurisdiction. Qualitative research of screening barriers and opportunities may provide a useful guide for reducing barriers across the population.

1. Introduction

BreastScreen NSW was launched as a population-based screening program in 1991, with a principal target age range of 50–69 years and screening eligibility from the age of 40 years [1,2]. From 2014, the principal age target was extended to include 50–74 years.

The accreditation standard for population coverage by biennial BreastScreen screening is 70 % for the 50–69-year target age range, although this has never been achieved at a national or jurisdictional level [1]. The standard covers all women, including Indigenous (Aboriginal and Torres Strait Islander) women, the culturally and linguistically diverse, and women from the more disadvantaged and geographically remote areas [1]. The aim of BreastScreen is to reduce breast cancer mortality and morbidity to levels equivalent to, or better than, that observed in the initial field trials, and to do so equitably across population sub-groups [1,3].

There is much debate about screening policy and discussion around taking a risk-based approach to all screening programs. Whatever the approach, monitoring and evaluating implementation would be an important component. BreastScreen can only affect breast cancer outcomes to the extent that women participate.

We linked BreastScreen NSW and NSW Cancer Registry data in this study to determine screening participation histories of women diagnosed with invasive breast cancers, including whether they had been screened in the 24 months preceding diagnosis [1]. This duration accords with the biennial BreastScreen screening standard at a population level although an interval of up to 27 months is allowed between screening rounds in national accreditation [1]. We selected 24 months in this study to determine whether BreastScreen participation, as measured in this study, appeared to be accurate (i.e., whether it was associated with expected differences in cancer stage).

An additional aim was to determine differences in a history of

Abbreviations: NSW, New South Wales; NSWCR, New South Wales Cancer Registry; LHD, Local Health District

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screening of diagnosed women by age, country of birth, Indigenous status, and place of residence classified by geographic remoteness and socio-economic disadvantage, to assist targeting of public education on screening. These data, by relating to women diagnosed with breast cancer, are complementary to population-based data. Among these diagnosed women would be some at elevated risk of breast cancer mortality.

Data for this project were obtained from BreastScreen NSW, and from the NSW Cancer Registry which operates under legal mandate through the NSW Public Health Act 2010. BreastScreen NSW and the Registry are both administered by Cancer Institute NSW under the Cancer Institute (NSW) Act 2013. The Cancer Institute is the NSW Government agency responsible for cancer monitoring in NSW and for providing data support for service planning and administration.

2. Methods

Principal data sources were BreastScreen NSW attendance records and the NSW Cancer Registry. The Registry receives cancer notifications under legal mandate from hospitals, diagnostic laboratories and ancillary sources for all cancers except basal and squamous cell carcinomas of the skin [4]. The Registry records: (a) demographic descriptors, including age at diagnosis, country of birth, Indigenous status, and residential address (used to determine local health district and geographic area of residence by remoteness and socio-economic disadvantage); and (b) stage at diagnosis (localized, regional or distant) for invasive female breast neoplasms (ICD-O-3 topography code: C50) [4–6].

All invasive female breast cancers recorded by the NSW Cancer Registry with a diagnosis during 2005–2014, and occurring in women aged 40–74 years, were included. Extracts of Registry and BreastScreen attendance data were linked by the Centre for Health Record Linkage in accordance with the principle of separating person-identified and content data to protect privacy [7].

Based on BreastScreen NSW records, women with breast cancer were classified as: (1) not having participated in the BreastScreen NSW program since program inception in 1991; (2) having participated but not in the 24 months immediately preceding their breast cancer diagnosis; and (3) having participated in that 24-month period.

Descriptors used in the analyses were: (a) age at diagnosis classified as 40–49, 50–59, 60–69 or 70–74 years; (b) diagnostic period classified as 2005–2009 or 2010–2014; (c) country of birth broadly classified by country/region using the Standard Australia Classification of Countries; [8] (d) Indigenous status, self-reported and summarized as Indigenous or non-Indigenous; (e) socioeconomic disadvantage classified using the Index of Relative Socioeconomic Disadvantage (SEIFA 2006) based on Statistical Local Areas grouped into quintiles [5]; (f) remoteness of residence using Statistical Local Areas grouped according to the 2006 Australian Standard Geographical Classification (ASGC) as major cities, inner regional, outer regional, remote, or very remote [6]; (g) local health district of residence; and (h) cancer stage (degree of spread) classified as localized, regional or distant.

Histories of BreastScreen participation were analysed by these descriptors, initially without statistical adjustment using the Pearson's chi-square test or Fisher's Exact test for small numbers [9]. Multivariate logistic regression analyses were also undertaken, by modelling descriptors as predictors of BreastScreen participation, and among participants, of time duration between diagnosis and the last screen as < 24 vs 25+ months [9]. Predictors were expressed as dummy variables using the first category listed for the respective predictor in Table 1 as the reference category. Relative odds (i.e., odds ratios) were derived from these regression analyses. Analyses were conducted using Stata 14 [9].

Approval for the study was obtained from the NSW Population and Health Services Research Ethics Committee (Cancer Institute sub-study reference: 2017/UMB1106) and the Aboriginal Health and Medical

Research Ethics Committee (reference: 120/16).

3. Results

3.1. Percentage of women with breast cancer with a history of “ever screened” by BreastScreen NSW

3.1.1. By age

The percentage with any history of participation varied by age ($p < 0.001$) from 23 % for 40–49 years to 68 % for 50–59 years, 78 % for 60–69 years, and 72 % for 70–74 years (Table 1). Multivariate regression analysis, adjusting for the other characteristics, was confirmatory, with the highest relative odds of a history of BreastScreen participation of 10.66 (95 % CI: 9.70–11.71) where cancers were diagnosed at age 60–69 years, 7.14 (95 % CI: 6.52–7.80) for diagnosis at 50–59 years, and 6.34 (95 % CI: 5.60–7.17) for diagnoses at 70–74 years, when compared with 40–49 years as the reference age (Table 2).

3.1.2. By country of birth

Any history of participation history by country of birth ($p < 0.001$) from 51 % for Asia and 54 % for Africa (other) to 63 % for Australia and 64 % for Europe (Table 1). Multivariate regression analysis was confirmatory, indicating a comparatively high adjusted odds of a screening history for the Australian born and lower relative odds for: Africa (other) at 0.73 (95 % CI: 0.53–0.99) and Asia at 0.77 (95 % CI: 0.68–0.88) (Table 2).

3.1.3. By Indigenous status

Indigenous women were less likely to have any history of BreastScreen NSW screening (56 % vs 62 % for non-Indigenous women, ($p = 0.003$) (Table 1), which was confirmed by an adjusted OR of 0.71 (95 % CI: 0.55–0.92) (Table 2).

3.1.4. By geographic remoteness

Any history of participation varied by geographic remoteness of residence ($p < 0.001$). The lowest participation of 61 % related to a major city area and the highest at 67 % for remote (Table 1). The lower participation for residents of major city areas is supported by the elevated adjusted relative odds of screening participation of 1.30 (95 % CI: 1.15–1.48) for inner regional and 3.60 (95 % CI: 1.87–6.94) for remote (Table 2).

3.1.5. By socioeconomic status

Variation in any history of participation history by SEIFA Index of Relative Socioeconomic Disadvantage was statistically significant ($p < 0.001$) (Table 1). Compared with the most disadvantaged quintile of geographic areas, the lowest adjusted relative odds of BreastScreen participation of 0.85 (95 % CI: 0.75–0.97) applied to the next most disadvantaged quintile (Table 2).

3.1.6. By local health district

Any history of participation varied by local health district ($p < 0.001$), ranging from 57 % for South West Sydney to 71 % for Hunter North East (Table 1). Albury, which abuts the Victorian border where optional Victorian screening services exist, had the lowest adjusted relative odds of 0.63 (95 % CI: 0.40–0.98) of screening through BreastScreen NSW when compared with the Sydney Local Health District (LHD) reference. By comparison, elevated relative odds applied to Hunter North East at 1.33 (95 % CI: 1.11–1.60) and Illawarra/Shoalhaven at 1.26 (95 % CI: 1.02–1.57) (Table 2).

3.1.7. By diagnostic period

History of any BreastScreen participation did not vary significantly by diagnostic epoch at 62 % both for 2005–2009 and 2010–2014 (Table 1), nor was a difference found in the adjusted analysis (Table 2).

Table 1

BreastScreen NSW participation history of women diagnosed with invasive breast cancer: NSW 2005-14* (n = 35192).

Characteristic	% never screened (n = 13391)	% screened 25+ months previously (n = 4968)	% screened ≤ 24 months previously (n = 16833)	3-group difference P value**
Age (years):				< 0.001
40–49 (n = 7870)	76.8	8.1	15.1	
50–59 (n = 11388)	31.7	11.7	56.6	
60–69 (n = 12038)	22.0	14.1	63.9	
70–74 (n = 3896)	27.9	33.4	38.7	
Country of birth:				< 0.001
Australia (n = 13322)	37.2	14.3	48.6	
Europe (n = 3099)	36.3	14.6	49.1	
North Africa/ Middle East (n = 556)	43.4	11.9	44.8	
Asia (n = 1450)	49.2	11.3	39.5	
Americas (n = 318)	41.8	15.4	42.8	
Africa (other) (n = 211)	46.0	13.7	40.3	
(Unknown (n = 615))	(43.5)	(13.3)	(47.5)	
15617 unrecorded				
Indigenous status identifier:				0.003
Non-Indigenous (n = 34592)	38.0	14.1	48.0	
Indigenous (n = 600)	43.7	15.3	41.0	
Residential location:				< 0.001
Major city (n = 24736)	39.1	14.4	46.5	
Inner regional (n = 7935)	35.2	13.5	51.3	
Outer regional (n = 2356)	37.6	13.3	49.1	
Remote (n = 141)	23.4	13.5	63.1	
Very remote (n = 21)	33.3	19.1	47.6	
(Unknown (n = 3))	(100)			
SEIFA IRD:				< 0.001
Most disadvantage (n = 6125)	37.8	14.0	48.2	
More disadvantage (n = 7157)	37.0	13.6	49.4	
Mid disadvantage (n = 6976)	36.5	14.4	49.1	
Less disadvantage (n = 6841)	40.4	13.9	45.7	
Least disadvantage (n = 8090)	39.5	14.5	46.9	
(Unknown (n = 3))				
Diagnosis period:				0.437
2005–09 (n = 16035)	38.4	14.2	47.5	
2010–14 (n = 19175)	37.8	14.1	48.1	
Local health district:				< 0.001
Sydney (n = 2353)	41.1	16.3	42.6	
South West Sydney (n = 3534)	42.6	13.7	43.7	
South East Sydney (n = 4027)	37.5	14.0	48.5	
Illawarra/Shoal (n = 1960)	31.6	12.6	55.9	
West Sydney (n = 3431)	41.0	13.9	45.1	
Nepean Blue Mountains (n = 1695)	40.4	14.0	45.6	
North Sydney (n = 4812)	38.9	14.2	46.9	
Central Coast (n = 1827)	37.0	15.4	47.7	
Hunter North East (n = 4647)	29.0	16.9	54.1	
North Valley NSW (n = 1727)	37.2	12.9	49.9	
Mid North NSW (n = 1185)	32.9	13.1	54.0	
Murrumbidgee (n = 1219)	38.9	12.6	48.6	
West NSW (n = 1371)	31.1	12.1	56.8	
Far West (n = 164)	38.4	15.2	46.3	
Albury (n = 248)	40.3	13.7	46.0	
Stage of cancer:				< 0.001
Localized (n = 18785)	31.0	13.4	55.5	
Regional (n = 13201)	43.4	14.9	41.8	
Distant (n = 2082)	56.9	15.9	27.3	

NSW: New South Wales; IRD: Index of Relative Disadvantage; SEIFA: Socio-Economic Indexes for Areas.

* Excludes missing values; excludes South NSW as records split with BreastScreen ACT.

** P value derived from Pearson Chi-square test or Fisher's exact test (see "2. Methods").

3.1.8. By stage

Any history of BreastScreen participation varied by stage ($p < 0.001$), with earlier stage applying where women had participated. A history of this participation applied to 69 % of women with localized cancer, 57 % of those with regional cancer, and 43 % of those with more advanced cancers (Table 1). Compared with localized cancer, the adjusted relative odds of BreastScreen participation for regional breast cancers was 0.63 (95 % CI: 0.59–0.68) and for distant spread, 0.30 (95 % CI: 0.26–0.34) (Table 2).

3.2. For women with breast cancer with a history of "ever screened" through BreastScreen NSW, the proportion last screened < 24 months prior to diagnosis

3.2.1. By age

The proportion of women of all ages diagnosed with breast cancer who had been screened < 24 months was 48 % (Table 1). They represented 77 % of all those with breast cancer who had a history of ever being screened through BreastScreen NSW (Table 1). The percentage screened < 24 months of the ever screened varied from 54 % for ages 70–74 years to 65 % for 40–49 years, with the percentage screened < 24 months being 82 % for 60–69 years and 83 % for 50–59

Table 2

Relative odds (95 % CI) of a BreastScreen history for women diagnosed with invasive breast cancer (n = 35192); NSW 2005–14.*

Characteristic	Unadjusted relative odds	Adjusted** relative odds
Age (years):		
40–49 (n = 7870)	1.00	1.00
50–59 (n = 11388)	7.10 (6.65–7.59)	7.14 (6.52–7.80)
60–69 (n = 12038)	11.70 (10.93–12.52)	10.66 (9.70–11.71)
70–74 (n = 3896)	8.56 (7.84–9.34)	6.34 (5.60–7.17)
Country of birth:		
Australia (n = 13322)	1.00	1.00
Europe (n = 3099)	1.04 (0.96–1.13)	0.93 (0.84–1.02)
North Africa/ Middle East (n = 556)	0.77 (0.65–0.92)	0.86 (0.70–1.05)
Asia (n = 1450)	0.61 (0.55–0.68)	0.77 (0.68–0.88)
Americas (n = 318)	0.82 (0.66–1.03)	0.78 (0.60–1.01)
Africa (other) (n = 211)	0.70 (0.53–0.91)	0.73 (0.53–0.99)
Indigenous status identifier:		
Non-Indigenous (n = 34592)	1.00	1.00
Indigenous (n = 600)	0.79 (0.67–0.93)	0.71 (0.55–0.92)
Residential location:		
Major city (n = 24736)	1.00	1.00
Inner regional (n = 7935)	1.18 (1.12–1.24)	1.30 (1.15–1.48)
Outer regional (n = 2356)	1.07 (0.98–1.16)	1.16 (0.95–1.43)
Remote (n = 141)	2.10 (1.42–3.10)	3.60 (1.87–6.94)
Very remote (n = 21)	1.28 (0.52–3.18)	0.41 (0.10–1.62)
SEIFA IRD:		
Most disadvantage (n = 6125)	1.00	1.00
More disadvantage (n = 7157)	1.03 (0.97–1.11)	0.85 (0.75–0.97)
Mid disadvantage (n = 6976)	1.06 (0.99–1.14)	1.00 (0.88–1.14)
Less disadvantage (n = 6841)	0.90 (0.84–0.96)	1.02 (0.90–1.16)
Least disadvantage (n = 8090)	0.97 (0.91–1.04)	1.12 (0.96–1.30)
Diagnosis period:		
2005–09 (n = 16035)	1.00	1.00
2010–14 (n = 19175)	1.02 (0.98–1.07)	0.95 (0.87–1.04)
Local health district:		
Sydney (n = 2353)	1.00	1.00
South West Sydney (n = 3534)	0.94 (0.84–1.05)	0.84 (0.71–1.00)
South East Sydney (n = 4027)	1.17 (1.05–1.29)	1.10 (0.93–1.30)
Illawarra/Shoal (n = 1960)	1.51 (1.33–1.71)	1.26 (1.02–1.57)
West Sydney (n = 3431)	1.00 (0.90–1.12)	1.00 (0.84–1.18)
Nepean Blue Mountains (n = 1695)	1.03 (0.91–1.17)	0.77 (0.63–0.94)
North Sydney (n = 4812)	1.10 (0.99–1.21)	0.93 (0.78–1.11)
Central Coast (n = 1827)	1.19 (1.05–1.35)	1.01 (0.83–1.24)
Hunter Valley North East (n = 4647)	1.71 (1.54–1.89)	1.33 (1.11–1.60)
North NSW (n = 1727)	1.18 (1.04–1.34)	0.89 (0.71–1.13)
Mid North NSW (n = 1185)	1.42 (1.23–1.65)	0.95 (0.72–1.25)
Murrumbidgee (n = 1219)	1.10 (0.95–1.26)	0.74 (0.56–0.97)
West NSW (n = 1371)	1.55 (1.34–1.78)	0.97 (0.75–1.27)
Far West (n = 164)	1.12 (0.81–1.55)	0.67 (0.39–1.14)
Albury (n = 248)	1.03 (0.79–1.35)	0.63 (0.40–0.98)
Stage of cancer:		
Localized (n = 18785)	1.00	1.00
Regional (n = 13201)	0.59 (0.56–0.62)	0.63 (0.59–0.68)
Distant (n = 2082)	0.34 (0.31–0.37)	0.30 (0.26–0.34)

NSW: New South Wales; CI: Confidence Interval; IRD: Index of Relative Disadvantage; SEIFA: Socio-Economic Indexes for Areas.

* Excludes Southern NSW as records split with BreastScreen ACT.

** Derived from multivariate logistic regression (see “2. Methods”).

years ($p < 0.001$) (Table 1). Multivariate regression analysis, adjusting for the other characteristics in Table 3, also indicated little difference between ages 50–59 and 60–69 years in the adjusted relative odds of being screened < 24 months among those ever screened at 3.49 (95 % CI: 3.01–4.03) and 3.58 (95 % CI: 3.09–4.13) respectively when compared with the 40–49 year reference, but the adjusted relative odds of being screened < 24 months among those ever screened was lower at 0.66 (95 % CI: 0.56–0.77) for 70–74 years compared with the 40–49-year reference (Table 3).

Table 3Relative odds (95 % CI) of a recent BreastScreen history (≤ 24 months) compared with an earlier Breast history (≥ 25 months) for women diagnosed with invasive breast cancer (n = 21801); NSW 2005–14.*

Characteristic	Unadjusted relative odds	Adjusted relative odds**
Age (years):		
40–49 (n = 1829)	1.00	1.00
50–59 (n = 7774)	2.61 (2.32–2.92)	3.49 (3.01–4.03)
60–69 (n = 9387)	2.44 (2.19–2.73)	3.58 (3.09–4.13)
70–74 (n = 2811)	0.62 (0.55–0.70)	0.66 (0.56–0.77)
Country of birth:		
Australia (n = 8368)	1.00	1.00
Europe (n = 1974)	0.99 (0.88–1.11)	0.97 (0.85–1.11)
North Africa/ Middle East (n = 315)	1.11 (0.84–1.46)	1.07 (0.79–1.44)
Asia (n = 738)	1.02 (0.86–1.23)	1.04 (0.85–1.27)
Americas (n = 185)	0.81 (0.59–1.13)	0.70 (0.49–0.99)
Africa (other) (n = 114)	0.86 (0.56–1.32)	0.75 (0.48–1.18)
Indigenous status identifier:		
Non-Indigenous (n = 21463)	1.00	1.00
Indigenous (n = 338)	0.79 (0.62–1.00)	0.54 (0.38–0.78)
Residential location:		
Major city (n = 15068)	1.00	1.00
Inner regional (n = 5140)	1.17 (1.08–1.27)	1.13 (0.96–1.33)
Outer regional (n = 1471)	1.14 (1.00–1.30)	1.06 (0.81–1.39)
Remote (n = 108)	1.45 (0.88–2.38)	1.41 (0.68–2.94)
Very remote (n = 14)	0.77 (0.24–2.47)	NA
SEIFA IRD:		
Most disadvantaged (n = 3809)	1.00	1.00
More disadvantaged (n = 4511)	1.06 (0.95–1.17)	0.86 (0.73–1.03)
Mid disadvantaged (n = 4431)	1.00 (0.90–1.11)	0.91 (0.77–1.08)
Less disadvantaged (n = 4078)	0.96 (0.86–1.06)	0.90 (0.75–1.08)
Least disadvantaged (n = 4972)	0.94 (0.85–1.04)	0.85 (0.69–1.05)
Diagnosis period:		
2005–09 (n = 9881)	1.00	1.00
2010–14 (n = 11920)	1.02 (0.96–1.09)	1.06 (0.94–1.20)
Local health district:		
Sydney (n = 1386)	1.00	1.00
South West Sydney (n = 2029)	1.22 (1.04–1.42)	1.06 (0.84–1.34)
South East Sydney (n = 2519)	1.32 (1.14–1.53)	1.51 (1.21–1.87)
Illawarra/Shoal (n = 1341)	1.70 (1.42–2.04)	2.09 (1.55–2.81)
West Sydney (n = 2025)	1.24 (1.06–1.44)	1.21 (0.96–1.52)
Nepean Blue Mountains (n = 1010)	1.24 (1.03–1.49)	1.10 (0.83–1.45)
North Sydney (n = 2942)	1.26 (1.09–1.46)	1.41 (1.12–1.78)
Central Coast (n = 1152)	1.18 (0.99–1.42)	1.22 (0.93–1.60)
Hunter Valley North East (n = 3298)	1.22 (1.06–1.41)	1.04 (0.82–1.32)
North NSW (n = 1084)	1.47 (1.22–1.78)	1.30 (0.95–1.79)
Mid North NSW (n = 795)	1.58 (1.28–1.95)	1.32 (0.92–1.90)
Murrumbidgee (n = 745)	1.48 (1.19–1.83)	1.37 (0.95–1.98)
West NSW (n = 945)	1.79 (1.46–2.20)	1.74 (1.21–2.49)
Far West (n = 101)	1.16 (0.73–1.85)	0.55 (0.28–1.08)
Albury (n = 148)	1.28 (0.86–2.95)	1.44 (0.72–2.85)
Stage of cancer:		
Localized (n = 12955)	1.00	1.00
Regional (n = 7476)	0.68 (0.64–0.73)	0.70 (0.63–0.77)
Distant (n = 898)	0.41 (0.36–0.48)	0.49 (0.40–0.60)

NSW: New South Wales; CI: Confidence Interval; IRD: Index of Relative Disadvantage; NA: non-applicable due to small numbers; SEIFA: Socio-Economic Indexes for Areas.

* Excludes Southern NSW as records split with BreastScreen ACT.

** Derived from multivariate logistic regression (see “2. Methods”).

3.2.2. By country of birth

Variations in the percentage of ever screened women last screened < 24 months of diagnosis approached but did not achieve statistical significance by country of birth ($p = 0.755$), ranging between 74 % and 79 % (Table 1). Multivariate regression analysis indicated the relative odds of being screened < 24 months among the ever screened born in the Americas was 0.70 (95 % CI: 0.49–0.99) when compared with Australia as the reference category (Table 3).

3.2.3. By indigenous status

Screening participation < 24 months of diagnosis among the ever screened was 73 % for Indigenous women, which was a lower than the corresponding 77 % for non-Indigenous women ($p = 0.050$) (Table 1). The adjusted relative odds of screening participation < 24 months among the ever screened was 0.54 (95 % CI: 0.38–0.78) for Indigenous compared with non-Indigenous women (Table 3).

3.2.4. By geographic remoteness

Participation < 24 months of diagnosis among the ever screened also varied by geographic remoteness ($p < 0.001$). A lower participation suggested for major city. Also, a low participation for < 24 months of diagnosis of 71 % presented among the ever screened for very remote areas, but this was based on a very small numbers ($n = 14$) (Table 1). Confidence intervals for the adjusted relative odds of screening participation < 24 months among the ever screened in each region overlapped the reference of 1.00 for major city areas, indicating that differences were potentially due to chance (Table 3).

3.2.5. By socioeconomic status

The variation in participation < 24 months among the ever screened by SEIFA Index of Relative Socioeconomic Disadvantage was small, with a range of 76–78 %, and was not statistically significant ($p = 0.117$). Similarly, adjusted relative odds did not point to differences by socioeconomic status (Table 3).

3.2.6. By local health district

BreastScreen NSW participation < 24 months among the ever screened also varied by local health district ($p < 0.001$), ranging from 72 % for Sydney LHD to 82 % for Western NSW and Illawarra/Shoalhaven LHDs (Table 1). Compared with Sydney LHD, higher relative odds generally applying for other LHDs, with the highest presenting for Illawarra/Shoalhaven at 2.09 (95 % CI: 1.55–2.81), Western NSW at 1.74 (95 % CI: 1.21–2.49), South East Sydney LHD at 1.51 (95 % CI: 1.21–1.87) and North Sydney 1.41 (1.12–1.78) (Table 3).

3.2.7. By diagnostic period

Participation did not vary by diagnostic period ($p = 0.548$) with participation < 24 months among the ever screened approximating 77 % for both 2005–2009 and 2010–2014 (Table 1). The adjusted relative odds of participation were 1.06 (95 % CI: 0.94–1.20) for 2010–2014 compared with 2005–2009 (Table 3).

3.2.8. By stage

Participation < 24 months among the ever screened was higher for localized tumours at 81 % compared with 74 % for regional cancers and 63 % for distant spread ($p < 0.001$) (Table 1). The adjusted relative odds of participation < 24 months among the ever screened were 0.70 (95 % CI: 0.63–0.77) for regional cancers and 0.49 (95 % CI: 0.40–0.60) for distant spread compared with localized tumours (Table 3).

4. Discussion

Approximately 73 % of NSW women aged 50–69 years at diagnosis of invasive breast lesions in 2005–14 had previously participated in the BreastScreen NSW screening program, and 72 % of those aged 70–74 years had done so. Meanwhile the percentage of women aged 40–49 years who had participated was much lower at 23 %. This difference is understandable. While these younger women were eligible for screening, they were not included in the principal screening target age range prior to 2014 and were not actively recruited for screening.

Data were not available to us on reasons women may choose to be or not to be screened. The study is therefore limited to describing screening history as such, although some factors that may have contributed to decisions on screening participation are suggested. In particular, the study is limited to describing screening histories in those

women who went on to be diagnosed with breast cancer.

We consider that these data, by relating to women diagnosed with breast cancer, are complementary to population-based data. Among those diagnosed women would be some at elevated risk of breast cancer mortality. Those with a history of BreastScreen NSW participation included women with screen-detected and interval cancers, and others whose cancers were found at a later time. History of screening within 24 months of diagnosis can better be used for comparison with screening policy.

The national accreditation standard is 70 % for women aged 50–69 years to be screened during a 24-month period with intervals between screening rounds up to 27 months allowed in national accreditation and reporting [1]. While the percentage of breast cancer patients recorded on the NSW Cancer Registry at this age who reported a history of screening within the 24 months of diagnosis was lower at 60 %, it exceeded the 53 % generally observed at a population level for this age range [2,10]. This may reflect a greater participation in screening of higher risk women, such as: (1) the Australian rather than overseas born [10]; and (2) those high-risk women encouraged to screen due to family history of breast cancer, use of hormone replacement therapy or personal history of benign breast disease [1,3]. In addition, differences in lead time and overdiagnosis are likely contributors.

The percentage of women diagnosed with invasive breast cancer at age 70–74 years, who had a screening history within 24 months prior to diagnosis, was lower at 39 %. Again, this is understandable as these women were not included in the screening target age range prior to 2014. Further monitoring will indicate whether their 24-month screening participation increases following the extension of the screening target age range to include them and the more active promotion of screening that has now occurred for this age range. Women aged 75 years or more, while not targeted for screening, should be included in future monitoring activity, given the important questions around net harms and benefit, especially as life expectancies and disability-free life expectancies improve.

A history of BreastScreen NSW participation within 24 months of diagnosis was generally not lower across more remote residential areas, which is reassuring. Indeed, this screening history experience was higher at 61 % for remote and very remote populations than the 48 % for less remote locations ($p < 0.001$). We attribute this difference, at least in part, to the emphasis given in the screening program to reaching remote country communities through mobile facilities.

Women with breast cancer who were born in Australia were more likely to have participated through BreastScreen NSW than other women, with lower participation most evident for women born in Asia and Africa (other than North Africa). The reasons are not known but could include cultural factors and language difficulties encountered by some Asian and African women. Further research is needed to identify the sub-populations and barriers involved such that more effective screening promotion can be designed.

Major city residents with breast cancer were less likely to have a BreastScreen NSW history after adjusting for confounders, with stronger screening histories indicated in particular for residents of inner regional and remote areas. This difference is consistent with the lower participation frequently reported at a population level in Australian screening monitoring reports [1,10,11]. The reasons are unclear as screening services are available throughout major cities in NSW. Further research is needed to identify barriers, including whether geographic differences in culture are involved, and availability of private de facto screening options.

Indigenous women with breast cancer were less likely than non-Indigenous women to have a history of participation in BreastScreen NSW and to be less likely to have participated within the 24 months preceding diagnosis. Further initiatives should be directed at screening promotion among Indigenous women, given their poorer survival outcomes following breast-cancer diagnosis [12]. By comparison, the lack of a gradient in history of screening participation by socioeconomic

status is reassuring, although this observation was based on residential SLAs where potential for masking, given differing population numbers and geographic sizes exist.

Women diagnosed with advanced metastatic breast cancers were less likely to have a history of breast screening, with 27 % being screened in the 24 months preceding diagnosis compared with 42 % for those with regional spread and 56 % for those with localized cancer. This pattern was expected and is interpreted as a validation of the measure of breast screening used in this study.

Compared with Sydney LHD as the reference category, the adjusted relative odds of having participated in BreastScreen NSW was lower for women diagnosed with breast cancer from Nepean Blue Mountains, Murrumbidgee and Albury LHDs and higher for Illawarra/Shoalhaven and Hunter North East LHDs. The potential to use interstate services may contribute to the lower participation in BreastScreen NSW for LHDs that abut the NSW border (e.g., Murrumbidgee and Albury LHDs) but the reasons for these differences and lower participation in Nepean Blue Mountains and higher participation for Illawarra/Shoalhaven and Hunter North East LHDs warrant further investigation.

Among screened women, the odds of being screened within 24 months of diagnosis were lower for the 70–74-year age range than for younger women. This probably reflects their non-inclusion in the principal screening target age range until 2014. Previously they were able to gain access to screening but they were not actively invited. Screened women with lower odds of being screened within 24 months of diagnosis also included Indigenous women. Further investigation into the reasons for this result is important, including any aspect of the screening experience that may have acted as a barrier.

5. Conclusions

Of NSW women aged 50–69 years who had been diagnosed with breast cancer, about 73 % had previously participated in BreastScreen NSW and about 60 % had participated in BreastScreen NSW in the 24 months preceding diagnosis. This is less than the 70 % target for biennial screening coverage at a population level, but this target has never been reached by an Australian jurisdiction.

About 39 % of women aged 70–74 years, who had been diagnosed with breast cancer, had been screened through BreastScreen NSW in the 24-month period immediately preceding diagnosis. With extension of the principal screening to cover this age group from 2014, increased promotion of screening participation is indicated for this age group.

Breast screening participation was lower in Indigenous than non-Indigenous women in both unadjusted and adjusted analyses. This underscores the need for further attention to screening participation in Indigenous women.

While differences in screening participation existed by country of birth and residential location, pronounced differences were not evident by socioeconomic status. Qualitative research of screening barriers and opportunities may provide a useful guide for public education and may reduce sociodemographic differences in screening history.

This study demonstrates the value of data linkage for determining screening coverage among women at highest risk of breast cancer, as testified by their subsequent diagnosis of invasive breast cancer.

Author contribution statement

ML, MWS, SM, DR and DC participated in the study design, interpretation of the data, drafting of the report and critical revisions. The New South Wales Cancer Registry and BreastScreen data were linked by the Centre of Health Record Linkage. The data analysis was undertaken by ML.

ML, MWS, SM, DR and DC have approved the publication of this report.

Author contribution statement

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Ethics

Approval for the study was obtained from the NSW Population and Health Services Research Ethics Committee (Cancer Institute sub-study ref: 2017/UMB1106, Aboriginal Health and Medical Research Ethics Committee ref: 120/16).

Data accessibility

Data used in this paper is available through the New South Wales Cancer Institute, subject to relevant institutional and ethical approvals.

Declaration of Competing Interest

All authors declare no competing interests.

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