

RESEARCH COMMUNICATION

Breast Screening and Breast Cancer Survival in Aboriginal and Torres Strait Islander Women of Australia**David Roder^{1,2}, Fleur Webster^{3*}, Helen Zorbas¹, Sue Sinclair⁴**

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Abstract

Aboriginal and Torres Strait Islander people comprise about 2.5% of the Australian population. Cancer registry data indicate that their breast cancer survivals are lower than for other women but the completeness and accuracy of Indigenous descriptors on registries are uncertain. We followed women receiving mammography screening in BreastScreen to determine differences in screening experiences and survivals from breast cancer by Aboriginal and Torres Strait Islander status, as recorded by BreastScreen. This status is self-reported and used in BreastScreen accreditation, and is considered to be more accurate. The study included breast cancers diagnosed during the period of screening and after leaving the screening program. **Design:** Least square regression models were used to compare screening experiences and outcomes adjusted for age, geographic remoteness, socio-economic disadvantage, screening period and round during 1996-2005. Survival of breast cancer patients from all causes and from breast cancer specifically was compared for the 1991-2006 diagnostic period using linked cancer-registry data. Cox proportional hazards regression was used to adjust for socio-demographic differences, screening period, and where available, tumour size, nodal status and proximity of diagnosis to time of screen. **Results:** After adjustment for socio-demographic differences and screening period, Aboriginal and Torres Strait Islander women participated less frequently than other women in screening and re-screening although this difference appeared to be diminishing; were less likely to attend post-screening assessment within the recommended 28 days if recalled for assessment; had an elevated ductal carcinoma in situ but not invasive cancer detection rate; had larger breast cancers; and were more likely than other women to be treated by mastectomy than complete local excision. Linked cancer registry data indicated that five-year year survivals of breast cancer cases from all causes of death were 81% for Aboriginal and Torres Strait Islander women, compared with 90% for other women, and that the former had larger breast cancers that were more likely to have nodal spread at diagnosis. After adjusting for socio-demographic factors, tumour size, nodal spread and time from last screen to diagnosis, Aboriginal and Torres Strait Islander women had approximately twice the risk of death from breast cancer as other women. **Conclusions:** Aboriginal and Torres Strait Islander women have less favourable screening experiences and those diagnosed with breast cancer (either during the screening period or after leaving the screening program) have lower survivals that persist after adjustment for socio-demographic differences, tumour size and nodal status.

Keywords: Indigenous status - breast cancer - screening - survival - Australia

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Introduction

Aboriginal and Torres Strait Islander people represent about 2.5% of the Australian population (ABS, 2008; AIHW, 2008; Cunningham et al., 2008). They more frequently live in remote areas than other Australians

and their health is often affected adversely by severe socio-economic disadvantage and cultural marginalization (ABS, 2008; Cunningham et al., 2008).

Studies using cancer registry data have shown lower breast cancer survivals among Aboriginal and Torres Strait Islander than other women, although the completeness

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and accuracy of Aboriginal and Torres Strait Islander descriptors have been uncertain (AIHW & NBOCC, 2009; Chong & Roder, 2010). The former have also shown more advanced stages of breast cancer that would predispose to lower survivals (Condon et al., 2005a; 2005b).

BreastScreen Australia provides screening mammography principally to detect breast cancer early to reduce mortality. Screening is directed primarily at 50-69 year olds although women aged 40-49 and over 70 years can participate. Screening participation has been lower in Aboriginal and Torres Strait Islander than other women although participation among the former has increased (AIHW, 2006; AG, 2009; AIHW, 2010; AIHW & AG, 2010). It is expected that accreditation and self-reporting of Aboriginal and Torres Strait Islander status would have contributed to a higher level of completeness and accuracy of Aboriginal and Torres Strait Islander descriptors in the BreastScreen database than in most administrative data (CAUS, 2005).

In this study, screening and assessment experiences and outcomes are compared by Aboriginal and Torres Strait Islander status in 50-69 year old Australian women to obtain benchmarks for monitoring and evaluation. In addition, invasive breast cancer survivals are compared by Aboriginal and Torres Strait Islander status within the screening cohort, irrespective of whether diagnosis occurred during the period of screening or after leaving the program. The purpose was to determine whether there were inequalities that needed attention.

By restricting the study to women with a screening history, it is recognized that differences in breast cancer characteristics are likely to have been smaller by Aboriginal and Torres Strait Islander status than in the population more generally. Inequalities would still be important, however, and potentially more amenable to change, given engagement of these women with BreastScreen Australia.

Materials and Methods

In part one of this study, unit record data for 50-69 year old BreastScreen participants held at the Australian Institute of Health and Welfare (AIHW) for the 1996-2005 screening period were analysed (AG, 2009). These were the most recent data aggregated nationally that included all the items required. Initially percentages of women with specified screening experiences (e.g., screening participation, recall to assessment, biopsies, cancer detection and surgical management) were analyzed by Aboriginal and Torres Strait Islander status, where applicable weighting equally for initial and subsequent screening rounds.

Relative odds (odds ratios) were derived from cross-tabulations by Aboriginal and Torres Strait Islander status (Armitage & Berry, 1987). The data generally were analyzed by screening round (initial versus subsequent) and pooled using the Mantel-Haenszel procedure (Armitage & Berry, 1987). Ninety-five per cent confidence limits were regarded as indicative rather than exact due to potential lack of independence from individual women contributing more than one observation.

Relative odds were the odds of a specified screening experience occurring in Aboriginal and Torres Strait Islander women, divided by the corresponding odds for other screened women. Where the lower 95% confidence limit was above 1.00, a greater probability of that experience occurring in Aboriginal and Torres Strait Islander than other women was indicated. Conversely where the upper 95% confidence limits was lower than 1.00, the probability was lower in Aboriginal and Torres Strait Islander than other women.

Potential for confounding was apparent from inter-relationships between Aboriginal and Torres Strait Islander status, breast cancer incidence, screening and socio-demographic characteristics. For example, breast cancer incidence increases with age and is lower in remote and lower socio-economic areas (AIHW & NBOCC, 2009). Detection rates are also known to be higher at initial than subsequent screens and there is evidence that they were higher in 2001-2005 than 1996-2000 (AG, 2009). Screening participation and experiences vary by socio-demographic characteristics and calendar year of screening (i.e., 1996-2000 compared with 2001-2005). For example, higher screening participation has been observed in inner and outer regional areas than in more remote areas and major cities, and secular increases have applied in rates of recall to assessment and invasive cancer detection (AG, 2009).

Least square regression models were therefore used to measure associations of Aboriginal and Torres Strait Islander status with each screening experience (Davis et al., 2001, Davis et al., 2002), adjusting for age (60-64 and 65-69 versus 50-59 years), remoteness of residence (i.e., inner regional, outer regional or more remote area versus major city according to the Australian Standard Geographical Classification (ASGC) of residential Statistical Local Areas (SLAs) (AIHW, CA & AACR, 2008)); socio-economic status of SLAs (i.e., five quintiles of the Socio-economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Disadvantage using the lowest quintile as the reference category (AIHW, CA & AACR, 2008)); screening time period (expressed as 2001-2005 versus 1996-2000); and screening round (subsequent versus initial) (AIHW, CA & AACR, 2008; Armitage & Berry, 1987).

Modeling was undertaken for dichotomous indicator variables for specific experiences. Specifically a linear function of the explanatory variables was estimated for the logit of the "yes" response proportion. Parameter estimation was based on weighted least square regression where regression weights were set equal to the observed rounds in the cross classification. The SAS module PROC REG was employed. The model produced relative odds (95% confidence limits) for each screening experience among Aboriginal and Torres Strait Islander compared with other women.

In part two of the study, BreastScreen data for 1991-2006 and corresponding invasive breast cancer data from Australian cancer registries were linked using probabilistic matching of names, birth dates and places of residence, with approval of ethics committees and Aboriginal and Torres Strait Islander health and medical

research administrations. All jurisdictions of Australia were included except the Australian Capital Territory where data were not available within the study time frame. The effect of this exclusion would have been negligible, in that only about 0.8% of Aboriginal and Torres Strait Islander people of Australia reside in the Australian Capital Territory (ABS, 2008).

Data items in the linked dataset included: (1) from BreastScreen - Aboriginal and Torres Strait Islander status and date of last screen; and (2) from cancer registries - date of birth, date of breast cancer diagnosis, date of death, cause of death, morphology type, and where available, tumour diameter and nodal status at diagnosis.

De-identified linked data were sent to the Australian Institute of Health and Welfare for analysis. Bivariate analyses of associations of socio-demographic and cancer characteristics with Aboriginal and Torres Strait Islander status were tested using the Mann-Whitney U test for ordinal and continuous variables and the Pearson chi-square test for nominal variables (Armitage & Berry, 1987). Characteristics analyzed included age at diagnosis (i.e., under 50, 50-59, 60-69, and 70 years or more); ASGC remoteness of residence; socio-economic status of SLAs (AIHW, CA & AACR, 2008); diagnostic period (i.e., 1991-94, 1995-99, and 2000-06); whether or not cancer diagnosis occurred within four months of the last screen (used as a marker of screen detection); morphology type (i.e., ductal, lobular or other); cancer diameter (in mm categories); and nodal status (i.e., positive or negative). Diagnostic period was categorized to enable comparison between the early and late 1990s, and 2000-06 data were pooled to enable sufficient follow-up time for survival analysis.

Relative survivals could not be calculated due to the absence of life tables for Aboriginal and Torres Strait Islander people for the period of study. Instead crude survivals were determined from date of diagnosis of breast cancer to date of death from any cause, as in prior analyses of survivals of Aboriginal and Torres Strait Islander women with breast cancer (AIHW & NBOCC, 2009).

Cox proportional hazards regression was used to estimate relative risks of death (i.e., hazards ratios) according to Aboriginal and Torres Strait Islander status. A multiple linear regression model was used to control for the confounding effects of other predictor variables in the models (i.e., age at diagnosis, remoteness of residence, socioeconomic status of area, and diagnostic period, and in some analyses, cancer size, nodal status and whether diagnosis occurred within four months of the last screen) (Armitage & Berry, 1987). When estimating this model, the only censoring criterion was survival until the end of the observation period (i.e., December 31st 2006). This approach was also used to estimate relative risks of death from breast cancer by Aboriginal and Torres Strait Islander status after adjusting for these predictor variables. In this latter analysis, deaths from other causes and the end of the observation period for living cases were censoring events. The technique relies on the condition that time to the event (i.e., deaths or deaths from breast cancer) has a distribution that is invariant with respect to each of the explanatory

Table 1. Socio-Demographic Differences for 50-69 Year Old Women by Aboriginal and Torres Strait Islander Status: BreastScreen Australia, 1996-2005

Characteristic	Aboriginal and Torres Strait Islander	Other	P Value*
Age (yrs.):	[n=36,204]	[n=5,330,779]	
50-54 [n=1,674,712]	35.9%	31.2%	
55-59 [n=1,474,009]	28.7%	27.5%	
60-64 [n=1,205,179]	20.8%	22.5%	p<0.001
65-69 [n=1,013,083]	14.6%	18.9%	
Total [n=5,366,983]	100%	100%	
Residence (ASGC):	[n=36,023]	[n=5,315,103]	
Major city [n=3,375,046]	28.2%	63.3%	
Inner regional [n=1,259,184]	19.6%	23.6%	
Outer regional [n=609,000]	26.5%	11.3%	p<0.001
Remote [n=80,886]	10.8%	1.4%	
Very remote [n=27,012]	14.9%	0.4%	
Total [n=5,351,128]	100%	100%	
Area socio-economic disadvantage (SEIFA):	[n=35,672]	[n=5,294,424]	
1 (lowest SES) [n=1,019,048]	41.3%	19.0%	
2 [n=1,112,482]	26.6%	20.8%	
3 [n=1,080,156]	17.8%	20.3%	p<0.001
4 [n=1,019,301]	10.1%	19.2%	
5 (highest SES) [n=1,099,109]	4.2%	20.7%	
Total [n=5,330,096]	100%	100%	
Screening period:	[n=36,204]	[n=5,330,779]	
1996-2000 [n=2,406,712]	40.9%	44.9%	
2001-2005 [n=2,960,271]	59.1%	55.1%	X ² ₍₁₎
Total [n=5,366,983]	100%	100%	p<0.001

*MW: Mann-Whitney U test (see text); X²₍₁₎: Pearson chi-square test (1 degree of freedom) (see text)

variables. A Chi-square test statistic that is a function of differences in observed monthly frequencies showed this to be a tenable assumption at the 5% significance level.

Results

I. Analyses of BreastScreen data

Socio-demographic characteristics (Table 1).

Differences were evident between Aboriginal and Torres Strait Islander and other screened women in: (1) age distribution (p<0.001) with 32.3% of the former being under 60 years compared with 29.4% of other women; (2) remoteness of place of residence (p<0.001) with 52.2% of the former living in outer regional or more remote areas compared with 13.1% of other women; (3) level of socio-economic disadvantage of area of residence (p<0.001) with 67.9% of Aboriginal and Torres Strait Islander compared with 39.8% of other women living in the bottom two socio-economic quintiles; and (4) screening period

Table 2. Screening Experiences of 50-69 Year Old Women by Aboriginal and Torres Strait Islander Status: BreastScreen Australia, 1996-2005*

Experiences	Aboriginal and Torres Strait Islander	Other	Relative odds (95% CLs)	
			RO1	RO2
1. Rescreened within 27 months				
- Among screened women	60.1%	70.4%	0.67 [0.65, 0.68]	0.60 [0.53, 0.69]
- Among rescreened women	80.2%	85.6%	0.69 [0.67, 0.72]	0.68 [0.57, 0.80]
2. Presenting with symptoms	3.6%	3.5%	1.08 [1.03, 1.15]	1.02 [1.00, 1.04]
3. Recalled to assessment	4.7%	5.8%	0.81 [0.77, 0.86]	0.89 [0.80, 0.98]
4. Assessed women assessed < 28 days	71.8%	84.1%	0.47 [0.42, 0.54]	0.76 [0.68, 0.85]
5. Having a biopsy				
- Among screened women	1.4%	1.5%	0.93 [0.84, 1.03]	1.04 [0.91, 1.19]
- Among recalled women	25.6%	23.8%	1.10 [0.98, 1.25]	1.13 [0.98, 1.31]
6. Having invasive cancer				
- Among screened women	0.3%	0.5%	0.72 [0.60, 0.87]	1.13 [0.98, 1.30]
- Among recalled women	6.5%	8.1%	0.81 [0.66, 1.01]	1.20 [1.01, 1.43]
7. Having DCIS				
- Among screened women	0.1%	0.1%	0.85 [0.59, 1.23]	2.32 [1.82, 2.95]
- Among recalled women	2.0%	2.0%	0.96 [0.64, 1.42]	1.11 [1.08, 1.14]
8. Having invasive cancer or DCIS				
- Among screened women	0.4%	0.6%	0.74 [0.63, 0.88]	1.03 [0.90, 1.18]
- Among recalled women	8.4%	10.0%	0.84 [0.69, 1.01]	1.08 [0.91, 1.29]
9. Having invasive cancer in those with invasive cancer or DCIS	75.7%	81.3%	0.84 [0.56, 1.28]	0.59 [0.43, 0.80]
10. Large (>15mm) Vs smaller				
- Invasive cancers	39.8%	37.7%	1.16 [0.77, 1.77]	1.84 [1.48, 2.29]
- Invasive cancers or DCIS	43.4%	38.5%	1.20 [0.82, 1.76]	1.63 [1.33, 2.01]
11. Mastectomy Vs complete local excision				
- Invasive cancers	34.8%	28.2%	1.50 [0.92, 2.43]	1.55 [1.02, 2.36]
- Invasive cancers or DCIS	31.0%	27.3%	1.36 [0.88, 2.11]	1.45 [1.01, 2.10]

*Initial and Subsequent screening round data weighted equally, RO1: adjusted for Initial Vs Subsequent round using Mantel-Haenszel procedure (see text)., RO2: adjusted for age, ASGC, socio-economic disadvantage (SEIFA), screening period (1996-2000 Vs 2001-2005) and Initial Vs Subsequent round using regression (see text).

($p < 0.001$) with 59.1% of Aboriginal and Torres Strait Islander screens occurring in 2001-2005 compared with 55.1% of screens of other women. In addition, more of the screening rounds for Aboriginal and Torres Strait Islander women (22.3%) were initial screens than for other women (17.2%) ($p < 0.001$).

Screening characteristics by Aboriginal and Torres Strait Islander status (Table 2).

1. 24-month screening participation rate. The participation rate was lower in Aboriginal and Torres Strait Islander (36.3%) than other women (57.5%). Compared with other screened women, the unadjusted relative odds of screening participation (95% confidence limits) were 0.55 (0.54, 0.56) for Aboriginal and Torres Strait Islander women, but this increased from 0.55 to 0.73 after adjusting for differences in age, remoteness, level of socio-economic disadvantage, and screening period.

2. Rescreening within 27 months (note: analysis only included index screens occurring 27 months or more before the end of the study). Aboriginal and Torres Strait Islander women were less likely than other women to be rescreened. For all screens combined, the proportion rescreened within 27 month was 60.1% for Aboriginal and Torres Strait Islander women and 70.4% for other women. The relative odds of rescreening within 27 months was 0.60 (0.53, 0.69) in Aboriginal and Torres Strait Islander women after adjusting for socio-demographic correlates

and differences in calendar year period. Among rescreened women, Aboriginal and Torres Strait Islander women were less likely than other women to be rescreened again within 27 months (80.2% compared with 85.6%). The relative odds also were low at 0.68 (0.57, 0.80) after adjusting for socio-demographic differences and difference in calendar year period.

3. Symptomatic status The percentage of women reporting symptoms at screening was low irrespective of Aboriginal and Torres Strait Islander status, at around 3.5%. This figure was higher for initial screens at 4.1% than the 3.0% for subsequent screens. Overall, the relative odds were slightly elevated in Aboriginal and Torres Strait Islander women at 1.08 (1.03, 1.15) (screening-round adjusted) and marginally so at 1.02 (1.00, 1.04) after also adjusting for socio-demographic differences and difference in calendar year period.

4. Recall to assessment. Aboriginal and Torres Strait Islander women were less likely than other women to be recalled to assessment (4.7% compared with 5.8%). The relative odds were 0.89 (0.80, 0.98) after adjusting for socio-demographic differences and difference in calendar year period. The probability of women being assessed within the recommended 28 days (BSA, 2008) was lower for Aboriginal and Torres Strait Islander (71.8%) than other women (84.1%). The relative odds for Aboriginal and Torres Strait Islander women remained low at 0.76

(0.68, 0.85) after adjusting for socio-demographic differences and difference in calendar year period.

5. Having a biopsy (including fine-needle aspiration and core biopsy but not open biopsy). There was little difference in biopsy rate by Aboriginal and Torres Strait Islander status, either among all screened women, where about 1.5% had a biopsy, or among recalled women where about 24% to 26% were biopsied.

6. Detection of invasive breast cancer. Aboriginal and Torres Strait Islander women were less likely than other women to have an invasive cancer diagnosis (0.3% compared with 0.5%). The relative odds were 0.72 (0.60, 0.87) (screening-round adjusted) but this increased to 1.13 (0.98, 1.30) after also adjusting for socio-demographic differences and difference in calendar year period. Among women recalled to assessment, a lower proportion of Aboriginal and Torres Strait Islander women (6.5%) than other women (8.1%) were found to have invasive breast cancer. The relative odds were not significantly reduced, however, at 0.81 (0.66, 1.01) (screening-round adjusted) and became significantly elevated at 1.20 (1.01, 1.43) after also adjusting for socio-demographic differences and difference in calendar year period.

7. Detection of ductal carcinoma in situ (DCIS). There was not a statistically significant difference in detection rate for DCIS in screened women by Aboriginal and Torres Strait Islander status (rates equaling 0.1%). The relative odds of DCIS in Aboriginal and Torres Strait Islander compared with other women became elevated at 2.32 (1.82, 2.95), however, after adjusting for socio-demographic correlates and difference in calendar year period. Among women recalled to assessment, there was also a similar detection rate for DCIS irrespective of Aboriginal and Torres Strait Islander status (rates equaling 2.0%). The relative odds of DCIS became elevated at 1.11 (1.08, 1.14) in Aboriginal and Torres Strait Islander women, however, after adjusting for socio-demographic differences and difference in calendar year period.

8. Detection of large (>15mm diameter) compared with smaller lesion. There was little difference in the proportions of invasive cancers that were large among Aboriginal and Torres Strait Islander (39.8%) and other screened women (37.7%). The relative odds for Aboriginal and Torres Strait Islander women were 1.16 (0.77, 1.77) (screening-round adjusted), but this increased to 1.84 (1.48, 2.29) after also adjusting for socio-demographic differences and difference in calendar year period. Large lesions among invasive cancers and DCIS lesions collectively were more common in Aboriginal and Torres Strait Islander (43.4%) than other women (38.5%). The relative odds for Aboriginal and Torres Strait Islander women were 1.20 (0.82, 1.76) (screening-round adjusted), with this increasing to 1.63 (1.33, 2.01) after also adjusting for socio-demographic differences and difference in calendar year period.

9. Surgical management. The proportion of cancers

treated by mastectomy rather than complete local excision was higher for Aboriginal and Torres Strait Islander (34.8%) than other screened women (28.2%). This gave a relative odds of 1.50 (0.92, 2.43) (screening-round adjusted) and 1.55 (1.02, 2.36) after also adjusting for socio-demographic correlates and difference in calendar year period. Similarly the proportion of women with invasive cancer or DCIS treated by mastectomy compared with complete local excision was higher for Aboriginal and Torres Strait Islander (31.0%) than other screened women (27.3%). The relative odds were 1.36 (0.88, 2.11) (screening-round adjusted) and 1.45 (1.01, 2.10) after also adjusting for socio-demographic differences and difference in calendar year period.

II. Analyses of linked BreastScreen and cancer registry data

Socio-demographic characteristics (Table 3).

The age distribution of Aboriginal and Torres Strait Islander women was lower than for other women with breast cancer ($p < 0.001$) (e.g., 20.6% Vs 11.7% under 50 years; 13.0% Vs 20.1% aged 70 years or more). Place of residence also varied ($p < 0.001$), with fewer Aboriginal and Torres Strait Islander than other women living in major cities (36.5% Vs 68.5%) and more of the former living in remote or very remote areas (20.4% Vs 1.5%). Meanwhile, Aboriginal and Torres Strait Islander women were more likely than other women to live in lower socio-economic areas ($p < 0.001$) (e.g., 41.1% Vs 20.2% in the lowest quintile; 6.2% Vs 22.1% in the highest quintile).

Table 3. Socio-demographic Characteristics of Women Diagnosed with Invasive Breast Cancer in 1991-2006 Who Had Been Screened Through BreastScreen Australia, by Aboriginal and Torres Strait Islander Status

Characteristics	Aboriginal and Torres Strait Islander status		P Value*
	Yes	No	
Age at diagnosis (yrs.):	[n=446]	[n=61,636]	
Under 50 [n=7,313]	20.6%	11.7%	
50-59 [n=22,024]	38.1%	35.5%	
60-69 [n=20,327]	28.3%	32.8%	MW $p < 0.001$
70+ [n=12,418]	13.0%	20.1%	
Total [n=62,082]	100%	100%	
Residence (ASGC):	[n=422]	[n=61,826]	
Major city [n=42,487]	36.5%	68.5%	
Inner regional [n=13,307]	21.1%	21.4%	
Outer regional [n=5,450]	22.0%	8.7%	$X^2_{(3)} p < 0.001$
Remote & very remote [n=1,004]	20.4%	1.5%	
Total [n=62,248]	100%	100%	
Area socio-economic (SEIFA):	[n=421]	[n=61,734]	
1 (lowest SES) [n=12,611]	41.1%	20.2%	
2 [n=13,846]	21.4%	22.3%	
3 [n=11,558]	19.0%	18.6%	MW $p < 0.001$
4 [n=10,498]	12.4%	16.9%	
5 (highest SES) [n=13,642]	6.2%	22.1%	
Total [n=62,155]	100%	100%	

* MW: Mann-Whitney U test (see text); $X^2_{(3)}$: Pearson chi-square test (3 degrees of freedom) (see text)

Table 4. Invasive Breast Cancer Characteristics for Women Diagnosed in 1991-2006 Who Had Been Screened Through BreastScreen Australia, by Aboriginal and Torres Strait Islander Status

Characteristics	Aboriginal and Torres Strait Islander status		P Value*
	Yes	No	
Diagnosis period**:	[n=454]	[n=63,287]	
1991-94 [n=4,688]	6.0%	7.4%	MW p<0.001
1995-99 [n=18,711]	19.6%	29.4%	
2000-06 [n=40,342]	74.5%	63.2%	
Total [n=63,741]	100%	100%	
Time from screen (months):	[n=356]	[n=56,201]	
Within 4 [n=34,548]	56.2%	61.1%	X ² ₍₁₎ p=0.961
Outside 4 [n=22,009]	43.8%	38.9%	
Total [n=56,557]	100%	100%	
Morphology type:	[n=445]	[n=62,076]	
Ductal [n=50,002]	81.8%	80.0%	X ² ₍₂₎ p=0.212
Lobular [n=7,390]	9.2%	11.8%	
Other [n=5,129]	9.0%	8.2%	
Total [n=62,521]	100%	100%	
Tumour size (mm):	[n=312]	[n=41,513]	
0-15 [n=23,495]	48.4%	56.2%	MW p=0.003
16-19 [n=12,994]	34.9%	31.0%	
30+ [n=5,336]	16.7%	12.7%	
Total [n=41,825]	100%	100%	
Nodal status:	[n=288]	[n=35,327]	
Positive [n=15,558]	54.9%	43.6%	X ² ₍₁₎ p<0.001
Negative [n=20,057]	45.1%	56.4%	
Total [n=35,615]	100%	100%	
Death cause:	[n=116]	[n=10,995]	
Breast cancer [n=5,862]	49.1%	52.8%	X ² ₍₁₎ p=0.432
Other [n=5,249]	50.9%	47.2%	
Total [n=11,111]	100%	100%	

*MW: Mann-Whitney U test (see text); X²₍₁₎ & X²₍₂₎: Pearson chi-squared test (1 and 2 degrees of freedom respectively) (see text); **Overall, 0.7% of breast cancers occurred in Aboriginal and Torres Strait Islander women, with this proportion increasing from 0.5% of those diagnosed in the 1990s to 0.8% of those diagnosed in 2000-06.

Breast cancer characteristics (Table 4)

A larger proportion of breast cancers among Aboriginal and Torres Strait Islander than other women was diagnosed in more recent time periods (p<0.001), the proportion diagnosed in 2000-06 being 74.5% and 63.2% respectively (note: there is the potential for secular differences in measurement of Aboriginal and Torres Strait Islander status to have affected this difference). Aboriginal and Torres Strait Islander women had on average larger breast cancers (p=0.003), the proportion exceeding 15mm being 51.6% compared with 43.8% for other women. Meanwhile, the proportion of breast cancers that were node positive was 54.9% for Aboriginal and Torres Strait Islander women compared with the 43.6% for other women (p<0.001). Statistically significant differences were not found by Aboriginal and Torres Strait Islander status for morphology type (p=0.212) or whether breast cancer diagnosis had occurred within four months of the last screen (p=0.961).

Crude five-year survivals (Table 5)

Table 5. Percentage 5-year Crude Survivals (95% Confidence Limits) for Invasive Breast Cancers for Women Diagnosed in 1991-2006 Who Had Been Screened Through BreastScreen Australia, by Aboriginal and Torres Strait Islander Status*

Characteristics	Aboriginal and Torres Strait Islander status		Difference
	Yes	No	
Age at diagnosis (yrs.):	[n=446]	[n=61,636]	
Under 50 [n=7,313]	85 [77, 93]	93 [92, 94]	-8 [-17, 0]
50-59 [n=22,024]	85 [78, 92]	92 [91, 92]	-7 [-14, 0]
60-69 [n=20,327]	79 [70, 88]	91 [90, 91]	-12 [-20, -3]
70+ [n=12,418]	77 [64, 90]	82 [82, 83]	-6 [-19, 7]
Residence (ASGC):	[n=422]	[n=61,826]	
Major city [n=42,487]	86 [80, 92]	90 [90, 90]	-4 [-10, 3]
Inner regional [n=13,307]	79 [68, 90]	89 [89, 90]	-10 [-21, 1]
Outer regional [n=5,450]	75 [63, 87]	88 [87, 89]	-13 [-25, -2]
Remote & very remote [n=1,004]	84 [75, 93]	90 [88, 93]	-6 [-16, 3]
Area socio-economic:	[n=421]	[n=61,734]	
1 (lowest SES) [n=12,611]	76 [69, 84]	89 [88, 89]	-12 [-20, -4]
2 [n=13,846]	81 [71, 92]	89 [88, 89]	-7 [-18, 3]
3 [n=11,558]	89 [79, 98]	89 [88, 90]	-1 [-10, 8]
4 [n=10,498]	91 [83, 99]	90 [90, 91]	1 [-7, 9]
5 (highest SES) [n=13,642]	84 [66, 100]	91 [91, 92]	-8 [-25, 9]
Diagnostic period:	[n=454]	[n=63,287]	
1991-94 [n=4,688]	96 [89, 100]	92 [91, 93]	5 [-3, 12]
1995-99 [n=18,711]	83 [75, 91]	89 [89, 90]	-6 [-14, 2]
2000-06 [n=40,342]	79 [73, 85]	89 [89, 90]	-11 [-17, -4]

*Crude survivals from diagnosis to death from any cause

Crude five-year survivals were lower for Aboriginal and Torres Strait Islander than other women at 80.8% compared with 89.6%. Aboriginal and Torres Strait Islander women had lower survivals in each age category, irrespective of remoteness of residential location. Differences in survival by Aboriginal and Torres Strait Islander status were not consistent, however, by socio-economic status or diagnostic period.

Multi-variable proportional hazards regression

1. Deaths from all causes (Table 6). After adjusting for age at diagnosis, remoteness of residence, socio-economic status and diagnostic period, Aboriginal and Torres Strait Islander women had an 84% higher risk of death from any cause than other women. Supplementary analysis was undertaken adjusting in addition for tumour size, nodal status and duration from last screen to diagnosis (i.e., whether it was within four months). (Note: this analysis was restricted to the 44.0% of women in the study where data were available on these additional characteristics.) This supplementary analysis gave a relative risk of 2.22 (1.53, 3.21) for Aboriginal and Torres Strait Islander women.

2. Deaths from breast cancer (Table 7). After adjusting for age at diagnosis, remoteness of residence, socio-

Table 6. Relative Risk (95% confidence limits) of Death from Any Cause Among Women Diagnosed with Invasive Breast Cancer in 1991-2006 Who Had Been Screened Through BreastScreen Australia* - Proportional Hazards Regression Analysis

	Relative risk
Aboriginal and Torres Strait Islander status:**	
No (reference) [n=63,319]	1.00
Yes [n=454]	1.84 [1.61, 2.08]
Age at diagnosis (yrs.):	
Under 50 (reference) [n=8,973]	1.00
50-59 [n=22,035]	1.18 [1.10, 1.27]
60-69 [n=20,341]	1.56 [1.07, 1.29]
70+ [n=12,424]	3.07 [1.40, 1.71]
Residence (ASGC):	
Major city (reference) [n=43,998]	1.00
Inner regional [n=13,314]	1.01 [0.95, 1.07]
Outer regional [n=5,456]	1.09 [1.01, 1.18]
Remote & very remote [n=1,005]	1.05 [0.87, 1.23]
Areas socio-economic (SEIFA):	
1 (lowest SES) (reference) [n=14,207]	1.00
2 [n=13,854]	0.98 [0.91, 1.05]
3 [n=11,565]	0.93 [0.86, 1.00]
4 [n=10,502]	0.90 [0.83, 0.98]
5 (highest SES) [n=13,645]	0.83 [0.75, 0.90]
Diagnostic period:	
1991-94 (reference) [n=4,689]	1.00
1995-99 [n=18,717]	1.20 [1.12, 1.27]
2000-06 [n=40,367]	1.19 [1.11, 1.28]

* Proportional hazards regression; date of censoring of live cases, Dec 31st 2006. ** Non-stated assigned to non-Aboriginal/non-Torres Strait Islander status.

Table 7. Relative Risk (95% confidence limits) of Death from Breast Cancer Among Women Diagnosed with Invasive Breast Cancer in 1991-2006 Who Had Been Screened Through BreastScreen Australia* - Proportional Hazards Regression Analysis

	Relative risk
Aboriginal and Torres Strait Islander status:**	
No (reference) [n=63,319]	1.00
Yes [n=454]	1.68 [1.37, 1.99]
Age at diagnosis (yrs.):	
Under 50 (reference) [n=8,973]	1.00
50-59 [n=22,035]	1.07 [0.97, 1.16]
60-69 [n=20,341]	1.05 [0.95, 1.15]
70+ [n=14,424]	1.35 [1.29, 1.49]
Residence (ASGC):	
Major city (reference) [n=43,998]	1.00
Inner regional [n=13,314]	0.99 [0.90, 1.06]
Outer regional [n=5,456]	1.03 [0.93, 1.16]
Remote & very remote [n=1,005]	1.08 [0.89, 1.40]
Areas socio-economic (SEIFA):	
1 (lowest SES) (reference) [n=14,207]	1.00
2 [n=13,854]	1.03 [0.94, 1.12]
3 [n=11,565]	0.97 [0.87, 1.06]
4 [n=10,502]	0.90 [0.80, 1.00]
5 (highest SES) [n=13,645]	0.87 [0.76, 0.95]
Diagnostic period:	
1991-94 (reference) [n=4,689]	1.00
1995-99 [n=18,717]	1.18 [1.08, 1.28]
2000-06 [n=40,367]	1.17 [1.06, 1.27]

* Proportional hazards regression; date of censoring of live cases, Dec 31st 2006. ** Non-stated assigned to non-Aboriginal/non-Torres Strait Islander status.

economic status and diagnostic period, Aboriginal and Torres Strait Islander women had a 68% higher risk of breast cancer death than other women. Supplementary analysis adjusting in addition for tumour size, nodal status and duration from last screen to diagnosis (i.e., whether it was within four months), gave a relative risk of 1.96 (1.20, 3.21) for Aboriginal and Torres Strait Islander women.

Discussion

Aboriginal and Torres Strait Islander women participated less frequently in breast screening and rescreening than other women which was not fully explained by their age, area of residence or period of screening. This is likely to contribute to the larger sizes of their breast cancers at diagnosis and their poorer survivals at a population level (Condon et al., 2005a, 2005b; AIHW & NBOCC, 2009; Chong & Roder, 2010). Opportunities to further increase screening participation by enhancing screening accessibility and cultural appropriateness may exist although there is much that has been done already and there is evidence from this study that the participation gap is decreasing.

Aboriginal and Torres Strait Islander women may have a slightly higher prevalence of symptoms at screening than other women, which is largely but potentially not entirely explained by socio-demographic differences and difference in calendar year period. If real, the explanation may be that these women are more likely than others to use BreastScreen for symptomatic purposes in preference to less accessible diagnostic services. Another explanation may be that the larger cancers in Aboriginal and Torres Strait Islander women were more likely to be symptomatic. Opportunities to increase access to appropriate diagnostic services should be investigated and all women with symptoms should be encouraged to attend diagnostic as opposed to screening services, although it is recognized that there would be substantial impediments due to geographic remoteness in some instances.

Aboriginal and Torres Strait Islander women were less likely than other women to be recalled for assessment and those who were recalled were less likely to be assessed within the recommended 28 days. This may be due to the time taken to obtain film reading, as for mobile services for example, in the pre-digital era, plus the longer travelling distances for assessment. Opportunities to reduce barriers through the provision of transport services and ongoing education should be explored, although again, it is recognized that there are difficulties inherent in geographic remoteness and that much has already been done.

The lower detection of invasive breast cancers in Aboriginal and Torres Strait Islander women is consistent with recognized differences in population-based incidence (AIHW & NBOCC, 2009), although this did not apply after adjusting for socio-demographic correlates.

Aboriginal and Torres Strait Islander women had elevated DCIS detection rates after adjusting for socio-demographic factors and difference in calendar year period. The reasons for this are not known. Possibly risk factors associated with lower invasive cancer detection in Aboriginal and Torres Strait Islander women, potentially

including differences in fertility rates, age at first full-term pregnancy, and use of hormone replacement therapy, did not have an equivalent effect on DCIS. This finding warrants further study.

Sizes of invasive cancer at diagnosis were larger in Aboriginal and Torres Strait Islander than other women after adjusting for socio-demographic correlates and difference in calendar year period, and likely would be contributing to higher case fatality. This underscores the need to optimize regular screening participation in this high-risk group of women.

Aboriginal and Torres Strait Islander women were more likely than other women to have a mastectomy than complete local excision of their breast cancers. This may be due to choice, larger tumour sizes or lower access to radiotherapy services. Further research is needed to determine reasons for this finding.

The five-year survivals of breast cancer cases (incorporating cancers diagnosed during the screening period and after leaving the screening program) were 81% for Aboriginal and Torres Strait Islander women and 90% for other women. These were higher than the corresponding population-based survivals of 65% and 82% respectively which were estimated previously for four Australian states and territories where Aboriginal and Torres Strait Islander descriptors were considered adequate for survival comparison (AIHW & NBOCC, 2009). The present survival data correspond with five-year case fatalities of 19% for Aboriginal and Torres Strait Islander women and 10% for other women in this study (i.e., 100-81 and 100-90 respectively).

Multivariable analysis showed that after adjusting for diagnostic period and socio-demographic factors (i.e., age, remoteness of residence, and socio-economic status), the risk of death (any cause) was 84% higher in Aboriginal and Torres Strait Islander than other women diagnosed with invasive breast cancer. A corresponding 68% elevation in risk of death from breast cancer was also observed in a parallel model. This indicates that the higher risks of death observed in Aboriginal and Torres Strait Islander women were not explained by socio-demographic factors.

When multivariable analyses were repeated, adjusting for tumour size, nodal spread, and whether diagnosis occurred within four months of prior screening (note: in a sub-group of 44% of women with recorded tumour size, nodal spread and time from prior screening), in addition to diagnostic period and socio-demographic factors, the risk of death (any cause) was 122% higher in Aboriginal and Torres Strait Islander than other women. A corresponding 96% elevation in risk of death from breast cancer also was observed in a parallel model. While a decrease in relative risk might have been expected after adjusting for these characteristics, this analysis applied to a sub-set of cases where these data were available that was not drawn to be representative of the total.

The reasons for excess deaths in Aboriginal and Torres Strait Islander women in this sub-set, after adjusting for socio-demographic and tumour characteristics, are not known, but it is likely from results of previous studies that they would reflect higher levels of co-morbidity in the Aboriginal and Torres Strait Islander population

(e.g., diabetes and respiratory, cardiovascular and renal diseases) and potentially less complete cancer treatment due to geographic remoteness and cultural factors (AIHW 2008). These cultural factors may include differences in perceived value of treatment and in obligations of community members with cancer to attend to community responsibilities.

In conclusions, this study shows less favourable screening experiences, screening outcomes, breast cancer characteristics and survivals in Aboriginal and Torres Strait Islander women than other women with a history of screening, although better survivals than generally observed among these women at a population level. Although these national findings may not apply in individual settings, they highlight the continuing need to address inequalities faced by the Aboriginal and Torres Strait population.

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