RESEARCH ARTICLE

Factors Predictive of Treatment by Australian Breast Surgeons of Invasive Female Breast Cancer by Mastectomy rather than Breast Conserving Surgery

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Abstract

Background: The National Breast Cancer Audit Database of the Society of Breast Surgeons of Australia and New Zealand is used by surgeons to monitor treatment quality and for research. About 60% of early invasive female breast cancers in Australia are recorded. The objectives of this study are: (1) to investigate associations of socio-demographic, health-system and clinical characteristics with treatment of invasive female breast cancer by mastectomy compared with breast conserving surgery; and (2) to consider service delivery implications. Materials and Methods: Bi-variable and multivariable analyses of associations of characteristics with surgery type for cancers diagnosed in 1998-2010. Results: Of 30,299 invasive cases analysed, 11,729 (39%) were treated by mastectomy as opposed to breast conserving surgery. This proportion did not vary by diagnostic year (p>0.200). With major city residence as the reference category, the relative rate (95% confidence limits) of mastectomy was 1.03 (0.99, 1.07) for women from inner regional areas and 1.05 (1.01, 1.10) for those from more remote areas. Low annual surgeon case load (≤10) was predictive of mastectomy, with a relative rate of 1.08 (1.03, 1.14) when compared with higher case loads. Tumour size was also predictive, with a relative rate of 1.05 (1.01, 1.10) for large cancers (40+ mm) compared with smaller cancers (<30 mm). These associations were confirmed in multiple logistic regression analysis. Conclusions: Results confirm previous studies showing higher mastectomy rates for residents of more remote areas, those treated by surgeons with low case loads, and those with large cancers. Reasons require further study, including possible effects of surgeon and woman's choice and access to radiotherapy services.

Keywords: Mastectomy - socio-demographic - clinical determinants

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Introduction

A Consensus Statement in 1990 from the United States National Institutes of Health indicated that equivalent survivals occur from early breast cancer irrespective of whether treatment is by mastectomy or breast conserving surgery and radiotherapy (U.S. Dept. Health and Human Services and National Institutes of Health, 1990). Australian clinical practice guidelines for the management of early breast cancer, released in 1995 and 2001, were consistent with this Statement and indicated the importance of providing women a choice between breast conserving surgery and mastectomy (National Breast Cancer Centre, 2001).

Following the U.S. Statement and reviews of evidence from randomized trials (Abrams et al., 1995; Fisher et al., 1995), mastectomy rates declined markedly in the U.S. (Lazovich et al., 1991; Lazovich et al., 1997; Habermann et al., 2010), Canada, (Gaudette et al., 2004) and some European countries, (Zorzi et al., 2006), although with a more recent upturn suggested in some North American localities (Tuttle et al., 2007; Katipamula et al., 2009; Dragun et al., 2012a; 2012b). Australian data also showed a trend away from mastectomy towards breast conserving surgery both nationally and in a number of jurisdictions (Hill et al., 1990; 1994; 1999; Byrne et al., 1993; South Australian Cancer Registry, 2000; Cuncins-Hearn et al., 2006; Kricker, 2011). Today only about 40% of early breast cancers are treated by mastectomy in the U.S. and Australia (Cuncins-Hearn et al., 2006; Habermann et al., 2010).

Mastectomy rates for early invasive disease vary widely within and between countries (Hill et al., 1990; 1994; 1999; Lazovich et al., 1991; Byrne et al., 1993; Taylor et al., 1999; South Australian Cancer Registry, 2000; Federation European Cancer Societies, 2004; Anderson et al., 2008; Dixon and Mak, 2008; Kricker, 2011; Dragun et al., 2012a), with higher rates reported for

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Central and Eastern Europe, and low resource countries (Federation European Cancer Societies, 2004; Anderson et al., 2008). Studies in Australia and North America have reported higher rates in residents of more remote rural settings than city locations, in women treated by surgeons with low case loads, and for larger and more advanced breast cancers (Lazovich et al., 1991; Taylor et al., 1999; Dragun et al., 2012a; 2012b). In North America, private health insurance has been linked to greater use of breast conserving surgery (Lazovich et al., 1991; Dragun et al., 2012a; 2012b). In general, breast cancers detected through mammography screening in Australia have had lower mastectomy rates (Samnakay et al., 2005; Cancer Australia, 2012; Roder et al., 2012) with rates of around 28% applying in 1996-2005 and with lower rates applying to cancers detected at subsequent than initial screening rounds (Cancer Australia, 2012; Roder et al., 2012).

Data from BreastScreen Australia have indicated that screen-detected invasive cancers are more likely to be treated by mastectomy in women from non-metropolitan than metropolitan areas, especially in women from outer regional and more remote locations (Cancer Australia, 2012). Aboriginal and Torres Strait Islander women have had much higher mastectomy rates than other women, as have women from the third and fourth lowest socio-economic quintiles (Kotwall et al., 1998; Cancer Australia, 2012). Other studies have shown higher mastectomy rates for women from lower than higher socio-economic areas (Taylor et al., 1999; Cancer Australia, 2012; Roder et al., 2012). A secular decrease in mastectomy rates was evident for screened women between 1996 and 2005 (Cancer Australia, 2012; Roder et al., 2012).

Many factors influence choice of surgery type apart from socio-demographic and tumour characteristics. Some studies have pointed to surgeon choice as a key determinant whereas others have emphasized the importance of the woman's choice (Kotwall et al., 1998; Dixon and Mak, 2008; Caldon et al., 2011). North American data indicate that surgeons trained prior to the 1980s are more likely to use mastectomy (Kotwall et al., 1998). North American data have also indicated that female surgeons are more likely to perform breast conserving surgery (Mandelblatt et al., 2001). Additional evidence suggests that many women, if given information on these procedures and time to consider the options, will select mastectomy (Caldon et al., 2011). Another factor affecting choice may be access to radiotherapy services, which would be lower in many remote areas and may predispose to higher mastectomy rates to avoid breast conserving surgery where adjuvant radiotherapy is strongly advised (U.S. Dept. Health and Human Services, 1990; National Breast Cancer Centre, 2001). Other considerations may include fear of recurrence in the absence of a mastectomy or fear of the side effects of radiotherapy if choosing breast conserving surgery. In addition, access to breast reconstruction may be considered by women in relation to surgical options.

In this study we investigate mastectomy rates among women treated by Australian breast surgeons participating in the National Breast Cancer Audit (Roder et al., 2010). Although early breast cancers treated by these surgeons were not selected to be representative of all early breast cancers in Australia, they comprise the majority and appear to be broadly representative in that their survivals are similar (Roder et al., 2010). Furthermore differences in survival from these cancers by conventional risk factors, such as tumour size, grade, nodal status and oestrogen receptor status, accord with differences observed in population-based studies, indicating that these data may be a credible basis for population-wide inferences (Roder et al., 2010).

Mastectomy rates are investigated by socio-demographic and cancer characteristics. In particular, associations of mastectomy rates with surgeon case load and remoteness of residence are investigated following international and regional evidence from Australia indicating the importance of these features as determinants of mastectomy (Lazovich et al., 1991; Taylor, et al., 1999; Cancer Australia, 2012; Dragun et al., 2012a). Implications of results for health-system improvement are considered. Ethics approval for this study was obtained from the research ethics committee of the Royal Australasian College of Surgeons.

Materials and Methods

Subjects

Approximately 95,700 early invasive breast cancers were diagnosed in Australia between 1998 and 2010 (Australian Institute of Health and Welfare, 2008; Australian Institute of Health and Welfare, Cancer Australia and Australasian Association of Cancer Registries, 2012; Cancer Institute NSW, 2012). The proportion recorded on the National Breast Cancer Database has increased progressively and represents about 60% of cases (Roder et al., 2010). The National Breast Cancer Audit did not include residential postcode in its minimum data set throughout the study period. In this study we analysed data for 30,299 early invasive breast cancers diagnosed in Australian women and treated by mastectomy or complete local excision where residential postcode was recorded (Roder et al., 2010).

Data collection

Variables analysed as candidate predictors of mastectomy included all person, provider and cancer descriptors recorded on the Database. This followed other studies that indicated the potential contribution of a wide range of person, provider and cancer characteristics to choosing mastectomy (Lazovich et al., 1997; Taylor et al., 1999; Zorzi et al., 2006; Dragun et al., 2012a; 2012b). Variables analysed included: 1) Age at diagnosis (<30, 30-39, 40-49, 50-59, 60-69, 70-79, 80+ years). 2) Place of residence (major city, inner regional, outer regional, and remote) (Australian Institute of Health and Welfare, Cancer Australia and Australasian Association of Cancer Registries, 2008). 3) Privately health insurance (yes/no). 4) Socio-economic quintile (SEIFA Index of Relative Index of Socioeconomic Disadvantage, inferred from residential postcode) (Australian Bureau of Statistics, 1998). 5) Location of treatment centre (major city, inner regional, more remote) (Australian Institute of Health and Welfare, Cancer Australia and Australasian Association of

Cancer Registries, 2008). 6) Surgeon mean annual case load (≤10, 11-30, 31-100, 101+). 7) Year of diagnosis. 8) Referral source (symptomatic, non-symptomatic from BreastScreen, non-symptomatic from other source). 9) Breast cancer size (<10, 10-14, 15-19, 20-29, 30-39, 40+ mm); histology type (ductal, lobular, other), grade (low, intermediate, high), lymphatic/vascular invasion (positive/negative), nodal involvement (positive/negative), oestrogen and progesterone receptor status (positive/negative), HER-2 receptor status (positive/negative), and number of tumour foci (1, 2, 3+).

Data analysis

Initially bi-variable associations of these variables with mastectomy (as opposed to breast conserving surgery) were investigated using the Pearson chi-square test for binary and nominal variables and the Mann-Whitney U test and Kruskal-Wallis ANOVA for ordinal variables (Armitage and Berry, 1987; StataCorp, 2005). Relative rates (i.e., rate ratios) for mastectomy were analysed by variable category. Bi-variable analyses were also undertaken of these variables with case load and residential location to gain a better understanding of factors associated with these characteristics. Finally multiple logistic regression analyses were undertaken to determine key predictors of mastectomy, checking that model assumptions such as lack of co-linearity were met (Armitage and Berry, 1987; StataCorp, 2005).

Results

The proportion of cases treated by mastectomy as opposed to complete local excision was 38.7%, which did not vary to a statically significant extent across the 1998-2010 diagnostic period (p>0.200). Results of bi-variable and multi-variable analyses were as follows:

A. Bi-variable: Mastectomy versus breast conserving surgery

Residential location: Associations were evident with mastectomy (p=0.045 and p=0.014 for location as a nominal and ordinal variable respectively). Relative rates (95% confidence limits) of mastectomy indicated small elevations for inner regional and more remote areas respectively of 1.03 (0.99, 1.07) and 1.05 (1.01, 1.10) when major city location was used as the reference category (Table 1). Outer regional, remote and very remote areas were combined in this analysis due to small numbers and because statistically significant differences were not evident in mastectomy rates between these areas (p=0.081 and p=0.218 for area treated as a nominal and ordinal variable respectively).

Case load: An association was evident with mastectomy (p=0.002 for case load as a nominal variable). No significant difference was evident, however, between case load categories of 11-30, 31-100 and 101+ (p=0.707 and p=0.405 for case load as a nominal and ordinal variable respectively). When these categories were combined, the relative rate of mastectomy between the lowest case load category (≤10) and higher case loads (11-101+) was 1.08 (1.03, 1.14) (Table 1).

Tumour size: Tumour size was associated with mastectomy (p=0.033 for size as a nominal variable). No difference in mastectomy rates was evident between sizes in the range below 30mm (p=0.460 and p=0.570 for size as nominal and ordinal variables respectively). When larger tumours of 30+ mm were compared with smaller categories, the relative rate of mastectomy was not elevated for the 30-39mm category at 0.97 (0.93, 1.02) (Table 1). When the mastectomy rate for the largest category (40+mm) was compared with all smaller categories combined, the relative rate was also 1.05 (1.01, 1.10).

Lymphatic/vascular invasion: A small elevation in rate of mastectomy of marginal statistical significance (p=0.069) was observed in cases with lymphatic/vascular invasion, the relative rate being 1.03 (1.00, 1.07) (Table 1).

Other characteristics: Other characteristics not showing associations with mastectomy included age at diagnosis, socio-economic status, referral source, year of diagnosis, treatment centre location, private health insurance, histology type, histology grade, nodal status, oestrogen receptor status, progesterone receptor status, HER-2 receptor status, and number of tumour foci (p>0.200).

Case load: Further bi-variable analyses indicated a positive association of low case load (≤10) with more

Table 1. Relative Rates (95% confidence limits) of Mastectomy Compared with Breast Conserving Surgery (BCS); Australian Breast Cancer Audit, 1998-2010*

		Number of cases (%) BCS	Mastectomy	Relative Rates	P values**
Residential location:	Major city (ref.)	13,166 (61.7)	8,169 (38.3)	1	$X^2_{(2)}$ p=0.045
	Inner regional	3,599 (60.6)	2,339 (39.4)	1.03 (0.99, 1.07)	MWp=0.014
	More remote	1,805 (59.6)	1,221 (40.4)	1.05 (1.01, 1.10)	
Annual surgeon case load:	> 10 (ref.)	17,111 (61.6)	10,687 (38.4)	1	$X^2_{(1)}$ p=0.002
	≤ 10	1,459 (58.3)	1,042 (41.7)	1.08 (1.03, 1.14)	
Large tumour size (mm):	< 30 (ref.)	14,022 (61.4)	8,807 (38.6)	1	$X^2_{(2)}$ p=0.033
	30-39	1,911 (62.4)	1,152 (37.6)	0.97 (0.93, 1.02)	MWp=0.222
	40+	2,159 (59.4)	1,472 (40.6)	1.05 (1.01, 1.10)	
Lymphatic/vascular invasion:	Absent (ref.)	12,237 (61.5)	7,672 (38.5)	1	$X^2_{(1)}$ p=0.069
	Present	4,518 (60.3)	2,979 (39.7)	1.03 (1.00, 1.07)	

*Invasive breast cancers treated by Australian breast surgeons (see text). ** $X^2_{(df)}$=Pearson chi-square (degrees of freedom); MW=Mann–Whitney U test

Table 2. Relative Rates (95% confidence limits) of Breast Cancer Cases Attending Surgeons with Low Annual Case Loads; Australian Breast Cancer Audit, 1998-2010*

		Case numbers (case load > 10)	(case load ≤ 10)	Relative Rates	P values**
Residential location:	Major city (ref.)	19,688	1,647	1	$X^2_{(1)}$p<0.001
	More remote	5,406	532	1.16 (1.06, 1.27)	MWp<0.001
	Inner regional	2,704	322	1.38 (1.23, 1.54)	
Treatment centre location:	Major city (ref.)	21,035	836	1	$X^2_{(2)}$p<0.001
	Inner regional	5,384	1,256	4.95 (4.55, 5.38)	MWp<0.001
	More remote	1,379	409	5.98 (5.37, 6.67)	
Private health insurance:	Yes (ref.)	14,346	1,070	1	$X^2_{(1)}$p<0.001
	No	9,772	1,199	1.57 (1.46, 1.70)	
SEIFA (SES) quintile:	1 {low} (ref.)	5,350	531	1	$X^2_{(2)}$p<0.001
	2	5,330	507	0.96 (0.86, 1.08)	MWp=0.002
	3 + {mid – high}	17,118	1,463	0.87 (0.79, 0.96)	
Referral source:	Symptomatic (ref.)	15,134	1,442	1	$X^2_{(2)}$p<0.001
	BreastScreen	7,789	580	0.80 (0.73, 0.87)	
	Other	2,361	154	0.70 (0.60, 0.83)	
Nodal status:	Negative (ref.)	15,875	1,254	1	$X^2_{(1)}$p<0.001
	Positive	9,552	910	1.19 (1.09, 1.29)	
Oestrogen receptor status:	Positive (ref.)	21,812	1,885	1	$X^2_{(1)}$p=0.001
	Negative	5,123	529	1.18 (1.07, 1.29)	
Progesterone receptor status:	Positive (ref.)	18,833	1,618	1.00	$X^2_{(1)}$p=0.014
	Negative	8,005	770	1.11 (1.02, 1.20)	
HER-2 receptor status:	Negative (ref.)	17,081	1,496	1	$X^2_{(1)}$p<0.001
	Positive	3,128	343	1.23 (1.10, 1.37)	
Number of cancer foci:	1 (ref.)	16,520	1,650	1	$X^2_{(2)}$p=0.018
	2	1,738	137	0.80 (0.68, 0.95)	MWp= 0.011
	3 +	1,979	176	0.90 (0.77, 1.04)	
Diagnostic years:	≤ 2001 (ref.)	2,137	323	1	$X^2_{(2)}$p<0.001
	2002-05	5,366	585	0.75 (0.66, 0.85)	MWp<0.001
	2006 +	20,295	1,593	0.55 (0.50, 0.62)	

*Invasive breast cancers treated by Australian breast surgeons (see text). **$X^2_{(df)}$=Pearson chi-square (degrees of freedom); MW=Mann–Whitney U test

Table 3. Relative Rates (95% confidence limits) of Breast Cancer Cases Residing Outside a Major City; Australian Breast Cancer Audit, 1998-2010*

		Number [%] Major City	Inner regional	More remote	Relative rates Major City	Inner regional	More remote	P values**
Treatment centre location:								
	Major city (n=21,871)	15,834 (72.4)	4,149 (19.1)	1,888 (8.6)	1	1	1	$X^2_{(4)}$ p<0.001
	Inner regional (n=6,640)	4,293 (64.7)	1,449 (21.8)	898 (13.5)	1	1.22 (1.15, 1.28)	1.62 (1.51, 1.75)	
	More remote (n=1,788)	1,208 (67.6)	340 (19.0)	240 (13.4)	1	1.06 (0.96, 1.17)	1.56 (1.38, 1.76)	
SEIFA (SES) quintile:								
	1 {low} (n=5,881)	2,513 (42.7)	1,795 (30.5)	1,573 (26.7)	1	1	1	$X2_{(4)}$ p<0.001
	2 (n=5,837)	3,195 (54.7)	1,873 (32.1)	769 (13.2)	1	0.89 (0.84, 0.93)	0.22 (0.21, 0.24)	KWp<0.001
	3 + {mid - high} (18,581)	15,627 (84.1)	2,270 (12.2)	684 (3.7)	1	0.30 (0.29, 0.32)	0.11 (0.10, 0.12)	
Referral source:	Symptomatic (n=16,576)	11,617 (70.1)	3,247 (19.6)	1,712 (10.3)	1	1	1	$X^2_{(4)}$ p<0.001
	BreastScreen (n=8,369)	5,808 (69.4)	1,741 (20.8)	820 (9.8)	1	1.05 (1.00, 1.09)	0.97 (0.91, 1.03)	KWp=0.028
	Other (n=2,515)	1,840 (73.2)	463 (18.4)	212 (8.4)	1	0.91 (0.83, 1.00)	0.81 (0.70, 0.92)	
Large tumour size (mm):								
	<30 (n=22,829)	15,978 (70.0)	4,581 (20.1)	2,270 (9.9)	1	1	1	$X^2_{(4)}$ p=0.005
	30-39 (n=3,063)	2,197 (71.7)	581 (19.0)	285 (9.3)	1	0.94 (0.87, 1.01)	0.92 (0.82, 1.04)	KWp=0.046
	40+ (n=3,631)	2,521 (69.4)	689 (19.0)	421 (11.6)	1	0.96 (0.90, 1.03)	1.15 (1.04, 1.27)	

*Invasive breast cancers treated by Australian breast surgeons (see text). ** $X^2_{(df)}$=Pearson chi-square (degrees of freedom); MW=Mann–Whitney U test; KW=Kruskal-Wallis ANOVA

remote residential location, more remote treatment centre location, not having primary health insurance, lower socio-economic status, an earlier diagnostic year, symptomatic presentation, positive nodal status, negative oestrogen and progesterone receptor status, positive HER-2 receptor status, and single cancer focus as opposed to multiple foci (Table 2). Other variables not showing an association with case load included large tumour size (p≥0.124) and lymphatic/vascular invasion (p=0.505).

Residential location: Further bi-variable analyses of associations with residential remoteness indicated a positive association with the remoteness of treatment location (p<0.001), lower socio-economic status (p<0.001), referral source (p≤0.028) and tumour size (p≤0.046) (Table 3). By comparison, other variables showed no association with more remote residential

Table 4. Relative Odds (95% confidence limits) of Mastectomy Compared with Breast Conserving Surgery; Australian Breast Cancer Audit, 1998-2010* Multiple Logistic Regression

	Relative odds	
	Model 1**	Model 2***
Residential location:		
Major city (n=21,335)	1	1
Inner regional (n=5,938)	1.05 (0.99, 1.11)	1.05 (0.99, 1.12)
More remote (n=3,026)	1.09 (1.00, 1.17)	1.11 (1.02, 1.20)
Annual surgeon case load:		
>10 (n=27,798)	1	1
≤10 (n=2,501)	1.14 (1.05, 1.24)	1.15 (1.05, 1.25)
Large tumour size (mm):		
<40 (n=25,892)	1	1
≥40 (n=3,631)	1.09 (1.02, 1.17)	1.08 (1.00, 1.17)
Unknown (n=776)	1.00 (0.87, 1.16)	1.11 (0.93, 1.33)

*Invasive breast cancers treated by Australian breast surgeons (see text). **Model 1 including residential location, annual case load and tumour size. ***Model 2 including these predictors and all other socio-demographic, tumour and provider characteristics in the data set (see text)

location (p≥0.106).

B. Multiple logistic regression analyses

Three models were produced, with Model 1 including only those variables found in the bi-variable analyses to be predictive of mastectomy, and Model 2 including those variables plus all other person, provider and tumour characteristics in the Database (listed in Methods). Model 3, which included only those variables found in the bi-variable analyses to be predictive of mastectomy, plus those associated with either low case load or residential location, produced identical odds ratios for residential location and case load as Model 2 (Table 4). Model 1 and Model 2 gave similar results for:

Residential location: compared with major city, the relative odds of mastectomy for inner regional and more remote areas were 1.05 (0.99, 1.11) and 1.09 (1.00, 1.17) respectively for Model 1 and 1.05 (0.99, 1.12) and 1.11 (1.02, 1.20) respectively for Model 2.

Annual surgeon case load: compared with an annual case load of over 10, lower case load gave relative odds of mastectomy of 1.14 (1.05, 1.24) and 1.15 (1.05, 1.25) respectively for Model 1 and Model 2.

Large tumour size: compared with tumours under 40mm, tumours of 40mm diameter or more gave relative odds of mastectomy of 1.09 (1.02, 1.17) and 1.08 (1.00, 1.17) respectively for Model 1 and Model 2.

Discussion

The results show a mastectomy rate in Australia from early invasive breast cancer of 39% between 1998 and 2010, which is very similar to the 40% reported for 1999-2004 from the same data source (Cuncins-Hearn et al., 2006). A similar rate of 37% was reported from USA SEER data for 2000-2006, although this applied to combined ductal carcinoma in situ and AJCC TNM stages I to III invasive cancers, whereas our data were for invasive cancers classified using the NHMRC definition of early invasive breast cancer (i.e., tumours <50mm in size and without fixed nodes or distant metastases) (National Breast Cancer Centre, 2001; Cuncins-Hearn et al., 2006; Habermann et al., 2010).

Results confirm international findings and earlier regional data from Australia of positive associations of mastectomy with remoteness of residential area (5% higher than for major cities) and attending low case load surgeons (8% higher than for higher case load surgeons) (Lazovich et al., 1997; Taylor et al., 1999; Dragun et al., 2012a). Notably BreastScreen Australia data have also indicated higher mastectomies rates for residents of more remote areas (Cancer Australia, 2012). Large tumour sizes of 40mm or more were also predictive of mastectomy in the present study which is consistent with the higher mastectomy rates seen for larger and more advanced tumours in other studies (Lazovich et al., 1997; Taylor et al., 1999; Dragun et al., 2012b; Zorzi et al., 2006).

The reasons for higher mastectomy rates in more remote areas are not known. The results of this study indicated that women from these areas were more likely to be symptomatic than asymptomatic referrals, and to receive their treatment in inner regional or more remote treatment locations than other women, but these characteristics were not selected in the first multivariable analysis (p>0.050) and had little effect when included in the second analysis. A plausible explanation may be poorer access to radiotherapy services in more remote areas which may discourage use of breast conserving surgery (note: adjuvant radiotherapy is strongly recommended with breast conserving surgery) (U.S. Dept. Health and Human Services and National Institutes of Health, 1990; National Breast Cancer Centre, 2001). The importance of surgeon and woman's choice has been reported in several studies and it is possible that the influence of these factors differs between major cities and more remote areas (Kotwall et al., 1998; Mandelblatt et al., 2001; Dixon and Mak, 2008; Caldon et al., 2011).

The reasons for higher mastectomy rates for women treated by surgeons with low annual case loads (≤10) are also not known. These women tend to live in more remote areas and be treated in non-metropolitan centres. They often have no private health insurance and come from lower socio-economic areas. In the settings of low surgeon case loads, tumours were more likely to be symptomatic, node positive, oestrogen and progesterone receptor negative, and HER-2 receptor positive. Again, these characteristics were not selected in the first multivariable model (p>0.05) and had little effect on the odds ratio for low case load when included in the second analysis. The possibility of surgeons with low case loads and patients attending them having different attitudes to surgery options may warrant further study (Kotwall et al., 1998; Mandelblatt et al., 2001; Dixon and Mak, 2008; Caldon et al., 2011).

While large tumour size per se does not preclude effective cancer treatment by breast conserving surgery and radiotherapy (National Breast Cancer Centre, 2001), prospects for an acceptable cosmetic result may be reduced, particularly for large central lesions in small breasts when mastectomy with breast reconstruction may be a preferred option. Mastectomy rates were consistent in this study by calendar year, which may indicate that the trend towards breast conserving surgery following release of the U.S. Consensus Statement and Australian Clinical Practice Guidelines has reached a plateau (Hill et al., 1990; U.S. Dept. Health and Human Services and National Institutes of Health, 1990; Byrne et al., 1993; Hill et al., 1994; 1999; South Australian Cancer Registry, 2000; National Breast Cancer Centre, 2001; Cuncins-Hearn et al., 2006; Kricker, 2011).

Mastectomy rates did not vary by diagnostic year in the present study. This is in contrast to results from U.S. SEER data that indicate a continuing decline in mastectomy rates from 2000 but with the possibility of an upturn during 2005-2006 (Fisher et al., 1995; Tuttle et al., 2007; Katipamula et al., 2009; Dragun et al., 2012a; 2012b). This was supported by some regional and institutional data from the U.S. and evidently was influenced by an upturn in contra-lateral prophylactic mastectomies (Tuttle et al., 2007; Katipamula et al., 2009; Dragun et al., 2012a; 2012b).

The higher mastectomy rates observed in women living in more remote areas and attending low case-load surgeons in the present study constitute relatively small differences. Nonetheless they warrant further investigation to determine whether treatment choices have been limited by factors such as transport and accommodation or the long periods that may be required away from home when accessing city based radiotherapy services. Other important considerations for women living in rural and remote areas considering breast conserving treatment include the availability of hypo fractionation techniques for low-risk cancers and abbreviated partial breast irradiation techniques (Freedman et al., 2007; 2012). Opportunities to increase options through access to high-case load surgeons also need investigation.

Results indicate that the proportion of invasive cancers less than 30 mm in diameter that were treated by mastectomy was about 39%. The extent to which mastectomy rates might change further in response to additional information and by increasing access to radiotherapy services should be explored. It is evident that the majority of women with early breast cancers were treated by breast conserving surgery, which likely reflects broad support of Australian surgeons for the U.S. Consensus Statement, results of international collaborative trials that equivalent survivals occur from mastectomy or breast conserving surgery and radiotherapy, and the response of surgeons to Australian clinical practice guidelines for the management of early breast cancer (U.S. Dept. Health and Human Services and National Institutes of Health, 1990; National Breast Cancer Centre, 2001). While large tumour size of 40mm or more was predictive of an increased odds of mastectomy compared with breast conserving surgery (an increase of 8-9%), the difference was smaller than expected.

In conclusions, our results confirm previous studies showing higher mastectomy rates for residents of more remote areas, women treated by surgeons with low case loads, and women with relatively large cancers. Reasons for these differences require further study, including investigation of effects of surgeon and woman's choice and differences in individual access to radiotherapy services.

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References

Abrams JS, Phillips PH, Friedman MA (1995). Meeting highlights: a reappraisal of research results for the local treatment of early stage breast cancer. *J Natl Cancer Inst*, **87**, 1837-45.

Anderson BO, Yip CH, Smith RA, et al (2008). Guideline implementation for breast healthcare in low-income and middle-income countries: overview of the Breast Health Global Initiative Global Summit 2007. *Cancer*, **113**, 2221-43.

Armitage P, Berry G (1987). Statistical methods in medical research. Oxford: Blackwell Scientific Publications.

Australian Bureau of Statistics (1998). 1996 census of population and housing. Socio-economic index for areas. Canberra: Australian Bureau of Statistics.

Australian Institute of Health and Welfare (2012). Australian cancer incidence and mortality (ACIM) books. Canberra: Australian Institute of Health and Welfare.

Australian Institute of Health and Welfare, Cancer Australia, Australasian Association of Cancer Registries (2008). Cancer Survival and prevalence in Australia: cancers diagnosed from 1982-2004. Cancer Series No. 42. Cat. No. CAN 38. Canberra: Australian Institute of Health and Welfare.

Byrne MJ, Jamrozik K, Parson RW, et al (1993). Breast cancer in Western Australia in 1989. II. Diagnosis and primary management. *Aust NZ J Surg*, **63**, 624-9.

Caldon LJ, Collins KA, Wilde DJ, et al (2011). Why do hospital mastectomy rates vary? Differences in the decision making experiences of women with breast cancer. *Br J Cancer*, **104**, 1551-7.

Cancer Australia (2012). Study of breast cancer screening characteristics and breast cancer survival in Aboriginal and Torres Strait Islander women of Australia. Sydney: Cancer Australia.

Cancer Institute NSW (2012). New cancer registry statistical reporting. Sydney: Cancer Institute NSW.

Cuncins-Hearn AV, Boult M, Babidge W, et al (2006) National breast cancer audit: overview of invasive breast cancer management. *ANZ J Surg*, **76**, 745-50.

Dixon JM, Mak C (2008). Predictors of mastectomy in a certified breast center – the surgeon is an independent risk factor. *Breast J*, **14**, 321-3.

Dragun AE, Huang B, Tucker TC, Spanos WJ (2012a). Increasing mastectomy rates among all age groups for early stage breast cancer: a 10-year study of surgical choice. *Breast J*, **18**, 318-25.

Dragun AE, Pan J, Riley EC, et al (2012b). Increasing use of elective mastectomy and contralateral prophylactic surgery among breast conservation candidates: a 14-year report from a comprehensive cancer center. *Am J Clin Oncol* [Epub ahead of print].

Federation European Cancer Societies (2004). New study reveals big disparity between countries in breast conservation rates. Hamburg: European Breast Conference Proceedings, Abstract 362.

Fisher B, Anderson S, Redmond CK, et al (1995). Reanalysis and results after 12 years of follow-up in a randomized clinical trial composing total mastectomy with lumpectomy with or without irradiation in the treatment of breast cancer. *N Engl J Med*, **333**, 1456-61.

Freedman GM, Anderson PR, Goldstein LJ, et al (2007). Four-week course of radiation for breast cancer using hypofractionated intensity modulated radiation therapy with an incorporated boost. *Int J Radiat Oncol Biol Phys*, **68**, 347-53.

Freedman GM, Anderson PR, Bleicher RJ, et al (2012). Five-year local control in a phase II study of hypofractionated intensity modulated radiation therapy with an incorporated boost for early stage breast cancer. *Int J Radiat Oncol Biol Phys* [Epub ahead of print].

Gaudette LA, Gao RN, Spence A, et al (2004). Declining use of mastectomy for invasive breast cancer in Canada, 1981-2000. *Can J Public Health*, **95**, 336-40.

Habermann EB, Abbott A, Parsons HM, et al (2010). Are mastectomy rates really increasing in the United States? *J Clin Oncol*, **28**, 3437-41.

Hill DJ, Giles GG, Russell IS, Collins JP, Mapperson KJ (1990). Management of primary, operable breast cancer in Victoria. *Med J Aust*, **152**, 67-72.

Hill DJ, White VM, Giles GG, Collins JP, Kitchen PR (1994). Changes in the investigation and management of primary operable breast cancer in Victoria. *Med J Aust*, **161**, 110-1.

Hill D, Jamrozik K, White V, et al (1999). Surgical management of breast cancer in Australia in 1995. Sydney: NHMRC National Breast Cancer Centre.

Katipamula R, Degnim AC, Hoskin T, et al (2009). Trends in mastectomy rates at the Mayo Clinic Rochester: effect of surgical year and preoperative magnetic resonance imaging. *J Clin Oncol*, **27**, 4082-8.

Kotwall C, Covington D, Churchill P, et al (1998). Breast conservation surgery for breast cancer at a regional medical center. *Am J Surg*, **176**, 510-4.

Kricker A (2011). Using linked data to explore quality of care for breast cancer. *NSW Pub Health Bull*, **12**, 110-3.

Lazovich DA, White E, Thomas DB, Moe RE (1991). Underutilization of breast-conserving surgery and radiation therapy among women with stage I or II breast cancer. *JAMA*, **266**, 3433-8.

Lazovich D, White E, Thomas DB, Moe RE, Taplin S (1997). Change in use of breast-conserving surgery in western Wahington after the 1990 NIH Consensus Development Conference. *Arch Surg*, **132**, 418-23.

Mandelblatt JS, Berg CD, Merepol NJ, et al (2001). Measuring and predicting surgeons' practice styles for breast cancer treatment in older women. *Med Care*, **39**, 228-42.

National Breast Cancer Centre (2001). Clinical Practice guidelines for the management of early breast cancer: Second Edition. Canberra: National Health & Medical Research Council.

Roder D, Wang JX, Zorbas H, Kollias J, Maddern G (2010). Survival from breast cancers managed by surgeons participating in the National Breast Cancer Audit of the Royal Australasian College of Surgeons. *ANZ J Surg*, **80**, 776-80.

Roder D, Webster F, Zorbas H, Sinclair S (2012). Breast screening and breast cancer survival in Aboriginal and Torres Strait Islander women of Australia. *Asian Pac J Cancer Prev*, **13**, 147-55.

Samnakay N, Tinning J, Ives A, et al (2005). Rates for mastectomy are low in women attending a breast-screening programme. *ANZ J Surg*, **75**, 936-9.

South Australian Cancer Registry (2000). Epidemiology of cancer in South Australia. Incidence, mortality and survival 1977 to 1999. Incidence and mortality 1999. Adelaide: Openbook Publ: 138.

StataCorp (2005). Stata Statistical Software. Release 9.2. College Station, Texas: StataCorp LP.

Taylor R, Stubbs JM, Langlands AO, Boyages J (1999). Predictors of mastectomy for women with breast cancer in the Greater Western Region of Sydney. *Breast J*, **5**, 116-21.

Tuttle TM, Habermann EB, Grund EH, Morris TJ, Virnig BA (2007). Increasing use of prophylactic mastectomy for breast cancer patients: a trend toward more aggressive surgical treatment. *J Clin Oncol*, **25**, 5203-9.

US Department Health and Human Services, National Institutes of Health (1990). NIH Consensus Development Program. Treatment of early-stage breast cancer. NIH Consensus Statement On-line. June. 18-21; 8(6) 1-19.

Zorzi M, Puliti D, Vettorazzi M, et al (2006). Mastectomy rates are decreasing in the era of service screening: a population-based study in Italy (1997-2001). *Br J Cancer*, **95**, 1265-8.