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Influence of socioeconomic factors and distance to radiotherapy on breast-conserving surgery rates for early breast cancer in regional Australia; implications of change

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Abstract

Aims: Breast conserving surgery rates are affected by many factors including distance to radiotherapy and tumor-related features. Numerous studies have found women who must travel further for radiotherapy are more likely to choose mastectomy and avoid radiotherapy. We examined relationships between socioeconomic group, distance to radiotherapy services and mastectomy rates across a range of rural and metropolitan settings.

Methods: We used a dataset extracted from the Evaluation of Cancer Outcomes Barwon South Western Registry, which captured data on new breast cancer diagnoses in the southwest region of Victoria, Australia. Using logistic regression, we modeled treatment choice of women with early breast cancer (mastectomy *vs* breast conserving surgery) using explanatory variables that included distance to radiotherapy, and area-level socioeconomic data from the Australian Bureau of Statistics, while controlling for clinical factors.

Results: Mastectomy was associated with tumor size, nodal burden and younger age at surgery. Distance to a radiotherapy center was also strongly associated with increased rates of mastectomy for women who traveled 100–200 km for radiotherapy (odds ratio = 1.663; $P = 0.03$) compared to the reference group who were within 100 km of radiotherapy. No socioeconomic differences were seen between the two groups.

Conclusion: A strong association between distance to radiotherapy and the type of surgery for early breast cancer was found. Improving access to radiotherapy therefore has the potential to improve breast cancer outcomes for women in regional Australia.

KEYWORDS
breast cancer, distance, mastectomy, radiotherapy, socioeconomic

1 | INTRODUCTION

In the management of early-stage breast cancer, multiple randomized-controlled trials dating back to the 1980s have established an equivalence between two management options, that is mastectomy or breast conserving surgery (BCS) with radiation, in terms of overall survival.[1] Clinical practice guidelines for the treatment of early breast cancer in Australia reflect this data, and allowing for clinical features of the resected tumor, including tumor size, nodal burden and age, women may choose between these treatments where appropriate. Importantly, there is evidence for improved body image, psycho-social well-being, fewer side effects and overall improved quality of life for women who undergo BCS and radiation.[2–4]

Of interest, there are more recent observational studies suggesting that overall survival is better for BCS plus radiotherapy versus mastectomy with or without radiotherapy.[5–9] Nevertheless, currently we can say that these two treatments are at least equivalent, and BCS plus radiotherapy has become the standard of care for early-stage breast cancer.

There are many studies that have investigated why women and their treating surgeon may choose one method over another. These variables have been difficult to separate out to date, but together with larger tumor size, other factors include patient age, socioeconomic status, surgeon case load and access to treatment.[10–17]

Women in regional and rural areas are more likely to undergo mastectomy as compared to those in metropolitan areas.[15,18,19]

Radiotherapy consists of daily treatments over a period of usually weeks, and therefore, travel distance imposes a real barrier in terms of inconvenience, travel and accommodation costs and issues with being away from friends and family.[16] In a study by Athas et al., women were less likely to receive radiotherapy after BCS with increasing travel distance to radiotherapy services.[18] Similarly, studies have found that women from rural areas are less likely to undergo adjuvant radiotherapy after BCS.[20,21] This is of substantial concern as women who undergo BCS without radiotherapy are at high risk of local disease recurrence and is associated with poorer overall survival.[19,22] However, the absolute benefit of adjuvant radiotherapy may be less in older patients with certain tumor characteristics, which may have influenced the findings in these studies.

As new radiation centers have been implemented across regional Australian centers, utilization of such services has also increased. In Victoria, Australia, the single machine unit (SMU) trial observed an increase in access to and utilization of radiotherapy after the implementation of radiation services in three rural areas.[16,23] Likewise, the implementation of radiotherapy services in rural areas of New South Wales has seen a positive impact also with increased utilization, further demonstrating a relationship between access to radiotherapy and uptake of such treatment.[23,24] This has been shown to apply more specifically to breast cancer, with Australian and international studies demonstrating an increase in radiotherapy utilization for breast cancer patients when a locally available publically funded facility was introduced.[24–26]

The pattern of treatment modality for early breast cancer and effect of variables such as distance to radiation, patient age and socioeconomic status in the Barwon South West (BSW) region of Victoria has not yet been rigorously evaluated. It is important to do so to better characterize this population and understand what affects their treatment choice and uptake. Furthermore, with the development of a new radiotherapy center in BSW, this provided the opportunity to explore differences in access to radiotherapy across that spectrum of distances and socioeconomic circumstance.

The BSW region covers an area of south west Victoria in Australia with a population of 380 000 dispersed over approximately 33 000 km^2.[27] The region has a mix of remoteness areas[28] that include Major Cities of Australia (designated RA1), Inner Regional Australia (RA2) and Outer Regional Australia(> RA2), and includes Victoria's second largest city, Geelong. The Evaluation of Cancer Outcomes (ECOBSW) Registry captures data on all new cancer cases in the region (excluding nonmelanoma skin cancers) since 2009[27] and allows for the comparison of data on cases across a range of populations.

Increasing volumes of data are becoming available from sources such as national census data, which allows for categorization of areas based on socioeconomic factors. When individual level data are not available, these data can help give researchers an idea of the expected level of advantage or disadvantage that may be applied to individuals in that area. Socio-Economic Indexes for Areas (SEIFA) are such a data resource produced by the Australian Bureau of Statistics (ABS) based on census data.[29] In this study, we modeled data from several sources, patient level data on cancer outcomes, together with population level data on socioeconomic outcomes, to better understand their influence on treatment choice.

The purpose of our study is to determine the current rates of mastectomy for early breast cancer and explore the potential variables that may influence treatment choice, including socioeconomic factors, geographic location, patient age and other clinically relevant factors.

2 | METHODS

2.1 | Database

The ECO database was piloted in 2008 and collects data that fall under the precinct of mandatory reporting to the Cancer Council Victoria in accordance with the Cancer Act 1958.[30] This dataset was used to extract data on females with early breast cancer who underwent their first breast cancer surgery between the years 2009 and 2014. Data extracted included breast cancer tumor characteristics, surgery type and demographic data including suburb of residence. Ethics approval for this study was granted by Deakin University Human Research Ethics Committee, ref. 2017–110.

2.2 | Socioeconomic and physical access data

The suburb of the patient was extracted from the ECO database and the spatial coordinate used to calculate the Euclidean distance to the nearest radiotherapy treatment option (Andrew Love Cancer Centre, Geelong). Socioeconomic data (Socio-Economic Indexes for Areas, SEIFA) at the Statistical Area Level 1 (SA1)[29] were appended to each suburb using a spatial join. SA1s are the smallest unit released of the Census data. SEIFA scores for the Index of Relative Socio-Economic Disadvantage (IRSD), the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), the Index of Education and Occupation (IEO), the Index of Economic Resources (IER) and the decile rank for reach relative to all Australian SA1s were appended to be used as explanatory variables in the logistic regression modeling. ArcGIS 10.2.2 was used for all spatial processing.

2.3 | Statistical analyses

Based upon the stratification of patients as opting for (i) a mastectomy and (ii) breast-conserving surgery (BCS), characteristics of patients were compared using parametric *t*-tests or Mann–Whitey *U* test for continuous measures and Chi-square tests for categorical variables where the assumption of homogeneity of variance was violated Welch's unequal variances *t* test were applied. Patients were allocated to the mastectomy group if the term “mastectomy” appeared in the variable detailing the surgery undertaken. All other records with information on surgery were assigned to BCS.

Logistic regression was used to quantify the odds ratios of explanatory variables for the binary outcome of mastectomy or BCS. Explanatory variables investigated were age, area-level SES, distance to radiotherapy and size of tumor. Independence of explanatory variables was assessed using a Chi-square test of association.

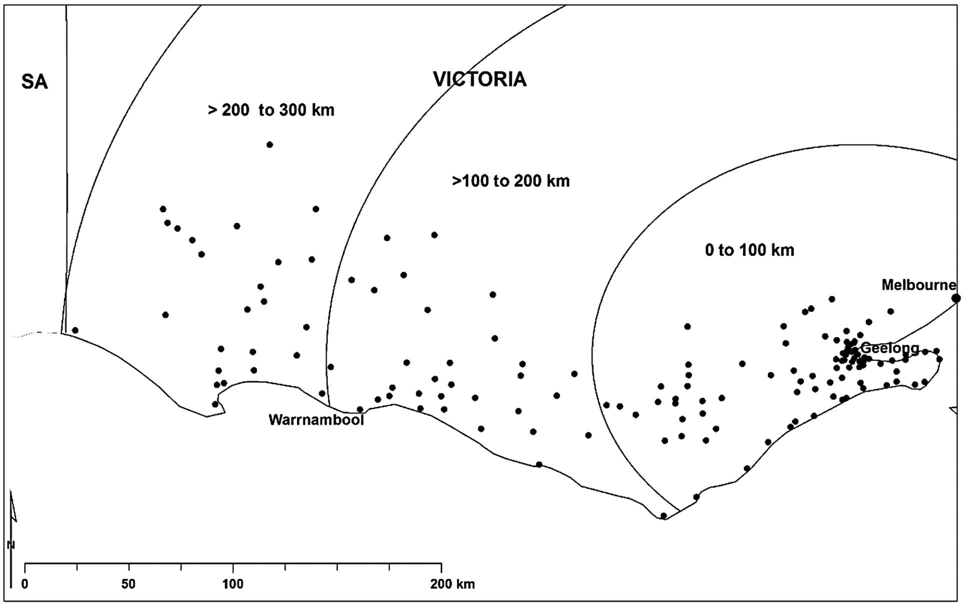

FIGURE 1 Localities of cancer cases. Concentric rings are relevant to Geelong where radiotherapy was available during the study period

IBM SPSS Statistics v23 was used for all statistical analyses and results of statistical tests were conducted at the 5% significance level ($\alpha = 0.05$).

3 | RESULTS

Of the total 1336 records, 1213 had complete information on whether a mastectomy ($n = 494$) or other treatment ($n = 719$; breast conserving surgery) was chosen. Figure 1 shows the home suburb of these women with distance to radiotherapy services.

Eight health services were recorded as the location of first surgery. A total of 971 first surgeries were conducted in the metropolitan areas (RA1), 140 in regional areas (RA2) and the remaining 102 procedures were in smaller localities with one surgery location (RA3; table not shown). Based upon where patients had their first surgery, we tested whether the volume of patients influenced the mastectomy rate (< 10 surgeries considered low volume, all others considered high volume). There was a numerical but not a statistically significant difference between the two groups (low volume 35.3% and high volume 40.8%, $P = 0.805$).

There was no evidence of differences in socioeconomic status (Table 1), nor patient type when stratified as private or public hospitals ($P = 0.747$). Examination of associations between the categorical variables age and tumor size ($P = 0.218$), and distance to treatment and tumor size ($P = 0.655$) were not significant (tables not shown). For patients with tumors < 20 mm there were significantly higher mastectomy rates in rural hospitals (< RA2) compared to metropolitan hospitals (RA1; 37.7% and 25.2%, respectively; $P = 0.010$), similar to comparative datasets.[31]

There was not a statistically significant association between the two explanatory categorical variables included in the final model (distance to treatment and tumor size, $P = 0.790$).

Patients opting for mastectomy were younger, and had larger tumors with more nodes taken, of which a greater proportion were positive (Table 1). There was a significant association between surgery type and breast cancer phenotype (Table 1), as expected. Distance to treatment was nonsignificant between the two groups when examined as a continuous variable (both as median and mean), but there was a significant association when this variable was compared as categories – this was the variable used in the binary logistic regression.

Controling for tumor size, patients who nominated a suburb as their place of residence that was 100–200 km from treatment were 1.6 times more likely to opt for a mastectomy relative to those less than 100 km from treatment (95% CI, 1.096–2.395, $P = 0.15$; Table 2). There was a no statistical evidence of a difference between the reference category and patients residing 200–300 km from treatment ($P = 0.722$). As expected, for clinical reasons, patients with larger tumors were more likely to opt for mastectomy, a trend that was significant (Wald = 87.702, df = 2, $P < 0.001$).

With regards to age at cancer surgery, women aged 55–64 years were less likely to opt for a mastectomy (see Table 1, 20% mastectomy *vs* 30.4% for breast conserving surgery). However, the opposite is seen in younger women aged 35–44 years who have a greater mastectomy rate (14% *vs* 6.7%).

4 | DISCUSSION

There is a growing awareness that there are great potential benefits to using the wealth of data contained in existing administrative datasets such as medical records or census data, to improve cancer care. Thus, well maintained, high quality and up to date datasets allow researchers to investigate outcomes for large numbers of patients and rigorously assess the influence of numerous explanatory variables. Coupled with freely available, objective data from sources such as the ABS, other

TABLE 1 Demographic characteristics of patients and cancer characteristics of patients having mastectomy and breast conserving surgery

	Mastectomy 494 (40.7%)	Breast-conserving surgery 719 (59.3%)	*P*-value
Age (years)		Mean (SD)	
	60.1 (14.4)	61.9 (12.2)	<0.001
		n (%)	
25–34	12 (2.4)	9 (1.3)	<0.001
35–44	69 (14.0)	48 (6.7)	
45–54	122 (24.7)	165 (22.9)	
55–64	99 (20.0)	217 (30.2)	
65–74	101 (20.4)	175 (24.3)	
≥75	91 (18.4)	105 (14.6)	
SES (IRSAD)			
		n (%)	
Quintile 1 (low SES)	103 (20.9)	150 (20.9)	0.103
Quintile 2	164 (33.2)	206 (28.7)	
Quintile 3	118 (23.9)	158 (22)	
Quintile 4	67 (13.6)	135 (18.8)	
Quintile 5 (high SES)	42 (8.5)	70 (9.7)	
Distance to treatment (km)		Mean (SD)	
	61.2 (78.9)	52.9 (75.9)	0.065
		Median (IQR)	
	18.1 (121.2)	16.1 (66.1)	0.074
		n (%)	
<100 km	366 (74.1)	571 (79.4)	0.012
>100–200 km	81 (16.4)	76 (10.6)	
>200 km	47 (9.5)	72 (10)	
Tumor size (mm) n (%)	n = 376	n = 646	
		Mean (SD)	
Mean (SD)	29.9 (22.3)	19.4 (13.9)	<0.001
<20	163 (43.4)	428 (66.3)	<0.001
≥20 ≤ 50	157 (41.8)	203 (31.4)	
>50	56 (14.9)	15 (2.3)	
Positive nodes taken, *n* (%)	*n* = 210	*n* = 186	
1–4	112 (53.3)	145 (78.0)	<0.001
4–7	63 (30.0)	31 (16.7)	
10+	35 (16.7)	10 (5.4)	
Subtype, *n* (%)	*n* = 409	*n* = 643	
Luminal A	41 (10.0)	135 (21.0)	<0.001
Luminal B	203 (49.6)	366 (56.9)	
HER2 type	101 (24.7)	64 (10.0)	
Triple negative	64 (15.6)	78 (12.1)	

explanatory variables from disparate sources can also be analyzed. Oncology has always been data-rich, but increasing volumes of data, especially genomic data, has led to a significant push towards better data use in cancer diagnosis, prognosis and treatment. The recent US *Cancer Moonshot* initiative, led by previous US Vice President Biden, is just one example of a push to use "big data" better. This current study highlights the potential to use population based data to better understand the needs and gaps in services for individual cancer care.

When examining rates of mastectomy versus BCS in this dataset, we found many of the expected clinical features that make mastectomy more likely, i.e. larger tumor size, nodal status and younger age at presentation.

TABLE 2 Summary of binary logistic regression for surgery type

	B	SE	Wald	df	*P*-value	Odds ratio	95% CI	
							Lower	Upper
Distance to treatment (km)								
<100 (Reference)			5.867	2	0.053			
≥100 to 200	0.483	0.199	5.866	1	0.015	1.620	1.096	2.395
≥200 to 300	0.078	0.220	0.127	1	0.722	1.082	0.703	1.665
Tumor size (mm)								
< 20 (Reference)			82.702	2	<0.001			
≥20 ≤ 50	0.711	0.141	25.395	1	<0.001	2.036	1.544	2.684
> 50	2.253	0.264	72.638	1	<0.001	9.517	5.669	15.978
Constant	−1.038	0.100	107.283	1	<0.001	0.354		

In our dataset, 59.3% of women underwent BCS versus 40.7% undergoing mastectomy. This is in concordance with a mastectomy rate of 39% found by Roder *et al*. in Australia between 1998 and 2010.[15] Churches *et al*. found a mastectomy rate of 45% in 1995, however, this dropped to 36% for women residing in rural areas.[21] They found that place of residence to be an independent predictor of undergoing mastectomy, and remained statistically significant after adjusting for age and tumor stage.[21] This is, however, in contrast to a study looking at Canberra and surrounding rural areas, which found no significant difference in mastectomy rates among rural and metropolitan women.[20]

Consistent with other studies,[10,11,15,23,25] we found that distance to a radiotherapy center, significantly influenced surgery type. Similarly to Butler *et al*.[23] we found this trend extended only to those patients who had to travel more than 100 km but less than 200 km for radiotherapy in our dataset.

In women who must travel more than 200 km for their therapy, we see no influence on choice of surgery type. It is plausible that these women, when they have made the choice to travel for their breast cancer treatment, including their surgery, have less concerns about traveling for radiotherapy also.

Distances reported as significant in affecting treatment has varied across studies however. Nattinger *et al*. found that women living more than 15 miles (24 km) from a radiation facility were less likely to undergo BCS, and of those that did undergo BCS, they were less likely to receive adjuvant radiation if they resided 40 miles (64 km) or more from a radiotherapy service.[19]

The relationship of access to radiation and uptake of these services has been shown to improve with the implementation of these facilities in regional areas.[16,23–26] In Orange, New South Wales, the implementation of a radiation center in 2011 saw the utilization of radiotherapy services in general increase by 10% between 2010 and 2012, with a reduction in average travel distance from 339 to 210 km.[23] With the recent implementation of a local radiation center in Warrnambool, Victoria, we will be in the position to further explore and evaluate the effect that access to a local radiation center on the utilization of radiotherapy services, and more specifically, the effect this has on the uptake of BCS and radiation in early breast cancer in this Australian region.

Socioeconomic status is often associated with geographic location[32] and has been reported as a potential factor affecting uptake of mastectomy and BCS plus radiation.[15] We did not find a statistically significant relationship between socioeconomic status and treatment method. One of the limitations of this study is the use of data from the ABS at a suburb level—the spatial resolution available from the ECOBSW database. As a function of the de-identified data, larger population centers in this study had all women allocated identical socioeconomic data and therefore did not account for smaller scale variation at the individual level. Although a statistically significant association was not apparent, individual socioeconomic circumstances cannot be ruled out as a contributing factor when deciding upon treatment options, a factor beyond the scope of this study.

Another limitation is the lack of data regarding the use of neoadjuvant systemic therapy to downstage tumors, making them smaller and more suitable for BCS. However, over the years of the data in this study, the number of women undergoing neoadjuvant therapy would likely have been lower than current practice.

Although other studies, and indeed clinical practice, have found comparable results in distance to radiotherapy as a factor in breast surgery choice, the opening of a new radiotherapy unit in regional southwest Victoria will allow for the isolation of radiotherapy as a factor in a complex decision making process. We know that other factors too can play a part in the choice of breast cancer surgery, including surgeon experience and center patient volume. In this setting, however, these other factors would be expected to remain static, although the introduction of the new radiotherapy center will greatly decrease the mean distance traveled and may have a measureable impact when the dataset is re-analyzed in future studies with these data as a comparator. Any changes seen in the future could be potentially important in evaluating the effectiveness of this new service.

The uneven spread of the population in geographically expansive countries such as Australia due to high levels of urbanization will always mean that some women will need to travel for radiotherapy. This effect can be seen in other countries too, including Canada.[33] There is a critical mass in terms of population size required to make such a specialized service cost-effective in a region. Thus, to ensure equity of access for all women to the best cancer care, it is crucial to ensure that other compensatory supports, including financial and social, exist to help women make their breast cancer choices be influenced by clinical best practice rather than distance to therapy or socioeconomic circumstance.

This study has shown that, as in other areas of the world, distance to radiotherapy has an impact on the choices women with early breast cancer make regarding their surgical management. We have successfully integrated data from clinical and statistical sources to explore the impact of these choices. Future changes in the availability of radiation in this region will allow for future research to measure the impact of new services for women with early breast cancer.

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