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USING RECORD LINKAGE TO MEASURE TRENDS IN BREAST CANCER SURGERY

Tim Churches and Kim Lim
Epidemiology and Surveillance Branch
NSW Department of Health

Since the early 1990s, there has been a growing acceptance in Australia of the efficacy of breast-conserving surgery (as defined as excision of the primary tumour and adjacent breast tissue, axillary node dissection and radiotherapy of the remaining breast) for the treatment of early breast cancer. This article describes changes in the patterns of the surgical treatment of breast cancer in NSW in the period 1991 to 1995. It follows on from an earlier study by Adelson et al,[1] which described the proportion of NSW women diagnosed with breast cancer in 1991 and 1992 who had breast-conserving therapy (BCT).

METHODS

Population-based data on the surgical treatment of breast cancer was assembled by linking two separate data collections: the NSW Central Cancer Registry data collection,[2] and the NSW Department of Health's Inpatient Statistics Collection (ISC).[3]

The NSW Central Cancer Registry (CCR) is a population-based registry to which notification of all cases of malignant neoplasm has been a statutory requirement in NSW since 1971.[4] Using data supplied by the CCR, we assembled a file of all cases of breast cancer (excepting intraductal carcinoma and Paget's disease of the nipple) diagnosed in female NSW residents between 1993 and 1995. Data items on the CCR data file used in the analysis were age at diagnosis, degree of spread, date of diagnosis, area of residence at diagnosis, and country of birth.

The NSW ISC contains records for all hospital separations (discharges, transfers and deaths) from all NSW public and private hospitals and day procedure centres. ISC records consist of demographic data items, administrative items and coded information on diagnoses related to and procedures performed during a particular admission to hospital. Records for NSW residents who were admitted to interstate hospitals were not used in this study because the partially-identifying data items used to link records, such as address and date of birth, were not available for these records. The ISC data file used for record linkage contained 6.8 million records, covering separations for the period July, 1992 to June 1996.

We used Automatch probabilistic record linkage software to create a single,[5] linked file of CCR and ISC records. Automatch software uses well established probabilistic linkage methods to link records in two data files under conditions of uncertainty,[6] such as where there is no unique identifying number common to both files. Before linking, address details from the two sources were separated into individual components (such as house number, street name and suburb or locality) and these items were standardised as far as possible using Autostan software.[7] The partially-identifying but non-unique data items common to the two sources that were used to link the files were hospital code, patients' medical record number (which, in most cases, is specific to each hospital), country of birth, full residential address, and date of birth.

These data sources and record linkage methods are essentially identical to those used in the earlier study which covered the period 1991–1992. McGeechan et al. undertook a validation study of a sample of the cohort used in the earlier study.[8] They concluded that the linked data file under-estimated the proportion of women receiving breast conserving therapy (39 per cent in the linked dataset versus an estimated true proportion of 42 per cent) but that there was no evidence that this under-estimation was biased with respect to age or geographical region.

Geographical area of residence was assigned to the cancer cases based on the boundaries of the 17 area health services defined by the NSW Department of Health in 1996. To evaluate trends in the types of surgical breast

procedures, we recoded place of residence in the 1991 and 1992 data file used in the earlier study to the current boundaries of areas health service.[1] For the purposes of this study, metropolitan area health services cover Sydney, the Central Coast, Hunter and Illawarra geographical areas. The remaining area health services cover rural areas.

Surgical breast procedures were categorised as breast-conserving (ICD-9-CM procedure codes 85.20–85.23) or mastectomy (ICD-9-CM procedure codes 85.41–85.48). Hospital admissions which included the ICD-9-CM procedure code for open breast biopsy (85.12) were not included in the main analyses for reasons discussed below.

Statistical analyses included tests for linear trend and multiple logistic regression.[9] In the logistic regression models, the outcome variable was the probability of having a mastectomy and the risk factors were age, degree of spread at diagnosis and area of residence (rural versus metropolitan). Cases with unknown degree of spread (*n*=1,062) were excluded from the data for the logistic regression. The choice of variables to include in the models was based on the *p*=0.05 criterion for main effects and *p*=0.01 for interaction terms. The base levels in the model were women aged under 60 years, localised spread, and residence in a metropolitan area.

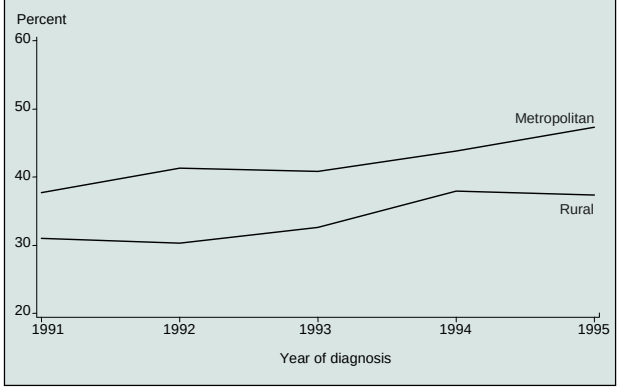
RESULTS

Record Linkage

In the period January 1993 to December 1995, there were 9849 NSW women diagnosed with breast cancer. Of these, 9417 cases were linked to ISC records, representing a match rate of 95.6 per cent. The proportion of linked cases was similar across the three years: 95.9 per cent in 1993, 95.7 per cent in 1994 and 95.2 per cent in 1995. The age distribution for the 432 cases which did not match to any ISC records was similar to those of the matched cases. The unmatched cases had a higher proportion of unknown degree of spread (38.4 per cent) compared to the same category in the linked cases (14.9 per cent). Unmatched cases were more likely to be resident in those rural area health services which share a border with other states: that is, Northern Rivers (15.3 per cent), Far West (7.4 per cent), Greater Murray (9.7 per cent) and Southern (7.4 per cent) area health services.

FIGURE 6

BREAST CONSERVING SURGERY FOR WOMEN DIAGNOSED DURING 1991 TO 1995, NSW, BY METROPOLITAN–RURAL AREA OF RESIDENCE



Hospital admissions

There were 43,254 hospital separations (that is, discharge, or transfer, or death) recorded for the linked cases of breast cancer (*n*=9,417). The hospital separations covered the period of six months before diagnosis and up to three years after diagnosis. Most of the women (77 per cent) had more than one admission to hospital. Of the women who were treated surgically, 82 per cent were admitted within one month of diagnosis and 14.6 per cent within two months of diagnosis.

Breast procedures

A small proportion of women in the linked cases (eight per cent, *n*=760) had no recorded breast procedures. As found in the earlier study, these women tended to be older: 44 per cent were aged 70 years or more compared to 25 per cent of the women who had breast procedures recorded. They were also more likely to have had metastatic disease at diagnosis (23 per cent versus two per cent of the women with recorded breast procedures) or an unknown degree of spread at diagnosis (30 per cent compared to 14 per cent of those who had breast procedures recorded). The most common procedures performed on these 760 women were administration of chemotherapy (25 per cent of admissions of the 760 women), blood transfusion, CAT scan, bone scan, thoracocentesis, pulmonary scan and bone marrow biopsy. Twenty of the 760 women were recorded as having undergone radical excision of axillary lymph nodes without mention of a breast procedure.

Table 8 shows the number of breast procedures for the remaining 8657 women. There was a small increase in the total number of breast conserving procedures over the three year period. The number of mastectomy and diagnostic breast procedures remained constant (Table 8).

Therapeutic breast procedures

The women who underwent therapeutic breast procedures (*n*=8,237) form the basis of subsequent analysis of treatment patterns. Table 9 shows that the overall proportion of women who underwent therapeutic breast surgery did not change significantly over the three year period: 2568 out of 3075 (83.5 per cent) in 1993, 2790 out of 3340 (83.5 per cent) in 1994 and 2879 out of 3434 (83.8 per cent) in 1995.

The proportion of women who underwent breast-conserving therapy (BCT) increased gradually from 39 per cent in 1993 to 45 per cent in 1995 (Table 9), with a corresponding fall in the proportion undergoing mastectomy over the same period. Forty-four per cent of women resident in metropolitan area health services underwent breast conserving therapy compared to 36 per cent of women resident in rural area health services.

Mastectomy was performed in 61 per cent of women diagnosed in 1993, 56 per cent of women diagnosed in

TABLE 8

BREAST PROCEDURES PERFORMED ON AN INPATIENT BASIS, NSW, RESIDENT WOMEN DIAGNOSED WITH BREAST CANCER IN 1993–1995

	Year of Diagnosis			Total Procedures	
	1993	1994	1995		
	n	*n*	*n*	*n*	%
Breast conserving therapy					
Local excision [85.20,85.21]	1592	1636	1722	4950	77.9
Resection of quadrant [85.22]	136	228	231	595	9.4
Subtotal mastectomy [85.23]	275	275	263	813	12.8
Subtotal	2003	2139	2216	6358	100.0
Mastectomy					
Simple unilateral [85.41]	266	236	208	710	14.6
Unilateral extended simple [85.43]	1212	1275	1278	3765	77.4
Unilateral radical mastectomy [85.45]	89	100	92	281	5.8
Unilateral extended radical [85.47]	18	11	10	39	0.8
Bilateral (simple,extended simple,radical,extended) [85.42,85.44,85.46,85.48]	24	22	25	71	1.5
Subtotal	1609	1644	1613	4866	100.0
Diagnostic procedures					
Percutaneous needle biopsy [85.11]	271	233	186	690	26.8
Other biopsy of breast,mastostomy [85.12,85.0,85.19]	617	626	643	1886	73.2
Subtotal	888	859	829	2576	100.0

1994 and 55 per cent of women diagnosed in 1995. There was considerable variation in mastectomy rates between metropolitan and rural area health services, with higher rates generally observed in the rural areas.

Figure 6 shows the change between 1991 and 1995 in the proportion of women undergoing breast-conserving therapy. Tests for linear trend indicate statistically significant increases in the proportion of women undergoing BCT in both rural and metropolitan AHSs (χ^2 statistic of 9.50 with one *df*, p=0.002 for rural areas and χ^2 statistic of 37.62 on one *df*, p <0.00001 for metropolitan areas).

The type of surgical treatment was influenced by age and degree of spread at diagnosis. Table 10 shows that, in general, women with regional spread or metastases at diagnosis were more likely to undergo mastectomy than women with local disease at diagnosis. Age and degree of spread combined do not influence the likelihood of a woman undergoing a mastectomy. There appears to be no variation in the proportion of mastectomy rates across the different age groups.

Health insurance status did not appear to influence the type of surgical treatment. Forty-three per cent of the women who underwent breast conserving surgery had private health insurance, while 42 per cent of the women were public patients.

A total of 268 women were recorded as undergoing open biopsy of the breast (ICD-9-CM procedure code 85.12) without mention of a therapeutic breast procedure in any of their other hospital admissions. There were 335 records for hospital admissions for these women: 100 of these admissions relating to 62 women included procedure codes for the dissection or clearance of the axillary lymph nodes (ICD-9-CM procedure codes 40.23, 40.3 and 40.51). A proportion of these procedures, which we have classified as diagnostic breast procedures for this study, may in fact represent therapeutic breast conserving procedures and may therefore cause the proportion of women receiving BCT to be underestimated. However, the degree of misclassification due to this cause is unlikely to exceed 1.5 per cent (up to 100 'misclassified' open biopsy procedures out of 6538 therapeutic breast-conserving procedures in the 1993–1995 period).

Place of residence and place of treatment

Of the 43,254 hospital separations for women diagnosed with breast cancer, 10,507 involved therapeutic breast surgical procedures. Of these procedures, 98 per cent were performed in hospitals located in the same area health service as that of the woman's residence. Almost all women whose usual residence was in a Sydney area health service underwent surgery within Sydney (99.8 per cent of separations). For residents of the Illawarra Area Health Service, 74 per cent of their separations involving therapeutic breast surgery were from Illawarra hospitals and 26 per cent from Sydney hospitals. Hunter Area Health Service residents had 97 per cent of their hospital separations for breast surgery from Hunter hospitals and two per cent from Sydney hospitals. Residents of rural area health services had 73.9 per cent of their surgical treatment in rural hospitals, 25.9 per cent in Sydney hospitals and 0.3 per cent in Illawarra hospitals. This is an increase in the utilisation of metropolitan hospitals compared to 1991–1992, when 90 per cent of the surgical treatment of breast cancer in women resident in rural areas was performed in rural hospitals.

Multivariate analysis

In the logistic regression models, variables found to have a significant independent association with the probability

TABLE 9

NUMBER OF NSW WOMEN DIAGNOSED WITH BREAST CANCER IN 1993,1994,1995 AND NUMBER UNDERGOING THERAPEUTIC BREAST SURGERY

NSW area health service of usual residence	BCT only			Mastectomy			Total women undergoing breast surgery			Total women diagnosed with breast cancer		
	1993 (%)	1994 (%)	1995 (%)	1993 (%)	1994 (%)	1995 (%)	1993 *n*	1994 *n*	1995 *n*	1993 *n*	1994 *n*	1995 *n*
Central Sydney	43.8	40.8	43.9	56.2	59.2	56.1	203	184	246	235	223	286
Northern Sydney	45.3	45.3	55.0	54.7	54.7	45.0	433	457	433	510	526	492
Western Sydney	48.0	52.7	52.3	52.0	47.3	47.7	229	275	262	282	315	308
Wentworth	45.7	50.8	53.5	54.3	49.2	46.5	116	130	114	136	151	137
Sth West Sydney	35.1	42.4	42.2	64.9	57.6	57.8	228	257	258	257	301	295
Central Coast	29.9	31.2	36.8	70.1	68.8	63.2	157	141	144	178	160	171
Hunter AHS	47.2	52.1	48.9	52.8	47.9	51.1	161	169	223	219	250	265
Illawarra AHS	33.8	34.2	45.4	66.2	65.8	54.6	136	190	183	149	213	198
Sth East Sydney	36.1	41.5	43.3	63.9	59.0	56.7	360	386	388	425	431	436
Northern Rivers	33.3	34.0	34.7	66.7	66.0	65.3	93	100	98	127	139	138
Mid North Coast	40.2	53.3	48.2	59.8	46.7	51.8	107	122	137	122	148	165
New England	55.4	54.5	51.3	44.6	45.5	48.8	65	77	80	80	92	104
Macquarie	24.4	24.3	30.9	75.6	75.7	69.1	45	37	55	55	47	62
Mid-Western	24.3	32.8	28.1	75.7	67.2	71.9	70	64	64	75	80	80
Far West	16.7	33.3	40.9	83.3	66.7	59.1	18	18	22	35	37	38
Greater Murray	22.2	22.4	28.7	77.8	77.6	71.3	90	116	101	115	143	144
Southern	29.8	37.3	29.6	70.2	62.7	70.4	57	67	71	75	84	115
Total	39.1	42.5	45.2	60.9	57.5	54.8	2568	2790	2879	3075	3340	3434

of undergoing mastectomy (as opposed to breast conserving treatment) were age, degree of spread, and place of residence. None of the interaction terms entered into the model were statistically significant. The final model demonstrated an adequate fit to the data (Hosmer-Lemeshow goodness of fit statistic =5.32 with five *df*, p=0.38).[10] The C statistic,[11] which provides a measure of predictive accuracy of the model, was 0.619.

Table 11 shows the likelihood of undergoing a mastectomy as opposed to breast conserving treatment while controlling for patient and tumour characteristics. Women aged 60 years and over were slightly more likely (odds ratio 1.21, 95 per cent CI 1.10, 1.34) to have a mastectomy than women under 60 years of age. Women with regional spread of disease were considerably more likely (odds ratio 2.38, 95 per cent CI 2.14, 2.65) to have a mastectomy than women with localised spread. The likelihood of a mastectomy for women with metastatic spread was not significantly different from those with localised spread (odds ratio 1.40, 95 per cent CI 0.88, 2.21). Women resident in rural area health services had a significant greater likelihood of undergoing mastectomy (odds ratio 1.50, 95 per cent CI 1.33, 1.70) than women residing in metropolitan area health services.

DISCUSSION

There are two main findings in this study. The first is that there has been a distinct increase in the utilisation of BCT in NSW, with the proportions increasing steadily from 36 per cent of all surgical treatments for breast cancer in 1991 to 45 per cent in 1995. This is an encouraging result and probably reflects both a greater acceptance of the efficacy and safety of BCT regimes by surgeons as well as the greater availability and accessibility of the radiotherapy services which are required for successful BCT.

The second finding is that the greater likelihood of undergoing mastectomy as opposed to breast conserving treatment for women resident in rural areas which was observed in 1991 and 1992 continued in the years 1993 to 1995. This difference persists after adjusting for differences in age and degree of spread at diagnosis and therefore is unlikely to be a result of earlier diagnosis in metropolitan women due to greater accessibility and uptake of mammography screening services in the cities.

Nevertheless, there has been a significant increase in the proportion of rural women who are undergoing BCT rather than mastectomy. This is reflected in the increasing number of rural women who are choosing to travel to metropolitan hospitals for the surgical treatment for their breast cancer (10 per cent in 1991–1992, 26 per cent in 1993–1995), presumably so that they can use the radiotherapy services associated with those metropolitan hospitals. Unfortunately, it is not possible to determine from currently available data what proportion of rural women are attending metropolitan radiotherapy services after undergoing breast conserving surgery in a local, rural hospital.

High quality radiotherapy services require considerable capital investment and a team of specialist staff.[12,13,] Clearly clinicians and health service administrators face policy and operational challenges in ensuring that all rural women with breast cancer have the option of choosing a form of treatment which requires radiotherapy even if there is no radiotherapy service available locally.

Like the previous study by Adelson et al.,[1] this study has used two existing data sources (a population-based cancer

TABLE 10

SURGICAL TREATMENT BY AGE AND DEGREE OF SPREAD AT DIAGNOSIS 1993–1995

Age and degree of spread	1993				1994				1995			
	Breast conserving		Mastectomy		Breast conserving		Mastectomy		Breast conserving		Mastectomy	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Local												
20–39 yrs	34	44.2	43	55.8	52	56.5	40	43.5	45	51.1	43	48.9
40–49 yrs	121	44.5	151	55.5	155	49.2	160	50.8	150	50.3	148	49.7
50–59 yrs	142	51.3	135	48.7	199	53.1	176	46.9	211	52.0	195	48.0
60–69 yrs	130	38.6	207	61.4	195	47.7	214	52.3	214	52.7	192	47.3
70+	126	42.1	173	57.9	173	43.7	223	56.3	223	52.3	203	47.7
Subtotal	553	43.8	709	56.2	774	48.8	813	51.2	843	51.9	781	48.1
Regional												
20–39 yrs	23	29.1	56	70.9	29	35.4	53	64.6	30	31.9	64	68.1
40–49 yrs	56	27.3	149	72.7	77	34.2	148	65.8	76	33.6	150	66.4
50–59 yrs	53	29.0	130	71.0	64	31.8	137	68.2	73	31.9	156	68.1
60–69 yrs	61	31.9	130	68.1	60	26.7	165	73.3	46	30.9	103	69.1
70+	40	21.1	150	78.9	33	20.4	129	79.6	37	20.4	144	79.6
Subtotal	233	27.5	615	72.5	263	29.4	632	70.6	262	29.8	617	70.2
Metastatic (All ages)	14	37.8	23	62.2	13	52.0	12	48.0	5	27.8	13	72.2
Unknown												
20–39 yrs	10	33.3	20	66.7	10	52.6	9	47.4	10	47.6	11	52.4
40–49 yrs	26	41.9	36	58.1	22	44.0	28	56.0	34	51.5	32	48.5
50–59 yrs	45	52.9	40	47.1	30	54.5	25	45.5	52	52.0	48	48.0
60–69 yrs	42	40.4	62	59.6	26	41.3	37	58.7	48	60.8	31	39.2
70+	82	58.6	58	41.4	49	51.0	47	49.0	47	51.1	45	48.9
Subtotal	205	48.7	216	51.3	137	48.4	146	51.6	191	53.4	167	46.6
Total	1005	39.1	1563	60.9	1187	42.5	1603	57.5	1301	45.2	1578	54.8

registry and an administrative hospital separations database) in order to provide information on the patterns and trends in the surgical treatment of breast cancer in NSW. Because neither of these data sources were designed specifically for this task, there are some inherent limitations to the accuracy of the information which can be derived from them. Possible misclassification of diagnostic open breast biopsy procedures has already been discussed. Other sources of error include under-enumeration of breast cancer cases by the NSW Central Cancer Registry, under-enumeration of therapeutic breast procedures in the Inpatient Statistics Collection, the absence of information about women who received their treatment interstate and the unquantifiable proportion of missed or false linkages between the two files.

Although the relative increase in BCT since 1991 undoubtedly represents an improvement in breast cancer care, it is still unclear whether 45 per cent of women receiving BCT is a good result in absolute terms. Furnival suggests that, based on the experience of a specialist breast clinic in Brisbane, the practical limit for BCT is between 50 and 60 per cent of all breast cancer cases treated in Australia.[14] Ideally, it should be possible to calculate the number of women with newly diagnosed breast cancer who meet the criteria for breast conserving therapy set out in the NHMRC and other guidelines, and then compare this number with the actual number receiving BCT. However, insufficient information on the degree of spread at diagnosis and tumour size was available to this study to accurately classify women into IUCC stages I and IIA, which are suitable for BCT. Future studies may be able to address this deficiency.

Published results from other Australian population-based studies report similar BCT utilisation rates to those we found in NSW. Hill et al. reported that the proportion of women diagnosed with breast cancer in Victoria who received BCT rose from 22 per cent in 1986 to 42 per cent in 1990.[15] A study of treatment patterns in women diagnosed with breast cancer in the greater western region of Sydney in 1992 found that 41 per cent received BCT.[16] Craft et al. found, in an analysis of Medicare data, that in 1993 39.9 per cent of Australian women who underwent some form of breast surgery for which a Medicare benefit was paid received BCT.[17] They also found similar urban–

TABLE 11

THE LIKELIHOOD OF HAVING MASTECTOMY, BY PATIENT AND TUMOUR CHARACTERISTICS, AS TAKEN FROM FINAL MODEL*

	No.	%	Adjusted odds ratio	95% confidence interval
Age				
<60 years	3760	52.4	1.00	
60+ years	3415	47.6	1.21	1.10, 1.34
Degree of spread				
Local	4473	62.3	1.00	
Regional	2622	36.5	2.38	2.14, 2.65
Metastatic	80	1.1	1.40	0.88, 2.21
Residence				
Metropolitan	5646	78.7	1.00	
Rural	1529	21.3	1.50	1.33, 1.70

* Final model used first-order terms for age at diagnosis, degree of spread at diagnosis and place of residence.

rural differences in the use of BCT. The largest and most comprehensive study to date, by Hill et al. collected detailed information on 4837 women through Australia diagnosed with breast cancer between April and September 1995.[18] This study found the overall utilisation of BCT to be 48 per cent. Eighty-five per cent of the 4837 women had early disease at diagnosis—of these women, 53 per cent underwent BCT compared to 32 per cent of the women who had advanced disease at diagnosis.

More recent linked hospital and cancer registry data for NSW is currently being prepared and will be reported on in the near future.

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USING LINKED DATA TO EXPLORE QUALITY OF CARE FOR BREAST CANCER

Anne Kricker
Senior Epidemiologist
National Breast Cancer Centre

Most women with early breast cancer have the option of surgery that conserves the breast or mastectomy. In 1990, a consensus statement of the United States National Institutes of Health concluded that breast conservation was appropriate for early breast cancer, and was preferable to total mastectomy because it provided equivalent survival while preserving the breast. This theme was taken up in Australia with the release of the *NHMRC Clinical practice guidelines for the management of early breast cancer* in October 1995. The proportion of women receiving breast conserving surgery thus became an indicator for monitoring the uptake of a new treatment option for breast cancer. This article compares patterns of breast cancer surgery in NSW in 1992 and 1995; and describes features of the women, and the breast cancers that were associated with changes in mastectomy rates.

METHODS

Routinely collected administrative data has been used for linkage studies of breast cancer surgery in NSW women.[1,2] For the present study, the NSW Department of Health used Automatch to link records of women with breast cancer in 1992 and 1995 in the NSW Cancer Registry with their treatment records in the NSW Inpatient Statistics Collection (ISC).

Some women whose records were linked had diagnostic breast procedures only (six per cent in 1992 and four per