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Treatment variation in patients diagnosed with early stage breast cancer in Alberta from 2002 to 2010: a population-based study

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Abstract

Background: Breast-conserving surgery (BCS) followed by radiotherapy is generally the preferred treatment for women diagnosed with early stage breast cancer. This study aimed to investigate the proportion of patients who receive BCS versus mastectomy and post-BCS radiotherapy, and explore factors associated with receipt of these treatments in Alberta, Canada.

Methods: A retrospective population-based study was conducted that including all patients surgically treated with stage I-III breast cancer diagnosed in Alberta from 2002–2010. Clinical characteristics, treatment information and patient age at diagnosis were collected from the Alberta Cancer Registry. Log binomial multiple regression was used to calculate stage-specific relative risk estimates of receiving BCS and post-BCS radiotherapy.

Results: Of the 14 646 patients included in the study, 44% received BCS, and of those, 88% received post-BCS radiotherapy. The adjusted relative risk of BCS was highest in Calgary and lowest in Central Alberta for all disease stages. Relative to surgeries performed in Calgary, those performed in Central Alberta were significantly less likely to be BCS for stage I (RR = 0.65; 95% 0.57, 0.72), II (RR = 0.58; 95% 0.49, 0.68), and III (RR = 0.62; 95% CI: 0.37, 0.95) disease, respectively, adjusting for patient age at diagnosis, clinical and treatment characteristics. No significant variation of post-BCS radiotherapy was found.

Conclusions: Factors such as region of surgical treatment should not be related to the receipt of standard care within a publicly-funded health care system. Further investigation is needed to understand the significant geographic variation present within the province in order to identify appropriate interventions.

Keywords: Breast cancer, Population-based, Radiotherapy, Surgery

Background

Standard surgical treatment for breast cancer has evolved over the last three decades leading to significantly improved outcomes [1]. Many women diagnosed with early stage breast cancer have the option of receiving either mastectomy or breast-conserving surgery (BCS) followed by adjuvant radiotherapy. This option is due to results of several clinical trials and meta-analyses which have demonstrated equivalent survival for women who receive these two treatment options [2-4]. BCS with radiotherapy is recommended as the preferred treatment option because BCS is a less invasive procedure, provides a better cosmetic outcome and is associated with less morbidity compared to mastectomy [5]. Research also suggests that those who receive mastectomy have significantly inferior body image, poorer sexual function, lower quality of life and a lower surgical satisfaction rate compared to those who receive BCS [6-9]. Receipt of BCS has been found to be associated with patient age and socioeconomic status in addition to tumor characteristics [10-13].

The receipt of radiotherapy is a vital component of treatment for women who receive breast-conserving surgery. A recent meta-analysis found that the 15-year breast cancer mortality risk was reduced by 5.4% (30.5% versus 35.9%) and the 5-year local recurrence risk was reduced by 19% (7% versus 26%) among women with early stage

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breast cancer who received BCS with versus without radiotherapy [14]. Receipt of radiotherapy after BCS has been found to be associated with patient age and race, geography, operating surgeon, and patient distance from radiotherapy facilities [15-17].

The purpose of this study was to: 1) assess the proportion of early stage breast cancer patients surgically treated with BCS versus mastectomy, 2) assess the proportion of those treated with BCS who subsequently receive radiotherapy, and 3) explore factors associated with the treatments received in Alberta, Canada. Alberta has a publicly-funded health care system, therefore, assessing variation in care and patient outcomes are important accountability factors for Alberta Health Services, the provincial provider of healthcare. Understanding treatment patterns and variation in jurisdictions is useful for informing potential strengths and issues that may exist in other similar jurisdictions and possibly dissimilar jurisdictions.

Methods

All cases of stage I, II or III breast cancer (International Classification of Diseases for Oncology [ICD-O-3] code c50 [18]) diagnosed in adult women from 2002 to 2010 who received breast cancer surgery were identified from the Alberta Cancer Registry. Cases of breast cancer were excluded if: 1) the cancer was not the first primary breast cancer diagnosis; 2) if the histology indicated it was a sarcoma, lymphoma or hematopoietic tumor and, 3) if the patient had another cancer diagnosis within 6 months prior to the breast cancer case, for this may influence breast cancer treatment decisions. Patient age, clinical, and treatment information were obtained from the cancer registry including: date of diagnosis; age at diagnosis; estrogen and progesterone receptor (ER/PR) status; cancer stage; type of surgery; geographic region of surgery; receipt of neo-adjuvant and adjuvant chemotherapy; receipt of post-operative radiotherapy; and receipt of hormone therapy. Cancer stage was determined using the American Joint Committee on Cancer (AJCC) 5th edition staging rules for years 2002 and 2003 and the 6th edition for years 2004–2010 [19,20]. Geographic region of surgery was categorized into the five administrative health zones of Alberta. The province of Alberta consists of an area of 662,000 km^2 and has a population of 3.7 million. Approximately 80% of the population reside in urban areas [21]. Patients diagnosed in 2002 and 2003 who received hormone therapy were classified as ER/PR positive, while those who did not receive hormone therapy were classified as ER/PR negative, since estrogen and progesterone receptor data was not collected in these years. If ER/PR status was missing in patients diagnosed from 2004 to 2010, the case was assumed to be ER/PR positive (N = 108), since roughly 75% of breast cancers in North American are ER/PR positive [22]. Sensitivity analysis found that this assumption did not affect the study results. The Alberta Cancer Registry was awarded the highest level of certification by the North American Association of Central Cancer Registries in all years of the study for its high level of completeness and for the timeliness of data collection and reporting.

Data analyses were performed on two different outcomes: receipt of BCS and receipt of radiotherapy after BCS. First, descriptive statistics were calculated for the demographic, clinical, and treatment characteristics of the breast cancer patients by receipt of BCS and stage at diagnosis; Chi-square and Fisher exact tests were used to determine statistical differences. Log-binomial multiple regression was then used to calculate stage-specific relative risk (probability ratio) estimates of receiving BCS by the following factors: age at diagnosis; geography of surgery; year of diagnosis; ER/PR status; and neo-adjuvant chemotherapy status. Interaction between year of diagnosis and geography of surgery was also assessed through an interaction model; interaction effects were displayed separately from the main effect model stratified by year of diagnosis and geography of surgery to enable easier interpretation (shown in Additional file 1: Tables S1-1, S1-2 and S1-3). The log-binomial regression method provides relative risk estimates as a measure of association using binary outcome data which are easier to interpret than odds ratios obtained from the more traditional logistic regression model.

The same data analysis procedures described above were used to assess associations with receipt of radiotherapy after BCS with slight modifications. For this outcome, hormone therapy was combined with ER/PR status as a single variable to assess whether ER/PR positive patients who did not receive hormone therapy were also less likely to receive radiotherapy after BCS. Secondly, adjuvant chemotherapy status was included in the regression model because receipt of adjuvant chemotherapy could affect whether a patient received post-surgical radiation. Log-binomial regression with the COPY method was used [23].

All statistical analyses were performed using SAS statistical software version 9.3 (SAS Institute, Cary, NC, USA). This study received ethics approval from the Health Research Ethics Board of the University of Alberta.

Results

There were 14 933 patients diagnosed with stage I, II or III first-ever breast cancer diagnosed in Alberta from 2002 to 2010, excluding patients with non-solid tumors and those who had another cancer diagnosis within 6 months prior to their breast cancer diagnosis. Patients

who were not treated with surgery (281 patients) and those who received an unknown or other surgery type were also excluded (6 patients). The final cohort consists of 14 646 patients.

Patient age, clinical and treatment characteristics and their associations with receipt of BCS are shown in Table 1. A total of 6 458 patients (44%) received BCS. The proportion of patients treated with BCS was 57%, 37% and 17%, for stage I, II and III cancers, respectively, and was relatively constant over the study period. Regardless of stage, the proportion of patients treated with BCS was highest when surgery occurred in an urban center (Edmonton or Calgary), when treatment with neo-adjuvant chemotherapy was not utilized, and when patients were less than 70 years old.

Table 2 displays the characteristics of breast cancer patients by geographic region of surgery. Most patients received surgery in one of the two urban centers, Calgary (38%) or Edmonton (43%). Patients differed to some extent in age distribution, clinical disease and treatment by geography of surgery. The percentage of patients under age 60 who received surgery in Southern or Central Alberta was 45-47% whereas patients under age 60 comprised 50-55% of the patients in the other regions. The percentage of patients with ER/PR negative disease ranged from a low of 16% in Calgary to a high of 25% in the North. Patients who received surgery in Northern Alberta, were also more likely to have stage II/III cancers (60%), and to receive neo-adjuvant (8%) and adjuvant chemotherapy (43%), compared to patients from other regions.

The stage-specific adjusted relative risk estimates of receiving BCS are displayed in Table 3. For all stages, receipt of BCS was associated with age less than 70 years at diagnosis and not receiving neo-adjuvant chemotherapy treatment. Substantial variation in the receipt of BCS was found by geographic area of surgery for stage I and II disease. The adjusted relative risk of BCS was highest in Calgary and lowest in Central Alberta for all disease stages. Relative to surgeries performed in Calgary, those

Table 1 Characteristics of stage I-III breast cancer patients who received breast conserving surgery (BCS)[1]

	Stage I		Stage II		Stage III	
	BCS N (%)[2]	Total N	BCS N (%)[2]	Total N	BCS N (%)[2]	Total N
Overall	4067 (57)	7091	2060 (37)	5619	331 (17)	1936
Age at diagnosis	**P < 0.001**		**P < 0.001**		**P = 0.018**	
<50	880 (58)	1509	656 (40)	1638	112 (18)	628
50-59	1171 (63)	1853	585 (41)	1417	101 (20)	505
60-69	1051 (58)	1801	430 (38)	1144	66 (18)	370
70-79	697 (50)	1394	248 (29)	861	27 (11)	251
≥80	268 (50)	534	141 (25)	559	25 (14)	182
Geography of surgery	**P < 0.001**		**P < 0.001**		**P = 0.20**	
Calgary	1637 (62)	2659	901 (42)	2156	139 (19)	739
South	289 (50)	577	145 (30)	490	25 (17)	146
Central	178 (39)	461	112 (24)	473	17 (11)	157
Edmonton	1849 (58)	3180	832 (37)	2258	134 (17)	804
North	114 (53)	214	70 (29)	242	16 (18)	90
Year of diagnosis	**P = 0.09**		**P = 0.39**		**P = 0.85**	
2002-2004	1277 (56)	2296	632 (36)	1767	86 (16)	522
2005-2007	1315 (58)	2284	668 (36)	1842	124 (18)	701
2008-2010	1475 (59)	2511	760 (38)	2010	121 (17)	713
ER/PR status	**P = 0.04**		**P = 0.22**		**P = 0.15**	
Positive	3407 (58)	5885	1686 (37)	4551	266 (18)	1495
Negative	660 (55)	1206	374 (35)	1068	65 (15)	441
Neo-adjuvant chemotherapy	**P < 0.001**		**P < 0.001**		**P < 0.001**	
Not received	4060 (58)	7054	1994 (37)	5336	303 (20)	1523
Received	7 (19)	37	66 (23)	283	28 (7)	413

[1]P values reflect Chi square tests of association for BCS versus mastectomy.
[2]The denominator for each percentage is the number of patients in the adjacent row for the same stage of disease.

Table 2 Characteristics of breast cancer patients by geographic region of surgery

	Geography of surgery				
	Calgary	South	Central	Edmonton	North
	N (%)	N (%)	N (%)	N (%)	N (%)
Total	5554 (38)	1213 (8)	1091 (7)	6242 (43)	546 (4)
Surgical treatment					
Mastectomy	2877 (52)	754 (62)	784 (72)	3427 (55)	346 (63)
BCS	2677 (48)	459 (38)	307 (28)	2815 (45)	200 (37)
With Radiation	2381 (89)	369 (80)	253 (82)	2492 (89)	168 (84)
Without Radiation	296 (11)	90 (20)	54 (18)	323 (11)	32 (16)
Stage					
I	2659 (48)	577 (48)	461 (42)	3180 (51)	214 (39)
II	2156 (29)	490 (40)	473 (43)	2258 (36)	242 (44)
III	739 (13)	146 (12)	157 (14)	804 (13)	90 (16)
Age at diagnosis					
<50	1597 (29)	244 (20)	256 (23)	1522 (24)	156 (29)
50-59	1471 (26)	298 (25)	265 (24)	1603 (26)	138 (25)
60-69	1170 (21)	284 (23)	247 (23)	1487 (24)	127 (23)
70-79	875 (16)	235 (19)	203 (19)	1103 (18)	90 (16)
≥80	441 (8)	152 (13)	120 (11)	527 (8)	35 (6)
Year of diagnosis					
2002-2004	1761 (32)	390 (32)	365 (33)	1900 (30)	169 (31)
2005-2007	1824 (33)	405 (33)	354 (32)	2052 (33)	192 (35)
2008-2010	1969 (35)	418 (34)	372 (34)	2290 (37)	185 (34)
ER/PR status					
Positive	4659 (84)	975 (80)	846 (76)	5044 (81)	407 (75)
Negative	895 (16)	238 (20)	245 (22)	1198 (19)	139 (25)
Neo-adjuvant chemotherapy					
Not Received	5322 (96)	1187 (98)	1035 (95)	5865 (94)	504 (92)
Received	232 (4)	26 (2)	56 (5)	377 (6)	42 (8)
Adjuvant chemotherapy					
Not Received	3460 (62)	825 (68)	657 (60)	3962 (63)	312 (57)
Received	2094 (38)	388 (32)	434 (40)	2280 (37)	234 (43)

performed in Central Alberta were significantly less likely to be BCS for stage I (RR = 0.65; 95% CI: 0.57, 0.72), II (RR = 0.58; 95% CI: 0.49, 0.68), and III (RR = 0.62; 95% CI: 0.37, 0.95) disease, respectively, adjusting for age at diagnosis, year of diagnosis, ER/PR status and receipt of neo-adjuvant chemotherapy. In the most recent time period (2008–2010), among stage I and II patients less than 70 years of age, 1601 (48%) patients received mastectomy, while 1707 (52%) patients received BCS; 578 (46%), 152 (57%), 144 (67%), 650 (45%) and 68 (58%) patients from Calgary, Southern, Central, Edmonton and Northern Alberta received mastectomy, as opposed to BCS. BCS uptake among stage I and II patients increased significantly over the study period in Edmonton ($P < 0.05$), decreased among stage II patients in Central Alberta ($P < 0.05$) and remained fairly steady in the other regions and in stage III patients over the study period (Additional file 1: Tables S1–1, S1–2 and S1–3).

Table 4 displays the relationship between patient age, clinical, and treatment characteristics and their associations with receipt of radiotherapy in the subgroup of patients treated with BCS. Of the 6 458 patients treated with BCS, 88% subsequently received adjuvant radiotherapy. The proportion of patients that received radiotherapy after BCS was 89%, 86%, and 83% for stage I, II and III breast cancers, respectively. Receipt of radiotherapy was highest among patients with ER/PR negative and ER/PR positive cancers treated with hormone therapy,

Table 3 Adjusted[1] relative risk estimates of receiving BCS rather than mastectomy

	Adjusted[1] relative risk estimates (95% confidence intervals)		
	Stage I	**Stage II**	**Stage III**
Age at diagnosis	**P < 0.001**	**P < 0.001**	**P < 0.001**
<50	1.00	1.00	1.00
50-59	1.08 (1.02, 1.14)	1.03 (0.95, 1.13)	1.10 (0.86, 1.39)
60-69	1.01 (0.95, 1.07)	0.94 (0.86, 1.03)	0.95 (0.72, 1.24)
70-79	0.87 (0.81, 0.93)	0.71 (0.63, 0.80)	0.53 (0.35, 0.77)
≥80	0.87 (0.79, 0.95)	0.62 (0.53, 0.73)	0.63 (0.41, 0.92)
Geography of surgery	**P < 0.001**	**P < 0.001**	**P = 0.30**
Calgary	1.00	1.00	1.00
South	0.83 (0.76, 0.90)	0.74 (0.63, 0.85)	0.92 (0.61, 1.32)
Central	0.65 (0.57, 0.72)	0.58 (0.49, 0.68)	0.62 (0.37, 0.95)
Edmonton	0.96 (0.92, 1.00)	0.91 (0.85, 0.98)	0.95 (0.77, 1.18)
North	0.88 (0.77, 0.99)	0.72 (0.58, 0.88)	0.95 (0.57, 1.45)
Year of diagnosis	**P = 0.24**	**P = 0.40**	**P = 0.99**
2002-2004	1.00	1.00	1.00
2005-2007	1.02 (0.97, 1.08)	1.02 (0.94, 1.11)	1.02 (0.80, 1.31)
2008-2010	1.04 (0.99, 1.09)	1.06 (0.97, 1.15)	1.02 (0.79, 1.31)
ER/PR status	**P = 0.11**	**P = 0.34**	**P = 0.44**
Positive	1.00	1.00	1.00
Negative	0.96 (0.90, 1.01)	0.96 (0.88, 1.04)	0.91 (0.70, 1.15)
Neo-adjuvant chemotherapy	**P < 0.001**	**P < 0.001**	**P < 0.001**
Not Received	1.00	1.00	1.00
Received	0.32 (0.15, 0.57)	0.57 (0.45, 0.70)	0.31 (0.21, 0.45)

[1]Adjusted for all variables in the table.

those who received surgery in an urban area (Edmonton or Calgary), those who received adjuvant chemotherapy and in those younger than 80 years of age, regardless of the cancer stage. Patients aged 80 years or older at diagnosis were at least 40% less likely to receive radiation after BCS compared to patients aged 70–79 years at diagnosis in all disease stages.

Table 5 displays the stage-specific adjusted relative risk estimates of receiving radiotherapy after BCS. Patients aged 80 years or older were 51%, 47% and 36% less likely to be treated with adjuvant radiotherapy for stage I (RR = 0.49; 95% CI: 0.43, 0.56), stage II (RR = 0.53; 95% CI: 0.43, 0.64), and stage III (RR = 0.64; 95% CI: 0.34, 1.05) cancers, respectively, compared to those less than 50 years of age, adjusting for age at diagnosis, year of diagnosis, ER/PR status and hormone therapy, neo-adjuvant chemotherapy and adjuvant chemotherapy. Patients who were ER/PR positive but did not receive hormone therapy were 14%, 41% and 65% less likely to receive radiation after BCS in stage I (RR = 0.86; 95% CI: 0.83, 0.89), II (RR = 0.59; 95% CI: 0.49, 0.68), and III (RR = 0.35; 95% CI: 0.16, 0.60) cancers, respectively, than those who were ER/PR positive and received hormone therapy. Treatment with adjuvant chemotherapy was also associated with receipt of radiotherapy, after adjustment, in stage II (RR = 1.08; 95% CI: 1.05, 1.13) and III (RR = 1.37; 95% CI: 1.14, 1.84) cancers, compared to not being treated with adjuvant chemotherapy. No significant geographical variation of post-BCS radiotherapy receipt was found.

Discussion

In this study, 44% of early stage breast cancer patients diagnosed from 2002 to 2010 in Alberta received breast conserving surgery, as opposed to mastectomy (57%, 37% and 17% of stage I, II and III patients, respectively). Similar population-based results have been reported in the Netherlands, where 48% of patients diagnosed between 2003 and 2006 received BCS (63%, 41% and 19% of stage I, II and III patients, respectively) [24]. BCS receipt among patients in the United States is higher, with estimates ranging from 50% to 70% [17,25-28]. Within Canada, estimates range from 74% in Quebec to 31% and 35% in Newfoundland and Saskatchewan, respectively [29]. Tyldesley *et al.* (2003) have estimated that in North America, 70% of all breast cancers are eligible for

Table 4 Characteristics of breast cancer patients who received radiotherapy treatment after breast conserving surgery[1]

	Stage I		Stage II		Stage III	
	Post-surgical radiation	Received BCS	Post-surgical radiation	Received BCS	Post-surgical radiation	Received BCS
	N (%)[2]	N	N (%)[2]	N	N (%)[2]	N
Overall	3607 (89)	4067	1780 (86)	2060	276 (83)	331
Age at diagnosis	**P < 0.001**		**P < 0.001**		**P < 0.001**	
<50	821 (93)	880	599 (91)	656	93 (83)	112
50-59	1096 (94)	1171	521 (89)	585	94 (93)	101
60-69	971 (92)	1051	392 (91)	430	57 (86)	66
70-79	601 (86)	697	211 (85)	248	23 (85)	27
≥80	118 (44)	268	57 (40)	141	9 (36)	25
Geography of surgery	**P < 0.001**		**P = 0.001**		**P = 0.70**	
Calgary	1485 (91)	1637	783 (87)	901	113 (81)	139
South	236 (82)	289	113 (78)	145	20 (80)	25
Central	149 (84)	178	90 (80)	112	14 (82)	17
Edmonton	1640 (89)	1849	738 (89)	832	114 (85)	134
North	97 (85)	114	56 (80)	70	15 (94)	16
Year of diagnosis	**P = 0.06**		**P = 0.01**		**P = 0.10**	
2002 - 2004	1148 (90)	1277	565 (89)	632	78 (91)	86
2005 - 2007	1145 (87)	1315	560 (84)	668	101 (81)	124
2008 - 2010	1314 (89)	1475	655 (86)	760	97 (80)	121
ER/PR Status & Hormone therapy	**P < 0.001**		**P < 0.001**		**P < 0.001**	
ER/PR positive & received hormone	2337 (93)	2514	1399 (92)	1516	213 (90)	237
ER/PR positive & no hormone	685 (77)	893	79 (46)	170	7 (24)	29
ER/PR negative	585 (89)	660	302 (81)	374	56 (86)	65
Neo-adjuvant chemotherapy	**P = 0.57**		**P = 0.36**		**P = 0.10**	
Not received	3601 (89)	4060	1720 (86)	1994	256 (84)	303
Received	6 (86)	7	60 (91)	66	20 (71)	28
Adjuvant chemotherapy	**P < 0.001**		**P < 0.001**		**P < 0.001**	
Not received	2951 (87)	3381	617 (75)	823	52 (55)	95
Received	656 (96)	686	1163 (94)	1237	224 (95)	236

[1]P values reflect Chi square tests of association for BCS versus mastectomy.
[2]The denominator for each percentage is the number of patients who received breast conserving surgery in the adjacent row for the same stage of disease.

BCS, and 48 ± 6% of cases are both eligible and prefer it to mastectomy [30]. The great variation present within and between countries, however, suggests that there is not a consensus on standard practice.

In a publicly-funded health care system, factors such as region of residence should not be related to the receipt of standard treatment. This study found significant variation in surgical breast cancer treatment received by geography in Alberta, while finding no apparent geographical variation in the receipt of post-BCS radiotherapy. The consistent finding across disease stage that the highest rate of mastectomy is in Central Alberta is rather surprising. Poor access to radiation therapy has been associated with low BCS rates in other studies [25,27,28], and may partially explain the geographic variation we found. At the time of this study, however, patients in Central Alberta did not have worse access to radiation facilities compared to those in Northern or Southern Alberta; in fact, many patients in Central Alberta live significantly closer to radiation facilities than those in Southern or Northern Alberta, suggesting better access. While poor access to radiation therapy may partially explain the lower BCS rates in Northern and Southern Alberta which have lower population densities than

Table 5 Adjusted[1] relative risk estimates of receiving radiotherapy treatment after breast conserving surgery

	Adjusted[1] relative risk estimates (95% confidence interval)		
	Stage I	**Stage II**	**Stage III**
Age at diagnosis	**P < 0.001**	**P < 0.001**	**P = 0.37**
<50	1.00	1.00	1.00
50-59	1.00 (0.98, 1.02)	0.99 (0.96, 1.02)	1.02 (0.96, 1.10)
60-69	0.99 (0.96, 1.01)	1.02 (0.99, 1.04)	1.02 (0.92, 1.10)
70-79	0.94 (0.91, 0.97)	1.01 (0.96, 1.04)	1.03 (0.90, 1.11)
≥80	0.49 (0.43, 0.56)	0.53 (0.43, 0.64)	0.64 (0.34, 1.05)
Geography of surgery	**P = 0.09**	**P = 0.07**	**P = 0.87**
Calgary	1.00	1.00	1.00
South	0.96 (0.91, 1.00)	0.94 (0.86, 1.00)	1.03 (0.89, 1.11)
Central	0.96 (0.91, 1.01)	0.97 (0.90, 1.01)	1.03 (0.86, 1.11)
Edmonton	0.99 (0.98, 1.01)	1.00 (0.98, 1.03)	1.03 (0.97, 1.10)
North	0.95 (0.88, 1.00)	0.92 (0.81, 1.01)	1.03 (0.82, 1.12)
Year of diagnosis	**P = 0.25**	**P = 0.15**	**P = 0.96**
2002 - 2004	1.00	1.00	1.00
2005 - 2007	0.99 (0.97, 1.01)	0.97 (0.94, 1.00)	1.00 (0.94, 1.06)
2008 - 2010	1.00 (0.98, 1.02)	0.98 (0.96, 1.01)	0.99 (0.92, 1.06)
ER/PR Status & Hormone therapy	**P < 0.001**	**P < 0.001**	**P < 0.001**
ER/PR positive & received hormone	1.00	1.00	1.00
ER/PR positive & no hormone	0.86 (0.83, 0.89)	0.59 (0.49, 0.68)	0.35 (0.16, 0.60)
ER/PR negative	0.94 (0.91, 0.97)	0.89 (0.84, 0.93)	0.95 (0.85, 1.02)
Neo-adjuvant chemotherapy	**P = 0.33**	**P = 0.04**	**P = 0.86**
Not received	1.00	1.00	1.00
Received	0.89 (0.52, 1.05)	1.10 (1.00, 1.14)	1.03 (0.72, 1.47)
Adjuvant chemotherapy	**P = 0.62**	**P < 0.001**	**P < 0.001**
Not received	1.00	1.00	1.00
Received	1.01 (0.98, 1.02)	1.08 (1.05, 1.13)	1.37 (1.14, 1.84)

[1]Adjusted for all variables in the table.

Central Alberta, the lower rates in Central Alberta suggests that distance to radiotherapy is not the only important factor influencing choice of surgical treatment.

Geographic variation in the receipt of breast conserving surgery has also been found in other health care systems, including in the Netherlands [24] and in Switzerland [31]. The results from both of these studies also suggest that distance to radiotherapy is not the primary reason for the observed geographic variation; the authors suggest instead that provider-related factors are a more likely explanation. We make the same hypothesis for the present results in Alberta, factors such as provider volume and preferences, which have been associated with patient surgery type received, influence the receipt of BCS by breast cancer patients differentially across the province [32,33]. Publicly-funded health care systems do not ensure equity of care by region, and effort is needed to further investigate and address these inequities. Since 2010, Alberta Health Services has increased the number of sites which provide radiotherapy across the province. Investigation into how this affects geographical variation of BCS receipt in the future will help elucidate the impact of access to radiation compared to other factors.

Of patients who received BCS, 88% subsequently received radiation therapy. In comparison, it can be estimated that around 80% of patients from the United States receive post-BCS radiation [15,17,27], and it has been reported that 99% of patients in the Netherlands received this treatment in 2008, rising from 87% in 1997 [34]. These estimates suggest that physicians collectively recognize the importance of radiotherapy treatment after BCS. We found that the proportion of patients who received post-BCS radiotherapy dropped dramatically with age greater than 80 years, however. This can be attributed to unclear advantages of radiotherapy in this population when life expectancy, potential toxicity and comorbidities

are taken in to account. There has been substantial recent discussion as to whether or not postoperative radiotherapy can be reasonably omitted in some women over the age of 70 with low-risk breast cancer [35-37].

A great strength of this study is that it is population-based and thus contains the entire population of interest in Alberta over an eight year period. In practice, treatment choices are made based on various factors including patient preference, feasibility (e.g. distance and access to transportation), and the presence of comorbidities. It is, therefore, of clinical interest to investigate treatments received in a population based series of patients. In addition to this, the data source used is known for being very complete and accurate, as the Alberta Cancer Registry captures 99.9% of cancer cases. A limitation of the study, however, was our inability to assess patient preferences and contraindications for breast-conserving surgery due to the nature of the data source. For example, there may be residual confounding of the BCS geography association by tumor size beyond that explained by stage as patients with very large tumors may be more likely to reside in rural areas. We were also not able to account for confounding by economic status, race or surgeon preference, all of which may explain some of the geographic variation seen. Further interpretation of the BCS receipt results could have been achieved if a subgroup analysis had been performed, in which patients with contraindications for BCS, such as those with very large tumors, were excluded.

Conclusions

This study found significant geographic variation in BCS receipt and consistently high rates of adjuvant radiation in those who received BCS across the province. Overall, treatment patterns did not change between 2002 and 2010, although some area-specific trends were found. Further investigation is needed to understand the low rates of breast-conserving surgery in certain parts of the province, such as Central Alberta, compared to other parts in order to identify appropriate interventions. This study provides strong baseline information on variation in rates of BCS and subsequent radiation therapy in Alberta over an eight year time period which will be useful for evaluating the effectiveness of interventions that are implemented in the future.

Additional file

Additional file 1: Table S1-1. Adjusted[1] relative risk estimates of receiving BCS rather than mastectomy by geography of surgery, among stage I patients. **Table S1-2.** Adjusted[1] relative risk estimates of receiving BCS rather than mastectomy by geography of surgery, among stage II patients. **Table S1-3.** Adjusted[1] relative risk estimates of receiving BCS rather than mastectomy by geography of surgery, among stage III patients.

Abbreviations

BCS: Breast-conserving surgery; CI: Confidence interval; ER: Estrogen receptor; PR: Progesterone receptor; RR: Relative risk.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SF was involved in the analysis and interpretation of the data, as well as drafting and revising the article. HG, YY and MW were involved in the conception and design of the study, analysis and interpretation of the data, and revision of the article. KD was involved in the design of the study, interpretation of the data, and revision of the article. All authors read and approved the final manuscript.

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References

1. Ho A, Morrow M. The evolution of the locoregional therapy of breast cancer. Oncologist. 2011;16:1367–79.
2. Jatoi I, Proschan MA. Randomized trials of breast-conserving therapy versus mastectomy for primary breast cancer: a pooled analysis of updated results. Am J Clin Oncol. 2005;28(3):289–94.
3. van der Hage JA, Putter H, Bonnema J, Bartelink H, Therasse P, van de Velde CJ, et al. Impact of locoregional treatment on the early stage breast cancer patients: a retrospective analysis. Eur J Cancer. 2003;39(15):2192–9.
4. Fisher B, Anderson S, Bryant J, Margolese RG, Deutsch M, Fisher ER, et al. Twenty-year follow-up of a randomized trail comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. N Engl J Med. 2002;347:1233–41.
5. National Institutes of Health. NIH Consensus Conference. Treatment of early stage breast cancer. JAMA. 1991;265(3):391–5.
6. Sun Y, Kim SW, Heo CY, Kim D, Hwang Y, Yom CK, et al. Comparison of quality of life based on surgical technique in patients with breast cancer. Jpn J Clin Oncol. 2014;44(1):22–7.
7. Engel J, Kerr J, Schlesinger-Raab A, Sauer H, Holzel D. Quality of life following breast-conserving therapy or mastectomy: Results of a 5-year prospective study. Breast J. 2004;10(3):223–31.
8. Han J, Grothuesmann D, Neises M, Hille U, Hillemanns P. Quality of life and satisfaction after breast cancer operation. Arch Gynecol Obstet. 2010;282:75–82.
9. Koch L, Jansen L, Herrmann A, Stegmaier C, Holleczek B, Singer S, et al. Quality of life in long-term breast cancer survivors- a 10-year longitudinal population-based study. Acta Oncol. 2013;52:1119–28.
10. Freedman RA, Virgo KS, Labadie J, He Y, Partridge AH, Keating NL. Receipt of locoregional therapy among young women with breast cancer. Breast Cancer Res Treat. 2012;135(3):893–906.
11. White A, Richardson LC, Krontiras H, Pisu M. Socioeconomic disparities in breast cancer treatment among older women. J Womens Health (Larchmt). 2014;23(4):335–41.
12. Alderman AK, Bynum J, Sutherland J, Birkmeyer N, Collins ED, Birkmeyer J. Surgical treatment of breast cancer among the elderly in the United States. Cancer. 2011;117(4):698–704.
13. McGuire KP, Santillan AA, Kaur P, Meade T, Parbhoo J, Mathias M, et al. Are mastectomies on the rise? A 13-year trend analysis of the selection of mastectomy versus breast conserving therapy in 5865 patients. Ann Surg Oncol. 2009;16:2682–90.
14. Clarke M, Collins R, Darby S, Davies C, Elphinstone P, Evans E, et al. Effects of radiotherapy and of differences in the extent of surgery for early breast cancer on local recurrence and 15-year survival: an overview of the randomized trials. Lancet. 2005;366(9503):2087–106.

15. Feinstein AJ, Soulos PR, Long JB, Herrin J, Roberts KB, Yu JB, et al. Variation in receipt of radiation therapy after breast-conserving surgery: assessing the impact of physicians and geographic regions. Med Care. 2013;51(4):330–8.
16. Dragun AE, Huang B, Tucker TC, Spanos WJ. Disparities in the application of adjuvant radiotherapy after breast-conserving surgery for early stage breast cancer. Cancer. 2011;117(12):2590–8.
17. Tuttle TM, Jarosek S, Habermann EB, Yee D, Yuan J, Virnig BA. Omission of radiation therapy after breast-conserving surgery in the United States: a population-based analysis of clinicopathologic factors. Cancer. 2012;118(8):2004–13.
18. Fritz A, Percy C, Jack A, Shanmugaratnam K, Sobin L, Parkin DM, Whelan S (Eds): International Classification of Diseases for Oncology, 3rd ed. Geneva, Switzerland: World Health Organization; 2000.
19. Fleming ID, Cooper JS, Henson DE, Hutter RVP, Kennedy BJ, Murphy GP, O'Sullivan B, Sobin LH, Yarbro JW (Eds): Cancer Staging Manual, 5th ed. New York: Springer-Verlag, 1997.
20. Greene FL, Page DL, Fleming ID, Fritz AG, Balch CM, Haller DG, Morrow M (Eds): Cancer Staging Manual, 6th ed. New York: Springer-Verlag, 2002.
21. Statistics Canada. Population, urban and rural, by province and territory (Alberta). Population, urban and rural, by province and territory, Population estimates and projections, Population and democracy. 2011. Summary Tables, 2011, last updated February 4.
22. Li C, Daling JR, Malone KE. Incidence of invasive breast cancer by hormone receptor status from 1992 to 1998. J Clin Oncol. 2003;21(1):28–34.
23. Deddens JA, Petersen MR, Lei X. Estimation of prevalence ratios when PROC GENMOD does not converge. Paper 270–28. Proceedings of the 28th Annual SAS Users Group International Conference. Cary NC: SAS Institute Inc (Available from: http://www2.sas.com/proceedings/sugi28/270-28.pdf.) 30 March–2 April 2003.
24. van Steenbergen LN, van de Poll-Franse LV, Wouters MWJM, Jansen-Landheer ML, Coebergh JW, Struikmans H, et al. Variation in the management of early breast cancer in the Netherlands, 2003–2006. Eur J Surg Oncol. 2010;36 Suppl 1:S36–43.
25. Boscoe FP, Johnson CJ, Henry KA, Goldberg DW, Shahabi K, Elkin EB, et al. Geographic proximity to treatment for early stage breast cancer and likelihood of mastectomy. Breast. 2011;20(4):324–8.
26. Habermann EB, Abbott A, Parsons HM, Virnig BA, Al-Refaie WB, Tuttle TM. Are mastectomy rates really increasing in the United States? J Clin Oncol. 2010;28(21):3437–41.
27. Celaya MO, Rees JR, Gibson JJ, Riddle BL, Greenberg ER. Travel distance and season of diagnosis affect treatment choices for women with early-stage breast cancer in a predominately rural population (United States). Cancer Causes Control. 2006;17(6):851–6.
28. Schroen AT, Brenin DR, Kelly MD, Knaus WA, Slingluff Jr CL. Impact of patient distance to radiation therapy on mastectomy use in early-stage breast cancer patients. J Clin Oncol. 2005;23(28):7074–80.
29. Canadian Institute for Health Information. Breast Cancer Surgery in Canada, 2007–2008 to 2009–2010. Ottawa, Ont.: CIHI; 2012.
30. Tyldesley S, Foroudi F, Barbera L, Boyd C, Schulze K, Walker H, et al. The appropriate rate of breast conserving surgery: an evidence-based estimate. Clin Oncol. 2003;15(3):144–55.
31. Ess S, Savidan A, Frick H, Rageth CH, Vlastos G, Lutolf U, et al. Geographic variation in breast cancer care in Switzerland. Cancer Epidemiol. 2010;34(2):116–21.
32. McDermott AM, Wall DM, Waters PS, Cheung S, Sibbering M, Horgan K, et al. Surgeon and breast unit volume-outcome relationships in breast cancer surgery and treatment. Ann Surg. 2013;285(5):808–13.
33. Peltoniemi P, Huhtala H, Holli K, Pylkkanen L. Effect of surgeon's caseload on the quality of surgery and breast cancer recurrence. Breast. 2012;21(4):539–43.
34. Struikmans H, Aarts MJ, Jobsen JJ, Koning CC, Merkus JW, Lubeert ML, et al. An increased utilization rate and better compliance to guidelines for primary radiotherapy for breast cancer from 1997 till 2008: a population-based study in the Netherlands. Radiother Oncol. 2011;100(2):320–5.
35. Sautter-Bihl ML, Sedlmayer F, Budach W, Dunst J, Feyer P, Fietkau R, et al. When are breast cancer patients old enough for the quitclaim of local control? Strahlenther Onkol. 2012;188(12):1069–73.
36. Giordano SH. Radiotherapy in older women with low-risk breast cancer: why did practice not change? J Clin Oncol. 2012;30(14):1577–8.
37. Kaidar-Person O, Walker G, Morgan DA, Kuten A. Radiotherapy in older women with low-risk breast cancer: why has practice not changed? J Clin Oncol. 2012;30(31):3899–900.