Geographic variations in surgical treatment for breast cancer: a systematic review

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Contributions: (I) Conception and design: N Chabba, S Tin Tin, JM Elwood; (II) Administrative support: None; (III) Provision of study materials or patients: S Tin Tin, JM Elwood; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: We conducted a systematic review with the aim of synthesising and examining existing evidence on geographic variations in the type of surgery received for invasive breast cancer. Our focus was on the alternatives of mastectomy or breast conserving surgery followed by radiotherapy. Studies were considered for inclusion if they involved women diagnosed with early invasive breast cancer (stage I-IIIA), were population-based or institution-based, assessed variations in the type of surgical treatment received based on area-level indices such as urban/rural status, accessibility (availability of and proximity to cancer services) and socioeconomic status, and published the findings in English as a full text article. The literature search was carried out from 29 November 2018 to 06 December 2018. Seven electronic databases were systematically searched, 3,109 citations screened, and 40 studies included. The studies were conducted in the United States (US) [31], Canada, China, Japan, and Australia and varied widely in terms of the patient population and geographic measures used. Significant and consistent disparities were found across various geographic locations, with breast conserving surgery being more often received by patients living in urban areas, in areas with better accessibility to cancer care and in areas of higher socioeconomic status. Our findings underscore the need for more efforts to address geographic disparities in breast cancer care. Most studies were from the US, and none from low- or middle-income countries.

Keywords: Breast conserving surgery; mastectomy; geographic variations

Received: 24 September 2019; Accepted: 09 January 2020.
doi: 10.21037/ace.2020.02.01
View this article at: http://dx.doi.org/10.21037/ace.2020.02.01

Introduction

Breast cancer is the most common cancer in women worldwide and is also a leading cause of cancer mortality (1). Breast cancer incidence varies internationally with a higher rate observed in Western countries however mortality rates vary less (2). Importantly, geographical inequalities exist within countries at all phases along the cancer care pathway (3-7), which has resulted in survival disparities (4).

Local control is important in breast cancer management as it can influence survival outcomes (8). Historically, mastectomy was the mainstay of primary breast cancer treatment. In the 1980s, several randomised control trials showed comparable survival outcomes for mastectomy and breast conserving therapy (BCT) which consists of breast conserving surgery (BCS) and radiotherapy. Since then, BCT has been established as the preferred modality of surgical treatment as it may lead to less morbidity and a better quality of life (9,10). More recent observational studies reported that survival outcomes were even better for BCT compared to mastectomy (11). Based on these findings, the question is raised of whether women suitable for BCT should still be offered a choice of mastectomy or BCT (9).
Women often choose mastectomy for individual reasons such as fear of cancer recurrence, worry about radiation side-effects, follow-up imaging and recall for further treatment (12). However, broader environmental factors such as travel distance to treatment facilities may also influence treatment decisions (13). This paper therefore aims to review the existing literature on geographic variations in the type of surgery received by women with early invasive breast cancer, focusing on three area-level indices—urban/rural status, accessibility (availability of and proximity to cancer services) and socioeconomic status.

The primary research question for this systematic review was whether the receipt of surgery for invasive breast cancer varies with indicators of access to care. To guide the review, specific secondary questions were: (I) are there urban-rural differences in the receipt and types of surgery for invasive breast cancer? (II) does the proximity and availability of cancer services matter in the receipt of surgery for invasive breast cancer? and (III) are there differences in the receipt and types of surgery for invasive breast cancer by area-level socio-economic status?

**Methods**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (14) was used to guide the reporting of this review.

**Literature Search (information sources; search)**

The literature search was carried out between 29 November and 06 December 2018, covering literature from the beginning for each included database till 2018. Searches were conducted across the following databases: Medline [1946–2018], EMBASE [1990–2018], CinhalPlus [1937–2018], Scopus [1970–2018], Cochrane [1992–2018], and Web of Science Core Collection [1900–2018]. Further international literature was sought through the use of WorldWideScience.org. Additionally, further secondary references were assessed for eligibility from the reference lists of publications screened for review.

The keywords and phrases used included breast cancer, breast carcinoma, breast tumors, rural, urban, urban-rural difference, place of residence, regional, travel distance, geographical or geographic, small-area analysis, variation, disparities, radiation therapy, surgery, and chemotherapy. The full electronic search strategy conducted on Medline is shown in Supplementary files. Note that the search terms used reflect the initial scope and focus of the review which covered all breast cancer treatments.

**Eligibility criteria and study selection**

Studies were included if they: (I) involved women diagnosed with early invasive breast cancer (stage I–III); (II) were either population-based or institution-based; (III) assessed variations in the type of surgical treatment received based on area-level indices such as urban/rural status, accessibility (availability of and proximity to cancer services) and socioeconomic status, and (IV) published the findings in English as a full text article. Studies that merely reported small-area level or regional/state variations without considering the above-mentioned indices were excluded due to limited generalisability of the results.

All records identified through searched databases and other sources were firstly screened for duplicates. The remaining records were screened for relevance by title and abstract. Then the full text of the remaining articles were retrieved and screened for inclusion in the qualitative synthesis. Additional studies were identified from the references of screened articles. All full-text articles were identified by NC, checked by MSA and approved by STT, JZ and ME to ensure that they met the inclusion criteria and could be included for review.

**Data extraction (data collection process and data items)**

Data was extracted from each included article using a data collection form, and information on study setting, how the study population was identified and gathered, total patient population, databases/data sources used, area-level indices used, confounding variables controlled for, and main results were collected.

**Quality assessment (risk of bias in individual studies and risk of bias across studies)**

The quality and risk of bias of each study were assessed using the Newcastle-Ottawa Scale (NOS) for quality assessment of non-randomised studies in meta-analyses (15). The NOS has strong face and content validity and is endorsed by the Cochrane Collaboration. Ratings were made using a point system, where points were given for the selection of study groups; the comparability of the groups; and the assessment of outcomes. The NOS was modified for retrospective cohort studies by omitting the
item assessing the presence of the outcome of interest at the beginning of the study. Eight criteria were assessed in the current systematic review: (I) representativeness of the exposed cohort; (II) selection of the non-exposed cohort; (III) ascertainment of exposure; (IV) adjustment for major confounders such as age and stage of diagnosis; (V) adjustment for other possible confounders; (VI) assessment of receipt of surgery; (VII) adequate follow-up period for receipt of surgery; and (VIII) adequacy of follow-up of cohorts. The total quality score was a maximum of eight points with higher scores indicative of higher study quality and less risk of bias.

Presentation of results

Results are presented in four tables, each addressing an indicator of care. The ‘results’ column gives the results as described in the paper. In addition, a column “key result” expresses that in a consistent fashion, as showing the association between higher use of BCS and urban setting, less distance to facilities, better facilities, and higher socio-economic status. Odds ratios are shown if they are given in the study: for the “key result” their reciprocal may be used.

Results

Study selection

Overall, the search resulted in 3,574 articles identified across Medline, EMBASE, CinhalPlus, Scopus, Cochrane, Web of Science Core Collection, and 783 articles from WorldWideScience.org. After removing duplicates, 3,109 articles remained and were subsequently screened. Seventy-two articles met the inclusion criteria after title and abstract screening. Seventy-two articles met the inclusion criteria after title and abstract screening. The full-text of these articles were then sought, and 39 were excluded for reasons shown in Figure 1. The remaining 33 articles were included in this review with a further 7 studies identified for addition from the reference lists of studies during eligibility screening, making a total of 40 (Figure 1).

Study characteristics

Most studies [31] included in this review were from the United States (US), with studies conducted in North Carolina (16), Washington (17), Georgia (18), Kentucky (19-21), Virginia (22-24), Florida (25), South Dakota (26), New Hampshire (27), Michigan (28), and across all regions (29-46). Four other studies were conducted in Canada (47-50), one in China (51), one in Japan (52), and finally, three in Australia (53-55). All were retrospective cohort studies in design. Surgery types examined included the receipt of BCS, BCT, and mastectomy. Further details of the characteristics of the studies are presented in Tables 1-4.

Out of the 40 studies, 22 performed analyses at the small area level (e.g., census tract, counties, and cities), 16 at the state level, and two at the national level.

Overall, study quality was good, with many studies [35] receiving quality scores of 7 or 8. The population-based studies were scored 1 for the first criterion (representativeness of the exposed cohort) and institution-based studies were scored 0.5. Most studies used registry and surgical records to examine exposures and outcomes, and controlled for important confounding factors such as age and tumour stage, along with various other factors such as median family income, ethnicity, year of diagnosis, and insurance status.

Results of individual studies

Urban-rural differences

Twenty-three articles examined variations in the receipt of different surgical treatments among women living in urban and rural regions (16,18-22,30,33-36,38,41,42,44,46,48,50-55), and were conducted in the US [16], Australia [3], Canada [2], China [1], and Japan [1] (Table 1).

All but one of these studies found that patients living in urban areas were significantly more likely to receive BCS or other more selective surgery, compared to mastectomy, and in the 11 studies where odds ratios are given, the urban excesses were always significant. Only one study (54) found a lower frequency of BCS in an urban area, in Australia, although this was not significant: the study found however that in rural areas radiotherapy was less often used after BCS. The odds ratios reported depend on the categorisations used and may not be comparable: they varied from small variations up to doubling of the odds of receiving BCS in studies in Kentucky (20) and in China (51).

Proximity to health care services

Fifteen studies in the US [13] and Canada [2] examined the association between travel distance and the type of surgery received by breast cancer patients (17,22-28,37,39,40,43,45,47,49) (Table 2). Fourteen studies found significant differences in the receipt of BCS/BCT versus mastectomy, with women living further away from radiation.
treatment facilities and treatment centres less likely to receive BCS and more likely to receive mastectomy (17,23-28,37,39,40,43,45,47,49). Only one study, in Virginia, US, found no significant associations with increasing distance from a treating hospital, but that study did find that large urban hospitals had significantly higher rates of BCT than smaller hospitals (22). However, in a US study of 1,833 women (40) the association was seen for African Americans, in whom it was strong, and no significant association was found in white patients. In one US study, it was initially found that those who lived further away from a radiation therapy facility were more likely to receive mastectomy (24), and when a new radiation facility was opened in the rural area, the rate of mastectomy fell from 61% to 45% among patients who lived within 15 miles of the new facility (24).

Other measures of the availability of health care facilities
Six studies, all conducted in the US, identified variations in the type of breast cancer surgery received by women according to measures other than distance in the availability of health care facilities (22,29,36,41,42,46).
### Table 1

**Variations by urban-rural difference**

<table>
<thead>
<tr>
<th>Author</th>
<th>Study area, country [level of geography]</th>
<th>Patient identification/population</th>
<th>Sample size</th>
<th>Stage</th>
<th>Geographic measures</th>
<th>Type of surgery</th>
<th>Results</th>
<th>Confounders controlled for</th>
<th>NOS Score</th>
<th>Key Result: Higher BCS in urban vs. rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addison et al. [1997]</td>
<td>NSW, Australia [States]</td>
<td>Registry/population</td>
<td>5,040</td>
<td>Stage I-IIIA</td>
<td>Local, regional, and metastatic</td>
<td>Regional Health Service (rural regions) vs. Area Health Service (urban regions)</td>
<td>Receipt of mastectomy</td>
<td>Adjusted OR for rural regions cf. urban regions =1.561; 95% CI, 1.218-2.001</td>
<td>Age, residence, hospital characteristics, private insurance status, spread of disease</td>
<td>8</td>
</tr>
<tr>
<td>Anderson et al. [2015]</td>
<td>7 States, United States [Census Tract]</td>
<td>Registry/population</td>
<td>6,505</td>
<td>Stage I-II</td>
<td>Urban vs. rural areas</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Adjusted OR for women &lt;65 in rural areas cf. urban areas =0.72; 95% CI, 0.53-0.96; adjusted OR for women ≥65 in rural areas cf. urban areas =0.68; 95% CI, 0.46-1.00</td>
<td>Age at diagnosis, race/ethnicity, health insurance, census tract poverty, census tract education, rural/urban residence, state of residence, surgical facility Commission on Cancer status, clinical tumour stage, tumour size, lymph node status, comorbidity, surgical approach, neoadjuvant chemotherapy</td>
<td>8</td>
<td>Positive (1.04–1.89)</td>
</tr>
<tr>
<td>Answini et al. [2001]</td>
<td>North Carolina, United States [Counties]</td>
<td>Registry/population</td>
<td>3,349</td>
<td>Stage 0-II</td>
<td>Urban vs. rural counties</td>
<td>Receipt of BCS</td>
<td>Higher rate of BCS in urban counties than in rural counties</td>
<td>Geographic location, tissue diagnosis, surgical treatment, tumour size, histologic grade, number of tumours, lymph node status, lymphovascular invasion</td>
<td>6</td>
<td>Positive</td>
</tr>
<tr>
<td>Azzopardi et al. [2014]</td>
<td>Australia [Australian State]</td>
<td>Clinic/institution</td>
<td>21,643</td>
<td>Stage 0-II</td>
<td>Outer regions vs. cities</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Lower rates of BCS and higher rates of mastectomy in outer regions vs. cities</td>
<td></td>
<td>7.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Beaulieu et al. [2003]</td>
<td>Kentucky, United States [Counties]</td>
<td>Registry/population</td>
<td>8094</td>
<td>Stage I-II</td>
<td>Rural vs. urban counties</td>
<td>Receipt of BCS</td>
<td>Lower rates of BCS in rural counties</td>
<td></td>
<td>6</td>
<td>Positive</td>
</tr>
<tr>
<td>Craft et al. [2010]</td>
<td>Canberra, Australia [State]</td>
<td>Clinic/institution</td>
<td>2,081</td>
<td>Early Breast Cancer</td>
<td>Rural vs. metropolitan areas</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Lower in metro area OR 0.82 (0.64-1.07)</td>
<td>Age, residence, tumour size, tumour grade, nodal involvement, hormone receptor status, lymphovascular invasion, type of surgery, place of surgery</td>
<td>7.5</td>
<td>negative, n.s. (0.74–1.07)</td>
</tr>
<tr>
<td>Dodgion et al. [2010]</td>
<td>United States [Census Tract]</td>
<td>Clinic/institution</td>
<td>4,766</td>
<td>Stage 0-IV</td>
<td>Hospitals located in non-metropolitan vs. non-metropolitan areas</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Lower rates of BCS, higher rates of mastectomy with reconstruction at hospitals in non-metropolitan areas</td>
<td></td>
<td>7.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Dragun et al. [2012]</td>
<td>Kentucky, United States [Counties]</td>
<td>Registry/population</td>
<td>21,869</td>
<td>Stage 0-II</td>
<td>Rural vs. urban counties</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Adjusted OR of receiving mastectomy for rural counties cf. urban counties =1.073; 95% CI, 1.012-1.138</td>
<td>Surgery procedure, race, age at diagnosis, urban/rural status and Appalachian status, year at diagnosis, smoking history, insurance status, survival status at the end of the study, primary cancer sequence number, laterality, stage, nodes examined, ER/PR status, tumour grade, histology, and tumour size</td>
<td>8</td>
<td>1.07 (1.01-1.14)</td>
</tr>
<tr>
<td>Eward et al. [1998]</td>
<td>Virginia, United States [State]</td>
<td>Clinic/institution</td>
<td>1,512</td>
<td>Stage I-II</td>
<td>Urban hospital vs. rural hospital</td>
<td>Receipt of BCS</td>
<td>Higher rates of BCS in large urban hospitals and those with on-campus radiation services</td>
<td>Stage of disease</td>
<td>6.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Fisher et al. [2015]</td>
<td>Alberta, Canada [State]</td>
<td>Registry/population</td>
<td>14,646</td>
<td>Stage I-III</td>
<td>Rural vs. urban regions</td>
<td>Receipt of BCS</td>
<td>Higher rates of BCS in urban centres (Calgary or Edmonton) cf. Central Alberta</td>
<td>Date of diagnosis, age at diagnosis, oestrogen and progesterone receptor status, cancer stage, type of surgery, geographic region of surgery, receipt of neo-adjuvant and adjuvant chemotherapy</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Freeman et al. [2012]</td>
<td>Appalachian Kentucky, United States [State]</td>
<td>Registry/population</td>
<td>5,541</td>
<td>Stage I-II</td>
<td>Rural vs. urban areas</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Adjusted OR for rural location vs. urban location =2.075; 95% CI, 1.743–2.472</td>
<td>Surgery type, race, age at diagnosis, urban/rural status, insurance status, year at diagnosis, smoking status, stage of disease, oestrogen receptor/progesterone receptor status, tumour grade, histology, tumour size, nodes examined</td>
<td>8</td>
<td>2.08 (1.7–2.47)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Author</th>
<th>Study area, country [level of geography]</th>
<th>Patient identification/population or institution</th>
<th>Sample size</th>
<th>Stage</th>
<th>Geographic measures</th>
<th>Type of surgery</th>
<th>Results</th>
<th>Confounders controlled for</th>
<th>NOS score</th>
<th>Key result: higher BCS in urban: result or OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gilligan et al. [2002] [33]</td>
<td>9 SEER regions, United States [Counties]</td>
<td>Registry/population</td>
<td>158,496</td>
<td>Local and regional</td>
<td>Rural vs. urban areas</td>
<td>Receipt of BCT</td>
<td>Lower rates of BCS whether accompanied by RT and LND in rural areas</td>
<td>Age, race, stage of disease, income, education, metropolitan statistical area, SEER site</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Hagstrom et al. [2005] [34]</td>
<td>SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>22,071</td>
<td>Stage I-II</td>
<td>Rural vs. metropolitan areas</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for rural areas cf. metropolitan areas =0.72; 95% CI, 0.65-0.79</td>
<td>Race/ethnicity, age, location of residence, socioeconomic status, individual year of diagnosis, SEER region, tumour size, tumour stage, comorbidity</td>
<td>8</td>
<td>1.58 (1.26-1.97)</td>
</tr>
<tr>
<td>Itso et al. [1994] [52]</td>
<td>7 Regions, Japan [State]</td>
<td>Clinic/Institution</td>
<td>31,686</td>
<td>Stage I-III</td>
<td>Rural vs. cities and urban regions</td>
<td>Receipt of BCS</td>
<td>Lower rates of BCS in rural regions</td>
<td>Age, race, marital status, income, stage, employment, education, transportation of the study population, density of radiation oncologists, density of radiation technologies</td>
<td>4.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Jacobs et al. [2008] [35]</td>
<td>SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>137,303</td>
<td>Stage I-III</td>
<td>Rural vs. urban areas</td>
<td>Receipt of mastectomy</td>
<td>Adjusted OR for rural areas cf. urban areas =1.58; 95% CI, 1.26-1.98; adjusted for density per population, and 1.69; 95% CI, 1.38-2.08; adjusted for density per area</td>
<td>Age, socioeconomic factors (median family income, mean proportion of college graduates, mean proportion of the population living below the poverty line, mean proportion of vacant housing units), race, stage of disease, population size of the zip code</td>
<td>8</td>
<td>1.58 (1.26-1.97)</td>
</tr>
<tr>
<td>LeMasters et al. [2016] [41]</td>
<td>SEER Regions and West Virginia, United States [Counties]</td>
<td>Registry/population</td>
<td>26,917</td>
<td>Stage I-II</td>
<td>Urban vs. rural areas</td>
<td>Receipt of mastectomy</td>
<td>Initial local treatment, year of diagnosis, age, frequency of Primary Care Provider visits, stage at diagnosis, ER status, PR status, tumour grade, area-level density of mammography screening and oncology treatment centres, specialisation of the treating surgeon(s), race, education, annual income, metro status</td>
<td>8</td>
<td>1.41 (1.54-1.27)</td>
<td></td>
</tr>
<tr>
<td>Liu et al. [2012] [51]</td>
<td>Tianjin, China [City]</td>
<td>Clinic/Institution</td>
<td>468</td>
<td>Stage I-II</td>
<td>Urban vs. rural areas</td>
<td>Receipt of BCT</td>
<td>Adjusted OR for urban areas cf. rural areas =0.14; 95% CI, 1.29-3.56</td>
<td>Age, educational level, occupation, family income, medical insurance, residence, source of BCT information, communication with the attending physician, tumour location, clinical stage, pathology, lymph node involvement, oestrogen receptor status</td>
<td>7.5</td>
<td>2.14 (1.29-3.56)</td>
</tr>
<tr>
<td>Markossian et al. [2012] [18]</td>
<td>Georgia, United States [Counties]</td>
<td>Registry/population</td>
<td>23,500</td>
<td>Stage I-IV</td>
<td>Rural vs. urban areas</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for rural areas cf. urban areas =0.73; 95% CI, 0.58-0.91</td>
<td>Age at diagnosis, race, hormone receptor status, tumour characteristics, county of residence, AJCC stage, hormone receptor status, tumour grade, BC treatment, surgery type, county-level SES, survival status</td>
<td>8</td>
<td>1.37 (1.72-1.10)</td>
</tr>
<tr>
<td>Michalski et al. [1997] [30]</td>
<td>United States [Census Tract]</td>
<td>Registry/population</td>
<td>41,937</td>
<td>Stage I-II</td>
<td>Urban areas vs. rural areas</td>
<td>Receipt of BCS</td>
<td>Significant negative association with increasing rurality</td>
<td>Socioeconomic factors (median family income, mean proportion of college graduates, mean proportion of the population living below the poverty line, mean proportion of vacant housing units), race, stage of disease, population size of the zip code</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Natlinger et al. [1992] [44]</td>
<td>United States [National]</td>
<td>Registry/population</td>
<td>36,982</td>
<td>Stage I-II</td>
<td>Non-metropolitan areas vs. metropolitan areas</td>
<td>Receipt of BCS</td>
<td>Significant positive association with increasing size of metropolitan areas</td>
<td>Race; population of metropolitan area, full-time house staff, geriatric services, radiation therapy facility</td>
<td>7</td>
<td>Positive</td>
</tr>
<tr>
<td>Siamet et al. [1994] [46]</td>
<td>9 SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>19,661</td>
<td>Stage I-II</td>
<td>City of ≥10,000 in county</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for city of ≥10,000 in county cf. city of &lt;10,000 in county =1.18; 95% CI, 1.10-1.28</td>
<td>Age at diagnosis, SEER region, number of physicians per 10,000 residents, percentage of residents with 16 or more years of education, percentage of families with incomes below the poverty level, presence of a city of 100,000 or larger within the county, and presence of a cancer treatment centre within the county; race</td>
<td>8</td>
<td>1.18 (1.10-1.28)</td>
</tr>
<tr>
<td>Smith et al. [2009] [36]</td>
<td>United States [Counties]</td>
<td>Registry/population</td>
<td>56,725</td>
<td>Stage I-II</td>
<td>Metropolitan areas vs. non-metropolitan areas</td>
<td>Receipt of BCS</td>
<td>Higher rates of BCS in metropolitan areas cf. non-metropolitan areas</td>
<td>Age, race, comorbidity score, axillary lymph node involvement, axillary dissection, chemotherapy, screening mammography, physician visits, surgeon density, radiation oncologist density, metropolitan area, education, tumour stage</td>
<td>8</td>
<td>Positive</td>
</tr>
</tbody>
</table>

*Key result* column positive means a higher BCS rate in urban areas, or the odds ratio and 95% limits for this association, if given. This is sometimes the reciprocal of that given in the paper: BCS, breast conserving surgery; BCT, breast conserving therapy; RT, radiotherapy; LND, lymph node dissection.
Table 2 Variations by cancer care accessibility (proximity to services)

<table>
<thead>
<tr>
<th>Author</th>
<th>Study area, country (level of geography)</th>
<th>Patient identification/ population or institution</th>
<th>Sample size</th>
<th>Stage</th>
<th>Geographic measures</th>
<th>Type of surgery</th>
<th>Results</th>
<th>Confounders controlled for</th>
<th>NOS Score</th>
<th>Key result: more BCS if closer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldwin et al. [2004]</td>
<td>Washington, United States [State]</td>
<td>Registry/population</td>
<td>1,188</td>
<td>Stage I-II</td>
<td>Distance to the radiation therapy centre</td>
<td>Receipt of BCS and radiotherapy vs. mastectomy</td>
<td>Adjusted OR for women living &gt;40 miles cf. women living &lt;30 miles from radiation therapy centre =0.62 [P=0.10]; &gt;50 miles cf. women living &lt;30 miles =0.58 [P&lt;0.08]</td>
<td>Significant positive associations with surgery proximity</td>
<td>Preoperative radiation and medical oncology consultation, surgical procedure, age at diagnosis, ethnicity, marital status, median household income, disease stage at diagnosis, tobacco use, case severity, rural or urban residence, residence in nursing home, Age, year of diagnosis, race, ethnicity, census tract-level household poverty rate and rural/urban status, tumour sequence, commuting proximity</td>
<td>8</td>
</tr>
<tr>
<td>Boscoe et al. [2011]</td>
<td>10 States, United States [State]</td>
<td>Registry/population</td>
<td>104,730</td>
<td>Stage I-II</td>
<td>Distance to surgery proximity</td>
<td>Receipt of mastectomy</td>
<td>Significant positive associations with distance to a radiation treatment facility</td>
<td>Age at diagnosis, marital status, primary sequence, distance to radiation treatment facility, time of year, tumour size, stage at diagnosis</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Celum et al. [2006]</td>
<td>New Hampshire, United States [State]</td>
<td>Registry/population</td>
<td>2,861</td>
<td>Stage I-II</td>
<td>Distance to a radiation treatment facility</td>
<td>Receipt of BCS and radiotherapy</td>
<td>Significant negative associations with distance to a radiation treatment facility</td>
<td>Age at diagnosis, marital status, primary sequence, distance to radiation treatment facility, time of year, tumour size, stage at diagnosis</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Ewert et al. [1998]</td>
<td>Virginia, United States [State]</td>
<td>Clinic/Institution</td>
<td>1,512</td>
<td>Stage I-II</td>
<td>Distance from the treating hospital</td>
<td>Receipt of BCS</td>
<td>Significant positive associations with distance to the treating hospital</td>
<td>Stage of disease</td>
<td>Age, systemic treatment, BMI, comorbidity score, income level, tumour size, number of positive nodes, HR status, AJCC stage, type of health insurance at presentation, employment status, number of reconstructive surgeons at each NCCN site, number of radiation oncologists on staff treating breast cancer at the beginning at each site</td>
<td>6.5</td>
</tr>
<tr>
<td>Greenberg et al. [2011]</td>
<td>8 States, United States [State]</td>
<td>Clinic/Institution</td>
<td>10,607</td>
<td>Stage I-II</td>
<td>Distance to radiation facility</td>
<td>Receipt of BCS vs. mastectomy with reconstruction, compared to BCS with increasing distance to radiation facility. OR per mile, 1.03 (1.00–1.05)</td>
<td>Significant positive associations with mastectomy with reconstruction</td>
<td>7.5</td>
<td>Positive</td>
<td></td>
</tr>
<tr>
<td>Hilgop et al. [1996]</td>
<td>British Columbia, Canada [Census Tract]</td>
<td>Registry/population</td>
<td>942</td>
<td>Stage I-II</td>
<td>Distance to radiation treatment facility</td>
<td>Receipt of BCS</td>
<td>Significant negative association. Adjusted OR for &lt;2 hours drive cf. 2+ hour drive =0.56; 95% CI, 0.36–0.76</td>
<td>Age at diagnosis, place of residence, median family income of neighbourhood, tumour size, histological type, tumour location in the breast, extent of ductal carcinoma in-situ, surgeon's sex, caseload, graduation year from medical school, university affiliation, family physician's graduation year from medical school and university affiliation</td>
<td>8</td>
<td>Positive 1.79 (1.32–2.78)</td>
</tr>
<tr>
<td>Lautner et al. [2010]</td>
<td>United States [national]</td>
<td>Registry/population</td>
<td>727,927</td>
<td>Stage I-III</td>
<td>Distance to a treatment facility</td>
<td>Receipt of BCT</td>
<td>Adjusted OR for patients with a travel distance of less than 27.7 km =1.21; 95% CI, 1.16–1.26</td>
<td>Year of breast cancer diagnosis; age; race/ethnicity; comorbidity; insurance status; median income; population density; without high school diploma; facility type; facility location; distance from treatment facility; clinical T stage; clinical N stage; hormone receptor status</td>
<td>8</td>
<td>Positive 1.21 (1.16–1.26)</td>
</tr>
<tr>
<td>Lin et al. [2018]</td>
<td>South Dakota, United States [Census]</td>
<td>Registry/population</td>
<td>4,031</td>
<td>Stage I-II</td>
<td>Distance from a radiation therapy facility</td>
<td>Receipt of mastectomy</td>
<td>Significant positive association with distance to a radiation therapy facility</td>
<td>Race/ethnicity, age at diagnosis, tumour grade, tumour sequence, year of diagnosis, poverty rate, rural/urban residence, travel distance to closest radiation therapy facility</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Mandelblatt et al. [2002]</td>
<td>United States [Census Tract]</td>
<td>Registry/population</td>
<td>1,833</td>
<td>Stage I-II</td>
<td>Distance from nearest cancer centre</td>
<td>Receipt of BCT</td>
<td>Significant positive association for African-American patients, significant positive association. Adjusted OR for fourth quartile cf. first quartile =3.13; 95% CI, 1.23–8.08</td>
<td>Surgical treatment received, chemotherapy, tamoxifen race, age, comorbidity, stage, area percent of elderly below poverty, area percent of HS education, individual monthly income, individual education, marital status, supplemental insurance, mean urban/rural continuum score, mean number of radiology specialists per 100,000, mean number of surgeons per 100,000, median distance to cancer centre, region perceptions of racism and ageism</td>
<td>8</td>
<td>Positive 3.13 (1.22–8.08)</td>
</tr>
<tr>
<td>Medlen et al. [2002]</td>
<td>Michigan, United States [State]</td>
<td>Clinic/Institution</td>
<td>66</td>
<td>Stage I-II</td>
<td>Travel distance to radiation oncology facility</td>
<td>Receipt of BCT</td>
<td>Significant negative association with distance to a radiation oncology facility</td>
<td>Age, stage of disease, race, education status, distance to hospital with radiotherapy facility, population density, SEER site</td>
<td>5.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Nattlinger et al. [2001]</td>
<td>SEER Regions, United States [Census]</td>
<td>Registry/population</td>
<td>17,729</td>
<td>Stage I-II</td>
<td>Distance from a radiation therapy facility</td>
<td>Receipt of BCS</td>
<td>Significant negative association with increasing distance from a radiation therapy facility</td>
<td>Age, stage of disease, race, education status, distance to hospital with radiotherapy facility, population density, SEER site</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Park et al. [2003]</td>
<td>Virginia, United States [State]</td>
<td>Clinic/Institution</td>
<td>928</td>
<td>Stage 0-II</td>
<td>Distance from a radiation centre</td>
<td>Receipt of BCT</td>
<td>Adjusted OR for distance of &gt;40 miles away from a radiation centre cf. distance of &lt;40 miles away from a radiation centre =0.48; P=0.007</td>
<td>Age, race, insurance status, stage, year of diagnosis, treating surgeon, type of surgery</td>
<td>7.5</td>
<td>Positive  OR =2.08</td>
</tr>
<tr>
<td>Schuerm et al. [2005]</td>
<td>Virginia, United States [State]</td>
<td>Registry/population</td>
<td>20,094</td>
<td>Stage I-III</td>
<td>Distance from nearest radiation facility</td>
<td>Receipt of mastectomy</td>
<td>Significant negative association with increasing distance from the closest radiation therapy facility</td>
<td>Age, race, year of diagnosis, tumour extent of disease, tumour size, distance to nearest RT facility</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Veit et al. [2006]</td>
<td>Florida, United States [Census Tract]</td>
<td>Registry/population</td>
<td>19,903</td>
<td>Stage I-IA</td>
<td>Distance from the closest radiation therapy facility</td>
<td>Receipt of BCT</td>
<td>Significant negative associations with increasing distance from the closest radiation therapy facility</td>
<td>Age at diagnosis, distance to radiation treatment facilities, marital status, insurance at the time of diagnosis, race/ethnicity</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Xu et al. [2018]</td>
<td>Alberta, Canada [State]</td>
<td>Registry/population</td>
<td>21,872</td>
<td>Stage 0-III</td>
<td>Distance to the nearest radiotherapy centre</td>
<td>Receipt of mastectomy</td>
<td>Significant positive association with increasing distance to the nearest radiotherapy centre. However, association not significant for Calgary and Red Deer regions</td>
<td>Primary surgery type, region, driving time, period of diagnosis, age, AJCC stage, RT centre, adjuvant therapy, tumour size, lobular histology type, lymph node involvement, tumour grade, molecular subtype, comorbidity, surgical institution type, educational attainment of neighbourhood, neighbourhood annual income, re-excision, chemotheraphy use, anti-endocrine use, radiotherapy use</td>
<td>8</td>
<td>Positive</td>
</tr>
</tbody>
</table>

"Key result" column positive means a higher BCS rate with a lower distance to facilities, or the odds ratio and 95% limits for this association, if given. This is sometimes the reciprocal of that given in the paper. BCS, breast conserving surgery; BCT, breast conserving therapy; RT, radiotherapy.
## Table 3: Variations by cancer care accessibility (availability of services)

<table>
<thead>
<tr>
<th>Author</th>
<th>Study area, country level of geography</th>
<th>Patient Identification/ population or institution</th>
<th>Sample size</th>
<th>Stage</th>
<th>Geographic measures</th>
<th>Type of surgery</th>
<th>Results</th>
<th>Confounders controlled for</th>
<th>NOS score</th>
<th>Key result: higher BCS if more access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballard-Barbash et al. [1996] (29)</td>
<td>9 SEER Regions, United States [Census Tract]</td>
<td>Registry/population</td>
<td>18,704</td>
<td>Stage I-IB</td>
<td>Number of physicians and hospitals with radiation megavolt equipment in the area</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for areas with &gt;601-999 physicians per 10,000 population =1.32, 95% CI, 1.16–1.55 cf. areas with &lt;900 physicians per 10,000 population</td>
<td>Age, stage of disease at diagnosis, ethnicity, comorbidity, health care characteristics, region</td>
<td>8</td>
<td>No association (1.07–0.86)</td>
</tr>
<tr>
<td>Dodgion et al. [2016] (42)</td>
<td>United States [Census Tract]</td>
<td>Clinic/institution</td>
<td>4,766</td>
<td>Stage 0-IV</td>
<td>Availability of radiation oncology services within the hospital or network</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Lower rates of BCS, higher rates of mastectomy and with reconstruction with lack of availability of radiation oncology services within the hospital or networks</td>
<td>Age, race, census median income, census educational level, tumour stage, nodal stage, oestrogen receptor, progesterone receptor, Her2 neu status, first therapeutic procedure, comorbidity, number of plastic surgeons per 100 annual breast procedures, plastic surgeons per 100,000 female population, radiation oncology services available, mean distance to nearest radiation facility, radiation oncologists per 100,000 female population, total bed size, total number of operating rooms, nursing staff ratio, hospital approval/accreditation, ambulatory surgery, chemotherapy administered, rural urban commuting area code</td>
<td>7.5</td>
<td>Positive</td>
</tr>
<tr>
<td>Elward et al. [1998] (22)</td>
<td>Virginia, United States [State]</td>
<td>Clinic/institution</td>
<td>1,512</td>
<td>Stage I-II</td>
<td>Presence of senior Members Hip Programmes and Women’s Health Centres in the community</td>
<td>Receipt of BCS</td>
<td>Higher rates of BCS in the presence of Senior Membership Programs and Women’s Health Centres in the community</td>
<td>Stage of disease</td>
<td>6.5</td>
<td>No association</td>
</tr>
<tr>
<td>LaMasters et al. [2016] (41)</td>
<td>SEER Regions and West Virginia, United States [Counties]</td>
<td>Registry/population</td>
<td>26,917</td>
<td>Stage I-II</td>
<td>Density of mammography and oncology treatment centres</td>
<td>Receipt of mastectomy vs. BCT</td>
<td>Adjusted OR for areas with high density of mammography screening centres cf. areas with low density, for mast vs. BCT =0.98, 95% CI, 0.86–1.12</td>
<td>Initial local treatment, year of diagnosis, age, frequency of Primary Care Provider visits, stage at diagnosis, ERI status, PR status, tumour grade, area-level density of mammography screening and oncology treatment centres, specialisation of the treating surgeon(s), race, education, annual income, metro status</td>
<td>8</td>
<td>No association (1.08–0.88)</td>
</tr>
<tr>
<td>Samet et al. [1994] (46)</td>
<td>9 SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>19,661</td>
<td>Stage I-II</td>
<td>Physician-to-population ratio</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for 26.3 or more physicians per 10,000 cf. fewer than 16.5 per 10,000=1.40, 95% CI 1.27–1.53</td>
<td>Age at diagnosis, SEER region, number of physicians per 10,000 residents, percentage of residents with 16 or more years of education, percentage of families with incomes below the poverty level, presence of a city of 100,000 or larger within the county, and presence of a cancer treatment centre within the county, race</td>
<td>8</td>
<td>No association (1.27–1.53)</td>
</tr>
<tr>
<td>Smith et al. [2009] (46)</td>
<td>United States [Counties]</td>
<td>Registry/population</td>
<td>56,725</td>
<td>Stage I-II</td>
<td>Density of radiation oncologists</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for higher density of radiation oncologists cf. lower density of radiation oncologists =1.37, 95% CI, 1.07–1.75</td>
<td>Age, race, comorbidity score, axillary lymph node involvement, axillary dissection, chemotherapy, screening mammography, physician visits, surgeon density, radiation oncologist density, metropolitan area, education, tumour stage</td>
<td>8</td>
<td>No association (1.07–1.75)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key result: higher BCS if more access</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Positive: 1.24 (1.12–1.37)</td>
</tr>
<tr>
<td>- No association: 1.02 (0.89–1.16)</td>
</tr>
<tr>
<td>- Positive: 1.32 (1.21–1.51)</td>
</tr>
<tr>
<td>- Positive: 1.37 (1.21–1.51)</td>
</tr>
<tr>
<td>- Positive: 1.40 (1.27–1.53)</td>
</tr>
<tr>
<td>- Positive: 1.35 (1.21–1.51)</td>
</tr>
</tbody>
</table>
Table 4 Variations by area-level socio-economic status

<table>
<thead>
<tr>
<th>Author</th>
<th>Study area, country [level of geography]</th>
<th>Patient identification/ population or institution</th>
<th>Sample size</th>
<th>Stage</th>
<th>Geographic measures</th>
<th>Type of surgery</th>
<th>Results</th>
<th>Confounders controlled for</th>
<th>NOS Score</th>
<th>Key result: more BCS if SES higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al. [2015]</td>
<td>7 States, United States [Census Tract]</td>
<td>Registry/population</td>
<td>6,505</td>
<td>Stage I-IIIA</td>
<td>Census tract education</td>
<td>Receipt of BCS vs. mastectomy</td>
<td>Adjusted OR for women &lt;65 years in areas with high census tract education cf. areas with low census tract education = 1.20, 95% CI, 0.93–1.54</td>
<td>Age at diagnosis, race/ethnicity, health insurance, census tract poverty, census tract education, rural/urban residence, state of residence, surgical facility Commission on Cancer status, clinical tumour stage, age, tumour size, lymph node status, comorbidity, surgical approach, adjuvant chemotherapy</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Ballard-Barbash et al. [1996] [39]</td>
<td>9 SEER Regions, United States [Census Tract]</td>
<td>Registry/population</td>
<td>18,704</td>
<td>Stage I-IB</td>
<td>Census tract education</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for census tracts with high education levels cf. tracts with low education levels = 1.15, 95% CI, 1.05–1.28</td>
<td>Age, stage of disease at diagnosis, ethnicity, comorbidity, health care characteristics, region</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Gilligan et al. [2002]</td>
<td>9 SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>158,496</td>
<td>Local and regional</td>
<td>County income</td>
<td>County education</td>
<td>Receipt of BCT</td>
<td>Lower rates of BCT whether accompanied by RT and LND in poorer counties</td>
<td>Age, race, stage of disease, income, education, metropolitan statistical area, SEER site</td>
<td>8</td>
</tr>
<tr>
<td>Goel et al. [1997] [48]</td>
<td>British Columbia and Ontario, Canada [State]</td>
<td>Registry/population</td>
<td>942</td>
<td>Nona-negative breast cancer</td>
<td>Stage I-III</td>
<td>Area median income level</td>
<td>Receipt of BCS</td>
<td>Lower rates of BCS in areas with lower median incomes. However, only significant in British Columbia</td>
<td>Age, tumour size and location</td>
<td>8</td>
</tr>
<tr>
<td>Haagstrom et al. [2000]</td>
<td>SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>22,071</td>
<td>Area socioeconomic status</td>
<td>Receipt of BCS</td>
<td>Significant positive association with increasing area socioeconomic status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lin et al. [2016] [36]</td>
<td>South Dakota, United States [Census Tract]</td>
<td>Registry/population</td>
<td>4,031</td>
<td>Stage I-III</td>
<td>Census tract federal poverty line</td>
<td>Receipt of mastectomy</td>
<td>Adjusted OR for census tracts with greater than 15% of the population under the federal poverty line cf. census tracts with less than 5% of the population under the federal poverty line = 1.28, 95% CI, 1.02–1.61</td>
<td>Race/ethnicity, age, location of residence, socioeconomic status, individual year of diagnosis, SEER region, tumour size, tumour stage, comorbidity</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Mandelblatt et al. [2002]</td>
<td>United States [Census Tract]</td>
<td>Registry/population</td>
<td>1,833</td>
<td>Stage I-III</td>
<td>Percent of elderly below poverty level quartiles</td>
<td>Receipt of mastectomy vs. BCT</td>
<td>Adjusted OR for areas highest quartile of elderly residents living below poverty level cf. lowest quartile of poverty = 7.59, 95% CI, 2.81–20.5</td>
<td>Surgical treatment received, chemotherapy, tamoxifen race, age, comorbidity, stage, percent of elderly below poverty, area percent of HS education, individual monthly income, individual education, marital status, supplemental insurance, mean urban-rural continuum score, mean number of radiology specialists per 100,000, mean number of surgeons per 100,000, median distance to cancer centre, region perceptions of racism and ageism</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>McGirvin, et al. [2002]</td>
<td>United States [State]</td>
<td>Registry/population</td>
<td>191,714</td>
<td>Stage I-III</td>
<td>Zip code income level</td>
<td>Receipt of mastectomy</td>
<td>Higher rates of partial mastectomy with or without radiation or systemic therapy cf. in higher income zip codes</td>
<td>Stage of disease, race</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Michalski et al. [1997]</td>
<td>United States [Census Tract]</td>
<td>Registry/population</td>
<td>41,937</td>
<td>Stage I-III</td>
<td>Area median family income</td>
<td>Area proportion of college graduates</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for areas with highest median family income cf. areas with lowest median family income =1.1, 95% CI, 1.0–1.2</td>
<td>Socioeconomic factors (median family income, mean proportion of college graduates, mean proportion of the population living below the poverty line, mean proportion of vacant housing units, race, stage of disease, population size of the zip code)</td>
<td>8</td>
</tr>
<tr>
<td>Riley et al. [1999] [51]</td>
<td>United States [Census Tract]</td>
<td>Registry/population</td>
<td>29,608</td>
<td>Stage I-IBB</td>
<td>Area education level</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for areas with lowest quartile education level cf. areas with highest quartile education level = 0.80, 95% CI, 0.73–0.87</td>
<td>Age, race, state and county of residence, cancer history, year of diagnosis, percentage of adults with fewer than 12 years of education at the census tract level, stage at diagnosis, tumour size, treatment pattern</td>
<td>8</td>
<td>Positive</td>
</tr>
<tr>
<td>Samet et al. [1994] [46]</td>
<td>9 SEER Regions, United States [Counties]</td>
<td>Registry/population</td>
<td>19,661</td>
<td>Stage I-III</td>
<td>Percent of county with college education</td>
<td>Receipt of BCS</td>
<td>Adjusted OR for areas with &gt;24.0 or more percent of county with college education cf. areas with less than 16.5% of county with college education = 1.68, 95% CI, 1.53–1.85</td>
<td>Age at diagnosis, SEER region, number of physicians per 10,000 residents, percentage of residents with 16 or more years of education, percentage of families with incomes below the poverty level, presence of a city of 100,000 or larger within the county, and less than 6.1 percent of county below poverty level =0.72, 95% CI, 0.68–0.78</td>
<td>8</td>
<td>Positive</td>
</tr>
</tbody>
</table>

*Key result* column positive means a higher BCS rate with higher socio-economic status, or the odds ratio and 95% limits for this association, if given. This is sometimes the reciprocal of that given in the paper. BCS, breast conserving surgery; BCT, breast conserving therapy; RT, radiotherapy; LND, lymph node dissection.
Most studies showed that women living in areas with more health facilities were more likely to have BCS rather than mastectomy. Thus, higher rates of BCS were seen in areas with a high density of radiation oncologists and a greater number of physicians (36,46), areas with a cancer care centre (46), and a high density of oncology treatment centres (41). Similarly, older patients who lived in areas with the presence of Senior Membership Programmes and Women’s Health Centres had higher rates of BCS (22). Areas with less availability of radiation oncology services within hospitals or hospital networks had higher rates of mastectomy and lower rates of mastectomy with reconstruction (42). Women from areas with a greater number of hospitals with radiation therapy megavolt equipment were more likely to receive BCS (29). Only a few findings were inconsistent: in this last study (29), women were more likely to receive BCS if they were in areas with a lower rate of physicians per 10,000 population. One study (41) also found that women in areas with a higher density of mammography screening centres are more likely to receive RT after BCS (41).

Area level socioeconomic status

Eleven studies, 10 in the US and one in Canada, examined and identified differences in the type of surgery received by breast cancer patients residing in areas of different socioeconomic status (26,29-34,38,40,46,48) (Table 4). All 11 studies found that women living in higher socioeconomic areas were more likely to receive BCS. In areas with a greater proportion of college graduates and higher education levels, patients were significantly more likely to receive BCS/BCT than mastectomy (29-31,33,38,46). Similarly, patients living in areas with a higher median income were more likely to receive BCS (30-34). Conversely, patients living in areas with a greater proportion of people living below the poverty line and in areas with lower median incomes were less likely to receive BCS and were significantly more likely to receive a mastectomy (26,30,32,33,40,46,48).

Discussion

This systematic review found that significant geographic variations existed in the receipt of different types of surgery in women diagnosed with early breast cancer. The evidence was generally consistent across the US as well as in the few studies from Canada, Australia, China, and Japan.

To our knowledge, this is the first systematic review on geographic variations assessed by area-level indicators in the types of surgery received by breast cancer patients. The review was limited to articles published in English only. As the majority of studies were published in the US (31 out of 40 studies included for review), the generalisability of our results may be limited as the healthcare systems are vastly different across countries, both in terms of funding and structure. As this review was based on peer-reviewed studies, we did not consider grey literature such as cancer registry reports or studies based on individual level data. We also excluded the studies that reported geographic differences only within a small area. We used the NOS scale to assess quality; this may not be sufficiently discriminating, as most studies received a high score. Several studies showed the size of these differences by odds ratios, which generally suggested variations of 20–50%, but the odds ratios were not comparable as they depended on the categorisation of the factors considered. Therefore, we do not present a quantitative meta-analysis.

We identified geographic variations in surgery types, in terms of urban and rural settings, distance and other aspects of accessibility to cancer care, and area-level socioeconomic status. In general, women living in urban areas, in close proximity to cancer care facilities, particularly radiation centres, and in more affluent neighbourhoods were more likely to receive BCS, and less likely to receive mastectomy. Similar findings have been reported in other narrative reviews on this topic (3,6,56). Ayanian et al. reported that patients living in urban and metropolitan areas were more likely to receive BCS than patients living in rural areas, with the likelihood of receipt of BCS being strongly associated with the size of the metropolitan region (6). Two other reviews also found that breast cancer patients were less likely to receive BCS if they had greater travel distance from cancer treatment centres and radiotherapy facilities (3,56). Other reviews have identified geographic disparities across the breast cancer care continuum, from diagnosis to survival (4,6,7,56). Overall, the evidence to date shows that area of residence and accessibility to cancer care play an important role in the types of cancer treatment received by breast cancer patients.

Our review of peer-reviewed literature showed that most studies were from the US. The US health care system has greater disparities in access to care than other developed countries (57). The few studies from other countries suggest their situation may be different. The only study not showing an urban-rural difference was from Australia (54), although the other Australian study did show an urban...
Inequities related to access to care exist in participation in screening programs, stage distribution and late diagnosis, and the use of most types of treatment. Radiotherapy is the most difficult treatment to provide equitably, as it requires expensive equipment, dedicated premises, and a specialised workforce. It is inevitable that many patients will live far from the nearest radiotherapy centre. The national radiotherapy plan for England proposes that all patients should live within 45 min travel time to their nearest centre, and so new satellite centres have been developed (62). Surgical services are more widely distributed, but quality varies, and there is good evidence that surgeons with higher cancer workloads give better outcomes (63), so access to the best service may be difficult. In Australia, BCS was less frequently used by women whose surgeons have a low case load, independently of the effect of rural residence (64). In northern Italy, lower use of BCS was seen in women treated at hospitals with low surgical volumes, as well as in those living far from radiotherapy facilities (65). Chemotherapy services can be provided locally if there is a system of training specialised nurses, and ensuring protocols used in the main centres are followed. Systems of giving primary care physicians extra training to enable them to supervise such services can be beneficial. Such a program exists in British Columbia, Canada, where rural patients were less likely to have BCS, but did not have reduced chemotherapy or hormonal therapy (66). Even primary care services for cancer have difficulties, and education and support for rural practitioners can be beneficial (67).

It seems likely that variations in the type of breast surgery used are largely driven by the requirement for radiotherapy after BCS and hence the issues of access to radiotherapy, which normally requires multiple visits over many weeks. New developments such as intra-operative radiotherapy, where radiotherapy is given only at the time of surgery, could improve access, but may be only appropriate for selected patients (68). It is understandable that women in rural areas more often opt to have mastectomy, thus avoiding the need for radiotherapy. However, the size of this variation may seem surprising. In Queensland, the use of BCS in very low access areas was less than half of that in the best access areas (13). In a study in 10 states in the US, the use of BCS was reduced by 30% in women living more than 75 km from a radiotherapy centre (45), with similar findings in South Dakota; but in New Jersey, similar disparities were seen in those living more than 15 km or 19 min travel time away (69). Distance from the centres relates to travel time, cost, and inconvenience. In New Hampshire,
a northern US state with severe winters, the use of BCS was lower with greater travel time, and also lower in winter. In Northern England, the use of BCS was not related to travel time in general, but was lower for women living in areas with no regular bus service (70).

It would be expected that variations in treatment by distance would be more marked for less affluent patients, in terms of direct cost, but also in terms of difficulties in employment and childcare. Few studies have appeared to look at this interaction, but several have reported lower BCS use in the lower socio-economic groups. In Florida, a reduction in BCS with increasing distance was seen in older women, but not in those under 50 years (71).

While these access issues have been well described, there seem to have been few interventions to improve them. In one area of New South Wales, the use of BCS showed no change after a free transport service to the nearest radiotherapy facilities (68 and 86 km distant) was introduced, but increased significantly when a local free radiotherapy service was started, with the largest increase for patients over age 70 (72).

Conclusions

This systematic review found that for women with early invasive breast cancer, higher rates of breast-conserving surgery rather than mastectomy were consistently associated with urban location, closeness to facilities, more advanced facilities, and higher socio-economic status. These variations were seen in many studies from the US, several having good control for clinical factors such as stage of disease, although our review did not address patient choice. Our findings highlighted that inequalities in care exist which may be substantial. The lack of studies from countries other than the US limits the ability to understand the extent of inequalities in other countries. There are no studies from low- or middle-income countries. Variations in care given, if not for clinical reasons or for informed patient choice, need to be documented and addressed in cancer care planning.

Acknowledgments

Funding for this review was provided by the generous contribution of the University of Auckland School of Medicine Foundation and Auckland Cancer Society Research Centre.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

12. Dorval M, Maunsell E, Deschênes L, et al. Type of


Supplementary

Medline (1946-2018) - 455 studies/articles identified
1. Search terms used
1. Breast cancer.mp.
2. Breast carcinoma.mp.
4. Breast Neoplasms/
7. 1 or 2 or 3 or 4 or 5 or 6
8. Rural.mp.
11. Metropolitan.mp.
12. suburb*.mp.
13. District.mp.
14. remote*.mp.
15. Remote population.mp.
16. Location.mp.
17. Geographic.mp.
18. Geographic pattern.mp.
20. Region.mp.
21. Spatial analysis/
22. Spatial analys*.mp.
23. Place of residency.mp.
24. Place of residence.mp.
25. Rural Population/
26. Rural population.mp.
27. Urban population/
29. Rural health/
30. Rural health services/
31. Hospitals, rural/
32. Urban health/
33. Hospitals, urban/
34. Travel distance.mp.
35. Travel time.mp.
36. Travel burden.mp.
37. Health service access*.mp.
38. Healthcare access*.mp.
39. Health service* accessibility.mp.
40. Health services accessibility/
41. Availability.mp.
42. Distance.mp.
43. utili#ation.mp.
44. Health service utili#ation.mp.
45. Geographic information system*.mp.
46. Geographic information systems/
47. Geospatial analysis.mp.
48. Geospatial analyses.mp.
49. Geographic mapping/
50. Small-area analysis/
51. Small area.mp.
52. Small area analy#s.mp.
53. Cancer map.mp.
54. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53
55. variation*.mp.
56. Disparity.mp.
57. Disparities.mp.
58. Healthcare Disparities/
59. Health care disparities.mp.
60. Inequality.mp.
61. Inequalities.mp.
62. difference*.mp.
63. Distribution.mp.
64. Disadvantage.mp.
65. 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64
66. radiotherapy/
67. Radiotherapy.mp.
68. Drug Therapy/
69. chemotherap*.mp.
70. Systemic treatment*.mp.
71. Systemic therapy.mp.
72. Systemic therapies.mp.
73. Local treatment*.mp.
74. Local therapy.mp.
75. Local therapies.mp.
76. hormon* therapy.mp.
77. hormon* therapies.mp.
78. Locoregional treatment*.mp.
80. Mastectomy/
81. Mastectomy.mp.
82. Breast conserving surgery.mp.
83. Mastectomy, Segmental/
84. Lumpectomy.mp.
85. Axillary surgery.mp.
86. General Surgery/
87. Surgery.mp.
88. Biological treatment*.mp.
89. Targeted therapy.mp.
90. Targeted therapies.mp.
91. Treatment.mp.
92. 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91
93. Receipt.mp.
94. Receiving.mp.
95. Compliance.mp.
96. Patient Compliance/
97. “Treatment Adherence and Compliance”/
98. 93 or 94 or 95 or 96 or 97/
99. 7 and 54 and 65 and 92 and 98