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Spatial and temporal changes of breast-conserving surgery rates and its influential factors among Chinese patients with breast cancer from 2013 to 2019: a registry-based study

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ABSTRACT

Objective Our study aims to evaluate the spatial and temporal changes of breast-conserving surgery (BCS) rates and influential factors of BCS in Guangdong Province, China.

Design, setting and participants This registry-based cohort study analysed the data of patients of all age groups, from the medical record cover page, which was mandatorily collected for inpatients by the Health Administrative Department of Guangdong Province, China. Patients with non-metastatic breast cancer, who underwent breast surgery between 2013 and 2019, were included.

Main outcomes and measures We analysed the BCS rate in Guangdong Province between 2013 and 2019. Logistic regression was applied to investigate the association between patient-level influential factors and BCS, respectively. We used restricted cubic spline regression to model the non-linear association between hospital volume rank with BCS rate. Linear regression was used to evaluate the association between city-level parameters with BCS rate of each city.

Results A total of 93 521 patients with non-metastatic breast cancer, who underwent breast surgery, were included in the analyses. Among them, 10 949 (11.7%) had BCS, with the BCS rates increasing from 0.8% in 2013 to 19.2% in 2019. Patients who were older (vs <40 years, 40–49 years: adjusted OR 0.72, 95% CI 0.68 to 0.76; 50–59 years: 0.51, 95% CI 0.48 to 0.54; ≥60 years: 0.37, 95% CI 0.35 to 0.40) and married (vs unmarried, 0.64, 95% CI 0.59 to 0.70) were less likely to undergo BCS. Patients who were employed (vs unemployed, 1.58, 95% CI 1.49 to 1.68), received cross-city surgery (vs local surgery, 1.37, 95% CI 1.31 to 1.44), lived in a high-income city (vs low-income city, β=4.40, 95% CI 1.55 to 7.24) or in a city with a higher number of physicians per 100 000 residents (0.57, 95% CI 0.31 to 0.82) were more likely to receive BCS.

Conclusions and relevance This study suggests a significant increase in BCS rates from 2013 to 2019 in Guangdong, China. Promotion of BCS is needed, particularly among older patients, lower-volume hospitals and economically underdeveloped areas. Healthcare system should be prepared to support the increased awareness of seeking BCS among younger patients with breast cancer by improving the availability of radiotherapy, multidisciplinary team and patients' education programme.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Our data were mandatorily collected by the governmental administration department for medical claims, ensuring high robustness.
⇒ Our analysis covered all tier hospitals in the whole province, providing comprehensive real-world insights into breast-conserving surgery rates and their influential factors.
⇒ Our data did not include outpatient records.
⇒ Information about tumour stages, molecular subtypes, non-surgical interventions such as chemotherapy schemes, and data on death were not included.

INTRODUCTION

In China, breast cancer has emerged as the most prevalent cancer among women.[1] In contrast to Europe and America where the median age of breast cancer diagnosis was 60–64 years, the median age of patients with breast cancer at diagnosis in China occurs a decade earlier at 50–54 years, posing a unique challenge due to the increasing incidence in younger patients.[2] These younger patients often have greater concerns regarding cosmetic outcomes after surgery.[3 4] Consequently, breast-conserving surgery (BCS) should be a primary consideration, given its benefits. Randomised controlled trials have demonstrated the survival equivalence of BCS with adjuvant radiotherapy and mastectomy.[5 6] The National Institutes of Health consensus conference endorses BCS as the preferred option for early-stage breast cancer due to its less invasiveness and superior cosmetic results.[7] In the USA and the UK, BCS rates have reached 60%.[8 9] In China, recent increases in BCS rates are notable. National and regional studies suggest BCS rates in China range from 17% to 30%.[10 11] However, these figures are primarily based on data from single centres or breast-specialised units that participate voluntarily, which may limit their representativeness. In less developed areas of China, where a vast number of patients with breast cancer receive treatment, BCS rates are presumably lower. Thus, a comprehensive real-world data analysis based on both developed and underdeveloped areas is essential to accurately map current BCS trends in China.

This study aims to explore the spatial and temporal changes in BCS rates among patients with breast cancer in Guangdong, a province with the largest population in China, using medical record cover page (MRCP) data from the Health Administration Department of Guangdong. The provincial Health Administration Department collected MRCP data from all inpatients with a mandatory and standardised method. It provides a reliable source for analysing real-world BCS rates.[12] Additionally, these data include patients' sociodemographic details, enabling an assessment of multiple factors influencing surgical decisions regarding BCS in a real-world context.

METHODS

Data source and study design

In this provincewide, retrospective, registry-based study, deidentified inpatient information was retrieved from the Hospital Quality Monitoring System (HQMS). In 2012, National Health Commission (NHC) of China introduced the HQMS to collect inpatient data by MRCP with a standardised national protocol. These data were used to evaluate the quality of the medical service provided by each hospital and to categorise diagnosis-related groups to serve as a basis for the state medical insurance budget distribution.[13] The information recorded in this cover page includes sociodemographic information; diagnosis codes based on the International Classification of Diseases, 10th revision (ICD-10); specific procedures coded under ICD-9 and the cost of each treatment during the inpatient period.[14] The details of the cover page can be seen in online supplemental appendix p2.

Data collection

The data were collated and cleaned centrally by the Health Administrative Department of Guangdong Province. Quality inspection of the data was conducted following specific guidelines before transferring to the NHC of China.[15] These records form the foundation for medical quality assessment, regulation and the allocation of provincial and national healthcare insurance budgets.[16] Given the massive amount of real-world data recorded by the MRCP, its potential in epidemiology and public health research is promising while remaining underexplored.[12] We included patients of all age groups, who were diagnosed with breast cancer as inpatients from 1 January 2013 to 31 December 2019, in Guangdong. ICD-10 codes used to identify breast cancer diagnosis were 'C50.000', 'C50.001', 'C50.100', 'C50.200', 'C50.300', 'C50.400', 'C50.500', 'C50.600', 'C50.800', 'C50.801', 'C50.802', 'C50.803', 'C50.804', 'C50.900', 'C50.901', 'C50.902', 'D05.000', 'D05.100', 'D05.700' and 'D05.900'). Among these patients, we further included those who underwent breast surgery. Patients who presented with distant metastasis before surgery were excluded from the analysis.

Data quality

The population of Guangdong province was 112 700 000 in 2013 and 124 890 000 in 2019.[17] The HQMS stored a total of 56 305 983 MRCP records in Guangdong from 4 252 998 (300 hospitals out of 1 222 registered hospitals) in 2013 to 11 584 447 (1552 hospitals out of 1 631 registered hospitals) in 2019. According to the ICD-10 codes of breast cancer, 756 328 records were extracted. Overall, there were 146 994 breast cancer cases in Guangdong from 2013 to 2019. The number of reported hospitals was lower before 2016 compared with later in Guangdong Province. Although fewer than 522 hospitals submitted their inpatient's data to HQMS from 2013 to 2015, these hospitals are leading hospitals that covered the majority (>90%) of patients with breast cancer in Guangdong (online supplemental etable 1).

Definitions of variables

Patient-level variables

Patients were categorised into four age groups by their age at the time of surgery: <40 years, 40–49 years, 50–59 years and ≥60 years. Marital status was categorised into married and unmarried. Employment status was classified as employed and unemployed. Payment type was categorised into urban insurance, rural or poverty insurance, public-funded care and others. For surgery location, cross-city surgery patients were defined as those who had at least one breast surgery in the city other than their residence city (online supplemental appendix p4).

Hospital-level variables

Hospital volume rank was ranked by the number of breast surgeries performed at each hospital over a 7-year period from 2013 to 2019. We then categorised hospital into four hospital rank categories: rank 1–25, rank 26–50, rank 51–75 and rank >75.

City-level variables

Income levels of the residence city were divided by the gross domestic product (GDP) per capita between 2013 and 2019 of each city with <25% percentile as low income, 25%–74% percentile as middle income, and >74% percentile as high income. GDP per capita and the medical resource parameters of each city including the number of physicians per 100 000 residents and the number of hospital beds per 100 000 residents were extracted from the Guangdong statistical yearbook.[17] Average values of these parameters between 2013 and 2019 were applied in the analysis. 21 cities in Guangdong Province were divided into the following four geographical regions: the Pearl River Delta region, eastern Guangdong, western Guangdong and northern Guangdong.

Statistical analysis

Continuous variables were presented as the mean and standard deviation (SD) and categorical variables were described as frequency and percentage. At the patient level, we employed logistic regression to assess the influential factors associated with BCS with basic adjustment of age and full adjustment of age group, marital status, employment status, payment type, and surgery location. Adjustment variables for both logistic were selected based on prior experience and required to be statistically significant with outcome variables in univariable regression analysis. We also modelled the non-linear association between OR of having BCS with age using restricted cubic spline (RCS) with five knots. At the hospital level, we used linear regression and RCS regression with five knots to evaluate the association between BCS rate and hospital volume rank. All statistical analyses were performed using R V.4.3.1. All the raw and cleaned data were archived and analysed using a computer system assigned and supervised by the Health Administrative Department of Guangdong, and all the statistical results for reporting were approved.

Patient and public involvement

Patients and the public were not involved in the design, conduct and reporting of this research.

RESULTS

Spatial and temporal changes of BCS rates in Guangdong

After exclusion, the current analyses included 93 521 patients with non-metastatic breast cancer, who received surgical treatment in 629 hospitals between 2013 and 2019. Among them, 10 949 (11.7%) underwent BCS (table 1). The BCS rates increased from 0.8% in 2013 to 19.2% in 2019. Patients aged <40 years had the largest increase in BCS rates, while the smallest increase was observed in patients aged ≥60 years (figure 1). Only 13.4% of hospitals (84/629) achieved BCS rates greater than 20% and a substantial proportion of hospitals (74.2%, 467/629) reported BCS rates below 10%. Hospitals ranked 1–25 showed the steadiest increase in BCS rates since 2013, whereas other hospital rank categories had a drastic increase after 2015 but still lagged behind those ranked 1–25. Patients who received breast surgery in the Pearl River Delta region had the highest BCS rates, while those in western Guangdong had the lowest, over these 7 years.

Table 1 Background characteristics of patients with breast cancer from 2013 to 2019 in Guangdong Province

	Patients with non-metastatic breast cancer underwent breast surgery (n=93 521)
Mean age, years (SD)	51.2 (11.1)
Age group (%)	
<40 years	12 501 (13.4)
40–49 years	32 757 (35.0)
50–59 years	26 812 (28.7)
≥60 years	21 451 (22.9)
Marital status (%)	
Married	88 986 (95.7)
Unmarried	3974 (4.3)
Employment status (%)	
Employed	74 979 (80.2)
Unemployed	18 542 (19.8)
Payment type (%)	
Rural or poverty insurance	9 330 (10.0)
Urban insurance	61 508 (65.8)
Free medical service	3351 (3.5)
Other payments	19 332 (20.7)
Surgery type (%)	
Breast-conserving surgery	10 949 (11.7)
Mastectomy	82 572 (88.3)
Surgical location (%)	
Cross-city surgery	22 942 (24.6)
Local surgery	70 184 (75.4)
Region of residence (%)	
Pearl River Delta	57 440 (61.6)
Eastern	14 045 (15.1)
Western	10 769 (11.6)
Northern	10 966 (11.8)
Hospital rank category (%)	
Rank 1–25	47 974 (51.3)
Rank 26–50	18 035 (19.3)
Rank 51–75	9093 (9.7)
Rank>75	18 419 (19.7)

Data are n (%) or mean (SD).

Influential factors of BCS

At the patient level, the fully adjusted logistic regression shows that patients of older age (vs<40 years, 40–49 years: adjusted OR 0.72, 95% CI 0.68 to 0.76; 50–59 years: 0.51, 95% CI 0.48 to 0.54; ≥60 years: 0.37, 95% CI 0.35 to 0.40) and being married (vs unmarried, 0.64, 95% CI 0.59 to 0.70) were less prone to undergo BCS (figure 2A). Patients covered by urban insurance (2.75, 95% CI 2.50 to 3.01), public-funded care (1.46, 95% CI 1.25 to 1.70),

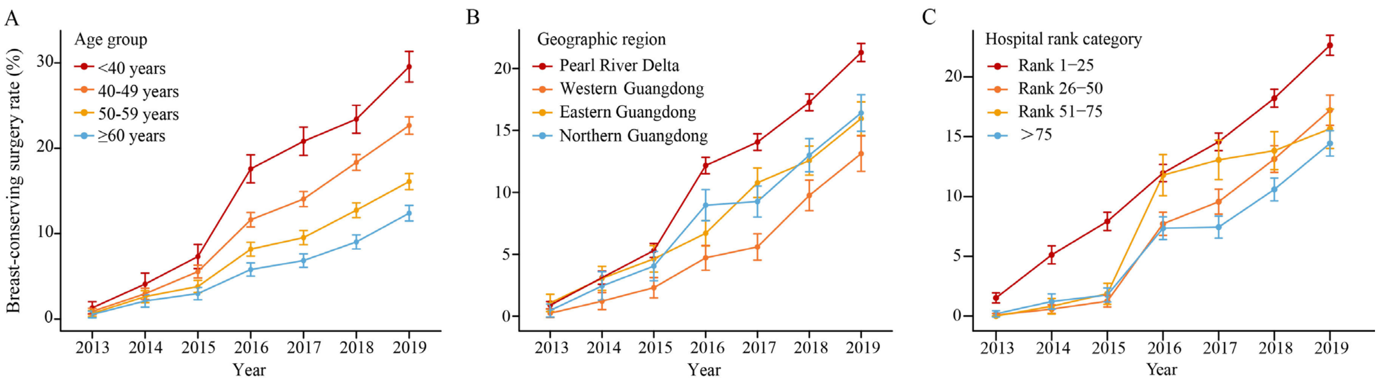

Figure 1 The trends of breast-conserving surgery rates in Guangdong from 2013 to 2019. (A) Breast-conserving surgery rates among breast surgery in four age groups. (B) Breast-conserving surgery rates among breast surgery in four subregions. (C) Breast-conserving surgery rates among breast surgery in four hospital rank categories.

and other payments (2.10, 95% CI 1.89 to 2.33) were more likely to have BCS compared with those paid by rural or poverty insurance. Patients being employed (vs unemployed, 1.58, 95% CI 1.49 to 1.68), and with cross-city surgery (vs local surgery, 1.37, 95% CI 1.31 to 1.44) were more likely to undergo BCS. We used the RCS to further investigate the non-linear association between age and BCS. The RCS plots revealed that the odds of having BCS decreased significantly as age increased with a particularly marked preference for mastectomy after the age of 50 years (figure 2B,C).

In the hospital-level analysis, we investigated the relationship between hospital volume rank and their BCS rates. Over 80% of patients opted for the top 100 hospitals by hospital volume rank for having breast surgery (online supplemental efigure 1).

Linear regression analysis revealed a significant decrease in BCS rates at hospitals with lower rank (p=0.032), which was also confirmed by the RCS regression (figure 3A). Notably, the hospital group ranked >75 exhibited significantly lower BCS rates compared with higher hospital rank categories (all p<0.001, figure 3B).

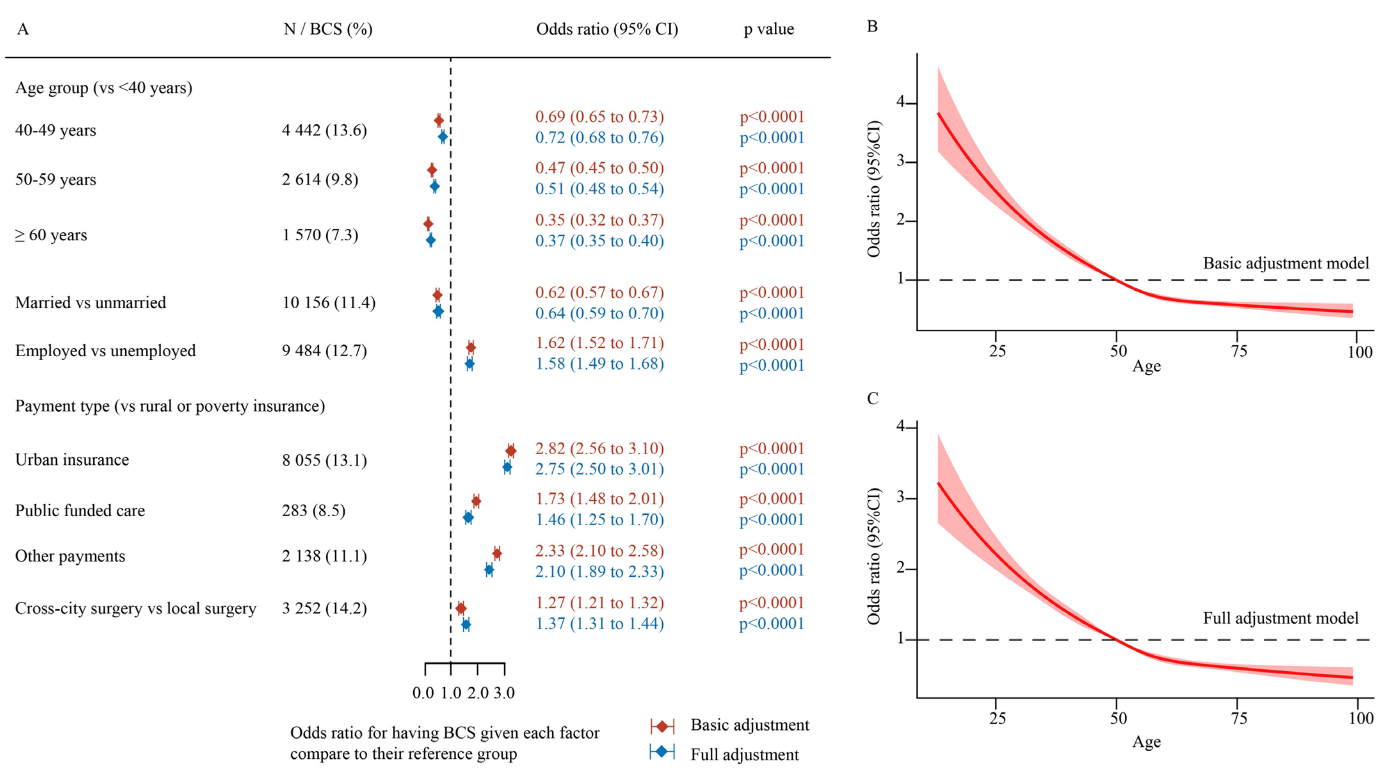

Figure 2 The association between odds of having breast-conserving surgery (BCS) and age groups and other covariates. (A) Forest plot of ORs for the associations between BCS with influential factors. (B) Change in ORs for having BCS with age increase from the basic adjustment model. (C) Change in ORs having BCS with age increase from full adjustment model. Basic adjustment: adjusted for age group. Full adjustment: adjusted for age group, marital status, employment status, payment type and surgery location.

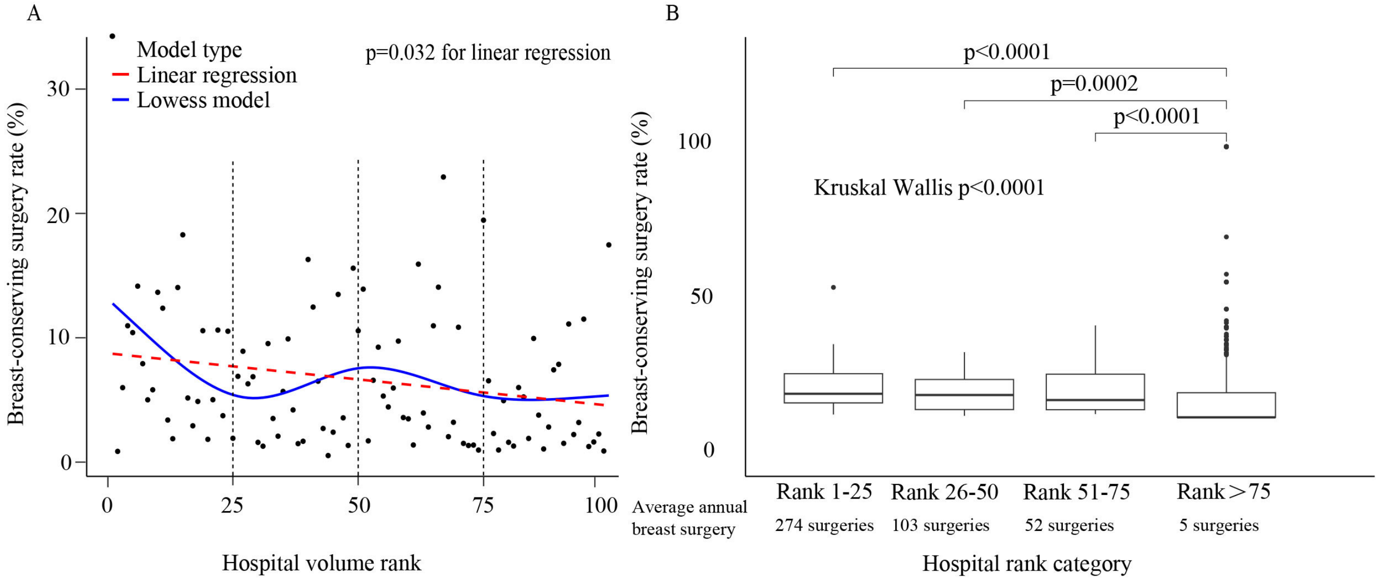

Figure 3 Breast-conserving surgery (BCS) rate by hospital volume rank and hospital rank categories. (A) Linear regression and restricted cubic spline regression model with five knots for the association between BCS rate with hospital volume rank. (B) Box plot for BCS rate in each hospital rank category. In the box plot, the Kruskal-Wallis test was used to test the differences in the BCS rate among different hospital rank categories. The Wilcoxon rank sum test was used to test the differences in the BCS rate between hospitals with a rank >75 and other hospital volume rank categories.

In the city-level analysis, multivariable linear regression indicated that cities with high-income levels (vs low-income cities, β=4.40, 95% CI 1.55 to 7.24) and a larger number of physicians per 100 000 residents (0.57, 95% CI 0.31 to 0.82) were associated with higher BCS rates (table 2). The change in BCS rates increased with the number of physicians per 100 000 residents and the GDP per capita of each city for each year from 2013 to 2019 (online supplemental efigure 2).

DISCUSSION

Currently, the BCS rate is considered an indicator of the breast cancer service performance for an institution or a region. The EUSOMA and the National Accreditation Program for Breast Centers encouraged their accredited breast centres to achieve BCS rates >70% and 50% in eligible patients, respectively.[18 19] However, the BCS rate in real-world scenarios in China remains unknown. Our study presented the spatiotemporal changes of BCS rates and their multilayer influential factors in the real-world scenario. Focusing on Guangdong, a province renowned for its robust economy and abundant medical resources, our findings indicate a disconcerting reality. The BCS rate in Guangdong was 19.2% in 2019, and only 13.4% of hospitals reached a 20% BCS rate. Given Guangdong's relative economic and medical advantages, these findings suggest that regions with less economic prosperity may face even greater challenges in achieving recommended BCS rates. The enhancement of BCS rate remains a significant and pressing task in China.

Optimistically, our study reveals a significant increase in BCS rate within Guangdong over these 7 years, particularly in younger populations. This improvement can be attributed to efforts from domestic breast surgery

Table 2 City-level analysis for the association between the breast-conserving surgery rate with each city-level parameter

	Univariable				Multivariable			
	Coefficient (95% CI)			P value	Coefficient (95% CI)			P value
Proportion of patients with breast cancer above 50 years	−0.15	−0.31	0.01	0.065				
Income level of the residence city								
Middle	4.55	2.00	7.10	0.001	1.71	−0.82	4.24	0.183
High	7.34	4.46	10.23	<0.0001	4.40	1.55	7.24	0.003
Number of hospital beds per 100 000 residents	0.18	0.09	0.28	<0.0001	0.05	−0.06	0.16	0.334
Number of physicians per 100 000 residents	0.47	0.29	0.65	<0.0001	0.57	0.31	0.82	<0.0001
Proportion of cross-city patients with breast cancer surgery	0.02	−0.03	0.07	0.472				

experts and academic organisations, who have established national guidelines and consensus documents. These include the 2013 and 2015 versions of the breast cancer treatment guideline by the Chinese Anti-Cancer Association, the 2018 national breast cancer treatment guideline, and the 2019 BCS consensus from the Chinese Association of Breast Surgery.[20–23] Additionally, the government also funded research on promoting BCS adoption.[24] Moreover, the improvements in oncological services including multidisciplinary team (MDT) and radiotherapy also played a pivotal role.[25 26] Further, patients with breast cancer are qualified with anti-cancer insurance funded by the government that covers the use of radiotherapy after BCS.[27] All of these initiatives have encouraged breast surgeons to consider BCS for their patients. Additionally, with increasing recognition of the cost-effectiveness and long-term benefits of these surgical approaches, more patients might be opting for BCS.[24 28] Despite the improvement, the overall BCS rate in China is still far lower than in developed countries. A study showed that the BCS rate among the top cancer hospitals in China was only 11% between 1999 and 2008.[29] In 2018, a survey distributed to representatives of 520 hospitals revealed that only 7% of these hospitals had achieved a BCS rate exceeding 50%.[30] The lower BCS rate in China, compared with the USA, aligns with expectations, reflecting factors like the higher prevalence of advanced breast cancer at diagnosis—possibly due to China's lack of a national screening programme—and the generally smaller breast size of Chinese women.[31] Additionally, the deficiency in radiotherapy and inadequate technique utilisation among physicians are likely contributing to this discrepancy.[5 31 32]

Large-scale studies investigating sociodemographic factors associated with BCS remain sparse in China. A review from Western countries indicated associations between BCS and factors such as patient age, hospital proximity and surgeon caseload.[33] This study confirms age as a critical factor in surgical decisions at the individual level, consistent with existing literature. Although BCS rates have risen more quickly among younger patients, they still fall short of those in Western counterparts.[8 9] Furthermore, the persistently low BCS rate among elderly patients in China demands attention. Unlike in the USA, where BCS rates exceed 50% across age groups, including those over 70, China requires intensified initiatives to boost BCS among its elderly. These should focus on broadening breast cancer screening, enhancing access to radiation facilities and amplifying patient awareness of BCS benefits.[34 35]

Our data show that most hospitals (73.9% or 467 hospitals) had BCS rates under 10%, and a mere 13.8% (87 hospitals) surpassed 20% from 2013 to 2019 in Guangdong. Hospitals with higher breast surgery volumes also reported greater BCS rates, echoing prior research.[36 37] This disparity in BCS performance across hospitals suggests a gap in expertise and resources. Addressing this requires forming networks between higher and lower-ranked hospitals. Elward *et al*'s study exemplifies the success of this strategy, where a year-long collaborative project in 40 Virginia hospitals notably minimised BCS rate discrepancies, elevating the lowest performers from 6.6% to 21.2%.[38] This presents a valuable model for China to emulate and improve on.

Previous studies have documented regional variations in BCS rates, a phenomenon also observed in our study.[39 40] Further, our results link city economic status to BCS rates. The BCS rate was higher in cities with higher income and a larger number of physicians. This factor influences individuals to seek BCS outside their hometowns, reflecting regional imbalance in China's medical resources.[41] Our results show that over 80% of patients opted for the top 100 hospitals by inpatient volume (online supplemental efigure 1). In response, current initiatives like the Integrated Health Networks programme, promoting remote support from advanced hospitals to rural clinics, are addressing healthcare access disparities. National expansion of such initiatives could improve primary care and balance medical services.[42] Finally, a Dutch study suggests that adopting nationwide BCS guidelines and landmark trials could diminish regional discrepancies.[43]

Patients often seek cross-city surgery in pursuit of superior hospitals, expecting better clinical outcomes.[44] However, this assumption might not apply to breast surgery, which is often considered less complex. Research from the USA and Taiwan shows that patients with breast cancer in high-volume hospitals have reduced 5-year recurrence and mortality rates, though these studies did not differentiate by surgery type.[45 46] Mastectomy patients, typically in advanced stages and requiring adjuvant local and/or systemic therapies, benefit from MDT discussions and integrated therapy available in higher-ranked hospitals. Conversely, early-stage BCS patients generally have consistent outcomes, regardless of local or cross-city surgery, hinting that travelling for BCS might be superfluous.

Limitations

Our study has several limitations. First, the HQMS data only covered hospitalised patients with breast cancer, providing limited information about outpatients. Yet, as most patients with breast cancer seeking surgery at inpatient department due to insurance stipulations, our research broadly represents the surgery demographic.

Additionally, initial hospital reporting rates were low, at 30%–40% in the first 3 years. However, as breast cancer admissions in Guangdong are concentrated, about 90% of subsequent cases were reported by these initial hospitals. Given China's medical resource imbalance, patients often favour select tertiary hospitals. Thus, our study's HQMS data are largely complete and reliable for drawing conclusions within Guangdong.

Moreover, our study excluded Guangdong residents treated in other provinces, possibly causing undercoverage bias. Future research could overcome this by employing National HQMS data for a more inclusive analysis. Furthermore, the lack of robust data sources about the comprehensive breast cancer treatment such as radiotherapy, MDT and endocrine therapy may be avoided for further adjustment of the confounding for the adoption of BCS.

Lastly, given the lack of concrete information about tumour stages, molecular subtypes, non-surgical interventions such as chemotherapy schemes and incomplete data on mortality, the analysis of the prognosis cannot be robustly done.

Conclusions

This study presents the first real-world data charactersing the spatiotemporal changes of the BCS pattern in Guangdong, China. From 2013 to 2019, there was a significant increase in BCS rates in the Guangdong Province, though it still lags far behind Western countries. Healthcare system should be prepared to support the increased awareness of seeking BCS among younger patients with breast cancer by improving the availability of radiotherapy, MDT and patients' education programme. Notably, the rates were particularly lower among elderly patients, hospitals with lower volume rank and economically underdeveloped areas. Therefore, targeted efforts are essential to enhance BCS rates within these groups.

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Contributors KC is the guarantor. KC, XH and QL conceived the study. PY, JH, ES and WH provided methodological support. QL, KC, SL, TS and LZ wrote the manuscript. QL, KC and TS conducted data analyses. YY, ZZ, XW and LD performed data cleaning. JZ, YX, QC and QY conducted the literature search. WH and ZL performed the data collection. All authors interpreted the data, revised the manuscript for important intellectual content and approved the final version. The first and last authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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Competing interests None declared.

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Patient consent for publication Not applicable.

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