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ORIGINAL ARTICLE

Association between variations in the number of hospital beds and inpatient chemo/radiotherapy for breast cancer: a study using a large claim database

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ABSTRACT

Objective: Chemo/radiotherapy for breast cancer patients does not require hospitalisation in most cases. We investigated the relationship between the proportion of hospitalisation for chemo/radiotherapy over total hospitalisation and the number of hospital beds per capita among breast cancer cases.
Design: A retrospective observational study.
Setting: Hospitals in Japan.
Participants: In total, 561,165 records of hospitalisation of breast cancer cases were extracted from the Japanese Diagnosis Procedure Combination database from April 2012 to March 2016.
Intervention(s) and main outcome measure(s): A multivariable beta regression model accounting for the clustering effect within each prefecture was used to examine the relationship between the number of hospital beds per capita in each prefecture and the proportion of hospitalisation for inpatient chemo/radiotherapy treatment or the number of surgical operations for breast cancer patients in each prefecture.
Results: The proportion of hospitalisation for inpatient chemo/radiotherapy treatment varied from 2.6% to 61.8% in 2016. The logit proportion of hospitalisation for inpatient chemo/radiotherapy treatment was significantly higher for every additional hospital bed per capita (0.0027, 95% confidence interval (95% CI) 0.0014–0.0040). In contrast, no significant relationship was observed between the number of surgical operations for breast cancer per capita and the number of hospital beds per capita.
Conclusions: We found that a higher number of regional hospital beds were associated with a higher proportion of hospitalisation for chemo/radiotherapy treatment, suggesting that inpatient chemo/radiotherapy may be a provider-induced practice.

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Maldistribution of beds; oncology; provider induced demand; health care system

Background

Growing health expenditure due to advances in technology and aging societies is a significant global problem. Given that health expenditure accounts for a substantial fraction of national expenditure and has increased in many countries, cost containment for healthcare is becoming an urgent issue. This is particularly crucial in Japan given the country's significant aging problem: the aging rate increased from 20.2% in 2005 to 26.6% in 2015 and is estimated to reach 30.0% in 2025 [1]. As of 2015, health expenditure as a percentage of total gross domestic product in Japan was 10.3%, an increase of 3.1% from 2005 [2,3].

According to a report from the Institution of Medicine, 30% of all healthcare resource expenditure is quality-associated waste, including unnecessary treatments and simple inefficiency [4]. A contributing factor to this waste is 'provider-induced demand', an economic term that means, in this case, doctors influence patient demands for the doctor's own interests. Doctors in high medical spending regions provide more care or intervention in discretionary settings than those in low-spending regions in the U.S. [5,6]. While residents in higher health expenditure regions receive more care, they do not have a better quality outcome of care [7]. From a macro viewpoint, previous studies have shown a correlation between healthcare employment and health expenditure [8]. The number of hospital beds per capita in Japan is the highest among developed countries and there is a strong correlation between the number of hospital beds per capita and health expenditure.

Despite an increase of USD 133 billion in global spending in the oncology field in 2017 [9,10], few studies have examined provider-induced demand in this area. The presence of provider-induced demand in oncology care may suggest massive potential savings of financial resources. One randomised controlled trial revealed that inpatient chemotherapy did not provide any clinical advantage to patients, including clinical survival outcome and quality of life, compared to

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Supplemental data for this article can be accessed here.

outpatient chemotherapy [11]. Despite limited evidence, there is a consensus that patients are highly satisfied with chemotherapy in an outpatient setting compared to an inpatient setting [12]. In Japan, a patient's decision to receive chemotherapy in an inpatient or outpatient setting is influenced only by their doctor's preference due to the availability of the universal health coverage system. In this system, the coinsurance rate is fixed at 30% of the total actual expenditure for any type of care [3]. The monthly maximum out-of-pocket expense is also fixed at a low level (approximately USD 800) [3]. Thus, patients' out-of-pocket payments for chemotherapy are similar in the two settings. However, there is an unignorable difference in total actual expenditure for chemotherapy in inpatient compared to outpatient settings, with the former being much higher than the latter (Supplementary Table 1). Chemotherapy in an outpatient setting is not only a better option because of the lower total expenditure, but patients are also happier when they can return to their usual surroundings (home, work/office).

Understanding the relationship between the number of hospital beds and inpatient chemotherapy rate may help many countries, including European and Asian countries, improve their healthcare policies regarding chemotherapy given that most chemotherapy is still provided in an inpatient setting in many countries [13].

In this context, 'providers' refers to doctors who care for patients in different setting in terms of the availability of hospital beds for chemotherapy or radiotherapy for breast cancer patients. In this study, we aimed to investigate whether provider-induced demand exists for care among breast cancer patients in three steps. First, we examined the geographic variation in the proportion of hospitalisation for inpatient chemo/radiotherapy treatment over total hospitalisation for breast cancer. Second, if there was any variation, we confirmed whether health resources, including the inpatient chemotherapy rate and the number of hospital beds, related with breast cancer fatality rates. Finally, we examined the relationship between the proportion of hospitalisation for inpatient chemo/radiotherapy treatment and the number of regional hospital beds per capita. We chose a breast cancer cohort for this study because patients are relatively young and should therefore have less heterogeneous background characteristics, including comorbidities, than patients with other types of malignant disease. Moreover, neo/adjuvant therapy for early-stage patients, who comprise 95% of all breast cancer patients, is highly standardised [14].

Methods

Study design, setting and data sources

This is the retrospective observational study analysing the records of hospitalisation of breast cancer cases extracted from the Japanese Diagnosis Procedure Combination (DPC) database from April 2012 to March 2016. The unit of analysis of this study was prefecture, and we aggregated the hospital-level records into prefecture-level data (Figure 1).

To determine the aging rate, the proportion of the Japanese population aged over 65 years and the total population of each prefecture were obtained from the *National Population Census* in 2015 and the *Annual Report of Population Estimates* by the Ministry of Internal Affairs and Communications in 2012–2014 and 2016. The average salary of employees of each prefecture was used as a proxy for the

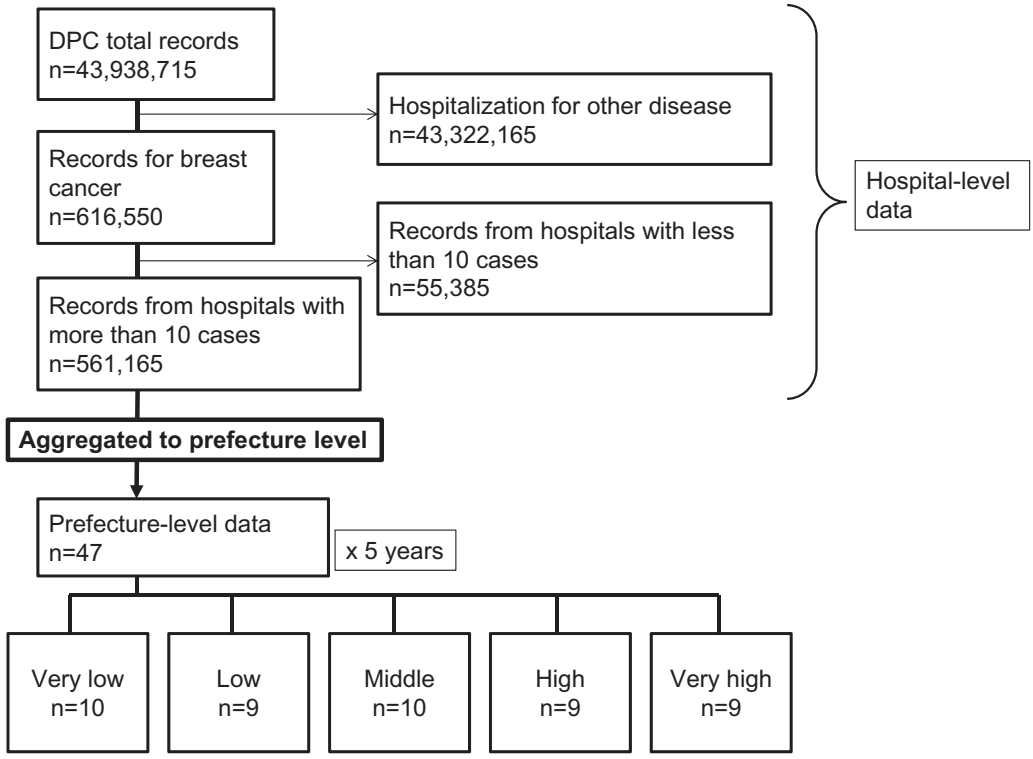

Figure 1. Flow diagram of the patient records selection and aggregation process. The quintiles are based on the number of hospital beds per capita in 2016. DPC: diagnosis procedure combination.

average salary of each prefecture and was obtained from the *Basic Survey on Wage Structure* by MHLW. Average driving time to the hospital for breast cancer patients was obtained from the DPC database and estimated using the patients' zip codes and hospital addresses in 2013–2015. The number of doctors and specialists certified by the Japanese Breast Cancer Society (breast cancer specialists) was obtained from the *Survey of Doctors, Dentists, and Pharmacists* conducted in 2012, 2014 and 2016. The incidence and mortality rate of breast cancer in each prefecture was obtained from the Cancer Registry and Statistics, National Cancer Center in 2013. We defined the fatality rate as the mortality rate over the incidence rate.

The Japanese healthcare system

Almost all residents of Japan are covered by the universal public health insurance system. Reimbursement prices for hospital care, procedures, tests, prescribed drugs and clinic visits are fixed by the government in a system called the single price system [3]. Japan comprises 47 prefectures at the first level of the administrative division, including the metropolis of Tokyo and two urban prefectures [3]. As the total number of hospital beds is strictly controlled by the prefecture governor, every hospital CEO must obtain approval from the prefecture governor to open a hospital or to change the number of beds in a hospital. However, the number of beds per capita (100,000 people) varies from prefecture to prefecture because control of bed number is a relatively new regulation, established in 1985.

Outcome and exposure of interest

Our primary outcome was the proportion of hospitalisation for inpatient chemo/radiotherapy treatment over total hospitalisation for any treatments or tests/examinations for breast cancer (proportion of hospitalisation for inpatient chemo/radiotherapy treatment) in each prefecture. Total hospitalisation included all hospitalised cases for breast cancer treatment. In clinical practice, patients with breast cancer are hospitalised to receive surgery (in most cases), chemotherapy, radiotherapy, and, to treat the symptoms caused as adverse events of treatments or ease the symptoms induced by breast cancer metastasis. Inpatients who received chemo/radiotherapy were defined as patients with breast cancer who did not receive a surgical operation but received non-surgical procedure II, which includes chemotherapy, radiotherapy, haemodialysis therapy, respiratory management and central catheterisation, and were admitted to hospital under the DPC payment system. Given that a survey report evaluating the DPC system showed that 98.8% of breast cancer patients classified under non-surgical procedure II received either chemotherapy or radiotherapy, we regarded the number of cases that received non-surgical procedure II as the number of cases that required chemo/radiotherapy treatment [15].

An additional outcome was the number of breast cancer surgical operations per capita in each prefecture. Breast cancer surgery was defined as either a mastectomy (simple, partial, radical, modified radical or total) with or without lymph node removal or any reconstructive surgery.

The exposure of interest was the number of hospital beds per capita in each prefecture. The definition of hospital beds in this study included all governor-approved hospital beds, including acute care beds and beds for infectious disease control and tuberculosis, and excluded both long-term care beds and beds for psychiatric disease.

Statistical analysis

The 47 prefectures were divided into quintiles (five equally sized groups) based on the number of hospital beds per capita to compare the characteristics of prefectures. Prefecture characteristics, the proportion of hospitalisation for inpatient chemo/radiotherapy treatment, and the number of surgical operations were compared among quintiles using the Kruskal–Wallis test for non-normal distributed variables and the ANOVA test for normal distributed variables.

A linear regression model was used to examine the association between the fatality rate due to breast cancer and proportion of hospitalisation for inpatient chemo/radiotherapy treatment, and between the fatality rate and the number of hospital beds per capita. A multivariable regression model was used to adjust for other covariates including the aging rate, number of doctors and breast cancer specialists per capita, average salary of the general population excluding business owners and employees of very small businesses (less than five employees in a company) in each prefecture, and average driving time to the hospital. The purpose of adjusting for average salary was to account for potential confounding due to socioeconomic status. Further, adjustment for average driving time to the hospital for breast cancer patients was conducted to account for the difference in doctors' or patients' preference between urban and suburban regions, where residents may prefer inpatient chemo/radiotherapy due to the need to travel longer distances.

Missing data for driving time and the number of doctors and breast cancer specialists per capita were imputed using a linear regression model with the outcome and other covariates (the number of hospital beds, aging rate, income and year). We assumed unobserved measurements were missing at random. For each imputation, we generated 10 imputed datasets and combined the coefficient estimates.

As a primary analysis, we examined the association between the number of hospital beds per capita and the proportion of hospitalisation for inpatient chemo/radiotherapy treatment. As an additional analysis, we examined the association between the number of hospital beds per capita and the number of surgical operations performed for breast cancer per capita. A beta regression model accounting for the clustering effect within each prefecture after adjusting for year indicators and aging rate was used. We used this strategy because our outcome variable is proportion bounded between 0 and 1 [16]. A sensitivity analysis was performed by adjusting for the number of doctors and

breast cancer specialists per capita, average salary and average driving time to the hospital.

The reported p values are two-sided and $\alpha < 0.05$ was used as the level of statistical significance. Point estimates are reported with 95% confidence intervals (95% CIs). All analyses were performed using STATA (version 15.1; StataCorp LLC, College Station, TX, USA) using the module *betafit*. SPSS (IBM SPSS, version 25; Armonk, NY, USA) was used to generate the figures.

Results

Regional variation

Over the five-year study period, there were 561,165 records of hospitalisation of breast cancer cases (Figure 1). The number of hospital beds per capita ranged from 492 to 1094 in 2016. The geographic trend in the number of hospital beds per capita by prefecture is shown in Figure 2 and Supplementary Figure 1. The prefectures in the highest (very high) or second-highest (high) quintiles of the number of hospital beds per capita were mainly located in the west of Japan. Table 1 shows the variation in characteristics of the prefectures in each quintile in 2014. There were significant differences in all characteristics except the number of breast cancer specialists and the incidence rate of breast cancer among the quintiles (p= .16 and .37, respectively). The average age of residents was lower in the lower quintiles. The same trend was observed in the aging rate and number of doctors per capita. In contrast, the average annual salary was higher in the lower quintiles.

Figure 3 shows the variation in the proportion of hospitalisation for inpatient chemo/radiotherapy treatment over total

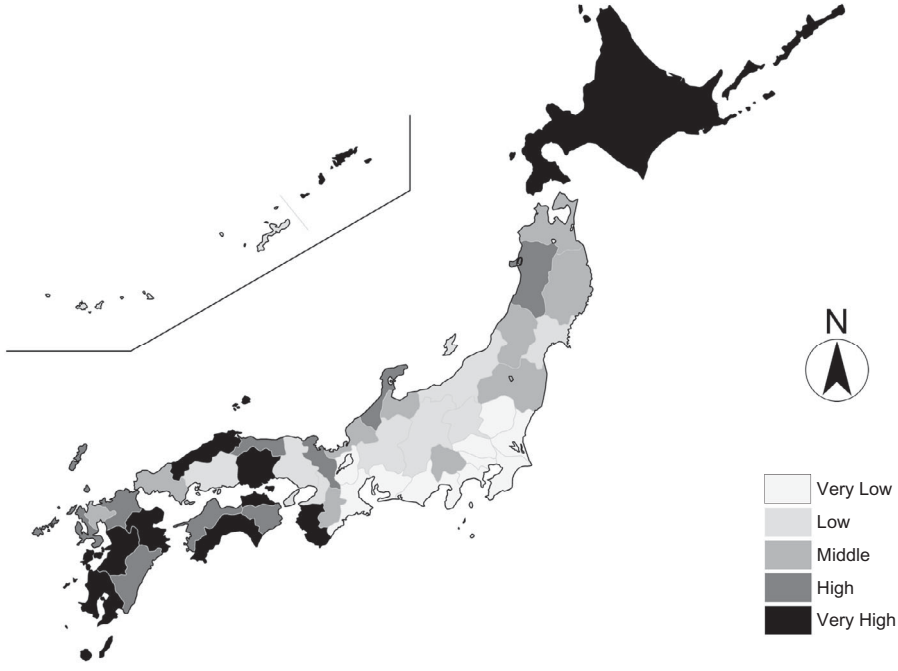

Figure 2. Geographic trend in the number of hospital beds per capita by prefecture. The quintiles are based on the number of hospital beds per capita in 2016. Prefectures in the highest (very high) and second highest (high) quintiles of the number of hospital beds are mainly located in the west of Japan.

Table 1. Prefecture characteristics by the number of hospital beds per capita in 2014.

	Very low ($N=10$)	Low ($N=9$)	Medium ($N=10$)	High ($N=9$)	Very high ($N=9$)	p Value
General hospitals, per 100k	586 [540–626]	719 [685–741]	791 [769–808]	873 [852–877]	933 [910–984]	<.001
Health expenditure, per capita (USD)	2,394 [2235–2476]	2,591 [2501–2673]	2,688 [2619–2763]	2,983 [2958–3116]	3,177 [2956–3216]	<.001
%Population aged 65 or older, %	25 [23–27]	26 [25–27]	28 [28–30]	29 [27–30]	29 [28–31]	<.001
Driving time, min	28 [22–30]	29 [27–31]	32 [28–40]	35 [30–42]	40 [37–42]	.001
Doctors, per 100k	209 [189–216]	232 [227–250]	232 [204–251]	301 [264–311]	282 [271–287]	<.001
Breast cancer specialists, per 100k	1 [0.7–0.8]	1 [0.7–1.1]	1 [0.5–1]	1 [0.6–1.1]	1 [0.9–1.1]	.157
Annual salary, per capita (USD)	43 [43–48]	40 [39–42]	38 [34–40]	37 [34–40]	37 [36–38]	<.001
Breast cancer incidence, per 100k (2013)	106 [100–109]	109 [106–110]	110 [102–117]	115 [108–117]	110 [101–118]	.37

Values indicate median [interquartile range]. p Value: Kruskal–Wallis's test.

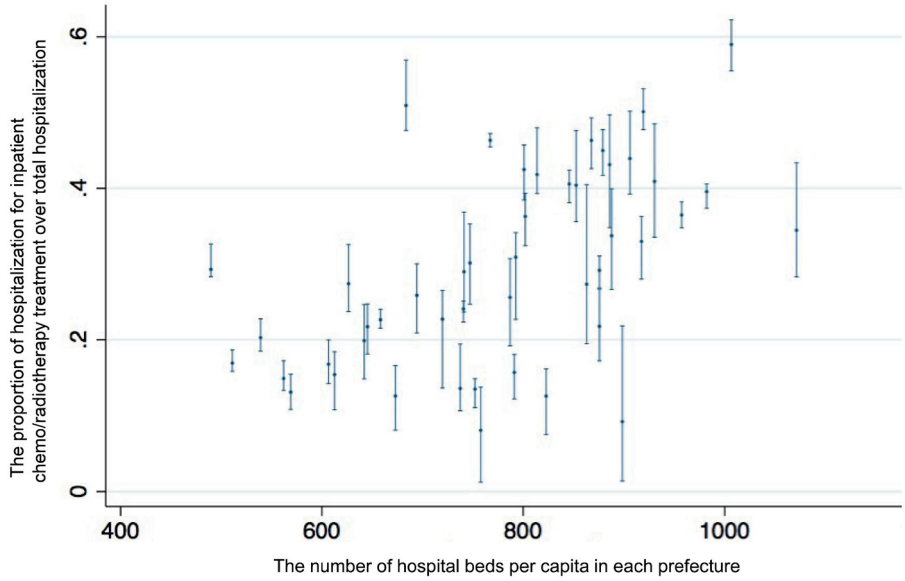

Figure 3. Regional variation in the proportion of hospitalisation for inpatient chemo/radiotherapy treatment over total hospitalisation in the order of the number of hospital beds per capita. Each vertical line represents the range (2012–2016) for each prefecture ($n = 47$). Each dot represents the median for each prefecture.

hospitalisation in each prefecture. The proportion in each prefecture ranged from 2.6% to 61.8% in 2016.

Fatality rate for breast cancer and health resources

There was no significant association between the fatality rate for breast cancer and the proportion of hospitalisation for inpatient chemo/radiotherapy treatment or the number of hospital beds per capita (Supplementary Figure 2). The proportion of hospitalisation for inpatient chemo/radiotherapy treatment and number of hospital beds per capita were likewise not significantly related with the fatality rate after adjusting for other variables in the multivariable model.

Association between the proportion of hospitalisation for inpatient chemo/radiotherapy treatment and the number of hospital beds

In the beta regression model analysis after adjusting for aging rate, the logit proportion of hospitalisation for inpatient chemo/radiotherapy treatment over total hospitalisation for breast cancer was significantly higher for every additional hospital bed per capita (0.0027, 95% CI 0.0014–0.0040). These differences remained statistically significant in the sensitivity analysis, which adjusted for other variables.

In contrast, no significant relationship was observed between the number of surgical operations for breast cancer per capita and the number of hospital beds per capita in the primary or sensitivity analysis.

Discussion

In this panel data study of approximately 560,000 records of breast cancer cases, we observed regional variations in characteristics including healthcare expenditure, aging rate and the number of doctors and breast cancer specialists per capita across quintiles of hospital beds. Differences in the proportion of hospitalisation for inpatient chemo/radiotherapy treatment for breast cancer were also observed. Most importantly, the proportion of hospitalisation for inpatient chemo/radiotherapy treatment for breast cancer was significantly higher for every additional hospital bed per capita. Further, no regional variation was observed in the number of surgical operations, an imperative procedure for breast cancer. Additionally, there was no significant relationship between health resources (inpatient chemo/radiotherapy and hospital beds) and the fatality rate due to breast cancer.

This study aimed to take the first step towards identifying the capacity for saving health resources in oncology care. To our knowledge, this is the first study to determine the association between the proportion of hospitalisation for inpatient chemo/radiotherapy treatment and staffed hospital beds per capita [17]. While a previous study described the regional variation in the proportion of chemotherapy cases in Taiwan, it did not examine the association between the proportion of chemo/radiotherapy cases and health resources [17]. Consistent with previous studies in other fields [9], our study revealed a positive association between the number of hospital beds and the proportion of hospitalisation for inpatient chemo/radiotherapy treatment for breast cancer, which extends the findings of the Taiwanese chemotherapy study.

Clinical implications

Multiple factors increase the proportion of hospitalisation for inpatient chemo/radiotherapy treatment, including (1) patients, (2) doctors, (3) hospital management and (4) technical considerations.

Patients may prefer inpatient chemo/radiotherapy if they have to endure prolonged driving times to the hospital. The mean driving time from patients' homes to the hospital was unexpectedly longer in the higher quintile of hospital beds,

which comprised prefectures with a higher density of hospital beds per capita (Table 1). Moreover, the proportion of hospitalisation for inpatient chemo/radiotherapy treatment was higher in the quintile with longer driving times (higher quintile of hospital beds). This suggests that patients drove longer distances despite there being more hospital beds. This may have arisen as a result of inefficient allocation of hospital beds.

Doctors fundamentally try to avoid risk, and therefore select the safest method among equivalent options. A doctor's practice is mainly influenced by his/her medical training; for example, doctors who trained in high-resource regions are more likely to recommend discretionary tests and interventions and have similar risk avoidance behaviour [18–20].

With regard to the financial management of a hospital, keeping chemo/radiotherapy patients hospitalised may be financially important because it is generally profitable. A hospital's marginal revenue for chemo/radiotherapy in the inpatient setting may be relatively greater than its marginal costs, which do not include fixed costs including infrastructure costs or wages for medical professionals [21]. In Japan, the average occupancy rate of staffed hospital beds is 80.1% [22]; this low average rate is probably due to the variation in the number of staffed hospital beds per capita. A lower occupancy rate may provide a hospital with the capacity to hospitalise low-imperative patients with smaller marginal costs. The exposure of interest in this study was the number of hospital beds, not only those for breast cancer patients but all beds in general hospitals. While we focussed on the number of inpatient chemo/radiotherapy cases among patients with breast cancer in this study, the proportion of hospitalisation for inpatient chemo/radiotherapy treatment may be higher for other oncology practices in areas with higher numbers of beds.

Regarding technical considerations, a knowledge gap about chemo/radiotherapy may be one of the barriers to implementing outpatient chemo/radiotherapy. Installing an outpatient chemotherapy room that follows government requirements may be another barrier due to the cost of installation and maintenance.

To remedy the situation, it is essential to centralise cancer treatment, given that 40% of surgical procedures for breast cancer are performed in small-sized hospitals, which are not core hospitals for oncology treatment. Centralisation may improve the quality of treatment, and consequently lead to greater patient satisfaction [23]. Awareness of regional variations in treatment patterns may be effective for not only doctors but also patients because both groups will have knowledge of what is achievable at their hospitals [24]. Finally, incentives related to chemo/radiotherapy should be changed, especially the pricing structure for hospitals and clinics, which incentivises outpatient chemo/radiotherapy over inpatient chemo/radiotherapy, and subsidies for installing new chemotherapy rooms. Such changes will not only save costs by promoting outpatient chemo/radiotherapy but will also increase patients' quality of life.

Strength and limitations

This study has several limitations. First, we did not investigate why regions with more hospital beds per capita had a higher proportion of hospitalisation for inpatient chemo/radiotherapy treatment. This would require the use of a longer-term longitudinal dataset and focus on possible mediators between hospital beds and inpatient chemo/radiotherapy. Second, data from hospitals with fewer than 10 cases of both inpatient chemo/radiotherapy and surgical operation for breast cancer per year could not be obtained due to the privacy protection rule in Japan. Third, we did not adjust for individual comorbidity, risk factors and disease stage because we were unable to obtain data relating to the prognostic factors of breast cancer in each prefecture.

Despite these limitations, this study used a large registration database that covers more than 95% of all hospitalisation cases in Japan and provides the detailed number of cases for each procedure, similar to the Diagnosis Related Group in the U.S [25].

All data used for this study were publicly available. We showed the regional variation in the number of chemo/radiotherapy cases for breast cancer and its association with health resources with the aim to reduce regional variation, which may lead to improved quality in the oncology field by reducing unnecessary admissions for chemo/radiotherapy. While our study represents a small part of the whole provider-induced demand problem, it presents striking findings for discussions related to the elimination of inefficient care. Further research using this database is warranted to improve the national healthcare system and to make it sustainable.

Conclusions

We found that a higher number of hospital beds were associated with a higher proportion of hospitalisation for inpatient chemo/radiotherapy treatment, suggesting that inpatient chemo/radiotherapy may be a provider-induced practice. Further studies are needed to evaluate the association between health resources and other types of procedures.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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