DRGs-based health system performance for breast cancer patients

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Abstract

Background: To evaluate health system performance for patients with breast cancer in Henan Province, China, using Diagnosis-Related Groups (DRGs) indicators and provide data to inform practices and policies for the prevention and control of breast cancer.

Methods: The data were collected from the front pages of the medical records (FPMR) of all hospitals above class II that admitted breast cancer patients in Henan Province between 2016 and 2019. Breast cancer patients were the subjects in our study. China DRGs (CN-DRGs) were used as a risk adjustment tool. Three indicators, including the Case-Mix Index (CMI), number of DRGs, and total weight, were used to evaluate the range of available services for patients with breast cancer, while indicators including the Charge Efficiency Index (CEI), Time Efficiency Index (TEI) and inpatient mortality of low-risk group cases (IMLRG) were used to evaluate the medical service efficiency and medical safety.

Results: Between 2016 and 2019, there were 103,760 cases of patients with breast cancer. The number of enrolled patients and total weight increased over the study period at an average annual rate of 21.38% and 21.88%, respectively. The TEI decreased over the study period by 15.60%. The CEI exhibited an increasing trend, but the average annual rate of increase was small (2.94%). The IMLRP was 0.02%, 0%, 0% and 0.01% in 2016, 2017, 2018 and 2019, respectively.

Conclusion: The health system performance improved between 2016 and 2019 for breast cancer patients discharged from the study hospitals in Henan Province. The main areas of improvement were in the range of available services, but medical institutions must still make efforts to improve the efficiency of medical services and ensure medical safety. DRGs are an effective evaluation tool.

Background

Breast cancer is the most common malignancy in women, and approximately 11% of breast cancer cases worldwide occur in China [1]. Approximately 169,000 new female breast cancer patients are diagnosed annually, and this number has increased over the past forty years [2]. Henan Province has a large population with health outcomes at or below the national average [3]. The incidence of breast cancer in Henan Province is more than 35/100,000 [4]. While health system performance evaluation for breast cancer patients has the potential to improve clinical practices, the key activity rests in the selection of the evaluation tool itself [5].

Health system performance evaluation tools are diverse and vary worldwide. For example, in Singapore, models based on the Singapore Quality Award criteria and the Balance Score Card (BSC) approach are used to evaluate the performance of hospitals [6]. The BSC method provides a framework that focuses on key management processes and evaluates the realization of the vision and strategy of a hospital based on the following four dimensions: finance, customer service, internal business, and innovation [7]. In America [8], the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) implemented evidence-based standardized measures of performance in more than 3,000 accredited hospitals. The

measures were designed to track performance over time and compare hospitals based on the following six dimensions: safety, patient satisfaction, efficiency, clinical quality, financial management, and medical expenses [9]. In China, the primary tools used for performance management in hospitals focus on the following: financial management, human resource management, and clinical management [10]. Different evaluation methods are chosen according to the different evaluation objects, such as hospitals, departments and doctors [11]. For instance, the BSC method, Key Performance Indicators (KPI) and achievement measurement method are used to evaluate the performance of hospitals, departments and doctors, respectively[5]. To achieve an ideal performance evaluation system, the most important feature is the accuracy of the evaluation results [12]. However, due to the inherent characteristics of medical services, including diversity, high risk, and difficulty in comparison, performance evaluations without risk adjustment, such as key performance indicators, etc., cannot guarantee reliable results [13]. Therefore, an evaluation tool based on risk adjustment can improve the accuracy of the evaluation results.

The Diagnosis-Related Groups (DRGs) system was the first health management tool to group patients into clinically meaningful categories representing equivalent health resource usage. The DRGs system was first adopted in the State of New Jersey in 1980 [14] and was implemented by the US federal government as a payment system in 1983 [15]. Subsequently, several countries adopted the DRGs system [16]. Currently, this system is the most widely used risk adjustment tool [17]. Considering the importance of risk adjustment in performance evaluations, researchers at Peking University began to study the DRGs system as a performance evaluation tool since 2005[12, 18, 19]. A series of health system performance evaluation indicators was constructed to evaluate the range of available services for patients, service efficiency, and medical safety. The DRGs system has been shown to have several advantages over traditional evaluation methods. First, in contrast with the subjectivity of the scoring system used in the BSC [20], the DRGs evaluation indicators are based on objective data, such as the number of discharged patients, [length of stay](#), medical cost and mortality. Therefore, an evaluation method using DRGs is likely to be more reliable and accurate than other methods. Second, the DRGs system effectively avoid biases in comparisons by adjusting case-mix across different hospitals [21]; thus, the results are more reliable and impartial [22, 23]. Third, this evaluation method is non-exclusive and can be combined with other performance evaluation methods [24]. Finally, continuous data are relatively easy to obtain because they are collected from medical records. Due to these advantages, health performance evaluations conducted in Beijing are based on the DRG system [12, 18, 19]. This line of studies has more recently been extended to other parts of China [25, 26], but to date, no study assessing DRGs-based health system performance in breast cancer patients has been performed.

Methods

1 Data sources

Since 2012, medical institutions in Henan Province have adopted a common and uniform discharge abstract, commonly referred to as the front page of the medical records (FPMR). The FPMR contains much information, including patient demographic information (age, gender, address, etc.), date of

admission and discharge, diagnosis (principal diagnosis and other diagnoses), procedures (principal procedures and other procedures), hospitalization outcome, medical costs and prescription records. The diagnoses and procedures were coded according to the International Classification of Diseases, Tenth Revision (ICD-10) and International Classification of Diseases Clinical Modification of 9th Revision Operations and Procedures (ICD-9-CM-3), respectively.

In this study, FPMRs from all hospitals above class II that admitted breast cancer patients from Henan Province between 2016 and 2019 were reviewed. The relevant information of each case was carefully collated and assessed. Cases were included if they met the following criteria: (i) the ICD-10 code of principal diagnosis contained C50: malignant neoplasm of breast, and (ii) the date of discharge was between January 2016 and December 2019. Cases were excluded if they met the following criteria: (i) the **length of stay** was longer than 60 days and (ii) critical information, such as the patient's age or gender, diagnoses, procedures performed, discharge date, medical costs, **length of stay**, etc., was missing. Based on these criteria, we collected 103,760 records between January 2016 and December 2019.

2 DRGs selection method

In 1988, the Institute of Hospital Management in Beijing took the lead in DRG research. Subsequently, China developed its own DRG system, laying the foundation for DRG-based technology. In 2004, the Beijing DRG project team introduced a trial version of Beijing DRGs (BJ-DRGs) based on studies conducted in the US and Australia. Because DRGs specific to Henan Province have not been developed, our study used the CN-DRGs (2018 edition) as a risk adjustment tool. According to the CN-DRGs, 26 Major Diagnostic Categories (MDCs) were established, and 806 DRGs were formed after the division of the Adjacent DRGs (ADRGs) of surgery, internal medicine, and operations [27]. Figure 1 shows the grouping path of the CN-DRGs.

3 DRGs evaluation indicators

According to the study conducted by Jian W [12, 18, 19], we constructed six objective health system performance indicators to evaluate the available range of medical services, efficiency, and safety. The average level of the DRG indicators of the hospitals included in the BJ-DRGs evaluation was selected as the standard during the calculation of the DRG indicators (Table 1).

(1)Service availability indicators[19]: The services availability can be evaluated by calculating the number of DRGs, total weight, and the Case-Mix index (CMI). Together, these indicators captured the range of services available, the total output of inpatient services and the technical difficulty in treating patients after adjusting for each hospital case mix.

(2)Service efficiency indicators [12, 19]: Service efficiency was captured by the following two indices: Charge Efficiency Index (CEI) and Time Efficiency Index (TEI). The two indicators were relative values that could be used to capture the cost and **length of stay** of same diseases comparing with the average level of the DRG indicators of the hospitals included in the BJ-DRGs evaluation. The larger the two values, the

lower the health service efficiency. If the TEI and CEI were greater than 1, the time efficiency and cost efficiency required to treat the same disease were lower than those in the standard sample. The calculation method of CEI and TEI was as follows.

$$\text{Cost ratio } (k^c) = \frac{\text{average cost of DRG in Henan Province } (c_i)}{\text{average cost of DRG in BJ - DRGs } (\overline{Ci})}$$

average length of stay(ALOS) ratio ()=

$$(k^l) = \frac{\text{average length of stay of DRG in Henan Province } (l_i)}{\text{average length of stay of DRG in BJ - DRGs } (\overline{Li})}$$

$$\text{CEI} = \frac{\sum_j k_j^c n_j}{\sum_j n_j}$$

$$\text{TEI} = \frac{\sum_j k_j^l n_j}{\sum_j n_j}$$

where n_j represents the number of cases in DRG j for the hospital.

(3) *Medical safety indicators*: Inpatient mortality of low-risk group cases (IMLRP) was adopted to reflect medical safety. Different from traditional mortality indicators, IMLRP represented the mortality rate from diseases that were extremely unlikely to cause death and could be employed as the index of service quality[28]. Based on the experience of previous researchers [12, 18, 19], the procedure used to assign patients to lower risks was as follows [12, 18, 19]: (1) The mortality rate (M_i) of each DRG was calculated; (2) the natural logarithm of these mortality rates ($\ln(M_i)$) was computed following a normal distribution, and the mean and standard deviation of $\ln(M_i)$ were derived; and (3) IMLRP referred to the mortality rate of those DRGs in which $\ln(M_i)$ was less than one standard deviation below the mean value of $\ln(M_i)$.

4 Statistical analysis

The continuous variables were expressed as the mean $\pm$ standard deviation. Ratios or rates were used to describe the categorical variables. Line charts were adopted to describe the time trend of the continuous variables. All analyses were conducted in SPSS version 22.0.

Results

1 Sample characteristics

We collected 103,760 records of breast cancer patients between January 2016 and December 2019. There were 19,329 cases in 2016, 23,056 cases in 2017, 26,807 cases in 2018, and 34,568 cases in 2019. The number of cases rapidly increased during the study period. The mean patient age was 51.24 ± 10.87 years, with a median age of 50 years. In total, 46,936 cases (45.24%), 44,450 cases (42.84%) and 12,374 cases (11.92%) were admitted via emergency, outpatient and other pathways, respectively.

2 Medical service availability

22 DRGs comprised 17 surgical groups treating 35,313 patients and five internal medicine groups treating 68,447 patients. During the study period, the number of enrolled cases and the total number of weighted cases as represented by total weight increased at an average annual rate of 21.38% and 21.88%, respectively. The CMI value increased marginally as shown in Table 2.

Six DRGs were associated with the overwhelming majority of all cases during the study period. Each of these six DRGs were associated with more than 1,000 cases during the entire study period. Specifically, these six DRGs comprised JR15(breast malignancy without complications or comorbidities, such as breast cancer patients who were admitted to the hospital for the first time accepted non-surgical treatment, including chemotherapy and radiation.), JA15(**total mastectomy** without complications or comorbidities, such as patients who accepted bilateral complete mastectomy without complications.), JB15(mammoplasty or other surgery without complications or comorbidities), JR11 (breast malignancy with severe complications or comorbidities), JA13(**total mastectomy** with general complications or comorbidities), and JA25(subtotal mastectomy without complications or comorbidities). The number of enrolled cases and the total weight of all six DRGs increased from yearly, and the average annual growth rate of the total weight was 46.93% for JA13, 45.32% for JR11, 22.14% for JR15, 17.64% for JA15, 14.51% for JA25, and 12.98% for JB15 (Table 3). Throughout the study, the number of enrolled cases and total weight were always smaller during the first quarter of each year in each of these six DRGs (Figures 2 and 3).

3 Medical service efficiency

The ALOS of breast cancer patients from 2016 to 2019 was 17.10, 15.40, 14.30, 13.20, respectively. The Time Efficiency Index (TEI) decreased yearly, and in 2019, the TEI was 15.60% lower than that in 2016. The average cost of breast cancer patients from 2016 to 2019 was ¥9875.85, ¥10661.75, ¥11077.87, ¥11102.41. The Charge Efficiency Index (CEI) exhibited an increasing trend, but the average annual increase rate was small (2.94%) (Table 4).

The TEI of JA25 was the highest, and the TEI of JR11 was the lowest among the six DRGs. The TEI of the six DRGs decreased yearly, and the TEI of JA25 decreased the most (31.15% lower in 2019 than that in 2016). The CEI of JB15 was the highest, and the CEI of JR11 was the lowest. The CEI of JR15, JA15 and JA13 increased slowly over the years, while the trend of the other three DRGs was not obvious (Table 5). During the same year, the time trend of the TEI and CEI of each DRG was inconsistent (Figures 4 and 5).

4 Medical service safety

The mortality rate of breast cancer patients was 0.41%, 0.36%, 0.43% and 0.36% in 2016, 2017, 2018 and 2019, respectively while two deaths occurred among the low-risk group cases (one in 2016 and another in 2019), and both cases occurred in JA15. The inpatient mortality rate of low-risk patients (IMLRP) was 0.02%, 0%, 0% and 0.01% in 2016, 2017, 2018 and 2019, respectively.

Discussion

Using the principles of clinical and resource-utilization similarity [29], we identified 103,760 cases of breast cancer that were divided into 22 DRGs during the study period. The number of separate DRGs recorded during the study period varied (18 in 2016, 17 in 2017, 19 in 2018, and 18 in 2019). Because the diseases and DRGs were inconsistent in different years, the number of discharged patients, [length of stay](#), medical costs and other conventional indicators without risk adjustment were not directly comparable across different years. Using the DRGs, we effectively avoided biases due to the heterogeneity of diseases and DRGs by assigning different weights to different DRGs, thereby allowing for comparisons to be performed across different years. In addition, the adoption of the benchmark data of the average level of the DRG indicators in hospitals in Beijing was beneficial to the comparison between Henan Province and developed regions.

We adopted the CN-DRGs (2018 edition) grouping method to analyze the health system performance in patients with breast cancer. This analysis showed that the health system performance improved during the study period, particularly in the total number of weighted cases as represented by total weight and the length of stay of those cases as represented by the TEI. The total number of weighted cases increased yearly, and the CMI value increased marginally. The number and total weight of the enrolled cases of the six DRGs (JR15, JA15, JB15, JR11, JA13, and JA25) also increased yearly. JR11 (breast malignancy with severe complications or comorbidities) and JA13 ([total mastectomy](#) with general complications or comorbidities) were the two fastest-growing groups. This finding may not only be related to the increase in the demand for medical services, but also to the improvement of the supply capacity of health services. On the one hand, the incidence of breast cancer among residents in Henan Province has been increasing in recent years[30, 31], and the demand for health services of breast cancer has increased, which may increase the hospitalization rate of breast cancer year by year. On the other hand, the introduction of policies, such as the regional medical union, “County-level Clinical Key Specialty Project” and “the 515 Action Plan”, increased financial support for medical institutions and improved access to primary health care institutions.

The TEI of all enrolled breast cancer patients was greater than 1 between 2016 and 2019 but decreased yearly, with the largest decrease observed in JA25 (subtotal mastectomy without complications or comorbidities). This finding indicated that the time efficiency of treating similar diseases in medical institutions in Henan Province was worse than that in institutions in Beijing, but it had improved yearly, particularly in patients who underwent surgery. This finding may be associated with the implementation

of clinical pathways[32, 33] . The CEI of all enrolled breast cancer patients was less than 1 between 2016 and 2019, while that of JR15 (breast malignancy without complications or comorbidities), JA15 (**total mastectomy** without complications or comorbidities), and JA13 (**total mastectomy** with general complications or comorbidities) increased slowly yearly from 2016 to 2019. These results indicated that the cost efficiency of medical institutions in Henan Province was better than that of institutions in Beijing, but the cost of treating certain diseases slightly increased over time. The implementation of the ring areola incision endoscopic-assisted modified radical mastectomy and the introduction of advanced equipment may explain the increase in cost. The above-mentioned results show that the efficiency of medical services in Henan Province had improved, but active measures must be taken to continuously support ongoing improvements in efficiency. Effective countermeasures such as can rational shorten average length of stay Hospitals should actively learn advanced methods, establish monitoring targets, shorten inspection and treatment waiting time, optimizing process, improving the efficiency of medical technical department, implementing clinical pathway and single diseases manageent, effective control nosocomial infection, etc[34, 35]. In addition, hospitals should pay attention to the strict control of costs and reduce medical expenses for patients while using advanced technology and introducing advanced equipment to maintain high-quality medical services[36].

The mortality rate of breast cancer patients was 0.41%, 0.36%, 0.43% and 0.36% in 2016, 2017, 2018 and 2019 and the annual IMLRP was 0.02%, 0%, 0% and 0.01% in 2016, 2017, 2018 and 2019, respectively. Although the mortality rate of breast cancer patients had declined from 2016 to 2019, there were still two deaths among the low-risk group cases. The results suggested that medical staff should continue to strengthen their medical safety precautions. The PDCA cycle can be adopted to achieve continuous improvement of medical quality, and the hospitals should strengthen the analysis of low-risk death cases to discover their own problems in the diagnosis and treatment behavior-process, and deal with these problems in the targeted manners[37].

Study Limitations

Several potential limitations should be noted. First, the grouping methods and DRGs evaluation indicator system have not been customized for clinical practice in Henan Province. Therefore, we used the relatively mature performance evaluation system of DRGs in Beijing; however, the suitability of this system should be verified. Second, highly accurate FPMRs are required for DRGs-based health system performance evaluations. The FPMR data used in our study were provided by the medical institutions. Although the relevant information of each case was carefully collated and assessed, the quality of the disease and procedure coding in the FPMR was difficult to control and may have affected the accuracy of the evaluation results. To better perform DRGs-based health system performance evaluations, it is important to accelerate a localized scheme design of DRGs to build a DRGs grouping scheme and evaluation indicators that are highly customized to the unique circumstances of Henan Province. Simultaneously, it is crucial to strengthen personnel training in medical institutions to improve the quality and coding accuracy in the FPMR.

Conclusions

DRGs represent a risk adjustment tool that can be used to compare the performance of a health system across different years more impartially. Between 2016 and 2019, the total number of weighted cases as represented by total weight increased from year to year, indicating that the medical service availability in Henan Province continuously improved. The TEI was greater than 1 but decreased yearly, while the CEI was less than 1 but slightly increased between 2016 and 2019, indicating that the medical efficiency had improved but needs greater improvement. Two deaths occurred among the low-risk group cases, illustrating that there are opportunities for greater improvement in medical safety.

Abbreviations

DRGs: Diagnosis-Related Groups; **FPMR:** The front pages of medical records; **CN-DRGs:** China DRGs; **CMI** :Case-Mix Index; **CEI:** Charge Efficiency Index; **TEI:** Time Efficiency Index ; **IMLRG:** Inpatient mortality for low-risk group cases; **BSC:** Balance Score Card; **JCAHO:** the Joint Commission on Accreditation of Healthcare Organizations ; **KPI** :Key Performance Indicators; **ICD-10:**the International Classification of Diseases, Tenth Revision; **ICD-9-CM-3:**International Classification of Diseases Clinical Modification of 9th Revision Operations and Procedures; **BJ-DRGs:** Beijing DRGs; **MDCs:** Major Diagnostic Categories ; **ADRGs:** Adjacent DRGs.

Declarations

Ethical approval and consent to participate

The ethics committee of The First Affiliated Hospital of Zhengzhou University ruled that no formal ethics approval was required in this particular case.

Consent for publication

All authors reviewed and agree on the final manuscript.

Availability of data and material

The data used in this manuscript were obtained from an FPMR database of all hospitals above class II in the Health Information Center of Henan Province between 2016 and 2019.

Competing interests

The authors have no competing interests to declare.

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Author contributions

XL designed the study, performed the analysis, and drafted the manuscript. FL contributed

to the study design, the statistical analysis and the final revision. LW1 and MW participated in the statistical analysis and the first draft of the paper. LY and LW2 participated in the final revision. All authors read and approved the final manuscript.

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Tables

Table 1 Health system performance evaluation indicators based on DRGs

Dimension	Indicators	Evaluation contents
Availability	Number of DRGs	The range of services available
	Total weight	Total output of in-patient services
	Case-Mix Index (CMI)	Average technical difficulty level of treating diseases in each discipline
Efficiency	Charge Efficiency Index(CEI)	Cost of treating similar diseases
	Time Efficiency index(TEI)	Time for treating similar diseases
Safety	Inpatient mortality of low-risk group cases (IMLRG)	Mortality of diseases that are extremely unlikely to cause death

Table 2 Medical service availability in breast cancer patients between 2016 and 2019

Year	Number of cases	Number of DRGs	Total weight	CMI
2016	19329	18	16382.20	0.90
2017	23056	17	19819.90	0.92
2018	26807	19	23096.20	0.92
2019	34568	18	29660.70	0.91

Table 3 Medical service availability of major DRGs between 2016 and 2019

DRGs	2016		2017		2018		2019	
	N	Total weight	N	Total weight	N	Total weight	N	Total weight
JR15 (breast malignancy without complications or comorbidities)	12478	10980.64	14425	12694.00	16725	14718.00	22735	20006.80
JA15 (total mastectomy without complications or comorbidities)	4719	5096.52	5923	6396.84	6787	7329.96	7682	8296.56
JB15 (mammoplasty or other surgery without complications or comorbidities)	1106	718.90	1254	815.10	1406	913.90	1595	1036.75
JR11 (breast malignancy with severe complications or comorbidities)	261	420.21	426	685.86	569	916.09	801	1289.61
JA13 (total mastectomy with general complications or comorbidities)	209	240.35	371	426.65	503	578.45	663	762.45
JA25 (subtotal mastectomy without complications or comorbidities)	301	168.56	293	164.08	328	183.68	452	253.12

Table 4 Medical service efficiency in breast cancer patients between 2016 and 2019

Index	2016	2017	2018	2019
TEI	1.41	1.31	1.24	1.19
CEI	0.55	0.58	0.59	0.60

Table 5 Medical service efficiency of major DRGs between 2016 and 2019

DRGs	2016		2017		2018		2019	
	TEI	CEI	TEI	CEI	TEI	CEI	TEI	CEI
JR15 (breast malignancy without complications or comorbidities)	1.77	0.52	1.65	0.54	1.57	0.55	1.50	0.57
JA15(total mastectomy without complications or comorbidities)	1.69	0.94	1.61	0.98	1.52	0.99	1.50	1.03
JB15(mammoplasty or other surgery without complications or comorbidities)	3.80	2.71	3.66	2.78	3.48	3.13	3.33	2.93
JR11 (breast malignancy with severe complications or comorbidities)	1.13	0.35	1.20	0.45	1.09	0.40	1.03	0.43
JA13(total mastectomy with general complications or comorbidities)	1.84	0.78	1.60	0.83	1.58	0.82	1.57	0.85
JA25 (subtotal mastectomy without complications or comorbidities)	4.88	2.13	4.26	2.16	3.48	1.85	3.36	2.39

Figures

Figure 1

CN-DRGs grouping path

Figure 2

Number of enrolled cases of major DRGs varies monthly

Figure 3

Total number of weight cases of major DRGs varies monthly

Figure 4

Time efficiency index (TEI) of major DRGs varies monthly

Figure 5

Charge efficiency index (CEI) of major DRGs varies monthly