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Original Article

Cluster analysis of medical service resources at district hospitals in Taiwan, 2007–2011

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Abstract

Background: A vast amount of the annual/national budget has been spent on the National Health Insurance program in Taiwan. However, the market for district hospitals has become increasingly competitive, and district hospitals are under pressure to optimize the use of health service resources. Therefore, we employed a clustering method to explore variations in input and output service volumes, and investigate resource allocation and health care service efficiency in district hospitals.
Methods: Descriptive and cluster analyses were conducted to examine the district hospitals included in the Ministry of Health and Welfare database during 2007–2011.
Results: The results, according to the types of hospital ownership, suggested that the number of public hospitals has decreased and that of private hospitals increased; the largest increase in the number of district hospitals occurred when Taichung City was merged into Taichung County. The descriptive statistics from 2007 to 2011 indicated that 43% and 36.4% of the hospitals had 501–800 occupied beds and 101–200 physicians, respectively, and > 401 medical staff members. However, the number of outpatients and discharged patients exceeded 6001 and 90,001, respectively. In addition, the highest percentage of hospitals (43.9%) had 30,001–60,000 emergency department patients. In 2010, the number of patients varied widely, and the analysis of variance cluster results were nonsignificant ($p > 0.05$).
Conclusion: District hospitals belonging to low-throughput and low-performance groups were encouraged to improve resource utilization for enhancing health care service efficiency.

Keywords: cluster analysis; district hospital; hospital market; resource utilization

1. Introduction

In 2010, NT$310.5 billion of the global budget was spent on health care in Taiwan, accounting for 34.84% of the national health expenditures.[1] Implementation of the National Health Insurance (NHI) program in 1995 altered the hospital environment and market.[2] Therefore, determining hospital status became vital. People had the freedom to choose products and services, government controlled the physician workforce and medical institutions, and dialogues of the Medical Expenditure Negotiation Committee pertaining to the hospital global budget payment system (GBS) propelled the hospital market forces.

District hospitals that maintained high market growth exhibited the largest shifts among various hospital levels (Appendix 1), and the geographical distribution was skewed. Data from 1995 to 2006 and from 2008 to 2011, obtained from

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the Taiwan Joint Commission on Hospital Accreditation, indicated that most district hospitals were in the Taipei Division (26 district hospitals) and only two district hospitals were located in the Eastern Division.[3,4] The growth of medical institutions caused medical resources to become scarce and options to become limited[5]; however, provision of various services in hospitals was strengthened following the implementation of the NHI program. District hospitals could either upgrade to retain their district hospital level status or invest in benefits obtainable from the health care market. The resource-based theory asserts that firms survive and grow by acquiring market resources that are not easily obtained by other firms[6]; thus, establishment of a competitive advantage must involve strategies pertaining to district hospital resources and capabilities. During the resource allocation process, power, status, and influence can outweigh purely commercial considerations. Key decisions to allocate many or fewer resources to district hospitals can vary according to the types of decisions that are made,[7] including decisions pertaining to the resources allocated to the increasing or decreasing number of district hospitals in the market.

Health care market research involves defining products and market areas to determine efficacy factors, basic resources, and changes.[8,9] Similarly, market analysis is conducted to determine the size and growth of hospitals and identify current and potential competitors. Chen and Zheng[10] investigated regional service centers to geographically define Taiwan's hospital market areas, determining that although patients entrust high-quality care providers with health recovery, they will cross regional borders to seek treatment at district hospitals; however, the results were inconclusive. Research investigating United States hospital markets has focused on price, shipment, and geopolitical boundaries,[5,11,12] all factors substantially differing from those affecting the Taiwanese health care system.

In 2007, health care insurance payments, which directly influence point-value incomes and hospital operations, were allocated to medical care institutions according to the Taiwan Joint Commission on Hospital Accreditation system, which was used to divide medical care institutions into regional hospitals, district hospitals, and medical centers. Following the method employed by Kuo and Ho[13] and Mintzberg et al,[14] we utilized cluster analysis and defined the market area based on accredited district hospitals in 2007–2011.

The purpose of this study was to analyze the characteristics of variations in the input and output service volumes of district hospitals, and cluster hospitals into groups and categories according to resource allocation and efficiency. The results can be a reference for district hospitals when enhancing management performance and for further studies.

2. Methods

2.1. Materials and data

The operation of district hospitals was assessed based on labor (input) and services produced (output)[5]; therefore, the results adequately represented the actual production activity of providers and productivity shifts that were relevant to the empirical study of hospital health service efficiency. Rational solutions based on health care economics must be implemented when exploring the relationship between input and output factors,[6,15–17] a relationship that can be used as a measure of resource allocation.

Hospital health service efficiency studies have used labor and capital, two major factors of production included in the economic production theory, as the production and cost functions to describe the relationship between inputs and outputs. The functions can be expressed as $Y = f(X)$, where Y is the production vector and X the input vector.[18] Hospital assessments are based on health care inputs, such as physicians, nurses, medical staff, and the number of hospital beds[18–21]; health care outputs include the numbers of outpatients, emergency department (ED) visits, inpatients, discharged patients, bed days, examinations, and dialysis patients. Hong et al[20] used two additional output variables—the weighted average of the total daily cost of hospitalization and the weighted average of the number of daily inpatient operations—to rate hospitals. In addition, Lu and Hsieh[5] studied the number of medical service products offered by hospitals to define hospital multiproduct diversity; the products comprised outpatient, inpatient, and ED products and various types of examination services. In data analysis, Lu and Hsieh[5] and Hong et al[20] analyzed the total hospital revenue, total inpatient revenue, total number of hospital beds, length of hospitalization, and number of discharged patients listed in the Current Hospital Conditions and Service Volume Survey issued by the Taiwanese Ministry of Health and Welfare.

In this study, we extracted district hospital sample data from an annual report on medical care institutions and from a hospital status database compiled by the Ministry of Health and Welfare (Appendix 2). Accreditation levels have changed over time; therefore, we analyzed the 66, 77, 80, 79, and 77 hospitals that received district hospital accreditation in 2007, 2008, 2009, 2010, and 2011, respectively. Input variables (resources) comprised the numbers of available beds and beds occupied by patients with acute diseases, chronic diseases, and special diseases; patients under observation; physicians (physicians and surgeons); and medical staff (including radiology staff and examination staff). Output variables included the numbers of discharged patients, outpatients, and ED patients.

2.2. Methods

This study was approved by the Department of Health, Republic of China (Taiwan) on February 22, 2013. Microsoft Excel 2003 (Microsoft, Redmond, WA, USA) and SPSS version 20.0 software (SPSS Inc., Chicago, IL, USA) were employed to conduct descriptive statistical and cluster analyses for analyzing the district hospital sample data. The input and output variables, excluding available beds, were categorized into five or six ranges. The variables were

divided based on the number of physicians, which was the variable that exerted the greatest direct effect on health care quality, health care accessibility, and health care costs.[22] The major source of revenue for hospitals was outpatient revenue.[23] According to the Ministry of Health and Welfare, the number of Western medicine physicians in Taiwan was 1.33 per 1000 people, and as of 1995, the number of physicians in Taipei was 230 per 100,000 people (Appendix 3).[24] Therefore, we divided the physicians by ranges of < 10. In addition, hospitals provide more than just unidirectional medical services.[19] Statistics have suggested that the number of outpatient visits is the major factor determining whether hospitals go out of business; the greater the number of outpatient visits, the less likely it is that a hospital will be forced to close down.[23] Therefore, we set the range for high outpatient numbers to be between 10,000 and 90,001. Table 1 lists the five ranges of occupied beds, discharged patients, and outpatients, and the six ranges of physicians, medical staff, and ED patients.

The input and output data were analyzed using descriptive analysis[25,26] and cluster analysis. The *K*-means of Ward's minimum variance was performed to categorize one group of observed values into clusters according to interobject similarity; thus, the iterative method and comparable means were employed to determine the accuracy and distinctiveness of the clusters.[27] Conceptually, distinct labels were assigned to the clusters based on cluster data characteristics, which we used to calculate the total input and output variables and percentages,[28] interpret the outcomes of district hospital groups, analyze resource allocation, and classify district hospitals.

3. Results

According to the types of hospital ownership and geographical distribution during 2007−2011, the number of public hospitals gradually decreased and that of private hospitals increased (Fig. 1). Furthermore, the number of hospitals in the Central, Southern, and Kaoping Divisions increased, with the largest increase occurring in the Central Division. Assessment of the influence of the increased number of hospitals on the resource distribution or utilization by hospitals in the Central Division during 2007−2011 requires further study.

The data ranges indicated that the values of the input and output variables were below the mean value. However, the numbers of ED patients both exceeded (2007: 30,001−60,000, 43.9%) and were below the mean value (2010: <300, 45.6%), indicating that the number of ED patients varied extensively (Table 1).

3.1. Resource distribution

During 2007−2011, the input resource distribution of occupied beds both increased and decreased. However, the number of physicians increased and then decreased, whereas the number of medical staff members increased, implying that staff changes were either high or low (Appendix 4). Three output variables (the numbers of outpatients, discharged patients, and ED patients) frequently fluctuated, and only the ED patient variable was significantly redistributed. The greatest and least numbers of outpatients were considerable, compared with those of the discharged patients, and the mean number of ED patients was significantly high and low. All the numbers were the least in 2010 (Table 1).

3.2. District hospital cluster

Clustering, which was performed to define the structure of district hospitals, involved categorization of hospitals into different groups based on the similarities in their characteristics. Two iterations and three iterations were conducted using the 2009−2011 and 2007−2008 data, respectively, yielding three clusters for each year. According to the procedure used by Kuo and Ho[13] and Lin,[29] we deleted data with a value of 0, which was the minimal output value during 2010 (Table 1). The means of the 2007−2009 and 2011 data were compared to ensure that all variations among the clusters achieved a significance level of 0.05 (Appendix 5) and that the clustering results were significant and distinctive. We then focused on the cluster groups based on the 2007−2009 and 2011 data (Appendix 6).

The cluster analysis results indicated that the ownership types of the clustered hospitals were the same as those of the nonclustered hospitals. A decrease in the number of public hospitals and a gradual increase in the number of private hospitals occurred on an annual basis. For example, the high-throughput/high-performance group (HT/HP) included 22 and 25 public hospitals in 2008 and 2009, respectively, and fewer in 2011. HT/HP comprised 24 and 23 public hospitals in 2007 and 2011, respectively.

Regarding the mean values of input variables of occupied beds, the numbers of physicians and medical staff were notable. The highest mean value for occupied beds was 3748.00 in the low-throughput/low-performance group (LT/LP), which had no hospitals with 501−800 beds in 2009. However, HT/HP comprised 21 hospitals having 501−800 beds in 2007 and 2011. The mean number of physicians was 73.63 in HT/HP during 2008, and 26 hospitals employed 51−100 physicians; the mean number of physicians in HT/HP increased to 76.20 during 2009, and 27 hospitals employed 51−100 physicians. In addition, in HT/HP, during 2008 and 2009, the mean number of medical staff members was 391.69 in 28 hospitals that employed > 401 staff members.

In HT/HP, which included 38 hospitals with > 6001 patients in 2008, only one hospital discharged > 6001 patients in 2011; the mean numbers of discharged patients in 2008 and 2011 were 11,083.63 and 71,293.00, respectively. LT/LP included the highest mean number of outpatients in 2009 (3,101,380.00), whereas HT/HP included the most hospitals (47) in which the number of outpatients exceeded 90,001. In 2008, the hospitals in HT/HP had a mean number of

Table 1
Descriptive statistics results for district hospitals in Taiwan, 2007−2011.[a]

Year (*n*)	2007 (66)	2008 (77)	2009 (80)	2010 (79)	2011 (77)
Input variables					
Occupied beds					
Sum	44,433	48,745	52,665	53,353	52,551
Max	3600	3666	3748	3807	3740
Min	213	33	33	207	199
Median	584.00	540.00	560.00	579.00	598.00
Mean	673.23	633.05	658.31	675.35	682.48
SD	425.01	428.04	439.03	442.33	440.72
Ranges (%)					
<300	1.5	6.5	3.8	6.3	6.5
301−500	33.3	35.1	3.8	29.1	27.3
501−800	48.5	41.6	2.5	43.0	41.6
801−1000	7.6	7.8	5.0	10.1	14.3
>1001	9.1	9.1	85.0	11.4	10.4
Physicians					
Sum	7663	8787	9340	9603	9606
Max	851	864	820	819	809
Min	6	5	5	9	8
Median	94.50	90.00	94.00	100.00	103.00
Mean	116.11	114.12	116.75	121.56	124.75
SD	107.98	107.06	103.13	105.27	107.81
Ranges (%)					
<10	1.5	2.6	2.5	1.3	1.3
11−50	15.2	16.9	15.0	13.9	14.3
51−100	37.9	39.0	37.5	35.4	32.5
101−200	33.3	29.9	31.3	34.2	36.4
201−300	10.6	10.4	12.5	11.4	10.4
>301	1.5	1.3	1.3	3.8	5.2
Medical staff					
Sum	37,510	42,753	46,790	48,699	43,470
Max	3075	3194	3189	3249	2886
Min	83	28	28	91	74
Median	506.00	481.00	498.50	544.00	495.00
Mean	568.33	555.23	584.88	616.44	564.55
SD	404.19	409.58	421.28	430.81	391.70
Ranges (%)					
<100	1.5	2.6	2.5	1.3	1.3
101−150	3.0	0	0	0	2.6
151−200	3.0	5.2	3.8	3.8	3.9
201−300	13.6	16.9	16.3	12.7	14.3
301−400	9.1	7.8	10.0	12.7	15.6
>401	69.7	67.5	67.5	69.6	62.3
Output variables					
Discharged patients					
Sum	1,107,192	1,231,019	1,324,513	604,145	1,369,696
Max	65,714	66,899	70,766	81,519	71,293
Min	345	277	291	0	550
Median	15,739.00	14,780.00	15,946.50	738.00	16,369.00
Mean	16,775.64	15,987.26	16,556.41	7,647.41	17,788.26
SD	11,595.36	11,322.03	11,524.64	16,906.91	11,976.02
Ranges (%)					
<1000	1.5	3.9	7.5	54.4	1.3
1001−2000	7.6	5.2	28.8	10.1	5.2
2001−4000	4.5	3.9	42.5	13.9	5.2
4001−6000	4.5	5.2	11.3	1.3	1.3
>6001	81.8	81.8	10.0	20.3	87.0
Outpatients					
Sum	30,634,763	35,207,666	38,118,061	21,953,015	38,776,815
Max	284,0145	300,4038	3,101,380	3,001,490	3,001,490
Min	29,743	32,345	17,832	0	9320
Median	400,647.00	389,059.00	402,197.50	65,618.00	412,012.00
Mean	464,163.08	457,242.42	476,475.76	277,886.27	503,595.00
SD	374,728.66	377,507.16	388,860.66	550,142.13	393,146.55

Table 1 (*continued*)

Year (*n*)	2007 (66)	2008 (77)	2009 (80)	2010 (79)	2011 (77)
Ranges (%)					
<10,000	0	0	0	10.1	1.3
10,001–30,000	1.5	0	1.3	17.7	0
30,001–60,000	4.5	6.5	3.8	16.5	2.6
60,001–90,000	1.5	1.3	3.8	15.2	1.3
>90,001	92.4	92.2	91.3	40.5	94.8
ED patients					
Sum	2,807,264	3,031,308	3,162,106	1,427,930	3,478,405
Max	212,273	213,020	88,254	243,446	243,446
Min	364	358	389	0	398
Median	42,208.50	35,844.00	40,944.50	559.00	43,491.00
Mean	42,534.30	39,367.64	39,526.33	18,075.06	45,174.09
SD	32,119.75	30,893.03	24,461.55	41,423.66	34,522.22
Ranges (%)					
<300	0	0	0	45.6	0
301–3000	9.1	9.1	8.8	19.0	6.5
3001–10,000	6.1	6.5	6.3	11.4	6.5
10,001–30,000	15.2	24.7	22.5	8.9	22.1
30,001–60,000	43.9	37.7	37.5	2.5	37.7
>60,001	25.8	22.1	25.0	12.7	27.3

ED = emergency department; Max. = maximum; Min. = minimum; *n* = number of district hospitals; SD = standard deviation.
[a] New Taipei City, Taichung, Tainan, and Kaohsiung were upgraded to municipalities in 2010.

outpatients of 290,356.42, which exceeded 90,001 in 46 hospitals. The mean numbers of ED patients in LT/LP were 243,446.00 and 24,376.00 in 2011 and 2009, respectively; however, in 2009, HT/HP consisted of 21 hospitals with 30,001–60,000 ED patients (columns of Figs. 2–5 represent clusters of the number of district hospitals in Taiwan during 2007–2009 and 2011).

3.3. Resource market

From a district hospital organizational-resource perspective, we used resource input and resource utilization as the input and output variables, respectively. As the market shares increased from 25% to 30%, the effects of market power became more substantial.[30] Using the numbers of hospitals and types of hospital ownership, we clustered hospital input and output variables and characteristics to calculate

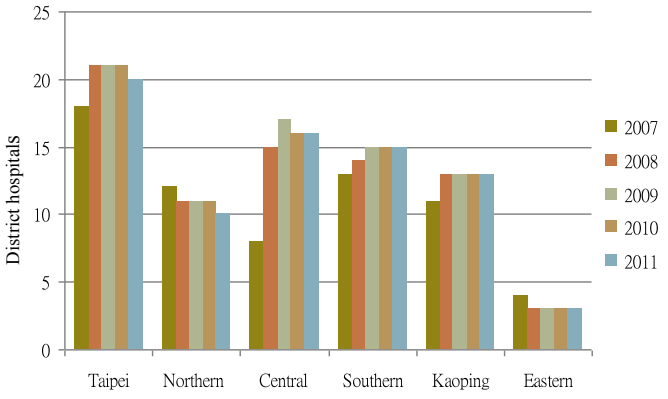

Fig. 1. Geographical distribution divisions of the number of district hospitals in Taiwan, 2007–2011.

percentages. Input or utilization values exceeding 30% indicated high input or utilization, and values less than 30% suggested low input or utilization. Subsequently, we gave meaningful names to each cluster in the three cluster groups: high throughput (HT) and high performance (HP), medium throughput (MT) and medium performance (MP), and low throughput (LT) and low performance (LP). Furthermore, for 2007–2009 and 2011, we defined the hospital groups according to annual input and utilization of resources. However, when the input and utilization were equal, the range was used as the criterion. For example, if the percentage of hospitals with the number of medical staff members exceeding 401 was high, then the resource input level was considered to be high, even though the percentages of other input resources were low. If this situation did not occur, then the resource input level was considered to be low or medium. For example, in 2011, the clusters were LT11/LP11 and MT11/MP11 (Appendix 7).

In 2007 and 2011, the groups exhibited the following combinations: LT and LP (LT07 and LT11, and LP07 and LP11), MT and MP (MT07 and MT11, and MP07 and MP11), and HT and HP (HT07 and HT11, and HP07 and HP11). By contrast, in 2008 and 2009, the groups exhibited the following combinations: HT and HP (HT08 and HT09, and HP08 and HP09), LT and LP (LT08 and LT09, and LP08 and LP09), and MT and MP (MT08 and MT09, and MP08 and MP09; Table 2).

3.4. Hospital efficiency

We clustered three types of resource utilization efficiency in district hospital during 2007–2009 and 2011. The high resource utilization efficiency category had fewer physicians; the number of discharged patients exceeded 6001, the number

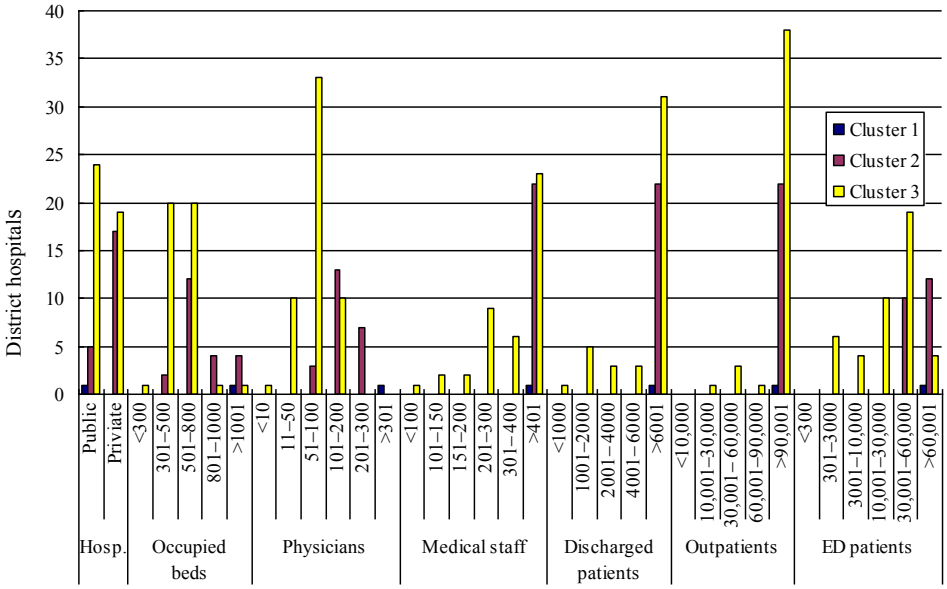

Fig. 2. Clusters of district hospitals in Taiwan, 2007. ED = emergency department; Hosp. = hospital.

of outpatients exceeded 90,001, and the number of ED patients ranged between 10,001 and 30,000 in this category (comprising HT07, HT11, HP07, HP11, HT08, HT09, HP08, and HP09; Appendix 7).

The medium resource utilization efficiency category (MT07, MT11, MP07, MP11, MT08, MT09, MP08, and MP09) exhibited a medium resource input level. In this category, 15.58–19.70% of hospitals employed 101–200 physicians; however, 29.87–33.75% of the hospitals in the HT category employed only 51–100 physicians. In addition, the percentages of hospitals that had 501–800 occupied beds ranged from 15.00% to 16.67%, and the number of medical staff members exceeded 401. Regarding resource utilization, the numbers of discharged patients and outpatients exceeded 6001 and 90,001, respectively, and percentages of hospitals with numbers of ED patients exceeding 60,001 in 2007, 2008, 2009, and 2011 were 18.18%, 14.29%, 17.50%, and 19.48%, respectively.

The categories of low input and low utilization (LT07, LT11, LP07, LP11, LT08, LT09, LP08, and LP09) exhibited fewer occupied beds, physicians, and medical staff members. The percentages of hospitals employing 101–200 physicians

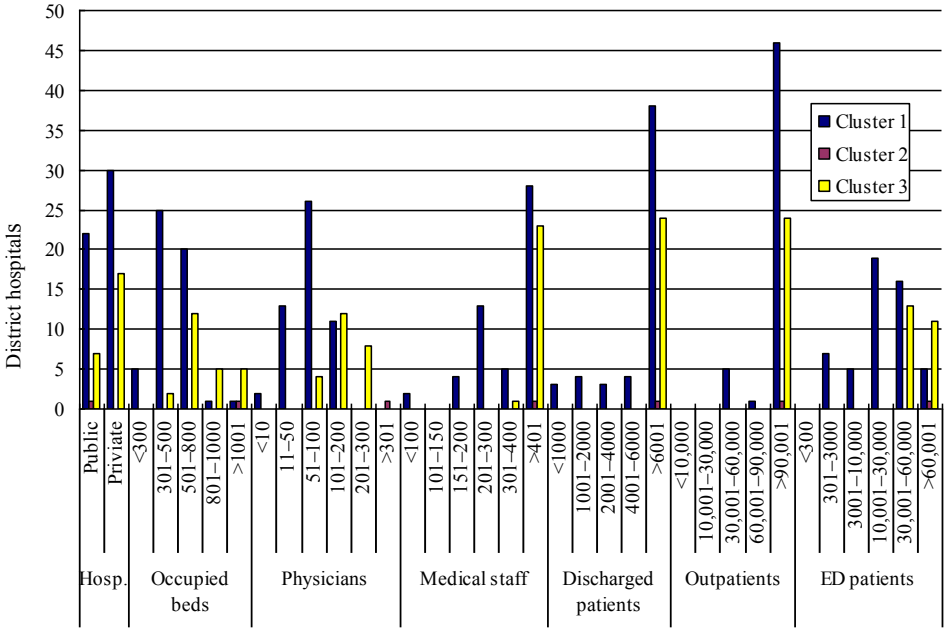

Fig. 3. Clusters of district hospitals in Taiwan, 2008. ED = emergency department; Hosp. = hospital.

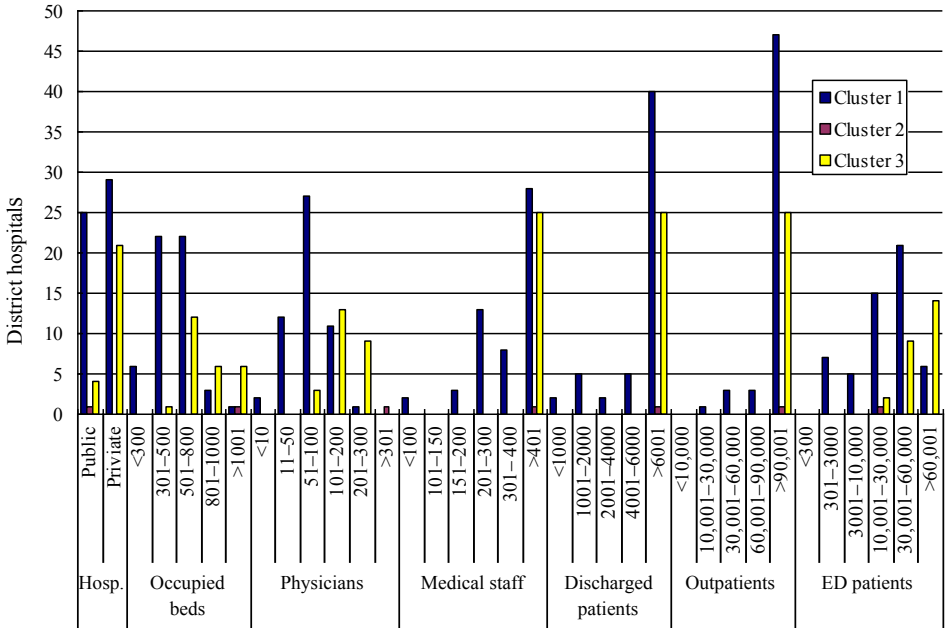

Fig. 4. Clusters of district hospitals in Taiwan, 2009. ED = emergency department; Hosp. = hospital.

and more than 401 medical staff members were lower. Similarly, the percentages of hospitals with more than 6001 discharged patients, 90,001 outpatients, and 60,001 ED patients were low. Particularly, in 2009, the percentage of hospitals with 10,001–30,000 ED patients was 1.25%.

4. Discussion

The primary objective of this study was to determine the cluster analysis distribution and efficiency of medical service resources at district hospitals in Taiwan. According to the results, district hospitals must be compatible with the hospital market environment to manage the uncertainty and ambiguity regarding the increase or decrease of district hospitals. In particular, the hospital industry is changing rapidly, causing the number of hospital beds and inpatient utilization to decrease and the amount of outpatient services to increase.[31–33] In addition, resource allocation is crucial,[7] and decisions regarding resource allocation are imperative for competing to acquire market resources and ensuring that district hospitals survive and thrive. Patients have heterogeneous preferences; thus, within a unique medical service market in which patients are expected to be involved directly and to obtain nonretradable resources quickly,

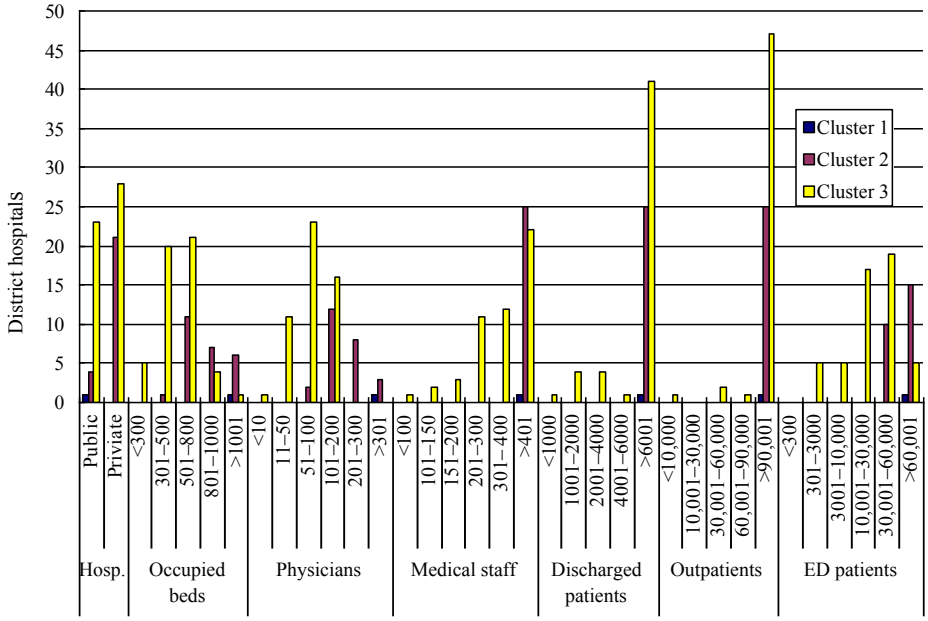

Fig. 5. Clusters of district hospitals in Taiwan, 2011. ED = emergency department; Hosp. = hospital.

Table 2
Percentage of overall outcomes for district hospital clusters and categories.[a,b]

		Cluster		
Year	Category	Low throughput/low performance	Medium throughput/medium performance	High throughput/high performance
2007	Ownership form	Public: 100 (1)	Public: 22.73 (5)	Public: 55.81 (24)
(n = 66)		Private: 0 (0)	Private: 77.27 (17)	Private: 44.19 (19)
	Occupied beds	>1001: 1.52	501–800: 16.67	501–800: 31.86
	Physicians	>301: 1.52	101–200: 19.70	51–100: 31.82
	Medical staff	>401: 1.52	>401: 33.33	>401: 36.36
	Discharged patients	>6001: 1.52	>6001: 33.33	>6001: 46.97
	Outpatients	>90,001: 1.52	>90,001: 33.33	>90,001: 57.58
	ED patients	>60,001: 1.52	>60,001: 18.18	30,001–60,000: 28.79
2008	Category	High throughput/high performance	Low throughput/low performance	Medium throughput/medium performance
(n = 77)	Ownership form	Public: 42.31 (22)	Public: 100.00 (1)	Public: 29.17 (7)
		Private: 57.69 (30)	Private: 0.00 (0)	Private: 70.83 (17)
	Occupied beds	301–500: 32.47	>1001: 1.30	501–800: 15.58
	Physicians	51–100: 33.77	>301: 1.30	101–200: 15.58
	Medical staff	>401: 36.36	>401: 1.30	>401: 29.87
	Discharged patients	>6001: 49.35	>6001: 1.30	>6001: 31.17
	Outpatients	>90,001: 59.74	>90,001: 1.30	>90,001: 31.17
	ED patients	10,001–30,000: 24.68	>60,001: 1.30	30,001–60,000: 16.88
2009	Category	High throughput/high performance	Low throughput/low performance	Medium throughput/medium performance
(n = 80)	Ownership form	Public: 46.30 (25)	Public: 100.00 (1)	Public: 16.00 (4)
		Private: 53.70 (29)	Private: 0.00 (0)	Private: 84.00 (21)
	Occupied beds	301–500: 27.50 501–800: 27.50	>1001: 1.25	501–800: 15.00
	Physicians	51–100: 33.75	>301: 1.25	101–200: 16.25
	Medical staff	>401: 35.00	>401: 1.25	>401: 31.25
	Discharged patients	>6001: 50.00	>6001: 1.25	>6001: 31.25
	Outpatients	>90,001: 58.75	>90,001: 1.25	>90,001: 31.25
	ED patients	30,001–60,000: 26.25	10,001–30,000: 1.25	>60,001: 17.50
2011	Category	Low throughput/low performance	Medium throughput/medium performance	High throughput/high performance
(n = 77)	Ownership form	Public: 100.00 (1)	Public: 16.00 (4)	Public: 45.10 (23)
		Private: 0.00 (0)	Private: 84.00 (21)	Private: 54.90 (28)
	Occupied beds	>1001: 1.30	501–800: 14.29	501–800: 27.27
	Physicians	>301: 1.30	101–200: 15.58	51–100: 29.87
	Medical staff	>401: 1.30	>401: 32.47	>401: 28.57
	Discharged patients	>6001: 1.30	>6001: 32.47	>6001: 53.25
	Outpatients	>90,001: 1.30	>90,001: 32.47	>90,001: 61.04
	ED patients	>60,001: 1.30	>60,001: 19.48	30,001–60,000: 24.68

Data are presented as % (n) or n/range: %.
All results reached a significance level of $p < 0.05$, except for those from 2010.
ED = emergency department.
[a] The number in parentheses in the ownership form row represents the number of public and private district hospitals. In addition, the percentage of hospitals (%) was calculated as follows: the number of public or private hospitals ÷ the total number of public and private hospitals.
[b] The percentage of input and output variables (%) was calculated as follows: the number of category district hospitals ÷ the total number of district hospitals.

patients will choose to receive treatment at hospitals that can achieve maximal utility (e.g., hospital ownership, geographic location, and staffing ratio). Resource allocation influences patient choice of hospitals and physicians; thus, other hospitals encounter difficulty when appointing physicians for patients and admitting inpatients who require a long length of stay.[5,6]

A high accreditation rating strategy is frequently used in Taiwan.[13] For example, St Joseph Hospital was restructured as a district hospital, and the Kaohsiung Minsheng Hospital was downgraded from a district hospital to a regional hospital.[3] When a hospital is upgraded to the district level, the method through which its growth is defined changes, and the established hospitals encounter barriers to entry in the market. Thus, in addition to obtaining increased beneficial resources from the market, hospitals must evaluate resource allocation to enhance resource efficiency.[34] For example, the percentage of hospitals that had 10,001–30,000 ED patients was 1.25% in the LT09 and LP09 category (Table 2).

4.1. Unequal medical resource allocation and distribution

We determined that the resource output of district hospitals, such as the number of discharged patients and outpatients,[35]

was low; however, the numbers of ED patients were significantly high as well as low. In other words, most values figures of the service volumes at district hospitals were allocated to low-value ranges. Regarding the types of ownership, the number of public hospitals decreased and that of private hospitals increased, and the geographical distribution was unequal: the Taipei Division had 25.97−27.27% of the total district hospitals, whereas the Eastern Division had only 3.75−6.05%.

The hospital bed use rates at district hospitals were sufficient, and the number of employees was not influenced by business fluctuations. Cluster analysis of the resource allocation at district hospitals indicated that the clustered hospitals exhibiting low resource input and output levels were located in Taipei; Cluster 1, in 2007 and 2011, and Cluster 2, in 2008 and 2009, had only one hospital. Moreover, the highest values of input and output variables were classified into clusters that were distributed among various counties and cities (Appendix 8). The results indicated that resource allocation and distribution at district hospitals were unequal, a result that was consistent with the results obtained by Chang et al,[36] who observed that only a few hospitals and no medical centers were within the areas accessible to patients, and that the majority of physicians were concentrated in highly populated cities, such as Taipei, Taichung, and Kaohsiung.[37] By using a clustering method to analyze Taiwan district hospitals, we identified spatial inequality in health care provision and utilization.

4.2. Some district hospitals require enhanced resource utilization

Hospitals automatically adjust the number of physicians to accommodate high ED patient volumes yearly. For example, in the HP11 efficiency category, the inputs were < 800 hospital beds (41 hospitals) and 51−100 physicians (23 hospitals), and the number of physicians in this category was less than that in the other categories (44 hospitals had < 800 hospital beds, and 27 hospitals employed 51−100 physicians in 2009); however, resource utilization remained high (Appendix 9). Regarding the MP09 category, the percentages of hospitals that had more than 1001, 501−800, and 301−500 occupied beds were 7.50%, 15.00%, and 1.25%, respectively. However, the number of hospitals employing 101−200 physicians and that with more than 60,001 ED patients exceeded the number of hospitals in categories HT09 and HP09. Appendix 6 indicates that the cluster ranking of the number of ED patients in 2009 (C1 > C3 > C2) differed from that in 2007 and 2011 (C3 > C2 > C1), and the mean number of ED patients (C2) in 2008 differed from that in 2009 (2008 = 213,020, 2009 = 24,376). These high ED patient numbers indicate that hospitals readily adjust physician manpower to accommodate health care demands. Chang et al[36] reported that the medical resources of district and cross-district hospitals substantially affected the hospital-seeking behavior of patients. Results regarding resource utilization suggested that resource redistribution at district hospitals requires further investigation.

4.3. Recommendations and limitations

The clustering method is useful for analyzing medical service resources and determining appropriate resource allocation for district hospitals. Therefore, we offer the following recommendations.

To preserve quality at the district hospital level, we suggest that hospitals enhance resource utilization, improve bed use efficiency, and increase the number of available beds. Although the sample data indicated that the ratio of occupied beds to available beds (2007, 95.72%; 2008, 93.65%; 2009, 94.90%; and 2011, 95.72%) exceeded 90%, from a management perspective, district hospitals should consider implementing resource-based strategies and strategies that can increase service efficiency.[34] For example, in 2009, the number of occupied beds (> 1001) was greater (85%) than that in other ranges (Table 1). District hospitals have begun to invest in human resources (the total number of physicians and medical staff members increased from 8787 in 2008 to 9606 in 2011, and from 37,510 in 2007 to 48,699 in 2010), and government policies implemented in the five distinct municipalities and uncontrolled by district hospitals affected hospital resource efficiency in 2010. Moreover, the number of district hospitals ranged from 66 to 80 in 2007−2009 and 2011; all district hospitals utilized resources efficiently. Therefore, whether the number of district hospitals should be increased remains in question. However, district hospital managers must have vital and unique internal resources that facilitate devising strategies, improving structural strength and resource adaptability, and remaining competitive within the health care system.

We recommend future investigation of the variations in resource input and utilization at district hospitals that are unaffected by the type of ownership; substantial changes in the number of outpatients and ED patients in the clustered hospitals, geographic factors should be examined. In addition, health care management academics have rarely focused on the hospital market; therefore, we suggest that health care management must address these concerns in future studies.

The major limitation of this study was the acquired data. An analysis of hospital markets requires data pertaining to hospital operations, skill and resource distribution, and relevant human resources. Analysis of the categories of LT07, LT11, LP07, LP11, LT08, LT09, LP08, and LP09 requires using hospital operations, skill and resource distribution, and relevant human resources data to enhance resource utilization. However, we used various data periods and a clustering

method to simplify the data structure of the various district hospitals, obtaining the clustering results. The data employed were obtained for 4 years (2007–2009, and 2011), and the cluster analysis results were used as a reference during the analysis of hospitals at other levels.

The following limitations should be considered. Although Lee and Wang[18] employed input–output price data to assess hospital efficiency in the hospital industry, their health care management analysis analyzed prices,[5] which are a financial indicator rather than a direct indicator of hospital resource efficiency. Furthermore, we assumed that competitive input markets [and thus, fixed input prices common to all firms (hospitals)] enabled us to describe allocative efficiency at the firm (hospital) level.[33] However, Smith et al[38] surveyed the vice-president level or the closest equivalent of senior decision makers in the Regional Health Authorities, Canada, between January 2011 and April 2011. They received replies from 60 out of 89 organizations and 92 respondents. Overall, 89% of the respondents agreed that resource allocation decisions concerned ethics, in spite of financial data being used to describe the relationship between input and output factors and to analyze details of the input and output resource allocation characteristics and efficiency at district hospitals. However, resource allocation decisions are more than business decisions that pertain solely to financial and budgetary matters.

New data must be collected, and novel modeling techniques should be employed to investigate questions regarding, for example, optimal outpatient visit regulations, and medical arms race effects of physician behaviors and resource allocation. To facilitate further analysis, more sophisticated techniques to obtain and maintain data are required.[39] Nevertheless, the results from our study clearly summarize resource allocation and indicate how resources are utilized at district hospitals in Taiwan.

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Appendix 1

Articles 1 and 9 of the Regulations Governing Contracting and Management of the NHI Medical Care Institutions state, “These Regulations are enacted pursuant to the principles set forth in Paragraph 1 of Article 66 and Paragraph 1 of Article 67 of the NHI Act (hereafter referred to as the Act),” and “hospitals applying for the contracting for hospital stays shall be reviewed by hospitals” (amended on December 28, 2012 and enforced on January 1, 2013). The Standard Procedures of Hospital Accreditation and Teaching Hospital Accreditation include the accreditations of medical centers, district hospitals, and regional hospitals (amended on May 8, 2013). The new hospital accreditation expiration date is based on the hospital accreditation results: 4 years, 4 years, and 3 years for hospitals that have outstanding, good, and satisfactory accreditation scores, respectively.[1,2] District hospitals are hospitals that have 300 or more hospital beds for every 400,000 residents in the region. District hospitals that pass the Hospital Accreditation and Teaching Hospital Accreditation should fulfill the criteria of teaching hospitals, be fully equipped to train medical students and specialist physicians, and develop physicians for district hospitals.[3,4] Regarding the laws governing the eligibility criteria for the establishment of medical institutions, the Medical Care Act of 1986 is typically referenced. Article 12 of the Medical Care Act states, “In establishment or expansion, hospitals may apply for building licenses in accordance with related regulations under the Building Code after approval from the competent authority,” suggesting that the establishment or expansion of hospitals must be approved by the government and that the hospital market is not characterized by free entry.[5] In addition, the accreditation results change the total number of district hospitals. Moreover, the district hospitals must obtain hospital accreditation to be eligible for NHI reimbursement and apply again for hospital accreditation prior to the accreditation expiration date.[1,2] Consequently, hospitals have a strong incentive to strive for “promotion”[5] and avoid downgrading. For example, Kaohsiung Minsheng Hospital was formerly a district hospital that was downgraded to a regional hospital, and St Joseph Hospital, formerly a regional hospital, was upgraded to a district hospital.[3]

Appendix 2

Since 1992, the Ministry of Health and Welfare has been conducting an annual census on hospitals concerning the current condition and service volume from the previous year. The implementation process is as follows. Referring to December 31 of the previous year, all public and private hospitals are required, by administrative order, to complete a form detailing basic information and annual service volume, which is submitted to the city or county health department for inspection. After being confirmed for accuracy, these data are forwarded to the Ministry of Health and Welfare and archived.[24] Researchers who fulfill the requirements for conducting research projects are eligible to apply for access to the NHI Research Database, the use of which is limited to research purposes. Applicants must adhere to the Computer-Processed Personal Data Protection Law and related regulations of the Bureau of National Health Insurance and National Health Research Institutes, and sign an agreement that requires the signature of their supervisor prior to submission of the application.[40]

Appendix 3

For countries and regions that have income per capita and elderly population ratios similar to those of Taiwan, the number of physicians per 1000 people during 2010 was 2.88, which was 1.55 more than the number of Western medicine physicians (1.33 per 1000 people) in Taiwan.[41] Wui et al[41] estimated that the inclusion of medical students to the calculation by the Ministry of Education in 2020 will increase the number of physicians per 1000 people to 1.63. Moreover, physicians are typically distributed in regional or higher-level hospitals, and concentrated in densely populated cities, such as Taipei, Taichung, and Kaohsiung.[37]

Appendix 4

In 1980, the number of hospitals and hospital beds in Taiwan totaled 835 and 68,382, respectively, averaging 82 hospital beds per hospital. In 2000, the number of hospitals decreased to 669 and the number of hospital beds increased to 114,179, an increase of almost 171 hospital beds per hospital. Annual statistics gathered after the NHI was introduced suggest that both medical centers and district hospitals exhibited a stronger growth rate than regional hospitals. Although hospitals reported an overall service volume growth, service volume growth among hospitals with various accreditation ratings differed significantly.[5] Huang et al[3] estimated that the Ministry of Health and Welfare Medical Service Project would increase the number of hospital beds at regional hospitals to 37.6 by 1985 (including beds that were approved, but remained to be opened to patients) and 12.5 per 10,000 people at district hospitals. According to the requirement that a district hospital having 300 standard hospital beds (not including beds for patients with serious or acute diseases and beds in the intensive care unit) should serve every 400,000 people in a region,[3] Taipei City, which has a population of 5,301,936,[42] required 13.25 hospitals and 6,627.42 hospital beds (5,301,936/10,000 $\times$ 12.5) in 2011. However, our study data indicated that only eight district hospitals existed and the number of beds available per 10,000 people was 12.5, indicating a bed deficiency.

Payments from the NHI (the largest source of revenue for hospitals) for the medical services provided by hospitals cannot be negotiated, resulting in a lack of competitive prices. Numerous studies have suggested that, regardless of the hospital market competition is nonprice and medical arms race in which hospital acquire and provide advanced medical equipment and services. This leads to rapid increases in the hospital usage frequency of high-tech medical equipment, which attracts more physicians and enhances productivity, and is a phenomenon that has become even more pronounced following the introduction of the NHI. Therefore, large-scale hospitals that are exposed to a high level of competition are located in areas with a high hospital density; the majority of these hospitals are situated in metropolitan areas, attracting patients from other regions.[5] Sung et al[22] analyzed the number of physicians completing general medicine training in 106 hospitals between 1991 and 1993, and determined that the maximal number of physicians allowed to train per year was 670. However, during the 1st year, only 452 resident physicians completed their training, accounting for merely two-thirds of the maximal capacity. The number of resident physicians totaled 1640, averaging 15.5 per hospital, which is incomparable with the average of 45.2 physicians per hospital in the USA. Moreover, each resident physician working in regional hospitals must attend to 20 hospital beds, and district hospital physicians must teach in addition to their clinical duties.[3] We calculated 9606 (physicians)/77 (hospitals) = 124.75 physicians per district hospitals in our study, indicating that the demand for physicians remains high.

Appendix 5

Cluster ANOVA results for district hospitals in Taiwan, 2007–2011.

	2007 (n = 66)		2008 (n = 77)		2009 (n = 80)		2010 (n = 79)		2011 (n = 77)	
	F test	p	F test	p	F test	p	F test	p	F test	p
Input variable										
Occupied beds	133.601	<0.001	126.764	<0.001	122.643	<0.001	2.441	0.94	123.906	<0.001
Physicians	196.799	<0.001	182.184	<0.001	153.467	<0.001	2.624	0.79	142.838	<0.001
Medical staff	116.769	<0.001	122.255	<0.001	133.447	<0.001	2.143	0.124	130.071	<0.001
Output variable										
Discharged patients	40.356	<0.001	49.554	<0.001	62.626	<0.001	196.786	<0.001	72.757	<0.001
Outpatients	208.350	<0.001	264.285	<0.001	266.659	<0.001	392.630	<0.001	243.248	<0.001
ED patients	43.679	<0.001	55.993	<0.001	15.581	<0.001	153.726	<0.001	66.292	<0.001

ANOVA = analysis of variance; ED = emergency department; n = number of district hospitals.

Appendix 6

Mean value comparison of the district hospital clusters (2007–2009 and 2011).[a,b]

Year (n)	2007 (n = 66)			2008 (n = 77)			2009 (n = 80)			2011 (n = 77)		
Group	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
Comparison	C2−C1	C2−C3	C1−C3	C2−C1	C2−C3	C1−C3	C2−C1	C2−C3	C1−C3	C2−C1	C2−C3	C1−C3
Occupied beds												
Mean	3600.00	784.00	549.00	499.02	3666.00	797.08	513.07	3748.00	848.44	3740.00	867.84	531.67
Mean difference	−2816.00	235.00	3051.00	3166.98	2868.92	−298.06	3234.93	2899.56	−335.37	−2872.16	336.17	3208.33
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C2 > C3			C3 > C2 > C1		
Physicians												
Mean	851.00	161.00	76.00	73.63	864.00	170.58	76.20	820.00	176.20	809.00	193.84	77.47
Mean difference	−690.00	85.00	775.00	790.37	693.42	−96.95	743.80	643.80	−100.00	−615.16	116.37	731.53
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C2 > C3			C3 > C2 > C1		
Medical staff												
Mean	3075.00	774.00	405.00	391.69	3194.00	799.63	398.54	3189.00	883.20	2886.00	845.64	381.24
Mean difference	−2301.00	369.00	2670.00	2802.31	2394.37	−407.94	2790.46	2305.8	−484.66	−2040.36	464.4	2504.76
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C2 > C3			C3 > C2 > C1		
Discharged patients												
Mean	65,714.00	24,652.00	11,608.00	11,083.63	66,899.00	24,490.46	11,327.07	70,766.00	25,683.40	71,293.00	27,859.20	11,802.41
Mean difference	−41,062.00	13,044.00	54,106.00	55,815.37	42,408.54	−13,406.83	59,438.93	45,082.60	−14,356.33	−43,433.80	16,056.79	59,490.59
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C2 > C3			C3 > C2 > C1		
Outpatients												
Mean	2,840,145.00	684,611.00	296,120.00	290,356.42	3,004,038.00	712,712.25	300,825.74	3,101,380.00	750,883.64	3,001,490.00	793,214.16	312,646.49
Mean difference	−2,155,534.00	388,491.00	2,544,025.00	2,713,681.58	2,291,325.75	−422,355.83	2,800,554.26	2,350,496.36	−450,057.90	−2,208,275.84	480,567.67	2,688,843.51
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C2 > C3			C3 > C2 > C1		
ED patients												
Mean	212,273.00	57,008.00	31,182.00	28,156.08	213,020.00	56,423.83	30,860.91	24,376.00	58,849.64	243,446.00	64,729.52	31,700.41
Mean difference	−155,265.00	25,826.00	181,091.00	184,863.92	156,596.17	−28,267.75	−6484.91	−34,473.64	−27,988.73	−178,716.48	33,029.11	211,745.59
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ranking	C3 > C2 > C1			C1 > C2 > C3			C1 > C3 > C2			C3 > C2 > C1		

C1 = Cluster 1; C2 = Cluster 2; C3 = Cluster 3.

[a] Groups for the ranking of clusters were compared before the percentages of the overall outcomes for district hospital clusters and categories were calculated (Table 2).

[b] Excluding 2010, all results exhibited a significance level of $p < 0.05$.

Appendix 7

Comparison table of cluster (group) labels.[a]

Year[b]	Cluster (Group) 1	Cluster (Group) 2	Cluster (Group) 3
2007	LT/LP	MT/MP	HT/HP
2008	HT/HP	LT/LP	MT/MP
2009	HT/HP	LT/LP	MT/MP
2011	LT/LP	MT/MP	HT/HP

HP = high performance; HT = high throughput; LP = low performance; LT = low throughput; MP = medium performance; MT = medium throughput.

[a] Three groups of HT and HP, MT and MP, and LT and LP include HT07–HT09, HT11, HP07–HP09, HP11, MT07–MT09, MT11, MP07–MP09, MP11, LT07–LT09, LT11, LP07–LP09, and LP11.

[b] Excluding 2010, all results exhibited a significance level of $p < 0.05$.

Appendix 8

Number of cluster hospitals and their locations.

Year[a]	Cluster	Counties/cities
2007	Cluster 1	Taipei (1)
	Cluster 2	Taipei (2), Kaohsiung (1), Keelung (2), Hsinchu (1), Tainan (1), Chiayi (2), Taipei County (3), Taoyuan (1), Yilan (2), Taichung County (2), Yunlin (1), Chiayi County (2), Tainan County (1), & Kaohsiung County (1)
	Cluster 3	Taipei (4), Kaohsiung (5), Hsinchu (1), Taichung (2), Tainan (3), Chiayi (1), Taipei County (3), Taoyuan (6), Hsinchu County (1), Yilan (1), Miaoli (2), Taichung County (2), Changhua (1), Nantou (1), Yunlin (1), Tainan County (1), Kaohsiung County (1), Pingtung (3), Hualien (3), & Taitung (1)
2008	Cluster 1	Taipei (5), Kaohsiung (5), Kaohsiung County (1), Taichung (2), Taichung County (5), Tainan (2), Tainan County (2), Taipei County (4), Keelung (1), Taoyuan (6), Changhua (3), Chiayi (1), Yilan (1), Miaoli (2), Nantou (2), Yunlin (2), Pingtung (4), Hualien (2), & Taitung (1)
	Cluster 2	Taipei (1)
	Cluster 3	Taipei (2), Kaohsiung (1), Kaohsiung County (1), Taichung County (3), Tainan (1), Tainan County (1), Taipei County (4), Keelung (2), Taoyuan (1), Hsinchu (2), Chiayi City (2), Chiayi County (2), Yilan (2), & Yunlin (1)
2009	Cluster 1	Taipei (5), Kaohsiung (6), Kaohsiung County (1), Taichung (3), Taichung County (5), Tainan (2), Tainan County (2), Taipei County (4), Keelung (1), Taoyuan (5), Changhua (3), Chiayi (1), Yilan (1), Miaoli (2), Nantou (2), Yunlin (3), Pingtung (4), Hualien (2), & Taitung (1)
	Cluster 2	Taipei (1)
	Cluster 3	Taipei (2), Kaohsiung (1), Taichung County (3), Tainan (1), Tainan County (1), Taipei County (4), Keelung (1), Taoyuan (1), Hsinchu (2), Changhua (1), Chiayi City (2), Chiayi County (2), Yilan (2), Yunlin (1), & Pingtung (1)
2011	Cluster 1	Taipei (1)
	Cluster 2	Taipei (2), Kaohsiung (2), Taichung (3), Tainan (2), New Taipei City (4), Keelung (1), Taoyuan (1), Hsinchu (1), Changhua (1), Chiayi City (2), Chiayi County (2), Yilan (2), Yunlin (1), & Pingtung (1)
	Cluster 3	Taipei (5), Kaohsiung (6), Taichung (7), Tainan (4), New Taipei City (3), Keelung (1), Taoyuan (6), Changhua (3), Chiayi City (1), Yilan (1), Miaoli (2), Nantou (2), Yunlin (3), Pingtung (4), Hualien (2), & Taitung (1)

The number in parentheses represents the number of district hospitals in each city or county.

[a] Excluding 2010, all results exhibited a significance level of $p < 0.05$.

Appendix 9

The Ministry of Health and Welfare established the Medical Expenditure Negotiation Committee pursuant to Article 48 of the NHI Act on November 8, 1996. The Medical Expenditure Negotiation Committee consults with each medical institution concerning the medical reimbursement budgets, growth rate, general service charge distribution, and clearing of ambiguities. After the benefit expense package has been drafted, the insurer asks premium payer representatives, insurance medical care provider representatives, and experts to study and promote the GBS (NHI Act, Article 61). In the GBS, medical institutions no longer apply for cash reimbursements, but rather to receive point values. The total amount is set as the numerator and the total point value as the denominator. Currently, the GBS payment is based on existing services offered or according to medical cases. To balance the costs filed and actual payments, the payment procedure involves paying a unit amount for a fixed point value (NT$1 per point), which is converted to a floating point.

Payments to physicians are influenced by the payment standards and prices, and the floating points change the absolute amount paid; the disposal behavior of physicians determines the floating point standard. Using the mechanism of GBS, the treatment behavior of one physician influences that of another physician, causing physicians to perform more treatments, tests, and measurements. Physicians gain substantially more when they work more than other physicians (big win) and receive less (big loss) when they work less than other physicians. Conversely, when all physicians perform the same amount of task, there are no big or small wins or losses; in other words, physicians bear the costs and receive the benefits of performing more treatments together.[43] However, concerning the assessment of hospital resource and capital use productivity and efficiency, Su et al[44] asserted that the optimal resource allocation efficiency is achieved when labor is minimized and service volume is maximized. Conversely, low efficiency occurs when labor is high (i.e., costs are high) and service volume is low (i.e., hospital output is low; hospitals have a few discharged patients, or a few outpatients and emergency room visits). Liu and Chiang[24] suggested that physician manpower and service volume were negatively correlated, implying that even when service volume increased, physician manpower decreased. Therefore, the point values changed as the service volume and service price of the hospitals shifted. The GBS is used to control health care reimbursements,[43] prompting managers to concentrate on the management and control of human resources. In our study, by merging quantified data that were similar, performing cluster

analysis on out-of-group data with high heterogeneity and in-group data with high homogeneity, using the *K*-means of Ward's minimum variance iterations, conducting the analysis of variance significance *F* test, and determining the number of clusters and cluster properties,[45] we ascertained the differences in resource allocation among district hospitals; for example, the results of Cluster 1 in 2007 and 2011 and Cluster 2 in 2008 and 2009 indicated that these clusters had only one medical institution, causing differences in subsequent hospital management.

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