

## Article

# The Impact of Hospital Specialization on Congestion and Efficiency

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**Abstract:** The purpose of this study is to verify the existence of congestion in Korean hospitals, to identify the causes of congestion, and to suggest directions for efficiency improvement of hospitals. The result showed that congestion occurred in 71.90% of 1185 hospitals. In addition, it was found that hospital specialization has a negative effect on congestion. In other words, the higher the hospital specialization, the lower the overall congestion rate of the hospital. More specifically, the specialization of hospitals also showed a negative effect on congestion of nurses. On the other hand, hospital specialization was found to have a positive effect on the congestion of the number of doctors, but it does not have a significant effect on the congestion of hospital beds. It was also found that hospital size has an effect on the relationship between hospital specialization and congestion, but the location of the hospital and the type of ownership did not act as a moderator.

**Keywords:** congestion; efficiency; data envelopment analysis; specialization; hospital management

## 1. Introduction

In the past few decades, the number of private hospitals has continued to increase, which has caused the over-supply of medical service in the Korean medical industry. In addition, since government regulations on medical care are being tightened gradually as the importance of public health grows, the Korean hospitals' profitability is getting diminished. Furthermore, the hospital's function has been reduced, as hospitals cannot sell medicines, that were a major revenue source, but only offer prescriptions for them [1]. Therefore, most hospitals are experiencing difficulties in management. To overcome these difficulties, hospitals are racing to secure profitability, considering the efficiency of hospitals as a means. As the importance of the efficiency of the hospital has been emphasized, studies related to this have been conducted, and most of the previous studies showed that the inefficiency exists in the operations of the hospital [2–7].

Recently, there have been many studies on the efficient operation of public hospitals, due to the introduction of competition logic in the public sector in Korea [8]. According to Cho et al. [2] on the efficiency of local public hospitals that are owned by city or local government, most local public hospitals are inefficient. Park and Kim [9] studied the efficiency of a total of 199 public hospitals, including local public hospitals, and they also found that most public hospitals had low efficiency. Especially, the efficiency of national hospitals owned by the government was lower than that of other ownership types of public hospitals, such as special purpose public hospitals and local public hospitals. The reason for the relatively low efficiency of national hospitals is that management supervision of the national hospitals is relatively looser than the other two types of hospitals. They also identified that the efficiency of public hospitals with private management was found to be more efficient than that

of public hospitals with direct management by the government. This implies that efficiency depends much on who manages the hospital rather than who owns it. The results of Yang and Chang [7], which compared the efficiency of national university hospitals with those of private university hospitals, showed that the operational ability of the management was more important than the ownership type of hospitals.

On the other hand, competition between hospitals has an important effect on efficiency. Bloom et al. [10] analyzed the effect of competition on managerial quality and performances of English public hospitals. They found that higher competition caused higher management quality and performances. Management quality can be improved by 0.4 standard deviations by adding a new hospital. Cooper et al. [11] also found that the efficiency of public hospitals improved when competing with for-profit hospitals and public hospitals in the UK.

Excessive input in operations was found to be a major cause of hospital inefficiency. If the input is excessive beyond a certain level, congestion could happen. Congestion refers to the phenomenon that one or more outputs increase when one or more inputs decrease. In other words, in general, the output is decreased when the input is decreased. However, if congestion exists, the output is increased when the input is decreased. Indeed, Cooper et al. [12] demonstrated the existence of congestion in the textile and automobile industries in China from 1981 to 1997. They found that congestion existed due to the guaranteed job security policy (also known as “iron rice bowl” policy) for the textile and automobile industry. This policy ultimately led to bankruptcy of the textile industry, while other industries were almost bankrupt. In addition, Simões and Marques [13] conducted a congestion analysis of 68 hospitals in Portugal, demonstrating that congestion occurred in more than half of the hospitals. As such, congestion is characterized by inefficiency, especially where the safety of the job is somewhat guaranteed, such as the “iron rice bowl” policy of China. In fact, there is a congestion in public hospitals in Korea, where job security is guaranteed to some extent [9]. According to Park and Kim [9], there are 86 cases of congestion in the area of nursing personnel, which account for about 54% of the total 159 public hospitals. This result can be predicted from the case of Jinju Medical Center, a local public hospital located in Jinju, Korea. In this hospital, personnel expenses accounted for almost all of the net medical revenues, and it was ultimately closed in 2013, due to the chronic deficit accumulation [8]. In particular, they identified that although the hospital had the same ownership type as a public hospital, the incidence of congestion was lower when it was managed by outsourced private management than when directly managed by the government. This implies that in the case of congestion, as in the study of efficiency, how to manage the hospital is more important than who owns it. This suggests that congestion can also be expected to occur in private hospitals, depending on management capabilities. In particular, hospitals are highly capital-intensive industries with high investment in facility equipment and personnel, while at the same time systematic management is needed to maximize the utilization of resources limited to labor-intensive organizations [7]. Since the operational complexity of large hospitals is relatively high, it is difficult to manage, which is likely to lead to operational inefficiency. Hence, we study three research questions. First, does congestion exist in private hospitals? Second, if the size of the hospital is large, is the congestion frequency high? Third, as with efficiency, is congestion less frequent in hospitals in urban areas where competition is more severe? On the other hand, several methods to improve the efficiency of hospitals have been studied. For example, one approach is to improve performance through optimization of staffing allocations in hospitals [14,15]. In addition, cooperating with hospitals or forming or joining multi-institutional arrangements are also proposed as ways to improve the performance of the hospital. Among them, specialization strategies are being considered as one of the most effective approaches to increase efficiency of hospitals. According to Eastaugh [16], the number of specialized hospitals has increased by 186 percent over the last decade and these specialized hospitals have experienced a 10.1% reduction in cost per admission on average in the United States. This is partly because specialization allows physicians and nurses to focus on a specific type of patients, which enhances their expertise [16,17]. Samiedaluie and Verter [18] suggested that all hospitals in the system could share

benefit from specialization when the patient load is balanced among hospitals. It was also suggested that as the number of patients who require shorter stays in the hospital increases, specialization can enhance the accessibility of care. Thus, when designing hospital specialization, patient mix, length of patient stay, and patient load between hospitals should be considered. Most prior studies that have analyzed the relationship between hospital specialization and hospital performance have reported that appropriately specialized hospitals could provide quality services at reduced costs [19,20].

Korean hospitals, more specifically small to medium-sized hospitals, also followed the trend to provide specialized services to secure profitability. This trend was further accelerated by the efforts of the government to support specialty hospitals [21]. To capture the effect of specialization on the efficiency of Korean hospitals, 106 acute care hospitals in Seoul were studied [1]. Lee et al. [1] demonstrated that hospital specialization increases efficiency. In general, reducing input reduces output. However, in the presence of congestion, reducing input does not significantly reduce output. The existence of congestion means that the organization has exceeded the appropriate size in terms of input size. Therefore, it is possible to understand the extent to which the size of hospitals in Korea exceeds the appropriate level through the study of congestion in Korea. For Korean hospitals, hospital unions are strong. This means there is a high possibility of congestion in the number of nurses. According to [1], hospital specialization is known to increase efficiency. Thus, the degree of specialization of hospitals can also affect the degree of congestion. However, no study on this has been done. This leads to the following research question: Is there a causal relationship between hospital specialization and congestion? That is, one of the purposes of this study is to demonstrate that hospital specialization is a factor to reduce congestion and provide suggestions that will help the future decision-making of hospitals, realistically.

This study provides several contributions to the research on hospital management. First, this is the first study to identify that congestion appears even in private hospitals in Korea. Second, we are the first to show that the specialization strategy affects congestion occurrence. Third, the difference in congestion occurrence, according to the size, ownership type, and region of the hospital, was analyzed for all hospitals, not only public hospitals. Fourth, we provided empirical evidence that specialization affects the efficiency of hospitals.

## 2. Congestion Model and Specialization Index

### 2.1. Congestion Analysis

#### Notations [12]

$DMU_j$	decision making unit. An entity converting inputs into outputs. ( $j = 1, \dots, n$ )
$\emptyset$	efficiency score to be determined
$x_{ij}, y_{rj}$	amounts of inputs ( $i = 1, \dots, m$ ) and outputs ( $r = 1, \dots, s$ ) for $DMU_j$ , respectively.
$x_{io}, y_{ro}$	amounts of inputs ( $i = 1, \dots, m$ ) and outputs ( $r = 1, \dots, s$ ) for $DMU_o$ , respectively.
$\lambda_j$	intensity variable ( $j = 1, \dots, n$ ).
$S_i^-, S_r^+$	input slack ( $i = 1, \dots, m$ ) and output slack ( $r = 1, \dots, s$ ), respectively.
$\hat{x}_{io}, \hat{y}_{ro}$	amounts of inputs ( $i = 1, \dots, m$ ) and outputs ( $r = 1, \dots, s$ ) obtained from an optimal solution for $DMU_o$ , respectively.
$\delta_i^-$	amount of inefficiency in the input $i$
$S_i^{-*}$	total amount of slack in the input $i$
$\varepsilon$	a non-Archimedean element

Congestion and (technical) inefficiency used in this study can be defined as follows [12]:

**Definition 1.** (Technical) Inefficiency.

Inefficiency is said to occur when a greater output can be produced from the same inputs, or when the same output can be produced from less of one or more inputs, without increasing other inputs.

**Definition 2.** *Congestion.*

Congestion is said to be present when one or more outputs can be increased by reducing one or more inputs, without worsening any other input or output.

An example of a phenomenon of congestion can be found in a production process. When too many raw materials are crowded in a factory floor, the amount of products produced will be reduced [12,22]. The reduction of raw material inventory can increase the amount of products produced. In this case, this reduced amount of inventory can be viewed as congestion.

**Definition 3.** *(Technical) Efficiency.*

Efficiency is said to be achieved if, and only if, it is not possible to improve some inputs or outputs without worsening other inputs or outputs [12].

The analysis of congestion and efficiency of Korean hospitals, which is the subject of this study, is based on Data Envelopment Analysis (DEA). DEA is a nonparametric technique designed to evaluate efficiency and has been widely used in various fields such as schools, banks, hospitals, and public institutions. The concept of efficiency is that an organization can achieve the maximum output with a given resource or use minimal resources to achieve a certain goal. Meanwhile, congestion is the concept of increasing one or more outputs when one or more inputs are reduced. Three different DEA approaches are available to measure congestion. Fare et al. [23] developed radial measure models with a two-stage approach to capture input congestion. Later, Cooper et al. [24] suggested a new additive DEA model as a non-radial measure. The third approach is a hybrid that uses a radial measure model at the first stage and a non-radial measure model in the next stage [13].

The hybrid model used in this study is a two-step model by Cooper et al. [12] to measure the congestion phenomenon as follows: In the first stage, the total slack obtained from the efficiency measurement is measured. In the second stage, technical inefficiency and congestion are measured separately.

$$\begin{aligned}
 & \text{(First stage)} \quad \text{Max } \theta + \epsilon (\sum_{r=1}^s S_r^+ + \sum_{i=1}^m S_i^-) \\
 & \text{s.t.} \quad \theta y_{r0} = \sum_{j=1}^n y_{rj} \lambda_j - S_r^+ \quad r = 1, 2, \dots, s \\
 & \quad \quad x_{i0} = \sum_{j=1}^n x_{ij} \lambda_j + S_i^- \quad i = 1, 2, \dots, m \\
 & \quad \quad 1 = \sum_{j=1}^n \lambda_j \\
 & \quad \quad \lambda_j, S_r^+, S_i^- \geq 0 \quad \text{for } i, j, r
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 & \text{(Second stage)} \quad \text{Max } \sum_{i=1}^m \delta_i^- \\
 & \text{s.t.} \quad \hat{x}_{i0} = \sum_{j=1}^n x_{ij} \lambda_j - \delta_i^- \quad i = 1, 2, \dots, m \\
 & \quad \quad \hat{y}_{r0} = \sum_{j=1}^n y_{rj} \lambda_j \quad r = 1, 2, \dots, s \\
 & \quad \quad 1 = \sum_{j=1}^n \lambda_j \\
 & \quad \quad S_i^{-*} \geq \delta_i^- \quad i = 1, 2, \dots, m
 \end{aligned} \tag{2}$$

In the study of Flegg and Allen [25], the efficiencies of the 41 universities converted from the former College of Science and Technology in the UK to the general university in 1992 were compared with those of the existing general universities [25]. Conversational colleges have a high incidence of congestion, and the reason for this is excessive academic staff. Park and Kim [9] examined the presence of congestion in the operations of public hospitals in South Korea [13] and it was proven that public hospitals generally showed a high rate of congestion occurrence, as well as a large size of congestion in the operations. Kim [26] empirically proved that congestion occurred in 51.7% of the 87 tourist hotels, and it occurred especially in the number of employees and area inputs. As can be seen from the

previous papers, congestion analysis can be used to determine if there is an overrun input factor and how much occurs in each input factor [27].

## 2.2. Hospital Specialization

Although it is difficult to measure specialization in medical services, many scholars have sought to develop various indicators to measure the level of specialization of a hospital [1]. The Information Theory Index (ITI) and the Internal Herfindahl Index (IHI) are among the most frequently used indicators in recent empirical studies, based on the medical services provided to patients. ITI is consisted of hospital DRG proportion and log of national DRG proportion. As the hospital DRG proportion increases, the index will increase. Hospital specialization measured from ITI reflects whether hospitals treat a very narrow or a broad range of patients. On the other hand, IHI measures the concentration of services provided by a single hospital. If the type of medical service provided by the hospital is small, the concentration of the service will be high and this can be regarded as high specialization of hospitals. If the hospital has only one type of service, the IHI index is 1. IHI is calculated by summing the squares of the percentage of patients discharged from one service to the total number of patients discharged from the hospital. Therefore, IHI increases with the narrower range of patients discharged from the hospital. The calculation formulas of ITI and IHI are as follows:

Information Theory Index (ITI) [1,28]

$$I_h = \sum_{i=1}^I \frac{N_{ih}}{N_h} \times \ln \left[ \frac{N_{ih}}{N_h} / \theta_i \right]$$

where

$N_{ih}$  = number of cases of DRG  $i$  provided in hospital  $h$ ;

$N_h$  = number of patients discharged in hospital  $h$ ;

$\theta_i$  = number of cases of DRG  $i$  provided in hospitals in Korea

And

$\ln [ * ]$  = natural log

Internal Herfindahl Index (IHI) [28,29]

$$IHI = \sum_i P_i^2$$

where  $P_i$  = proportion of the discharges from DRG  $i$  in the hospital.

## 3. Materials and Methods

In this study, HIRA-NIS (National Inpatient Sample) data was used, provided by the Health Insurance Review & Assessment Service. HIRA-NIS is a statistical sample of secondary data (hospitalized patient rate of 13%, about 1 million people) after removing information on individuals and corporations, using the health claim data as a population. The data is constructed by the details of medical treatment that has been billed for one year. The validity of HIRA-NIS has been evaluated through several studies. In this study, the hospital specialization index (ITI, IHI) was calculated based on HIRA-NIS in 2013, and input and output variables were selected for congestion analysis. After excluding hospitals with missing variables, 1185 hospitals were selected for this study. Table 1 shows the general characteristics of the analysis subjects.

The congestion and efficiency of the hospital, which is a dependent variable of this study, were selected based on previous studies. The DEA model is based on a combination of multiple input and output factors, and it is essential to select a clear variable that is appropriate for the purpose of the study based on the relevant studies. As the number of DMUs increases, the reliability of the DEA model increases, and the reliability could be decreased as the number of input and output elements

increases [27]. In addition, because of the characteristics of the research purpose, it is necessary to select variables that can be adjusted for the future direction of operation. The most common prior research studies on the efficiency of hospitals using DEA involved the selection of medical and non-medical manpower and capital as input factors and the number of patient days and the medical revenues as output factors. Therefore, in this study, the variables necessary for congestion analysis and efficiency analysis were selected, as shown in Table 2. The descriptive statistics of the measured variables are shown in Table 3.

**Table 1.** General characteristics of the analysis subjects.

	Division	Number	Ratio
Hospital Size	Advanced General Hospital	23	1.9
	General Hospital	296	25.0
	Hospital	866	73.1
Location	Urban area	559	47.2
	Rural area	626	52.8
Foundation Type	Private	1147	96.8
	Public	38	3.2
Advanced Medical Equipment (MRI/CT/PTE)	Possession	904	76.3
	Absent	281	23.7
Total		1185	100

**Table 2.** Input/output factors required to measure dependent variables.

Variable	
Input Factor	Number of Doctors
	Number of Nurses
	Number of Beds
Output Factor	Number of Hospitalized Patients
	Number of Operations
	Medical Revenues

The level of hospital specialization, which is a dependent variable of this study, was measured using the specialization index used in previous studies. The Information Theory Index (ITI) and the Internal Herfindahl Index (IHI) have been used in existing literature [28–32]. ITI is measured relative to the hospital's average specialization level, while IHI is measured based on service concentration within a hospital. The measurement of specialization level is not clear because the scope of service is relatively comprehensive and diverse, compared to the general service industry. Therefore, it is very important knowing how to advantageously define the concept of specialization. Therefore, this study defined the specialization considering two aspects, in the hospital and outside. In other words, narrowing the range of services provided by the hospital itself, and defining and centralizing the services provided by the entire hospital (or a competitive hospital). Table 4 shows the specialization index descriptive statistics of the subjects analyzed using ITI and IHI.

**Table 3.** Descriptive statistics of the input/output factors.

Division			Input Factors			Output Factors		
			Doctor	Nurse	Bed	Inpatient	Operation	Revenue
Size	Advanced General	Mean	25.96	39.91	18.74	6325.43	2968.48	17359.6
		SD	6.64	9.17	2.63	3919.37	2002.58	12658.2
		Min	16	20	11	2649	1220	6276.4
		Max	46	61	21	17037	8842	56929.6
	General	Mean	8.71	21.92	8.08	1377.61	548.51	2875.1
		SD	6.19	10.71	4.26	1166.74	585.79	3033.4
		Min	1	0	3	182	4	164.2
		Max	28	76	21	7395	3856	17990.8
	Hospital	Mean	4.82	10.84	2.66	304.58	141.07	386.4
		SD	3.75	10.36	1.54	200.73	154.87	319.1
		Min	0	0	1	100	0	31.5
		Max	28	101	12	1519	1396	2715.2
Location	Urban	Mean	7.30	15.73	4.48	790.88	374.74	1672.1
		SD	6.39	12.51	4.43	1541.79	745.62	4444.2
		Min	0	0	1	100	0	31.5
		Max	46	76	21	17037	8842	56929.6
	Rural	Mean	5.23	12.78	4.19	598.92	228.95	1038.6
		SD	4.53	11.40	3.56	835.33	395.24	2030.1
		Min	0	0	1	100	0	36.5
		Max	28	101	21	7395	3856	17990.8
Foundation	Private	Mean	6.22	14.04	4.27	690.03	300.98	1399.1
		SD	5.65	12.14	4.01	1238.71	598.17	3449.8
		Min	0	0	1	100	0	31.5
		Max	46	101	21	17037	8842	56929.6
	Public	Mean	5.87	18.32	6.08	672.50	199.29	1288.9
		SD	3.14	6.29	2.93	636.19	316.50	1440.2
		Min	3	8	2	127	1	352.7
		Max	20	36	16	4144	1993	9096.9
Medical Equipment	Possession	Mean	6.07	14.47	5.07	829.17	342.27	1668.8
		SD	5.85	11.25	4.26	1369.42	665.46	3835.4
		Min	0	0	1	100	0	38.3
		Max	46	76	21	17037	8842	56929.6
	Absent	Mean	6.64	13.21	1.94	240.05	154.40	271.3
		SD	4.60	14.20	1.21	141.58	154.40	214.0
		Min	0	0	1	100	0	31.5
		Max	19	101	11	798	764	1182.0
Total	Mean	6.21	14.17	4.33	689.47	297.72	1337.4	
	SD	5.58	12.02	3.99	1223.85	597.41	3403.5	
	Min	0	0	1	100	0	31.5	
	Max	46	101	21	17037	8842	56929.6	



**Table 4.** Descriptive statistics of the hospital specialization index.

Division			Hospital Specialization Index	
			ITI	IHI
Size	Advanced General	Mean	0.59535	0.00978
		SD	0.10661	0.00292
		Min	0.436	0.007
		Max	0.781	0.018
	General	Mean	0.94395	0.02103
		SD	0.49949	0.02161
		Min	0.3585	0.005
		Max	5.070	0.196
	Hospital	Mean	2.1391	0.12160
		SD	0.90371	0.13433
		Min	0.6530	0.012
		Max	6.587	0.992
Location	Urban	Mean	1.99231	0.11639
		SD	1.06456	0.14496
		Min	0.358	0.005
		Max	6.587	0.992
	Rural	Mean	1.64831	0.07460
		SD	0.86041	0.09719
		Min	0.368	0.006
		Max	6.553	0.949
Foundation	Private	Mean	1.82345	0.09651
		SD	0.98289	0.12505
		Min	0.358	0.005
		Max	6.587	0.992
	Public	Mean	1.42226	0.02784
		SD	0.67767	0.03762
		Min	0.362	0.006
		Max	4.888	0.244
Medical Equipment	Possession	Mean	1.45755	0.05713
		SD	0.69618	0.07153
		Min	0.358	0.005
		Max	5.070	0.731
	Absent	Mean	2.94635	0.21394
		SD	0.88077	0.17169
		Min	0.863	0.018
		Max	6.587	0.992
Total	Mean	1.81059	0.09431	
	SD	0.97694	0.12380	
	Min	0.358	0.005	
	Max	6.587	0.992	

## 4. Results

### 4.1. Congestion Analysis Results

The congestion analysis results of 1185 hospitals were as shown in Table 5. As a result, congestion occurred in 71.90% of all hospitals ((852 of 1185) and the average size of congestion was 34.74%. Furthermore, the congestion rate and the size of congestion in the number of nurses were the largest. The congestion rate of nurses was 69.37%, which means that congestion exists in 822 hospitals, 69.37% of the total number of hospitals. The mean was 33.62%, which means that about 33.62% of 822 hospitals' nurses were overworked. Conversely, the incidence of doctor congestion was 3.71%, and the mean was 0.61%, which is relatively low compared to the number of nurses. The incidence of bed congestion was similar to the congestion rate of doctors. The incidence was 3.04% and the mean was 0.51%. As a



result of examining the congestion level reflecting the size of hospitals, the incidence of congestion in advanced general hospitals and general hospitals was higher than in smaller hospitals (advanced general hospital: 95.65%, general hospital: 93.92%, hospital: 63.74%). The average was the highest in general hospitals. Characteristically, the incidence of congestion (43.48%) and the average (8.72%) for the number of doctors in general hospitals were significantly higher than the total. Regarding the location of hospitals, the incidence and size of congestion in urban and rural hospitals were found to be similar. Considering the type of foundation of hospitals, the incidence and size of congestion were somewhat higher in public hospitals than in private hospitals. However, there was no congestion in the number of doctors in the public hospitals, which can be interpreted as an efficient input of the number of doctors in public hospitals. Hospitals with advanced medical equipment had a slightly higher incidence and size of congestion than hospitals that did not, but the congestion of hospitals with advanced medical equipment was lower in the number of doctors.

**Table 5.** Congestion analysis result.

Environmental Factor		Division	Congestion			
			Total	Doctor	Nurse	Bed
Size	Advanced General	mean	37.26	8.72	27.52	1.02
		frequency	22	10	20	1
		percent	95.65	43.48	86.96	4.35
	General	mean	46.14	0.33	45.24	0.57
		frequency	278	13	269	12
		percent	93.92	4.39	90.88	4.05
	Hospital	mean	30.79	0.49	29.82	0.48
		frequency	552	21	533	23
		percent	63.74	2.42	61.55	2.66
Location	Urban	mean	35.41	1.12	33.88	0.41
		frequency	407	34	389	17
		percent	72.81	6.08	69.59	3.04
	Rural	mean	34.15	0.16	33.39	0.60
		frequency	445	10	433	19
		percent	71.09	1.60	69.17	3.04
Foundation	Private	mean	34.31	0.63	33.18	0.50
		frequency	817	44	787	33
		percent	71.23	3.84	68.61	2.88
	Public	mean	48.18	0.00	47.17	1.01
		frequency	35	0	35	3
		percent	92.11	0.00	92.11	7.89
Medical Equipment	Possession	mean	36.62	0.45	35.58	0.59
		frequency	684	29	666	30
		percent	75.66	3.21	73.67	3.32
	Absent	mean	28.74	1.13	27.35	0.26
		frequency	168	15	156	6
		percent	59.79	5.34	55.52	2.14
Total	mean	34.74	0.61	33.62	0.51	
	frequency	852	44	822	36	
	percent	71.90	3.71	69.37	3.04	

#### 4.2. Efficiency Analysis Results

The efficiency analysis results of the hospitals are shown in Table 6 below. As a result, the overall hospital efficiency (VRS) average was 0.34 and the standard deviation was 0.21. The inefficiency was caused by pure technology efficiency (PTE) rather than by scale efficiency (SE) (SE = 9.1%, PTE = 91.9%).

In terms of the size of hospitals, the efficiency of advanced general hospitals was relatively high (0.43), followed by hospitals (0.35), and general hospitals (0.28). Of the hospital location, the urban hospital (0.35) was slightly higher than the rural hospital (0.32), and the private hospital (0.34) was more efficient than the public hospital (0.21). In terms of having advanced medical devices or not, the efficiency was lower than that of hospitals that did not have advanced medical devices (0.31).

**Table 6.** Efficiency analysis result.

Environmental Factor	Division	Efficiency							
		TE	PTE	SE	Cause of Inefficiency (%)		Returns to Scale (%)		
Size	Advanced General	mean	0.43	0.43	0.99	PTE SE	95.7 4.3	CRS	21.7
		SD	0.21	0.21	0.01			DRS	47.8
		Min	0.23	0.23	0.97			IRS	30.4
		Max	1.00	1.00	1.00				
	General	mean	0.27	0.28	0.95	PTE SE	99.0 1.0	CRS	0.7
		SD	0.12	0.12	0.06			DRS	53.4
		Min	0.07	0.08	0.63			IRS	45.9
		Max	1.00	1.00	1.00				
	Hospital	mean	0.26	0.35	0.78	PTE SE	88.0 12.0	CRS	2.2
		SD	0.18	0.23	0.18			DRS	85.7
		Min	0.05	0.05	0.18			IRS	12.1
		Max	1.00	1.00	1.00				
Location	Urban	mean	0.28	0.35	0.83	PTE SE	88.7 11.3	CRS	3.2
		SD	0.18	0.23	0.17			DRS	79.2
		Min	0.05	0.05	0.24			IRS	17.5
		Max	1.00	1.00	1.00				
	Rural	mean	0.26	0.32	0.82	PTE SE	92.8 7.2	CRS	1.3
		SD	0.15	0.19	0.17			DRS	74.8
		Min	0.05	0.06	0.18			IRS	24.0
		Max	1.00	1.00	1.00				
Foundation	Private	mean	0.27	0.34	0.82	PTE SE	90.6 9.4	CRS	2.3
		SD	0.17	0.21	0.17			DRS	77.8
		Min	0.05	0.05	0.18			IRS	20.0
		Max	1.00	1.00	1.00				
	Public	mean	0.19	0.21	0.93	PTE SE	100.0 0.0	CRS	0.0
		SD	0.09	0.10	0.10			DRS	50.0
		Min	0.05	0.06	0.76			IRS	50.0
		Max	0.49	0.51	1.00				
Medical Equipment	Possession	mean	0.26	0.31	0.85	PTE SE	94.5 5.5	CRS	1.9
		SD	0.16	0.18	0.16			DRS	72.7
		Min	0.05	0.06	0.25			IRS	25.4
		Max	1.00	1.00	1.00				
	Absent	mean	0.30	0.43	0.73	PTE SE	79.4 20.6	CRS	3.2
		SD	0.19	0.25	0.19			DRS	90.4
		Min	0.05	0.05	0.18			IRS	6.4
		Max	1.00	1.00	1.00				
Total	mean	0.27	0.34	0.82	PTE SE	90.9 9.1	CRS	2.2	
	SD	0.17	0.21	0.17			DRS	76.9	
	Min	0.05	0.05	0.18			IRS	20.9	
	Max	1.00	1.00	1.00					

### 4.3. The Impact between Hospital Specialization and Congestion

Considering the hypothesis that hospital specialization (ITI) would have a negative effect on the overall congestion, the hypothesis was validated ( $t$ -value =  $-3.922$ ,  $\text{sig} = 0.000$ ,  $\alpha = 0.01$ ) as in Table 7. In other words, the higher the hospital specialization, the lower the overall congestion rate of the hospital. The specialization of hospitals was also found to have negative effects on the congestion of nurses ( $\text{sig} = 0.000$ ,  $\alpha = 0.01$ ). On the other hand, hospital specialization has a positive effect on the congestion of the number of doctors. Hospital specialization was not found to have a significant effect on the congestion of beds ( $\text{sig} = 0.904$ ,  $\alpha = 0.01$ ).

**Table 7.** The impact of hospital specialization (ITI) and congestion.

Independent Variable	Dependent Variable	Std. Error	$\beta$	t	Sig.	Statistic
Specialization	Congestion					
ITI	(Constant)	1.764		22.876	0.000	$R^2 = 0.013$
	Total	0.858	$-0.113$	$-3.922$	0.000	Adjusted $R^2 = 0.012$ ; $F = 15.386$
	(Constant)	0.242		0.773	0.440	$R^2 = 0.003$
	Doctor	0.118	0.058	1.992	0.047	Adjusted $R^2 = 0.003$ ; $F = 3.968$
	(Constant)	1.769		22.635	0.000	$R^2 = 0.014$
	Nurse	0.860	$-0.119$	$-4.117$	0.000	Adjusted $R^2 = 0.013$ ; $F = 16.948$
	(Constant)	0.209		2.560	0.011	$R^2 = 0.000$
	Bed	0.102	$-0.004$	$-0.121$	0.904	Adjusted $R^2 = -0.001$ ; $F = 0.015$

The results of the test between the hospital specialization and congestion using the Internal Herfindahl Index (IHI) were the same as those of the hospital specialization using the information theory index (ITI) as in Table 8.

**Table 8.** The impact of hospital specialization (IHI) and congestion.

Independent Variable	Dependent Variable	Std. Error	$\beta$	t	Sig.	Statistic
Specialization	Congestion					
IHI	(Constant)	1.052		35.098	0.000	$R^2 = 0.014$
	Total	6.762	$-0.120$	$-4.170$	0.000	Adjusted $R^2 = 0.014$ ; $F = 17.392$
	(Constant)	0.143		1.176	0.240	$R^2 = 0.022$
	Doctor	0.921	0.147	5.105	0.000	Adjusted $R^2 = 0.021$ ; $F = 26.065$
	(Constant)	1.054		34.722	0.000	$R^2 = 0.018$
	Nurse	6.772	$-0.134$	$-4.634$	0.000	Adjusted $R^2 = 0.017$ ; $F = 21.474$
	(Constant)	0.125		5.051	0.000	$R^2 = 0.002$
	Bed	0.802	$-0.045$	$-1.543$	0.123	Adjusted $R^2 = 0.001$ ; $F = 2.382$

### 4.4. The Impact between Hospital Specialization and Efficiency

Analysis of the impact between hospital specialization (ITI) and efficiency shows that hospital specialization has a positive impact on efficiency under statistical significance ( $\text{sig} = 0.000$ ,  $\alpha = 0.01$ ) as in Table 9. In other words, the higher the hospital specialization, the higher the efficiency of the hospital. The results of the test between the hospital specialization and the efficiency using the Internal Herfindahl Index (IHI) were the same as those of the hospital specialization using the information theory index (ITI).

**Table 9.** The impact of hospital specialization and efficiency.

Independent Variable	Dependent Variable	Std. Error	$\beta$	t	Sig.	Statistic
Specialization	Efficiency					
ITI	(Constant)	0.012		19.749	0.000	$R^2 = 0.060$
	PTE	0.006	0.246	8.721	0.000	$Adjusted R^2 = 0.060; F = 76.058$
IHI	(Constant)	0.007		40.119	0.000	$R^2 = 0.091$
	PTE	0.046	0.302	10.884	0.000	$Adjusted R^2 = 0.090; F = 118.465$

## 5. Discussion

The purpose of this study is to identify the causes of congestion and to suggest the direction of improvement through the verification of the presence of congestion in hospitals in Korea. This paper also aims to clarify that hospital specialization is a factor in reducing congestion. The main results of this study are as follows: First, congestion analysis showed that congestion occurred in 71.90% of hospitals (852 hospitals of 1185 hospitals), and the size of congestion (average) was 34.74%. The congestion rate and the size of congestion in the number of nurses were the largest. The congestion rate of nurses was 69.37%, which means that congestion exists in 822 hospitals, 69.37% of the total number of hospitals. The mean was 33.62%, which means that about 33.62% of 822 hospitals' nurses were overworked. Conversely, the incidence of doctor congestion was 3.71% and the mean was 0.61%, which is relatively low compared to the number of nurses. The incidence of bed congestion was similar to the congestion rate of doctors. The incidence was 3.04% and the mean was 0.51%.

In addition to congestion analysis, this study also analyzed the efficiency of the study subjects. As a result, the overall hospital efficiency (VRS) average was 0.34 and the standard deviation was 0.21. The inefficiency was caused by pure technology efficiency (PTE) rather than by scale efficiency (SE, SE = 9.1%, PTE = 91.9%). In terms of the size of hospitals, the efficiency of advanced general hospitals was relatively high (0.43), followed by hospitals (0.35), and general hospitals (0.28). Regarding the hospital location, the urban hospital (0.35) was slightly higher than the rural hospital (0.32), and the private hospital (0.34) was more efficient than the public hospital (0.21). In terms of having advanced medical devices or not, the efficiency was lower than that of hospitals (0.31) that did not have advanced medical devices (0.31).

Considering the hypothesis that hospital specialization (ITI) will have a negative effect on the overall congestion, the hypothesis was validated ( $t$ -value =  $-3.922$ , sig = 0.000,  $\alpha = 0.01$ ). In other words, the higher the hospital specialization, the lower the overall congestion rate of the hospital. The specialization of hospitals was also found to have negative effects on the congestion of nurses (sig = 0.000,  $\alpha = 0.01$ ). On the other hand, hospital specialization has a positive effect on the congestion of the number of doctors. Hospital specialization was not found to have a significant effect on the congestion of beds (sig = 0.904,  $\alpha = 0.01$ ). The results of the test between the hospital specialization and the congestion using the Internal Herfindahl Index (IHI) were the same as those of the hospital specialization using the information theory index (ITI).

Analysis of the impact between hospital specialization (ITI) and efficiency shows that hospital specialization has a positive impact on efficiency under statistical significance (sig = 0.000,  $\alpha = 0.01$ ). In other words, the higher the hospital specialization, the higher the efficiency of the hospital. The results of the test between the hospital specialization and the efficiency using the Internal Herfindahl Index (IHI) were the same as those of the hospital specialization using the information theory index (ITI).

This study suggests that private hospitals are not a safe zone for congestion and should try to improve the efficiency of operation. Especially in the case of public hospitals, it is also one of the ways to entrust management to institutions that have accumulated know-how and experience in hospital management [9]. In hospitals where congestion exists, removal of congestion should be the first priority to improve operational efficiency [12]. In addition, it is also a way to improve efficiency and

performance through optimization of personnel allocation, as in [14]. This allocation and placement of personnel may be more efficient if these are made through cooperation between hospitals [15]. In addition, cooperating with hospitals or forming or joining multi-institutional arrangements are also proposed as ways to improve the performance of hospitals [32].

On the other hand, specialization is a strategy that improves overall efficiency, as shown in other studies. As we have also seen in the results of this study, specialization has a negative correlation with congestion. Therefore, it can be seen that specialization is a way to reduce the possibility of congestion. In other words, at first, through the thorough analysis of hospital operation, the least in-demand and least important parts are identified. Then, the specialization of hospitals is enhanced by selectively pruning out those service lines that are less profitable, increasing the efficiency of the hospital operation. It is also another way of improving efficiency, as in the case of Spanish hospitals, where several hospitals work together to share information and form or join multi-institutional arrangements.

The academic significance of this study is as follows: First, it can be said that there is a primary significance, in that evidence is presented on the basis of empirical analysis of the advantages of hospital specialization, which has been suggested theoretically or politically. Second, unlike studies that have demonstrated the relationship between management performance and specialization focusing on existing output only, the study suggests efficiency and specialization that considers inputs and output amounts simultaneously as well. Third, there is a difference, in that it is the first time that we have studied the relationship between congestion and specialization, which are necessary to measure over-input factors.

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