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ORIGINAL RESEARCH

The association between demographic, economic, and medical resource factors and the inflow and outflow of critically ill emergency patients by medical service districts in South Korea

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Abstract

This study identified the in- and outflow of critically ill emergency patients in 70 medical service districts, categorized them into regional types, and analyzed their association with demographics, economy, and medical resources in South Korea. This study analyzed 922,108 emergency department (ED) visits for severe diseases from 01 January to 31 December 2021. The relevance (RI) and commitment (CI) indices were calculated, followed by cluster analysis to categorize region types for critical care. Demographic, economic, and medical resource factors were compared and analyzed for each district type. Finally, a correlation analysis and multiple linear regression analysis were conducted to compare the association of demographic, economic, and medical resources with RI and CI. The district types were divided into 21 outflow and 49 inflow districts. Additionally, RI was associated with the number of primary clinics (β = −0.805), the average number of performed computed tomography scanners (β = 1.320), the average number of performed magnetic resonance imaging (MRI) scanners (β = −1.125), and the average number of dedicated specialists in the ED (β = 1.176) ($p < 0.01$). The CI was associated with the financial autonomy rate (β = 0.366), the number of primary clinics (β = 0.708), the number of intensive care units (ICUs) (β = −1.290), the number of vulnerable areas for emergency medicine (β = 0.395), the average number of dedicated specialists in the ED (β = −0.512), and the number of beds in the ED (β = 0.915) ($p < 0.01$). The lower the average number of MRIs and the number of primary clinics, the greater the outflow of critically ill emergency patients from the central region. The higher the number of ICUs and the average number of dedicated specialists in the ED, the greater the inflow of critically ill emergency patients from other districts.

Keywords

Critically ill emergency patient; Medical service district; Inflow; Outflow

1. Introduction

Emergency medical services are essential areas where public intervention is needed since they represent a low-profit sector requiring efficient use of limited resources to provide rapid and appropriate care to emergency patients [1]. Although emergency medical centers are assigned specific functions, their roles are becoming unclear due to patient preferences for large hospitals and ignorance of severity classifications. This causes overcrowding in certain emergency medical centers and increases patient mortality [2, 3].

Establishing emergency medical service districts to ensure that patients needing emergency medical services can receive appropriate care anytime and anywhere is essential in creating and applying an emergency medical resource deployment plan and improving the distribution and level of emergency medical resources [4, 5]. Therefore, the Ministry of Health and Welfare established 29 emergency medical districts that consider the demand for emergency medical services and the supply of medical resources by regions and designate an appropriate number of regional emergency medical centers for each region to use emergency medical resources efficiently [6]. However, disparities in essential medical services and health levels between regions continued due to the unwillingness to supply low-profit essential medical services and the concentration of high-quality medical personnel and resources in the capital region. In 2021, the Ministry of Health and Welfare announced a plan to significantly expand the critical emergency care infrastructure by establishing at least one severe emergency medical center in each of the 70 medical service districts based on medical utilization data, the number of minimum populations, self-fulfillment rate and merger recognition distance, to establish a regional complete emergency medical system [7].

One of the methods for establishing medical service districts is to analyze the utilization of emergency medical services through the inter-regional flow of emergency patients. The most commonly used indicators of inter-regional flow are Griffith's relevance index (RI) and commitment index (CI) [8]. Previous studies using RI and CI analyzed the determinants of medical utilization by regions for emergency and critical care patients [9–11].

However, previous studies did not fully reflect the recent medical and medical emergency usage patterns. This study aimed to analyze the in- and outflow patterns of critically ill emergency patients in the redefined 70 emergency medical service districts. Specifically, it sought to categorize these regions based on their utilization of emergency medical services, identify demographic, economic and healthcare resource factors associated with each regional type, and provide evidence to enhance the quality and accessibility of regional emergency medical systems. Furthermore, building upon previous research, this study aimed to contribute to understanding the flow of critically ill emergency patients and developing policies for optimizing emergency medical service.

2. Material and method

2.1 Research subjects and methods

The National Emergency Department Information System (NEDIS) was used to obtain patient data. NEDIS, a nationwide database developed in 2003, is an emergency information network operated by the government (Ministry of Health and Welfare) that includes clinical and administrative data for all patients visiting an emergency department (ED) in South Korea to evaluate the performances of the emergency care systems nationwide [12]. NEDIS reports have been released annually since 2013 by the National Emergency Medical Center (NEMC) of the National Medical Center [13]. Healthcare providers and administrators in regional emergency medical centers must input data related to the NEDIS system and hire coordinators from the NEMC to be in charge of hospital-based monitoring and feedback. Critically ill emergency patients are those diagnosed by one of 1120 severe disease codes in 28 disease groups (**Supplementary Table 1**) designated by the NEMC. These critically ill emergency patients have a high risk of death from internal, surgical, or injury-induced diseases and include those whose acute phase treatment closely influences the patient's prognosis. The data are collected anonymously without personally identifiable information. As of 2021, patient care information was collected from 397 emergency medical centers, including 38 regional emergency medical centers, 127 local emergency medical centers, and 232 local emergency medical agencies. This study included the data of critically ill emergency patients from 01 January through 31 December 2021, using the NEDIS. Although our study period coincided with the (Coronavirus disease) COVID-19 pandemic, the number of critically ill emergency patients decreased only slightly compared to the pre-pandemic year of 2019, while the overall number of such patients decreased significantly [14].

The RI is the percentage of healthcare utilization by patients out of the total healthcare utilization in a given region (i). The RI measures the outflow from a region, and a low RI indicates low utilization within the region. CI, which captures the degree of inflow from other regions, is the percentage of healthcare utilization by patients residing in the same specific region (j) as the healthcare organization. A high CI indicates little inflow from outside the region. The RI and CI can be calculated as shown in the Eqn. 1. If region A has no healthcare providers, CI is not calculated; hence, it is excluded from analysis that use both RI and CI.

$$RI_{ij} = \frac{O_{ij}}{O_{i\bullet}}, \quad CI_{ij} = \frac{O_{ij}}{O_{\bullet i}} \tag{1}$$

Where $O_{i\bullet} = \sum_{i=1}^{n} O_{ij}$, $O_{\bullet j} = \sum_{i=1}^{m} O_{ij}$, and $i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n.$

2.2 Analytic variables

Patient and emergency medical center addresses from the NEDIS were utilized to calculate the RI and CI. Additionally, data from variables related to population, economy, and medical resources were collected to examine factors influencing the RI and CI. The variables related to population were population density, number of people aged <19 years (in thousands), number of people aged 19–64 years (in thousands), and number of people aged ≥65 years (in thousands). This information was collected from the population data from the Ministry of the Interior and Safety and the area data from the Ministry of Land, Infrastructure, and Transport [15, 16]. The variables related to the economy were the financial autonomy rate collected from Statistics Korea and the proportion of patients receiving national basic livelihood benefits collected from the Korea Disease Control and Prevention Agency [17, 18]. Resources were divided into medical resources and emergency medical resources. Variables related to medical resources comprised the number of tertiary hospitals, the number of general hospitals, the number of all hospitals, the number of primary health care centers, the average number of performed computed tomography (CT) scanners, and the average number of performed magnetic resonance imaging (MRI) scanners. This information was collected from the Fifth National Health and Medical Care Survey [19]. Emergency medical resources were the number of emergency medicine specialists collected from the Fifth National Health and Medical Care Survey; the number of intensive care units (ICUs), general admission rooms, and emergency beds collected from the NEMC; the number of emergency medical centers collected from the NEMC 2021 emergency medical centers evaluation results; and the number of ED visits, the average number of dedicated specialists in the ED, the average number of dedicated nurses in the ED, and the number of emergency medical vulnerable areas collected from the Public Health and Medical Care Law [19–22].

2.3 Analytic method

The cluster analysis that used RI and CI determined the number of clusters by the majority rule using the NbClust package in R. The K-means method was applied to classify regional types [23]. Tests for normality of region type and population, economic, and health resources did not follow normality; thus, we used the Mann-Whitney test. The regional types and population, economic, and medical resources were tested using the parametric independent *t*-test for normal distribution and the nonparametric Mann-Whitney test for non-normal distribution. Pearson's correlation and multiple linear regression analyses were used to analyze the associations between population, economic, and medical resources with the RI and CI. The independent variables from the multiple linear regression analysis were selected by the stepwise method using variables with probability significance $<$0.05 in the correlation analysis. Multicollinearity was checked, and variables with variance inflation factor $>$10 were excluded. Normality and equality of variances were tested for residuals, and scatterplots were used to test linearity between independent and dependent variables. IBM SPSS Statistics 27 (IBM Corp., Armok, NY, USA) and R 4.2.1 (https://www.r-project.org/) were used for data analysis. A p-value < 0.05 indicated statistical significance.

3. Results

A total of 991,332 cases of critically ill emergency patients were included in the study. Among these, 69,224 cases were excluded due to non-medical visits or cancellations, death on arrival (DOA) as an outcome or no value, or unknown patient address. Finally, 922,108 cases were analyzed.

3.1 Categorization of the types of outflow and inflow regions for critically ill emergency patients by medical service districts

3.1.1 The RI and CI of critically ill emergency patients by 70 medical service districts

At the median of RI and CI (the first quartile–the third quartile), the RI was 61.4% (42.3%–74.2%) and the CI was 74.3% (60.1%–81.7%) (Fig. 1). RI represents the utilization rate within the home district, with the highest and lowest districts being Jeju (95.0%) and Paju (1.0%), respectively. CI represents inflows from other regions, with the highest and lowest being Jeongeup (93.6%) and Gwangju Southeast (40.3%), respectively (Table 1, **Supplementary Table 2**).

TABLE 1. Top 5 and bottom 5 regions for RI and CI.

No	Top 5		Bottom 5	
	Region	RI (%)	Region	RI (%)
1	Jeju	95.0	Paju	1.0
2	Wonju	89.8	Gongju	13.7
3	Gangneung	89.7	Yeongju	15.9
4	Jinju	86.6	Busan west	18.0
5	Cheonan	85.8	Yeongwo	18.7
No	Region	CI (%)	Region	CI (%)
1	Jeongeup	93.6	Gwangju southeast	40.3
2	Haenam	89.7	Gangneung	44.2
3	Yeosu	89.7	Seoul northwest	45.6
4	Tongyeong	89.0	Daejeon west	46.3
5	Donghae	86.9	Central Busan	49.0

RI, relevance index; CI, commitment index.

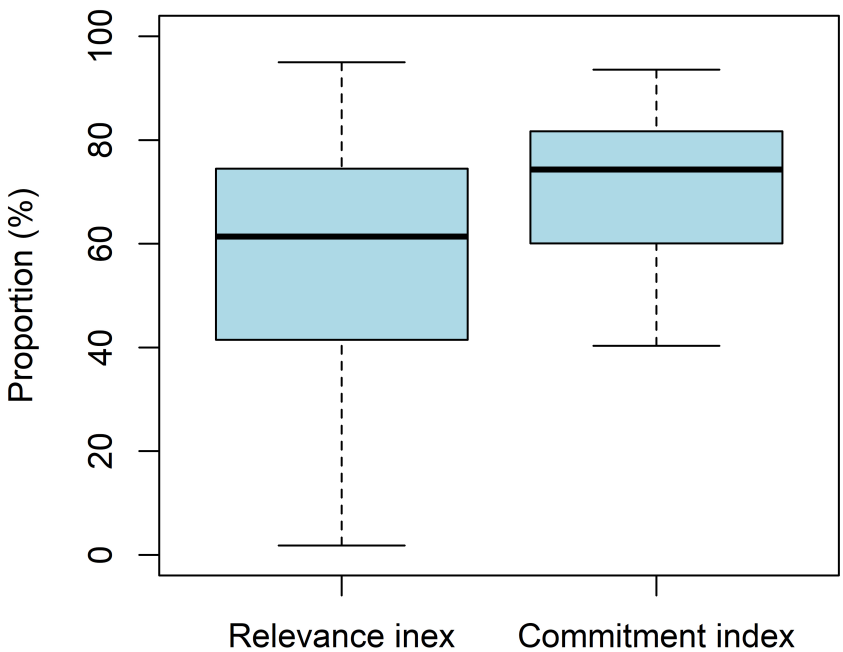

FIGURE 1. A boxplot of relevance index and commitment index.

3.1.2 The number of clusters and district types

The RI and CI results indicated that the optimal number of clusters was two and contained 10 (38.5%) of 26 indices (Fig. 2A, **Supplementary Table 3**). Cluster 1 had 21 (30.0%) regions with a low RI and a high CI, which can be characterized as outflow regions with many patients going to other regions. Cluster 2 comprised 49 (70.0%) regions with a high RI, which can be characterized as inflow regions with many patients from other regions coming to the healthcare organizations within these regions (Fig. 2B). Cluster 1 included Busan Metropolitan City (Busan West and Busan East), Ulsan Metropolitan City (Ulsan South), Gyeonggi-do (Paju, Icheon and Pocheon), Gangwon-do (Yeongwol, Donghae and Sokcho), Chungcheongbuk-do (Chungju), Chungcheongnam-do (Gongju, Nonsan and Hongseong), Jeollabuk-do (Jeongeup and Namwon), Jeollanam-do (Naju and Glory), Gyeongsangbuk-do (Gyeongju and Yeongju), Gyeongsangnam-do (Geochang), and Jeju Special Self-Governing Province (Seogwipo). Cluster 2 included Seoul (Seoul North, Seoul East, Seoul South, Seoul West and Seoul East), Busan (Busan Central), Daegu (Daegu East, Daegu West and Daegu South), Incheon (Incheon North, Incheon East, Incheon Central and Incheon South), Gwangju (Gwangju Gwangseo and Gwangju East), Daejeon (Daejeon West and Daejeon East), Ulsan (Ulsan East), Sejong Special Self-Governing Province, Gyeonggi-do (Suwon, Seongnam, Uijeongbu, Anyang, Bucheon, Pyeongtaek, Ansan, Goyang and Namyangju), Gangwon-do (Chuncheon, Wonju and Gangneung), Chungcheongbuk-do (Cheongju and Jecheon), Chungcheongnam-do (Cheonan and Seosan), Jeollabuk-do (Jeonju, Gunsan and Iksan), Jeollanam-do (Mokpo, Yeosu, Suncheon and Haenam), Gyeongsangbuk-do (Pohang, Andong, Gumi and Sangju), Gyeongsangnam-do (Changwon-gun, Jinju, Tongyeong and Gimhae), and Jeju Special Self-Governing Province (Jeju) (Fig. 3).

3.1.3 Comparison of critically ill emergency patients' characteristics by medical service districts concerning demographic, economic, and healthcare resources

Among demographic characteristics, population density, number of people aged <19 years, number of people aged 19–64 years, and number of people aged ≥65 years were higher in the inflow regions ($p < 0.05$) (Table 2). Regarding economic factors, financial independence was lower in the inflow regions, and the proportion of recipients of the National Basic Livelihood Program was higher in the inflow regions ($p < 0.05$) (Table 2). The number of emergency medical vulnerable areas was lower in the inflow districts compared to the outflow districts, while all other medical resource variables showed higher values in the inflow districts ($p < 0.001$) (Table 2).

3.2 Relation of RI and CI to population, economic, and healthcare resources

3.2.1 Correlation of RI and CI with population, economic, and healthcare resources

The numbers of dedicated emergency physicians ($r = 0.518$) and urgent care centers ($r = 0.501$) were positively strongly correlated with RI ($p < 0.01$). The number of underserved health centers ($r = 0.633$) was positively strongly correlated with CI ($p < 0.001$). The average number of CT scanners ($r = 0.579$), financial independence ($r = 0.554$), the average number of MRI scanners ($r = -0.544$), and the number of tertiary hospitals ($r = -0.514$) were negatively strongly correlated with CI ($p < 0.001$) (Table 3).

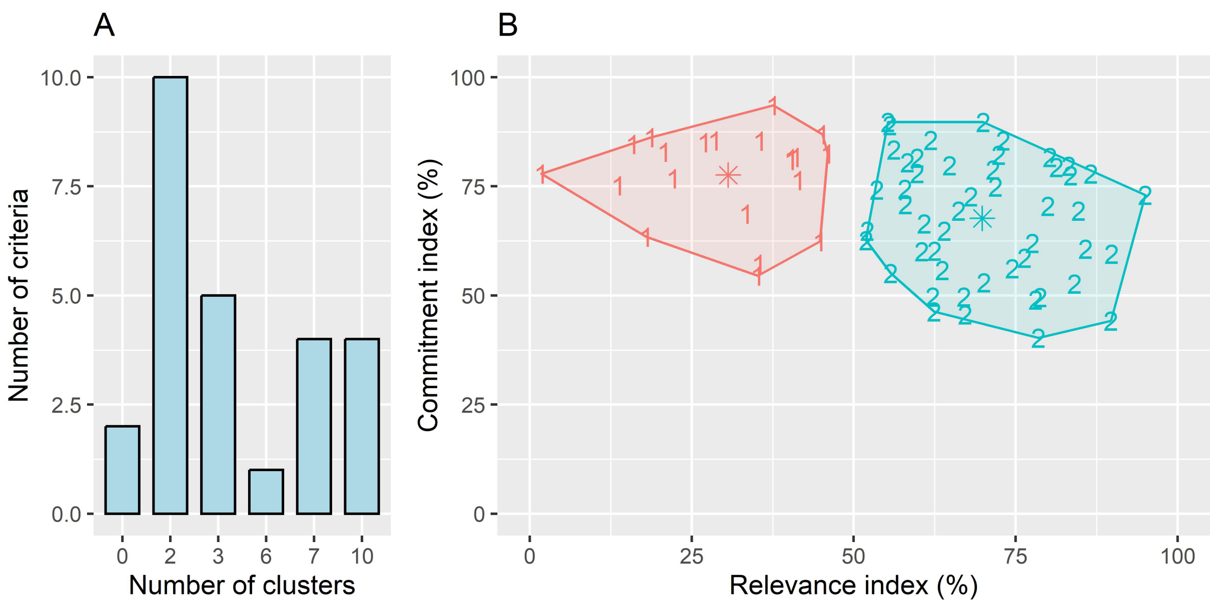

FIGURE 2. The number of clusters and cluster types for relevance and commitment indices. (A) NbClust was used to determine the number of clusters, providing the most frequent number of clusters. (B) Cluster analysis (K-means) results for 70 medical service districts using the optimal cluster number of 2.

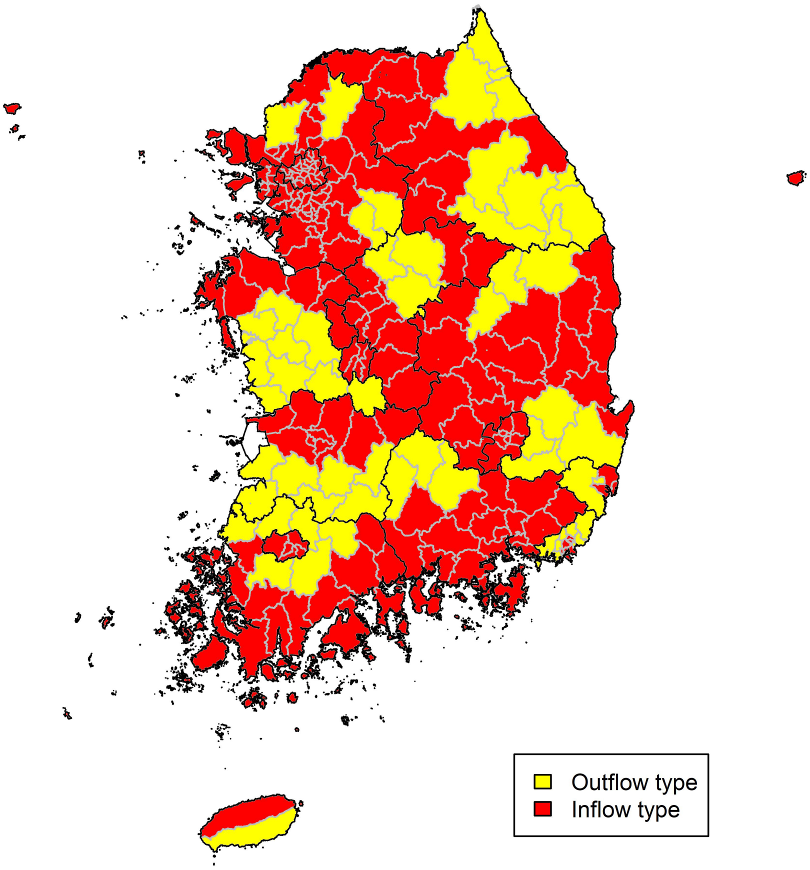

FIGURE 3. Clusters and types of critically ill emergency patients in 70 intermediate medical service districts.

TABLE 2. Comparison of critically ill emergency patients' characteristics with population, economic and medical resources according to cluster type.

	Mean	Standard deviation (SD)	Median (Q1–Q3)	U	*p*-value
Demographic factors					
Population density (n/km^2)					
Outflow region	551.9	933.4	148.4 (106.5–313.4)	305.000	0.007
Inflow region	3137.2	4749.8	745.0 (216.6–3032.9)		
Number of people aged <19 years (1000 people)					
Outflow region	45.6	37.8	29.3 (21.7–52.7)	151.000	<0.001
Inflow region	143.3	104.1	126.5 (75.6–181.9)		
Number of people aged 19–64 years (1000 people)					
Outflow region	204.0	171.1	120.4 (99.4–223.7)	155.000	<0.001
Inflow region	623.0	482.2	506.8 (282.6–756.1)		
Number of people aged ≥65 years (1000 people)					
Outflow region	72.4	45.8	57.9 (43.8–78.1)	206.000	<0.001
Inflow region	149.6	105.2	120.7 (82.6–183.5)		
Economic factors					
Financial autonomy rate (%)					
Outflow region	55.8	8.5	56.2 (54.2–61.8)	352.000	0.037
Inflow region	51.0	9.6	54.2 (46.7–57.4)		
Ratio of national basic livelihood recipients (%)					
Outflow region	0.6	0.4	0.5 (0.3–1.0)	319.000	0.012
Inflow region	1.1	0.8	0.9 (0.5–1.4)		

TABLE 2. Continued.

	Mean	Standard deviation (SD)	Median (Q1–Q3)	U	*p*-value
Medical resource factors					
Number of tertiary general hospitals (n)					
Outflow region	0.0	0.2	0 (0–0)	283.000	<0.001
Inflow region	0.8	1.2	0 (0–1)		
Number of general hospitals (n)					
Outflow region	2.3	1.6	2 (1–3)	195.500	<0.001
Inflow region	5.5	3.5	5 (3–7)		
Number of hospitals (n)					
Outflow region	9.8	11.0	6 (3–10)	208.500	<0.001
Inflow region	26.7	19.8	23 (13–40)		
Number of primary clinics (n)					
Outflow region	64.8	47.7	41 (35–70)	179.000	<0.001
Inflow region	177.4	143.8	141 (84–207)		
Average number of CT scanners (n)					
Outflow region	3.9	3.1	3.0 (2.0–4.7)	124.000	<0.001
Inflow region	11.6	6.4	11.0 (6.3–15.8)		
Average number of MRI scanners (n)					
Outflow region	2.8	2.5	2.0 (1.0–3.5)	136.500	<0.001
Inflow region	9.7	6.6	8.4 (5.2–12.8)		
Number of ICUs (n)					
Outflow region	72.9	174.4	25 (11–44)	139.500	<0.001
Inflow region	193.4	168.5	139 (94–232)		
Number of admission rooms (n)					
Outflow region	1195.4	2087.9	561 (350–1070)	174.000	<0.001
Inflow region	2450.9	1930.7	1861 (1278–2923)		
Number of vulnerable areas in emergency medical care (n)					
Outflow region	2.0	1.5	3 (1–3)	342.500	0.020
Inflow region	1.1	1.5	0 (0–2)		
Number of emergency medical centers (n)					
Outflow region	3.1	1.3	3 (2–4)	150.000	<0.001
Inflow region	7.1	4.3	6 (4–10)		
Number of patients visiting the ED (n)					
Outflow region	39,567.4	51,147.5	28,366 (17,890–34,982)	101.000	<0.001
Inflow region	116,595.7	76,014.6	93,755 (69,732–133,551)		
Number of emergency medicine specialists (n)					
Outflow region	7.9	6.4	6 (4–10)	79.000	<0.001
Inflow region	35.8	25.5	30 (21–42)		
The average number of dedicated specialists in the ED (n)					
Outflow region	11.2	6.4	9.0 (8.2–13.5)	73.000	<0.001
Inflow region	38.6	23.8	32.8 (23.2–47.6)		
The average number of dedicated nurses in the ED (n)					
Outflow region	36.0	24.3	29.3 (18.7–41.2)	77.000	<0.001
Inflow region	151.0	115.6	120.5 (714.0–165.2)		
Number of ED beds (n)					
Outflow region	69.4	113.1	42 (25–55)	156.000	<0.001
Inflow region	130.9	80.6	107 (78–166)		

The outflow region (N1) = 26 and the inflow region (N2) = 49. Q1: the first quartile; Q3: the third quartile; U, Mann-Whitney test statistic; CT, computed tomography; MRI, magnetic resonance imaging; ED, emergency department.

TABLE 3. Correlation with RI and CI values for critically ill emergency patients in 70 intermediate medical service districts.

Variables	RI	CI
Demographic		
Population density	0.168	−0.431***
Number of people aged <19 years	0.397**	−0.319**
Number of people aged 19–64 years	0.370**	−0.340**
Number of people aged ≥65 years	0.347**	−0.299*
Economic		
Financial autonomy rate	−0.156	0.554***
Ratio of national basic livelihood recipients	0.413***	−0.407***
Medical Resource		
Number of tertiary general hospitals	0.350**	−0.514***
Number of general hospitals	0.432***	−0.383**
Number of hospitals	0.396**	−0.453***
Number of primary clinics	0.349**	−0.362**
Average number of CT scanners	0.480***	−0.579***
Average number of MRI scanners	0.418***	−0.542***
Number of ICUs	0.355**	−0.482**
Number of admission rooms	0.329**	−0.423**
Number of vulnerable areas in emergency medical care	−0.154	0.633***
Number of emergency medical centers	0.501**	−0.170
Number of patients visiting the ED	0.425***	−0.378***
Number of emergency medicine specialists	0.485***	−0.425***
The average number of dedicated specialists in the ED	0.518***	−0.416***
The average number of dedicated nurses in the ED	0.480***	−0.449***
Number of ED beds	0.355**	−0.361**

*RI, relevance index; CI, commitment index; CT, computed tomography; MRI, magnetic resonance imaging; ICUs, intensive care units; ED, emergency department. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.*

3.2.2 Multiple linear regression analysis of RI and CI with demographic, economic, and health resources

In the standardized coefficients of the multiple linear regression analysis, RI influenced the average number of CT scanners ($\beta = 1.320$), followed by the average numbers of dedicated specialists ($\beta = 1.176$) and MRI scanners ($\beta = -1.125$) in the mentioned order ($p < 0.01$). The CI was most influenced by the number of ICUs ($\beta = -1.290$) ($p < 0.01$) (Table 4).

4. Discussion

This study examined critically ill emergency patient area types and compared 70 medical service districts with their associated factors. Particularly, the distribution of EDs that can provide definitive care by medical service districts is important because severe illnesses are time-sensitive, requiring prompt treatment for positive patient outcomes. Basic factors that can be used to determine the placement of EDs to fulfill appropriate specific functions include local demographics, economic factors, and the general state of local healthcare resources. Additionally, the numbers of emergency beds, ICU beds, admission room beds and major facility equipment, such as CT and MRI scanners, are indicators of response capacity for severe emergencies, including available emergency medical personnel. Regions with a high RI and a low CI generally have an inflow of patients, and conversely, regions with a low RI and a high CI usually have an outflow of patients [24, 25]. Regarding region types for critically ill emergency patients, 21 and 49 regions were identified as outflow and inflow regions, respectively. Previous Korean studies analyzed the regional type of critical care patients at the provincial level and found similar results [26, 27]. Specifically, Seoul, Incheon and Gyeonggi are typical inflow regions, indicating a high inflow of patients from other regions. These results indicate an increase in inter-regional migration due to the development of transportation methods, such as the opening of high-speed rails, which reduced the geographic constraints on a patient's choice of hospitals [28].

Various measures have been implemented to improve the emergency medical infrastructure in outflow regions, although without significant results. Instead, the imbalance of medical

TABLE 4. Multiple linear regression analysis on RI and CI values for critically ill emergency patients in 70 intermediate medical service districts.

Variables	Unstandardized coefficient		Standardized coefficient	t	F
	B	SE	β		
RI					
(constant)	32.933	3.899		12.157***	
Number of primary clinics	−0.130	0.036	−0.805	−3.589**	
Average number of CT scanners	4.286	1.158	1.320	3.702***	14.961***
Average number of MRI scanners	−3.695	1.245	−1.125	−2.967**	
The average number of dedicated specialists in the ED	1.064	0.204	1.176	5.214***	
CI					
(constant)	37.707	5.890		6.401***	
Financial autonomy	0.523	0.108	0.366	4.853***	
Number of primary clinics	0.072	0.018	0.708	3.894***	
Number of ICUs	−0.098	0.022	−1.290	−4.545***	24.633***
Number of vulnerable areas in emergency medical care	3.418	0.703	0.395	4.864***	
The average number of dedicated specialists in the ED	−0.291	0.103	−0.512	−2.820**	
Number of ED beds	0.130	0.036	0.915	3.607**	

*RI, relevance index; CI, commitment index; CT, computed tomography; MRI, magnetic resonance imaging; ED, emergency department; SE, standard error; ICUs, intensive care units. **: $p < 0.01$, ***: $p < 0.001$.*

resources between regions is further intensified by the increase in branches and beds in large hospitals in metropolitan areas. This phenomenon has caused new problems, such as the accelerating gap in local medical resources [28]. Concerning the expansion of large hospitals in metropolitan areas, studies in the United States showed that the amount of medical resources and the quality of medical care are not proportional; thus, the unplanned inputs of medical resources will not solve the current problems in Korea [29, 30]. Similar to Korea, Denmark tried to reorganize its emergency medical system to ensure that patients can access emergency medical care at any time and receive high-quality care; however, there are still problems that cannot be solved due to disease severity or long patient transportation [31].

Regarding RIs characterizing the extent to which critically ill emergency patients utilize emergency medical centers in other regions, 12 districts had an RI >80%, and 21 districts had an RI <50%. Regarding CIs providing insight into the extent of the influx from other regions, 22 districts had a CI >80%, and 8 districts had a CI <50%. We could check the regional variation by medical service districts and found that outflow regions had lower outcomes for all demographic factors. In terms of economic factors, the financial autonomy rate was higher in outflow regions, but the proportion of patients receiving National Basic Livelihood assistance was higher in the inflow regions. Comparing healthcare resources, most factors, except for the number of emergency medical vulnerable areas, were significantly higher in the outflow regions. Most factors associated with outflow regions are likely to harm medical center utilization. Moreover, the higher financial autonomy rate suggests a greater need for financial distribution for critically ill emergency patients in this area.

The average number of MRI scanners and the number of primary clinics had a negative association with the RI. In contrast, the average number of CT scanners and the average number of dedicated specialists in the ED had a positive association. The number of ICUs and the average number of dedicated specialists in the ED had a negative association with the CI, followed by the number of emergency beds, the number of primary clinics, the financial autonomy rate, and the number of emergency medical vulnerable areas. This is similar to previous studies showing that a higher number of physicians increases the amount of emergency medical services provided in a region [5]. The more ICUs and dedicated specialists in the ED, the greater the influx of out-of-area patients. However, the higher the financial autonomy rate, the number of primary clinics, the number of emergency medical vulnerable areas, and the number of emergency beds, the lower the influx of out-of-area patients. Out-of-area patients incur higher healthcare expenditures than in-area patients [11]. These additional healthcare expenditures can increase the economic burden of medical expenses. In South Korea, healthcare out-of-pocket expenditures account for 5.3% of household consumption, the second highest percentage among Organization for Economic Co-operation and Development (OECD) countries [32]. This burden of medical expenses can cause patients to avoid medical care, especially for severe emergencies requiring higher costs; hence, it should be considered at the policy level.

This study had several limitations. First, detailed information was unavailable due to de-identified national registry data used. Second, verifying a patient's address not matching the actual address was impossible. Third, the emergency medical system in South Korea is structured into three tiers: Local Emergency Medical Agency (LEMA), Local Emergency Medical Center (LEMC), and Regional Emergency Medical Center (REMC), with each level designated to handle severe cases progressively. Due to the nature of our NEDIS data, which is more limited in the variables collected from the LEMA, we only utilized data from critically ill emergency patients visiting REMC and LEMC. Therefore, one limitation was no inclusion of data from some critically ill emergency patients utilizing the LEMA. Finally, since this study was research performed in the Korean medical environment, results may vary depending on the medical environment and situation in other countries.

5. Conclusions

This study identified regional differences and variations in the types of 70 medical service districts for critically ill emergency patients in South Korea. When considering these differences, regions with higher average numbers of MRI scanners and primary clinics tend to have a lower patient outflow, whereas regions with higher numbers of ICUs and ED specialists tend to have a higher patient inflow from other regions. Finally, our research findings will help formulate policies for transporting critically ill emergency patients and determining the final treatment institution based on regional districts by presenting vulnerable populations, age groups, and medical resources related to critically ill emergency patients.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper, and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

MRO and SML—study conception and design. YJH, HNL and SHK—draft manuscript preparation. YJH and HNL—data curation. MRO—data analysis. SML—critical review of the manuscript. All authors reviewed the results and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the ethics committee of the National Medical Center (NMC-2023-01-004). The need for informed consent has been waived owing to its retrospective nature.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest. The authors did not receive a specific grant for this research from any funding agency in the public, commercial, or not-for-profit sector.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1843467914887217152/attachment/Supplementary%20material.docx.

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