Usage patterns of emergency medical services in Korea: analysis of patient flow

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Abstract
Background: This study used the National Emergency Department Information System (NEDIS) data to analyze the flow of emergency and critical emergency patients and to identify the patterns of emergency medical service usage in Korea.
Methods: The relevance index (RI) and commitment index (CI) were calculated from the 2016 NEDIS data. In this study, the number of clusters was determined using NbClust, and cluster analysis was used to analyze the usage patterns of emergency and critical emergency patients.
Results: The RI and CI were calculated using 8,389,766 cases of 214 districts. The results of the RI and CI suggested that there were 3 types of clusters among the emergency patients. In Cluster 1, 54 districts (25.2%) had low RI and high CI, and it was of outflow type. Cluster 2 was categorized as the influx-type in 58 districts (27.1%) irrespective of RI and low CI. Cluster 3 was categorized as the self-sufficient type found in 102 districts (47.7%), with high RI and high CI. The cluster analysis of the critical emergency patients was divided into 2 types. Cluster 1 was categorized as outflow type with high CI found in 129 districts (60.3%), while Cluster 2 was categorized as inflow type with low CI found in 85 districts (39.7%).
Conclusions: This study elucidates the regional status of usage patterns of emergency and critical emergency patients in Korea. This study might serve as a basis for the establishment and selection of emergency medical service areas and vulnerable emergency medical service areas.
Keywords: Clustering; Commitment Index; Emergency Department; National Emergency Department Information System; Relevance Index

Introduction
Most Korean emergency medical services depend on public health care and indicate disparity in supply and demand for emergency medical services.[1] In addition, there are differences among the quality level of regional emergency medical services. The regional distribution of emergency medical services is essential to not only establish the emergency medical delivery system but also secure the provision equity of emergency medical services. The state of regional imbalance limits the use of emergency medical services and does not guarantee equality. To overcome this disparity, emergency medical regionalization strategies are being used. Current regionalization strategies have shown improvements in the time to patient treatment and in patient outcome, with the incorporation of emergency medical services bypass as a key component of the system of care.[2-4]

Therefore, it is an extremely crucial concern in establishing a medical treatment zone, which is the basis for resource allocation in the emergency medical system.[5] And, it is possible to provide the information necessary for effective allocation of medical resources and policy establishment, if while setting up a medical treatment zone, the tendency of patients in a certain area to prefer a specific area is analyzed.

The patient origin method, which is one of the methods of establishing a medical treatment zone, can reveal the usage pattern of emergency medical services, based on the distribution of patients using the emergency medical institution.[6-8] In addition, the most important factor in deriving a medical treatment zone is the flow of patients in the region. Representative indicators are relevance index (RI) and commitment index (CI), used by Griffith.[7] RI is the percentage of patients who want to visit a hospital; it can identify the regional preference of the patients visiting...
the hospital and the range of the hospital’s care. Furthermore, CI indicates the percentage of patients using the hospital in the region where the hospital is located, and the residents of the region are aware of the preference for the hospital. Among the studies using RI and CI, domestic studies that have classified the regional usage include the study by the Korea Health and Medical Research Institute,[8] in which the 1994 and 1996 healthcare utilization data of the Ministry of Health and Welfare was used, the study by Lee and Park[6] in which the 2002 data of the Ministry of Health and Welfare were used, the study by Park et al[10] in which data were analyzed using electronic data interchange (EDI), and Park and Lee.[11] The previous studies, however, do not fully reflect the recent medical and emergency medical usage patterns after 2010; therefore, there is a possibility that the results of these studies may be altered because of the changes in the emergency medical environment that followed.

The National Emergency Department Information System (NEDIS), which is currently registering nationwide emergency medical information, has been administered to 16 regional emergency medical centers since June 2003, based on the Act on Emergency Medical Care. Since December 2005, the system has been extended to 45 regional emergency medical centers. Thus, since January 2010, the system has been expanded to 300 emergency medical institutions nationwide, and the standard registration system has been established to transmit 461 emergency medical institutions nationwide.[12] Therefore, in this study, we used the NEDIS data to first calculate the RI and CI indices that can reflect the status of both emergency medical and critical emergency medical usage in each region of the country, following which a cluster analysis was performed.

Methods

Ethical approval

The study was approved by the Regional Ethical Review Board in National Emergency Medical Center, Seoul (IRB NO.H-1706-079-003). This study is a database study on anonymous patient visits; therefore, no informed consent of patients was required.

Data source/collection

This study used the data of patients enrolled in the NEDIS among the patients who visited the emergency room from January 1 to December 31, 2016; the data were analyzed using the address of the emergency medical institution or the address of the patient. And patients with critical emergency illness were analyzed only as patients with severe Korea Classification of Diseases-7 (KCD-7) codes assigned by the Ministry of Health and Welfare. As of December 31, 2016, there are 31 regional emergency medical centers, 120 local emergency medical centers, and 262 local emergency medical agencies among 413 emergency medical institutions. Of these, 411 institutions transmit data to the NEDIS. The patients’ addresses were divided into city / province, (si/gun/gu) based on the postal code. The addresses of emergency medical institutions were divided into city / province, (si/gun/gu) based on the Integrated Emergency Medical Information Intranet (portal.nemc.or.kr) or the number of medical institutions in the Health Insurance Review and Assessment Service.

Study setting

\[ RI_{ij} = \frac{O_{ij}}{O_{i}}, \quad CI_{ij} = \frac{O_{ij}}{O_{i}}, \quad i = 1, 2, \ldots, m, \quad j = 1, 2, \ldots, n. \]

The RI and CI for the residence area \( i \) and the medical institution \( j \), which were defined by Griffith,[7] were calculated using the following equation in which \( O_{ij} \) is the amount of medical use of the patient living in area \( i \) using medical institution \( j \); \( O_{i} \) is the total amount of medical use of the patient living in area \( i \); \( O_{j} \) is the total amount of medical use of medical institution \( j \). RI is an available indicator of the amount of medical use at the location of a medical facility relative to the total amount of medical use of a patient in a particular area. It can be used to express the RI for the patient’s self-sufficiency rate as well as the degree of leakage. In other words, a high RI for an area indicates that the medical use in the area is high and that the amount of medical service outflows to other areas is relatively small. The CI is an indicator of a resident patient’s amount of medical service from the total amount of medical use at a particular local medical institution, which can also determine the extent of patient inflow from other areas. Thus, the lower the CI of a region is, the greater is the amount of medical access for other local patients.

Primary and secondary outcomes

The primary outcome of this study was the observations of the nationwide regional usage of emergency medical services through RI and CI analyses. In addition, we analyzed the type of regional usage of emergency and critical emergency patients by performing a cluster analysis on the results.

Statistical analysis

All of the analyses in this study were conducted using R 3.4.0 (https://www.r-project.org); the NbClust package method was applied to determine the number of clusters.[13] In addition, the K-means method was used for cluster analysis, which helped in distinguishing regional usage types. In general, the K-means method has the disadvantage of having researchers randomly decide on the number of clusters before relocating them. However, in this study, the majority rule was used to determine the optimal number of clusters selected from various indicators rather than by specifying different number of clusters. The non-parametric Kruskal-Wallis test and Mann-Whitney test were performed to examine the difference between the clusters of RI and CI for the clustering of regional usage types determined by cluster analysis. Data are represented by box-plots, which include the median and the inter-quartile range. Statistical significance was identified if the probability \( (P) \) value was less than 0.05.
Results

The 2016 NEDIS data used for the RI and CI analyzes were 8,389,766 (92.3%), out of the total of 9,089,518 cases from 411 emergency medical institutions; 699,752 cases (7.7%) were excluded because of reasons such as missing address or unknown. In addition, based on the information of 837,623 severe emergency patients from 409 emergency medical institutions, we calculated the RI and CI of the severely ill patients [Figure 1]. The 36 areas excluded from the analysis are those where there was no emergency medical institution or where the emergency medical institution did not transmit data to the NEDIS.

Determining the number of clusters for the total ED patients

The number of clusters was determined using RI and CI; the NbClust provided the most frequent number of clusters, which were 3 in the index of 13 out of the 26 indicators (50.0%). In addition, in the square sum method, the total number of squares in the group was not significantly different when the number of cluster was 3 [Figure 2]. Therefore, according to the principle of the majority rule, the number of cluster was determined to be 3.

Analysis of cluster type for the total ED patients

Using the optimal number of clusters, 3 (k = 3), the results of the cluster analysis (K-means) of 214 regions were summarized in Table 1. Cluster 1 included 54 regions (25.2%), with low RI and high CI. These areas are known to have a large number of outflows to other areas. Furthermore, Cluster 2 comprised 58 areas (27.1%); it was not related to RI and had low CI. This indicated an inflow of patients from other regions. Cluster 3 encompassed 102 regions (47.7%), with high RI and high CI, the inflow and outflow of patients into other regions were self-sufficient type. For the RI and CI difference between clusters, both RI and CI indicated significant differences and had the highest quartile range in Cluster 3. [The inter-quartile range: RI: Cluster 1 = 24.7–45.4%, Cluster 2 46.4–64.1%, Cluster 3 = 60.3–78.0%; CI: Cluster 1 = 64.0–82.1%, Cluster 2 = 30.2–47.4%, Cluster 3 = 70.3–80.6%] [Figure 2]. And, we mapped the regional distribution pattern of the total emergency patient flow in Korea [Figure 3].

Determining the number of clusters for critical ED patients

To determine the number of clusters for critical emergency patients, the NbClust provided the most frequent number of clusters, which were 2 in the index of 9 out of the 26 indicators (34.6%). In addition, in the square sum method, the total number of squares in the group was not significantly different when the number of cluster was 2. Therefore, according to the principle of the majority rule, the number of cluster was determined to be 2.

Analysis of cluster type for the critical ED patients

Using the optimal number of clusters, 2 (k = 2), the results of Cluster 1 was 129 areas (60.3%), which was not related to RI and had high CI. These areas are known to have a large number of outflows to other areas. Cluster 2 comprised 85 areas (39.7%); it was not related to RI and had low CI. This influent type is evident in a region with a large influx of patients from other regions [Table 2]. For the RI and CI difference between clusters, RI had the highest quartile range in Cluster 2, while CI had the highest quartile range in Cluster 1; both RI and CI showed significant differences between clusters. [The inter-quartile range: RI: Cluster 1 = 18.8–45.0%, Cluster 2 = 43.4–68.1%; CI: Cluster 1 = 67.1–82.7%, Cluster 2 = 27.4–49.4%] [Figure 4]. Also, we mapped the regional distribution pattern of the critical emergency patient flow in Korea [Figure 5].

Discussion

The pursuit of equality in health care access is the core goal of the general health care system. Various definitions have been used to establish medical rights or select underserved areas. Goddard and Smith defined the accessibility of health care in the England as follows: (1) retain a specific amount of information, (2) ensure that the discomfort and cost of the individual is below a certain level, (3) ensure a certain level of quality, (4) provide the ability to use certain types of health care services. Aday and Andersen identified the following characteristics affecting medical accessibility: (1) the amount of available medical resources, (2) the spatial distribution of resources, (3) the socioeconomic characteristics of resources, and (4) the willingness and cost of medical care, influenced by consumer attitudes and culture. In the context of Korea, vulnerable areas for health research are identified based on the setting of a “living area,” which extends the range of residence based on traffic analysis, and the research and analysis of health outcomes and socioeconomic factors. In the emergency medical field, vulnerable areas are selected by considering medical resources and quality. In addition, areas where the stability and effectiveness of emergency medical services are weak and the results of use are poor are defined as vulnerable areas.
This study was based on the NEDIS, a current dataset for the nationwide use of emergency medical institutions. The regional usage type was determined by analyzing the regional patients’ flow indices of RI and CI; moreover, a cluster analysis was performed using the RI and CI of 215 cities, counties, and districts or si/gun/gu. While determining the number of clusters for the total ED patients, the optimal number of clusters was selected as 3. Cluster 1 was an inflow type cluster that included 54 areas with low RI and high CI; Cluster 2 included was inflow type cluster that had 58 regions with low CI; and Cluster 3 comprised 102 self-sufficient areas with high RI and high CI. Park et al[10] reported that inflow type (RI > 65%), mixed type (RI 30%–60%), and outflow type (RI < 30%) were deter-
Table 1: Results of cluster analysis for total emergency department patients – 214 si-gu regions.

| Groups | N1  | Si do  | N2  | Si-gu gu          |
|--------|-----|--------|-----|-------------------|
| Cluster 1 | 54  | Seoul  | 5   | Jungnang-gu, Eunpyeong-gu, Gangseo-gu, Geumcheon-gu, Gwanak-gu |
|         |     | Busan  | 4   | Nam-gu, Geumjeong-gu, Suyeong-gu, Gijang-gun |
|         |     | Daegu  | 4   | Buk-gu, Suseong-gu, Dalseo-gu, Dalseong-gu |
|         |     | Incheon| 2   | Nam-gu, Yeonson-gu |
|         |     | Daejeon| 2   | Yuseong-gu, Daedeok-gu |
|         |     | Sejong | 1   | Sejong-si |
|         |     | Gyeonggi | 15  | Jangan-gu Suwon-si, Suyeong-gu Seongnam-si, Manan-gu Anyang-si, Sangnok-gu Ansan-si, Namyangju-si, Osan-si, Gyeong-gu Yongin-si, Paju-si, Icheon-si, Anseong-si, Gwangju-si, Yangju-si, Pocheon-si, Gapyeong-gun |
|         |     | Gangwon| 2   | Pyeongchang-gun, Jeongseon-gun |
|         |     | Chungbuk| 2   | Heungdeok-gu Cheongju-si, Boseong-gun |
|         |     | Chungnam| 1   | Asan-si |
|         |     | Jeonbuk| 2   | Wanyang-si, Daemyang-gu, Gokseo-gu, Gurye-gu, Muan-gu, Jangseong-gu, Wando-gu, Jindo-gu, Sinan-gu |
|         |     | Jeonnam| 9   | Gwangyang-si, Damyang-gu, Gokseong-gun, Gurye-gun, Muan-gun, Jangseong-gun, Paldal-gu Suwon-si, Bundang-gu Seongnam-si, Dongan-gu Anyang-si, Danwon-gu Ansan-si, Itandong-gu Goyang-si, Ikseong-gu Goyang-si, Guri-si |
|         |     | Gyeongbuk| 3   | Pohang-Buk-gu, Uişehir-gu, Yechon-si |
|         |     | Gyeongnam| 2   | Changnyeong-gu, Goseong-gun |
| Cluster 2 | 58  | Seoul  | 17  | Jongno-gu, Jung-gu, Yongsin-gu, Seongdong-gu, Gwangjin-gu, Dongdaemun-gu, Seongbuk-gu, Dobong-gu, Seodaemun-gu, Yangcheon-gu, Guro-gu, Yeongdeungpo-gu, Dongjak-gu, Seocho-gu, Gangnam-gu, Songpa-gu, Gangdong-gu |
|         |     | Busan  | 8   | Jung-gu, Seo-gu, Dong-gu, Busanjin-gu, Dongnai-gu, Haeundae-gu, Yeonje-gu, Sasang-gu |
|         |     | Daegu  | 4   | Jung-gu, Dong-gu, Seo-gu, Nam-gu |
|         |     | Incheon| 3   | Jung-gu, Dong-gu, Namdong-gu |
|         |     | Gwangju| 2   | Dong-gu, Nam-gu |
|         |     | Daejeon| 3   | Dong-gu, Jung-gu, Seo-gu |
|         |     | Ulsan  | 3   | Jung-gu, Dong-gu, Buk-gu |
|         |     | Gyeonggi | 8   | Paldal-gu Suwon-si, Yeonbong-gu Suwon-si, Bundang-gu Seongnam-si, Dongan-gu Anyang-si, Danwon-gu Ansan-si, Itandong-gu Goyang-si, Ikseong-gu Goyang-si, Guri-si |
|         |     | Gangwon| 1   | Sokcho-si |
|         |     | Chungbuk| 3   | Sangdang-gu Cheongju-si, Seowon-gu Cheongju-si, Cheongwon-gu Cheongju-si |
|         |     | Chungnam| 2   | Dongnam-gu Cheonan-si, sSeobuk-gu Cheonan-si |
|         |     | Jeonbuk| 1   | Deokjin-gu Jeonju-si |
|         |     | Gyeongbuk | 1    | Nam-gu Pohang-si |
|         |     | Gyeongnam| 2   | Uichang-gu Changwon-si, Masanhoewon-gu Changwon-si |
| Cluster 3 | 102 | Seoul  | 1   | Nowon-gu |
|         |     | Busan  | 2   | Yeondo-gu, Buk-gu |
|         |     | Incheon| 5   | Bupyeong-gu, Gyeong-gu, Seo-gu, Ganghwa-gu, Ongjin-gu |
|         |     | Gwangju| 3   | Seo-gu, Buk-gu, Gwangsan-gu |
|         |     | Ulsan  | 2   | Nam-gu, Ulju-gu |
|         |     | Gyeonggi | 12  | Uijeongbu-si, Buccheon-gu, Gwangmyeong-si, Pyeongtae-gu, Deogyang-gu Goyang-si, Siheung-si, Gunpo-si, Cheongju-gu Yongin-si, Gimpo-si, Hwaseong-si, Yeoju-si, Yeoncheon-gun |
|         |     | Gangwon| 12  | Chunchon-si, Wonju-si, Gangneung-si, Donghae-si, Taebetae-si, Samcheok-si, Hongcheon-gun, Hoengseong-gun, Yeongwol-gun, Cheorwon-gun, Hwacheon-gun, Yanggun-gu |
|         |     | Chungbuk| 6   | Chunchu-si, Jecheon-si, Okcheon-gu, Yeongdong-gun, Jinchon-gu, Goesan-gun |
|         |     | Chungnam| 9   | Gungju-si, Boryeong-si, Seosan-si, Nonsan-si, Dangjin-si, Buyeo-gu, Cheongang-gun, Hongseong-gun, Taean-gun |
|         |     | Jeonbuk| 11  | Wansan-gu Jeonju-si, Gunsan-si, Iksan-si, Jeongeup-si, Namwon-si, Jinan-gu, Muju-gun, Jangju-gu, Sunchang-gun, Gochang-gun, Buan-gun |
|         |     | Jeonnam| 11  | Mokpo-si, Yeosu-si, Suncheon-si, Naju-si, Goheung-gun, Boseong-gun, Hwasun-gun, Jangheung-gun, Gwangyang-gun, Haenam-gun, Yeonggwang-gun |
|         |     | Gyeongbuk| 15  | Gyeongju-si, Gimcheon-si, Andong-si, Gumi-si, Yeongju-si, Yeongcheon-gu, Sangju-si, Mungyeong-si, Gyeyongsan-si, Cheongbuk-gu, Cheongdo-gun, Goryeong-gun, Seongju-si, Uljin-gun, Uleung-gun |
|         |     | Gyeongnam| 11  | Jinhae-gu Changwon-si, Jinju-si, Tongyeong-si, Sacheon-si, Gimhae-si, Geoje-si, Yangsan-si, Uiryegun, Sacheong-gun, Geochang-gun, Hapcheon-gun |
|         |     | Jeju  | 2   | Jeju-si, Seogwipo-si |

N1, N2: number of areas.
mined by RI rather than CI. However, in this study, both RI and CI were used meaningfully, indicating that regional types were distinguished.

However, previous studies have presented 2 to 4 regional types. Therefore, their results are not presented in this study; however, if the number of clusters in this study was changed to 2 and 4 and the analysis indicated that the number of clusters was 2 \( (k=2) \), then Cluster 1 would include 141 self-sufficient type regions with high CI, and Cluster 2 would have 73 outflow type regions with low CI. Park classified areas into high self-sufficient types with large outflows to other areas. If, however, the number of clusters was 4 \( (k=4) \), then Cluster 1 would include 71 regions (concentrated type) with normal RI and high CI; Cluster 2 would have 56 regions (mixed type) with normal RI and low CI; Cluster 3 would comprise 39 regions (adjacent/outflow type) with low RI and high CI; and Cluster 4 would include 48 regions (self-sufficient type) with high RI and high CI. The study by the Korea Health and Medical Care Research Institute elucidated that the treatment rights were divided into 4 regional types: hub type (RI high, low CI), self-sufficient type (high RI, high CI), mixed type (low RI, CI low), and outflow type (low RI and high CI). Similarly, Lee and Park stated that the treatment rights were divided into 4 regional types: inflow type (RI is the highest and CI is the lowest), mixed (both RI and CI are the lowest), outflow type (RI is the lowest and CI is the highest), self-fulfilling type (RI is usually high and CI is high).

While determining the number of clusters for critically ill patients, the optimal number of clusters was 2. Cluster 1 was classified into 129 regions (outflow type) with CI was high; Cluster 2 was divided into 85 regions (inflow type) with low CI. Regarding the comparison of differences between RI and CI clusters, in the case of RI, the difference in Cluster 1 was 18.8% to 45.0% and that in Cluster 2 was 43.4% to 68.1%; in the case of CI, the difference in Cluster 1 was 67.1% to 82.7% and that in Cluster 2 was 27.4% to 49.4%. Analysis of the regional usage types of critically ill patients suggests that the efficacy of the final treatment for
severe diseases is probably less than that of the inflow type. Patients from these outflow areas moving to inflow areas because of a lack of personnel, facilities, and equipment capable of ultimately treating serious illnesses. In January 2017, 71 out of the 79 (89.9%) areas included in this study were among the 99 emergency medical service vulnerable areas identified by the Ministry of Health and Welfare.\textsuperscript{19} In addition, according to Kwak 2016 study, 24 emergency

| Groups  | N1 | Si do | N2 | Si gun gu |
|---------|----|-------|----|-----------|
| Cluster 1 | 129 | Seoul | 4 | Eunpyeong-gu, Gangseo-gu, Geumcheon-gu, Gwanak-gu |
|         |    | Busan | 5 | Yeongdo-gu, Nam-gu, Buk-gu, Geumjeong-gu, Gijang-gun |
|         |    | Daegu | 3 | Buk-gu, Suseong-gu, Dalseong-gu |
|         |    | Incheon | 6 | Nam-gu, Yeonsu-gu, Bupyeong-gu, Gyeyang-gu, Ganghwa-gu, Ongjin-gun |
|         |    | Gwangju | 2 | Seo-gu, Buk-gu |
|         |    | Daejeon | 3 | Dong-gu, Yuseong-gu, Daedeok-gu |
|         |    | Ulsan | 2 | Buk-gu, Uijeong-gu |
|         |    | Sejong | 1 | Sejong-si |
|         |    | Gyeonggi | 23 | Sujeong-gu Seongnam-si, Jungwon-gu Seongnam-si, Manan-gu Anyang-si, wangmyeong-si, Pyeongtaek-si, Sangnok-gu Ansan-si, Deogyang-gu Goyang-si, Namyangju-si, Osan-si, Siheung-si, Gunpo-si, Cheon-gu Yongin-si, Giheung-gu Yongin-si, Paju-si, Icheon-si, Anseong-si, Gimpo-si, Gwangju-si, Yangju-si, Pocheon-si, Yeonju-si, Yeongcheon-gun, Gapyeong-gun |
|         |    | Gangwon | 11 | Donghae-si, Taebak-si, Samcheok-si, Hongcheon-gun, Hoengseong-gun, Yeongwol-gun, Pyeongchang-gun, Jeongseon-gun, Cheorwon-gun, Hwacheon-gun, Yanggu-gun |
|         |    | Chungbuk | 7 | Heungdeok-gu Cheongju-si, Chungju-si, Boeun-gun, Okcheon-gun, Yeongdong-gun, Jinchon-gun, Goesan-gun |
|         |    | Chungnam | 8 | Gongsu-si, Boryeong-si, Asan-si, Nonsan-si, Dangjin-si, Buyeo-gun, Cheongju-gun, Taean-gun |
|         |    | Jeonbuk | 10 | Gunsan-si, Jeongeup-si, Wanju_Gun, Jinan-gun, Muju-gun, Jangsu-gun, Imilgun, Sunchang-gun, Gochang-gun, Buan-gun |
|         |    | Jeonnam | 17 | Yeosu-si, Naju-si, Gwangyang-si, Damyang-gun, Gokseong-gun, Gurye-gun, Goheung-gun, Boseong-gun, Jangheung-gun, Gangjin-gun, Haenam-gun, Muan-gun, Yeonggwang-gun, Jangseong-gun, Wando-gun, Jindo-gun, Sinan-gun |
|         |    | Gyeongbuk | 15 | Buk-gu Pohang-si, Gyeongju-si, Gimcheon-si, Yeongju-si, Yeongcheon-si, Sangju-si, Gyeongsan-si, Uiseong-gun, Cheongju-gun, Cheongju-gun, Goryeong-gun, Seongju-gun, Yecheon-gun, Uijeong-gun, Ulleung-gun |
|         |    | Gyeongnam | 11 | Jinhae-gun Changwon-si, Tongyeong-si, Sacheon-si, Gimhae-si, Geoje-si, Uiryung-gun, Changnyeong-gun, Goseong-gun, Sancheong-gun, Geochang-gun, Hapcheon-gun |
|         |    | Jeju | 1 | Seogwipo-si |
| Cluster 2 | 85 | Seoul | 19 | Jongro-gu, Jung-gu, Yongsan-gu, Seongdong-gu, Gwangjin-gu, Dongdaemun-gu, Jungnang-gu, Seongbuk-gu, Dobong-gu, Nowon-gu, Seodaemun-gu, Yangcheon-gu, Guro-gu, Yeongdeungpo-gu, Dongjak-gu, Seocho-gu, Gangnam-gu, Sogong-gu, Gwangong-gu |
|         |    | Busan | 9 | Jung-gu, Seo-gu, Dong-gu, Busanjin-gu, Dongnae-gu, Haeundae-gu, Yeonje-gu, Suyeong-gu, Sasang-gu |
|         |    | Daegu | 5 | Jung-gu, Dong-gu, Seo-gu, Nam-gu, Dalseo-gu |
|         |    | Incheon | 4 | Jung-gu, Dong-gu, Namdong-gu, Seo-gu |
|         |    | Gwangju | 3 | Dong-gu, Nam-gu, Gwangsan-gu |
|         |    | Daejeon | 2 | Jung-gu, Seo-gu |
|         |    | Ulsan | 3 | Jung-gu, Nam-gu, Dong-gu |
|         |    | Gyeonggi | 12 | Jangan-gun Suwon-si, Paldal-gun Suwon-si, Yeongcheong-gu Suwon-si, Bundang-gu Seongnam-si, Uijeongbu-si, Dongan-gu Anyang-si, Bucheon-si, Danwon-gu Ansan-si, Ilsandong-gu Goyang-si, Ilsanseo-gu Goyang-si, Guri-si, Hwaseong-si |
|         |    | Gangwon | 4 | Chuncheon-si, Wonju-si, Gangneung-si, Sokcho-si |
|         |    | Chungbuk | 4 | Sangdang-gu Cheonju-si, Seowon-gu Cheonju-si, Cheongwon-gu Cheonju-si, Jecheon-si |
|         |    | Chungnam | 4 | Dongnam-gu Cheonan-si, Seobuk-gu Cheonan-si, Seosan-si, Hongseong-gun |
|         |    | Jeonbuk | 4 | Wansan-gu Jeonju-si, Deokjin-gu Jeonju-si, Iksan-si, Namwon-si |
|         |    | Jeonnam | 3 | Mokpo-si, Suncheon-si, Hwasun-gun |
|         |    | Gyeongbuk | 4 | Nam-gu Pohang-si, Andong-si, Gumi-si, Mungyeong-si |
|         |    | Gyeongnam | 4 | Uichang-gu Changwon-si, Masanhappy-gu Changwon-si, Jinju-si, Yangsan-si |
|         |    | Jeju | 1 | Jeju-si |

N1, N2: number of areas.
medical service vulnerable areas were selected based on the condition that the population could not access emergency medical services within 30 minutes and the emergency medical usage rate was below 60%. Thus, it is confirmed that this is the entire region of Cluster 1 of all emergency patients in the outflow area of this study. In particular, outflow areas with critically ill patient overflow should be selected as vulnerable areas to provide additional emergency medical resources. In addition, using RI and CI for each critically ill patient will help identify areas with serious emergency diseases that are lacking in specific regions. Finally, to provide appropriate emergency medical resources.
services in this region, it is essential to adopt a monitoring system that is capable of identifying the availability of emergency medical resources, by regional variables, for their most effective allocation. Such a system can be used to develop principles and guidelines for long-term and rational resource allocation by considering local needs.

Because of the use of the NEDIS data in this study, it was necessary to discuss the reliability of the NEDIS data based on the actual practice information in the emergency room. The results of a national emergency medical institution evaluation, which can verify the reliability of the information, suggested that the input rate of emergency rooms was 94.4% and the completion rate was 95.8%. Considering these results, we concluded that the validity of the data for this study in which the 2016 NEDIS data is used would not be a problem.

According to Park, the inter-regional flow of emergency medical services is determined by the supply of emergency medical resources and the size of the city. In future studies, it is necessary to analyze not only the determinants of RI and CI such as patient composition ratio, disease group classification, patient socio-demographic characteristics, characteristics of emergency medical institutions (eg, number of doctors, percentage of specialists, composition of regional emergency medical center, number of intensive care unit, and number of ventilators or CT, or MRI), but also complex indicators such as mortality and complication rates.

In this study, we calculated the RI and CI of si/gun/gu for nationwide ED patients and revealed that the patterns of emergency patient usage were divided into 3 types, based on a cluster analysis. In addition, the usage patterns of critical emergency patients were of 2 types. Through this study, we were able to identify the regional status of medical services usage of emergency and critical emergency patients in Korea. This study will serve as a basis for the establishment and selection of emergency medical service areas and emergency medical vulnerable areas.
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Conflicts of interest

None.

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