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ORIGINAL RESEARCH

Analysis of characteristics and trends of the In-Hospital Cardiac Arrest incidence in the Republic of Korea: clinical usefulness of national health insurance claim data

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Abstract

Backgrounds: In-Hospital Cardiac Arrest (IHCA) requires the preparation of considerable medical resources in hospitals. Furthermore, compared to Out-of-Hospital Cardiac Arrest, until recently, there have not been many studies on the incidence, characteristics, and prognosis of IHCA. This study is to examine IHCA event rates among hospitalized patients in the Republic of Korea from 2011 to 2015.

Methods: The incidence of IHCA in adults was extracted from claim data of the National Health Insurance Service from 2011 to 2015, and analyzed according to age, sex, the classification under the 7th revision of the Korean Standard Classification of Diseases (KCD-7), hospital types, and provinces.

Results: From 2011 to 2015, the overall incidence of IHCA in Korea was founded to be 3.00 per 1,000 hospitalizations. The overall 5-year IHCA incidence was higher in male at 3.92 cases per 1,000 hospitalizations and at female 2.19 cases per 1,000 hospitalizations. Incidence due to cardiovascular disease increased year by year, whereas incidences due to respiratory, neurological and infectious disease were decreasing, and in the case of oncologic disease, there was no change. In particular, patients with diseases of the circulatory system had at least a two times higher incidence compared to those with other diseases. The IHCA incidence in general hospitals and tertiary hospitals was at least two-fold higher than the national overall and showed an increasing trend. The provinces that showed a higher IHCA incidence than the five-year national overall were Jeju Special Self-Governing Province, Gangwon Province, and Seoul.

Conclusions: The results of this study can be used as important basic data to secure patient safety by reducing the occurrence of IHCA.

Keywords

In-Hospital Cardiac Arrest; Incidence; Epidemiology; Big data; Claim data

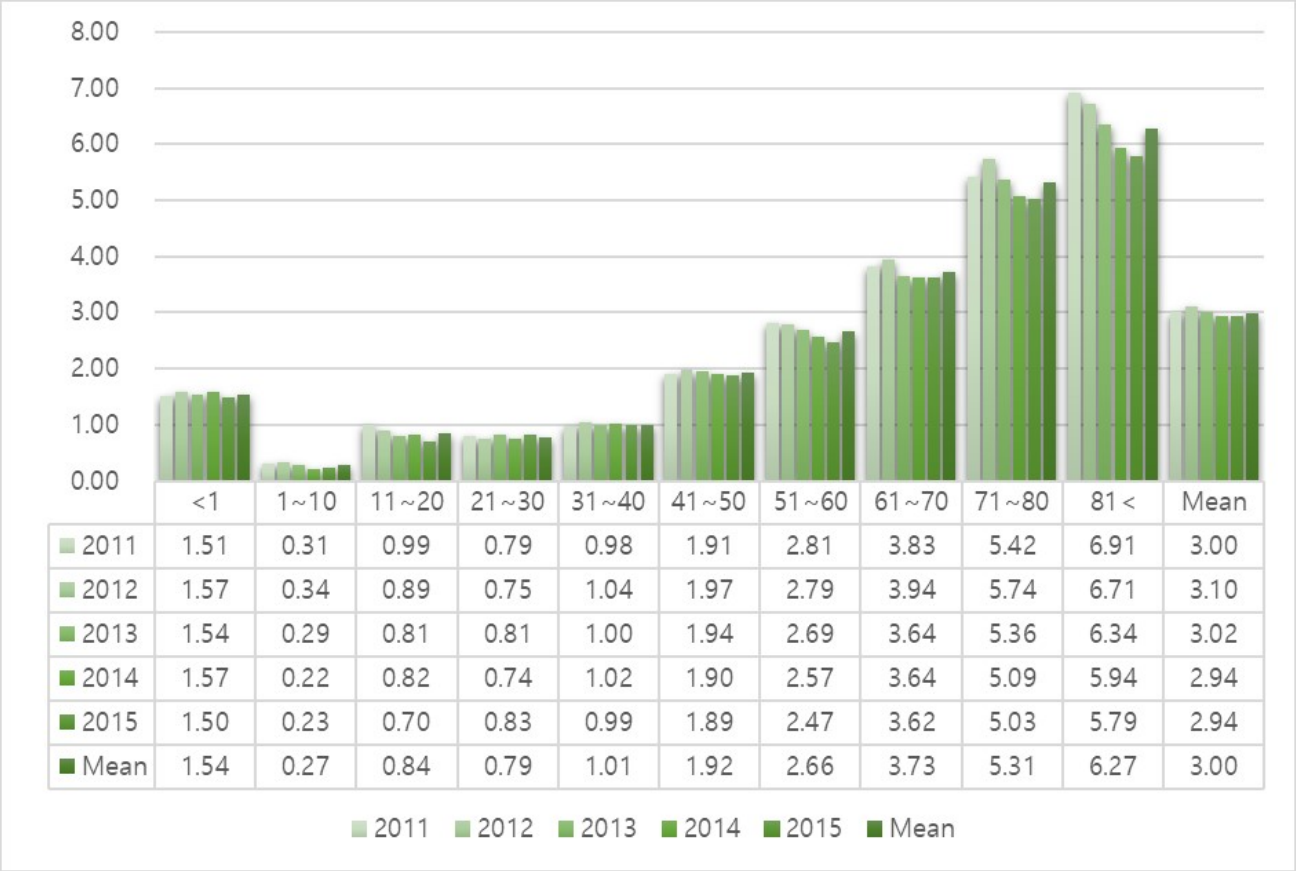
1. Introduction

Cardiac arrests are emergency situations that require medical professionals to provide immediate, adequate care within minutes, and cardiac arrest treatment, that is, cardio-pulmonary resuscitation (CPR), involves many human and physical resources [1, 2]. The lack of an immediate response in the event of a cardiac arrest may lead to death or permanent brain damage, and use up significant medical resources.

Cardiac arrest is traditionally classified into In-Hospital Cardiac Arrest (IHCA) and Out of Hospital Cardiac Arrest (OHCA) depending on whether or not it has occurred in a hospital [3]. For decades, various studies on the incidence and characteristics of OHCA, as well as the development of guidelines to improve the prognosis, have been actively conducted [4–6]. IHCA has tended to be considered a branch of OHCA or to be valued with low importance [7]. However, IHCA requires the preparation of considerable medical resources in hospitals [1]. Furthermore, compared to OHCA, until recently, there have not been many studies on the incidence, characteristics, and prognosis of IHCA [8].

Recently, as several registry-based studies have been conducted, the incidence rate and the characteristics of IHCA have been analyzed [8, 9]. Previous studies have shown that IHCA has approximately 1-5 occurrences per 1000 beds [2]. According to the data of the American Heart Association's nationally representative Get With The Guidelines Resuscitation (GWTG-R) registry it was estimated that there were approximately 6-7 cases per 1000 hospitalizations (0.92/1000 bed-days) from 2003 to 2007 [10, 11]. The United Kingdom (UK) national cardiac arrest audit reported 1.6 cases per 1000 hospitalizations [12]. Denmark's nationwide IHCA registry base incidence reported 1.8 cases per 1000 hospitalizations [9].

However, the incidence of IHCA based on real data rather than estimated data is difficult to predict [2]. Although it has



	<1	1~10	11~20	21~30	31~40	41~50	51~60	61~70	71~80	81<	Mean
2011	1.51	0.31	0.99	0.79	0.98	1.91	2.81	3.83	5.42	6.91	3.00
2012	1.57	0.34	0.89	0.75	1.04	1.97	2.79	3.94	5.74	6.71	3.10
2013	1.54	0.29	0.81	0.81	1.00	1.94	2.69	3.64	5.36	6.34	3.02
2014	1.57	0.22	0.82	0.74	1.02	1.90	2.57	3.64	5.09	5.94	2.94
2015	1.50	0.23	0.70	0.83	0.99	1.89	2.47	3.62	5.03	5.79	2.94
Mean	1.54	0.27	0.84	0.79	1.01	1.92	2.66	3.73	5.31	6.27	3.00

FIGURE 1. In-Hospital Cardiac Arrest Incidence Trends by Age Group. * Incidence unit: cases per 1,000 hospitalization.

been estimated based on the registry, there are not many studies have suggested the exact incidence of IHCA. The Republic of Korea is one of the relatively few countries in the world that implements national health insurance for the whole nation, and data for insurance claims can be identified on an actual scale [13]. From this insurance claim data, Choi *et al.* [14] and Kwon *et al.* [15] reported a nationwide IHCA incidence of 2.46 for every 1,000 hospitalizations using 2009 sample data and 3.00 per 1,000 hospitalizations using whole data from 2011 to 2015, respectively. Based on this pilot study, the present study attempts to grasp the IHCA incidence and analyze its characteristics by using the total data for several years.

2. Materials and methods

2.1 Source of data

This study was conducted based on insurance claims submitted to the Health Insurance Review & Assessment Service (HIRA) of the Republic of Korea for patients hospitalized in various hospitals from 2011 to 2015, retrospectively. The data comprise four tables: a table for general information (TABLE 20), a table for detailed services provided (TABLE 30), a table for diagnostic codes (TABLE 40), and a table for medical prescriptions (TABLE 53). Each was assigned a unique key value. A separate table was generated for information on medical institutions.

2.2 Case description

2.2.1 Classification of medical institutions

Under the Medical Act of the Republic of Korea, medical institutions are classified into clinic-level medical institutions and hospital-level medical institutions. However, insurance claims are made using a separate classification of medical institutions into tertiary hospitals, general hospitals, long-term care hospitals, dental hospitals, oriental medical hospitals, hospitals, clinics and health centers. This study excluded dental hospitals, oriental medical hospitals, and health centers, and focused only on tertiary hospitals, general hospitals, long-term care hospitals, hospitals, and clinics.

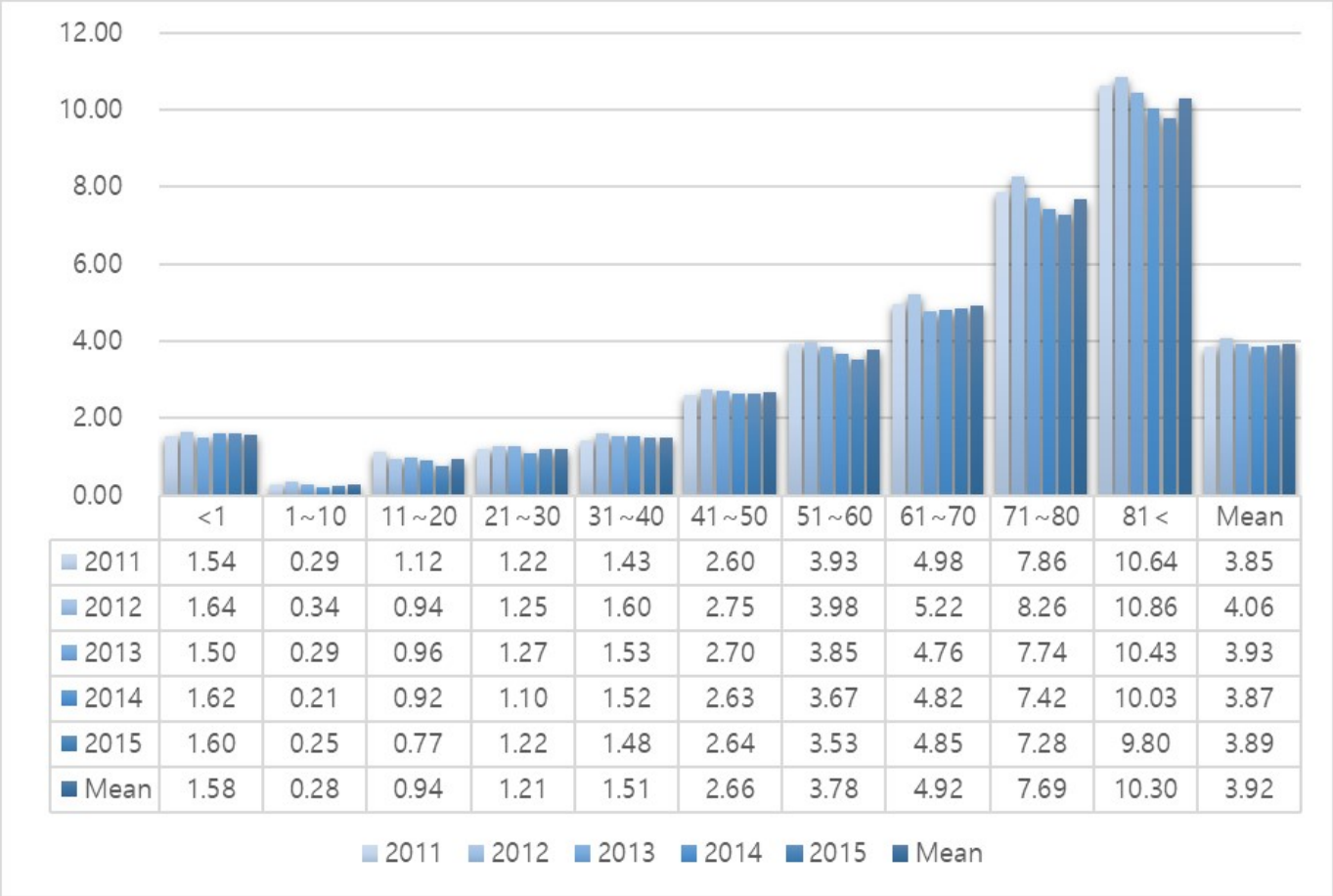
2.2.2 Extraction of IHCA cases

To extract IHCA cases, this study extracted medical records of patients hospitalized for treatment in medical institutions from 2011 to 2015 where the related insurance claims contained cardiac arrest treatment codes in TABLE 30: M5873, M5874, M5875, M5876, and M5877. The analysis focused mostly on TABLE 20.

(1) Since IHCA tends to be recurring, patients with multiple cardiac arrest codes during the same hospitalization period were counted once, and hospitalizations that followed were excluded.

(2) Among insurance claims of the Health Insurance Review & Assessment Service, this study used only data on hospitalized patients. OHCA patients who did not recover or died shortly after recovery (within six hours of emergency room arrival) were excluded.

(3) Cases with significantly fewer claim codes other than



	<1	1~10	11~20	21~30	31~40	41~50	51~60	61~70	71~80	81<	Mean
2011	1.54	0.29	1.12	1.22	1.43	2.60	3.93	4.98	7.86	10.64	3.85
2012	1.64	0.34	0.94	1.25	1.60	2.75	3.98	5.22	8.26	10.86	4.06
2013	1.50	0.29	0.96	1.27	1.53	2.70	3.85	4.76	7.74	10.43	3.93
2014	1.62	0.21	0.92	1.10	1.52	2.63	3.67	4.82	7.42	10.03	3.87
2015	1.60	0.25	0.77	1.22	1.48	2.64	3.53	4.85	7.28	9.80	3.89
Mean	1.58	0.28	0.94	1.21	1.51	2.66	3.78	4.92	7.69	10.30	3.92

FIGURE 2. In-Hospital Cardiac Arrest Incidence Trends by Male and Age Group. * Incidence unit: cases per 1,000 hospitalization.

cardiac arrest codes in TABLE 30 were excluded as they were regarded as not being hospitalized.

2.3 Statistical analysis

Incidence was defined as cases per 1,000 hospitalizations and calculated.

The IHCA incidence were analyzed based on gender, age, and disease as defined in the 7th revision of the Korean Standard Classification of Diseases (KCD-7), type of institution, and province.

All data were analyzed in SAS version 9.4 (SAS Institute, Cary, NC, USA).

3. Results

3.1 Analysis based on gender and age

3.1.1 Analysis based on age

A bimodal distribution is observed when the IHCA incidence is analyzed for patients below one year old and by age group in 10-year increments. The IHCA incidence is 1.54 cases for every 1,000 hospitalizations in patients below one year old, and 1.01 cases for every 1,000 hospitalizations for 41 years onwards. The event rate is highest in the 81-90 age group (Fig. 1, Supplement Table 1).

The overall IHCA incidence from 2011 to 2015 is 3.00 cases per 1,000 hospitalization, and the IHCA incidences was increased in 61 years onward. However, the IHCA incidence showed a declining trend from 2011 to 2015 for patients aged 51 and older.

3.1.2 Analysis based on gender and age

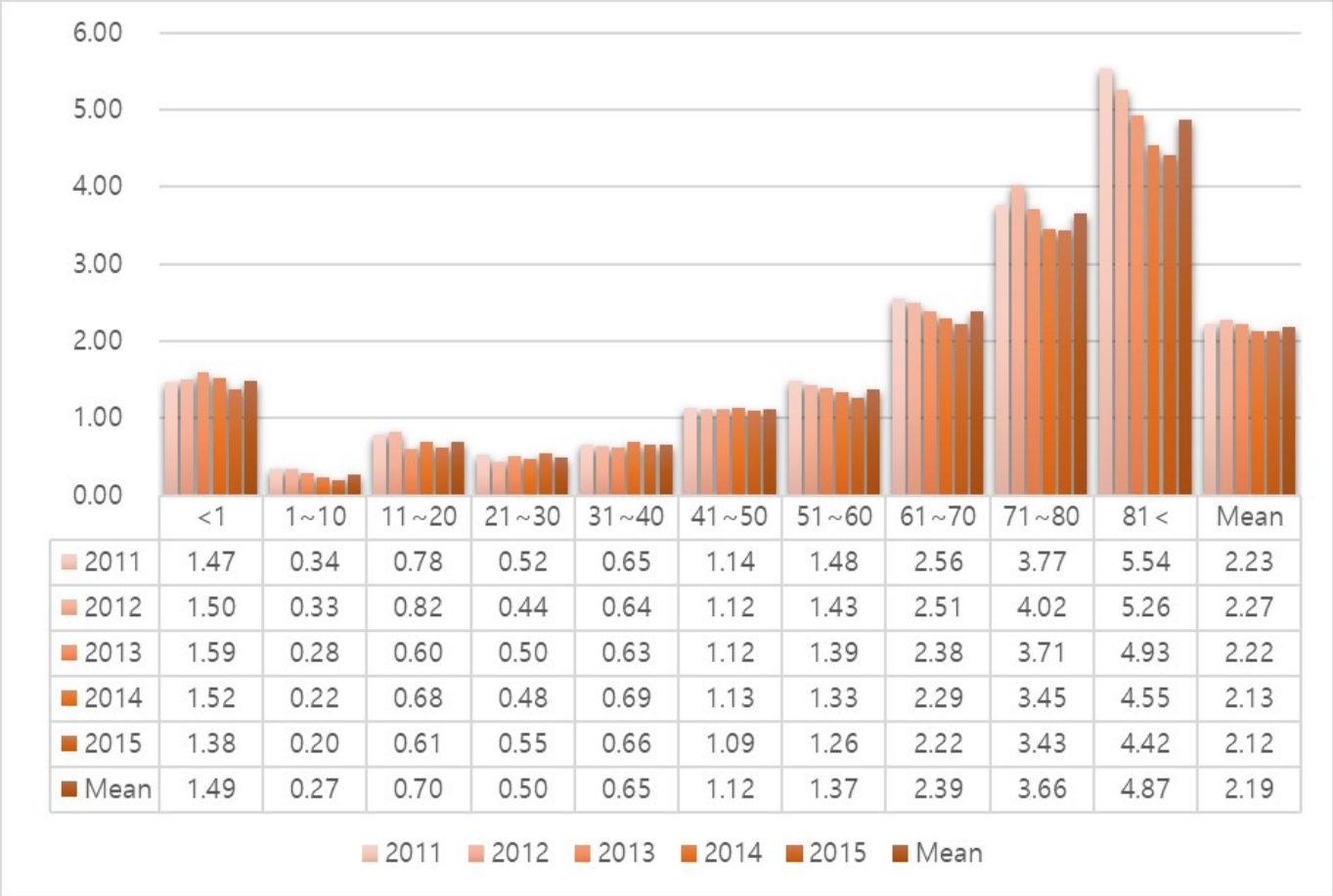
The IHCA incidence of male and female patients by age group and year are shown in Fig. 2, Fig. 3, and Supplement Table 1.

The overall 5-year IHCA incidence was 3.92 cases per 1,000 hospitalizations for male patients, and 2.19 cases per 1,000 hospitalizations for female patients. That is, male patients had a roughly 1.8 times higher IHCA event rate.

The IHCA incidence by age group exhibited a similar binodal distribution for both male and female patients.

3.2 Analysis based on disease group and gender

Looking at the IHCA incidence by KCD disease classification, the highest event rate was seen for diseases classified under R00-R99, which is defined as “symptoms, signs, and abnormal clinical and laboratory findings; not elsewhere classified”. The next highest IHCA incidence was for I00-I95, or “diseases of the circulatory system”. This was followed by P00-P96 or “certain conditions originating in the perinatal period”, A00-B99 or “certain infectious and parasitic diseases”, and J00-J99 or “diseases of the respiratory system”. The incidence



	<1	1~10	11~20	21~30	31~40	41~50	51~60	61~70	71~80	81<	Mean
2011	1.47	0.34	0.78	0.52	0.65	1.14	1.48	2.56	3.77	5.54	2.23
2012	1.50	0.33	0.82	0.44	0.64	1.12	1.43	2.51	4.02	5.26	2.27
2013	1.59	0.28	0.60	0.50	0.63	1.12	1.39	2.38	3.71	4.93	2.22
2014	1.52	0.22	0.68	0.48	0.69	1.13	1.33	2.29	3.45	4.55	2.13
2015	1.38	0.20	0.61	0.55	0.66	1.09	1.26	2.22	3.43	4.42	2.12
Mean	1.49	0.27	0.70	0.50	0.65	1.12	1.37	2.39	3.66	4.87	2.19

FIGURE 3. In-Hospital Cardiac Arrest Incidence Trends by Female and Age Group. * Incidence unit: cases per 1,000 hospitalization.

by disease group, gender, and age is presented in Supplement Table 2.

3.3 Analysis based on major cause of death and infectious diseases

A separate analysis was performed for major diseases - cardiovascular diseases, cerebrovascular diseases, respiratory diseases, and oncologic disease and infectious diseases (Fig. 4).

The IHCA incidence among patients with diseases of the circulatory system, including cardiovascular diseases, showed an increasing trend at 9.57 cases per 1,000 hospitalizations in 2011, 10.41 cases in 2012, 10.36 in 2013, 11.20 in 2014, and 12.00 in 2015. The number of male patients with diseases of the circulatory system was about 1.67 times higher than the number of female patients in the five-year period, and the IHCA incidence increased for both genders.

The IHCA incidence among patients with diseases of the respiratory system, including types of pneumonia, showed a decreasing trend at 4.09 cases per 1,000 hospitalizations in 2011, 4.15 cases in 2012, 4.09 in 2013, 3.50 in 2014, and 3.42 in 2015. The number of male patients with diseases of the respiratory system was relatively higher than the number of female patients in the five-year period, and the IHCA incidence decreased for both genders.

The IHCA incidence among patients with infectious diseases decreased from 5.00 cases per 1,000 hospitalizations in 2011, 4.79 cases in 2012, 4.33 cases in 2013, and 3.85 cases in 2014 to 3.48 cases in 2015. Diseases of the nervous system including cerebrovascular diseases showed a similar decreasing trend from 1.45 cases per 1,000 hospitalizations in 2011, 1.29 cases in 2012, 1.09 cases in 2013, and 1.04 cases in 2014 to 0.86 cases in 2015.

The IHCA incidence among oncologic patients was similar each year.

3.4 Analysis based on institution type

The IHCA incidence by year and hospital type is shown in Fig. 5 and Supplement Table 3.

The IHCA incidence in tertiary hospitals showed an increasing trend at 5.43 cases per 1,000 hospitalizations in 2011, 6.25 cases in 2012, 6.13 cases in 2013, 6.31 cases in 2014, and 6.29 cases in 2015.

The IHCA incidence was generally higher for general hospitals than for tertiary hospitals, with a similar increasing trend at 5.71 cases per 1,000 hospitalizations in 2011, 6.51 cases in 2012, 6.56 cases in 2013, 6.44 cases in 2014, and 6.65 cases in 2015.

On the other hand, the IHCA event rate for hospitals and long-term care hospitals was 1.38 cases and 0.77 cases, respectively, in 2011, and dropped to 0.98 cases and 0.40 cases in 2015.

The IHCA incidence for clinic-level medical institutions

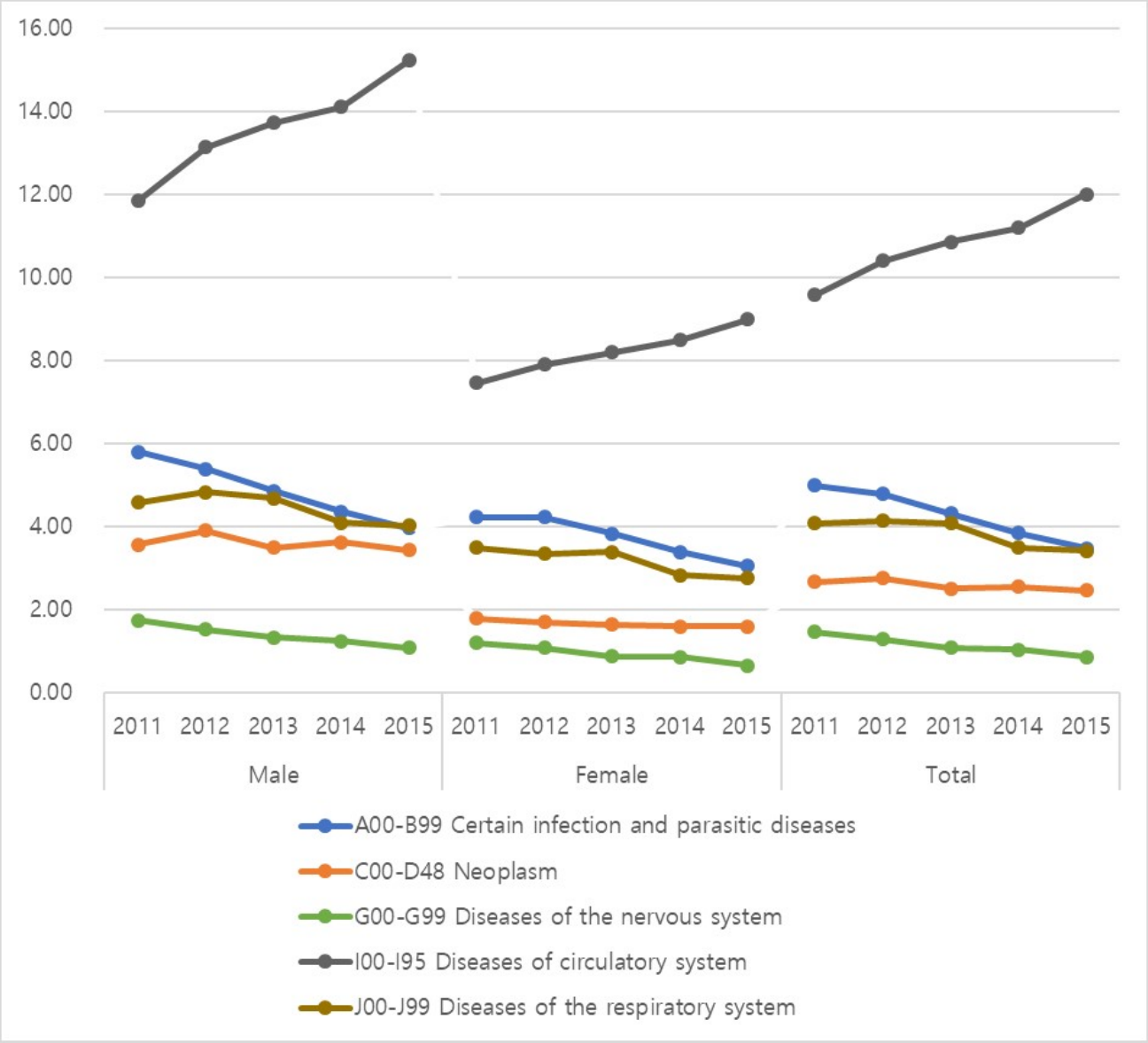


FIGURE 4. In-Hospital Cardiac Arrest Incidence Trends by Major cause of Death and Infectious Disease. * Incidence unit: cases per 1,000 hospitalization.

increased slightly from 0.05 cases per 1,000 hospitalizations in 2011 to 0.10 cases in 2015.

3.5 Analysis based on province

Compared to the overall IHCA incidence of 3.00 cases per 1,000 hospitalizations from 2011 to 2015, the cities or provinces with a sub-overall incidence were Busan Metropolitan City, Daejeon Metropolitan City, Ulsan Metropolitan City, Jeollabuk Province, Jeollanam Province, Gyeongsangbuk Province, and Gyeongsangnam Province (Fig. 6).

Jeju Special Self-Governing Province had the highest incidence, followed by Gangwon Province, Seoul, and Chungcheongbuk Province.

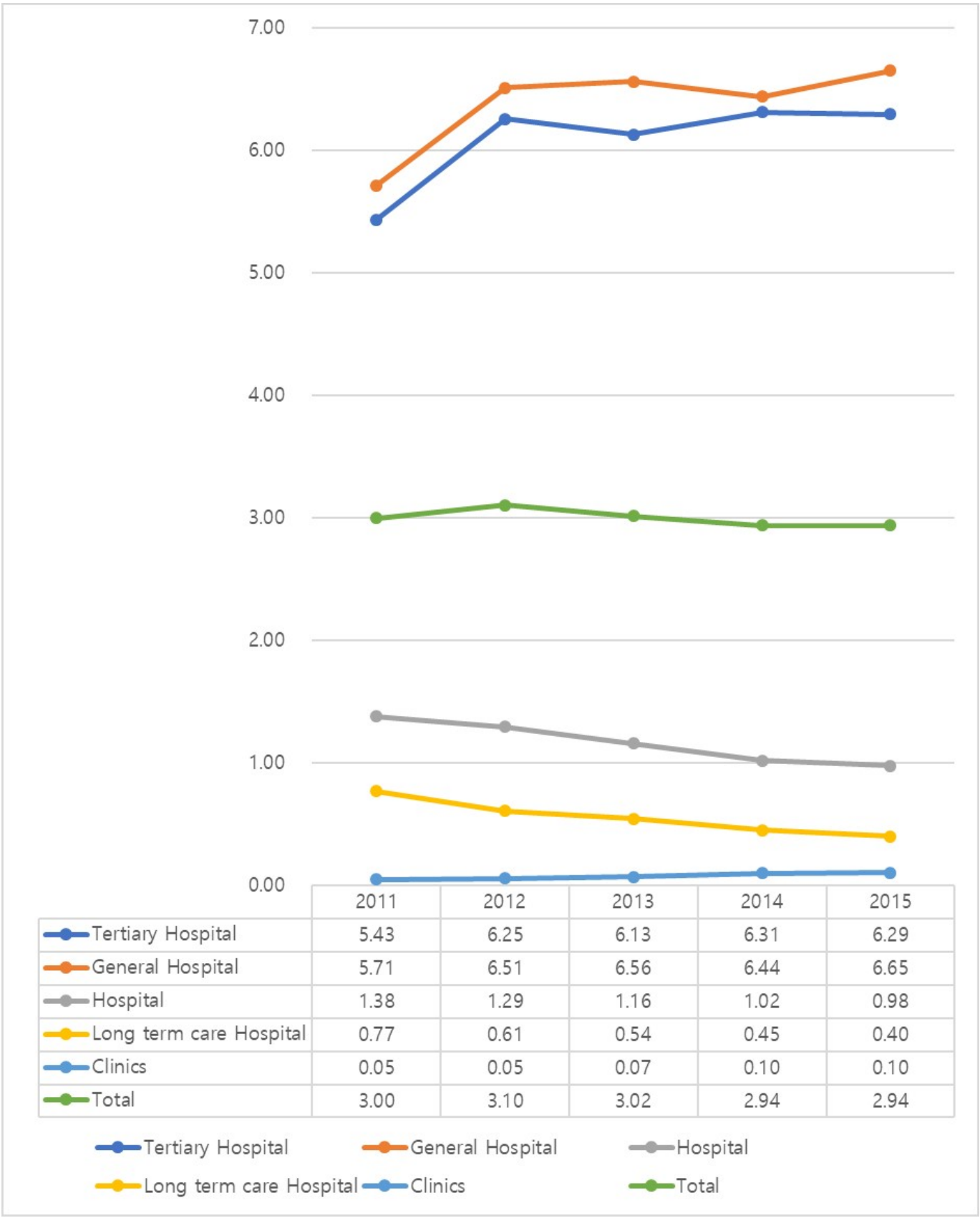
The incidence of IHCA was slightly higher than the overall in three metropolitan areas, including Seoul, Incheon Metropolitan City, and Gyeonggi Province, where patients from all over the country are concentrated.

The IHCA incidence increased for Gangwon Province, Chungcheongbuk Province, and Sejong Special Self-Governing City.

Meanwhile, the IHCA event rate decreased yearly in Busan Metropolitan City, Gwangju Metropolitan City, Jeollanam Province, and Jeollabuk Province. Other provinces had similar IHCA event rates each year.

4. Discussion

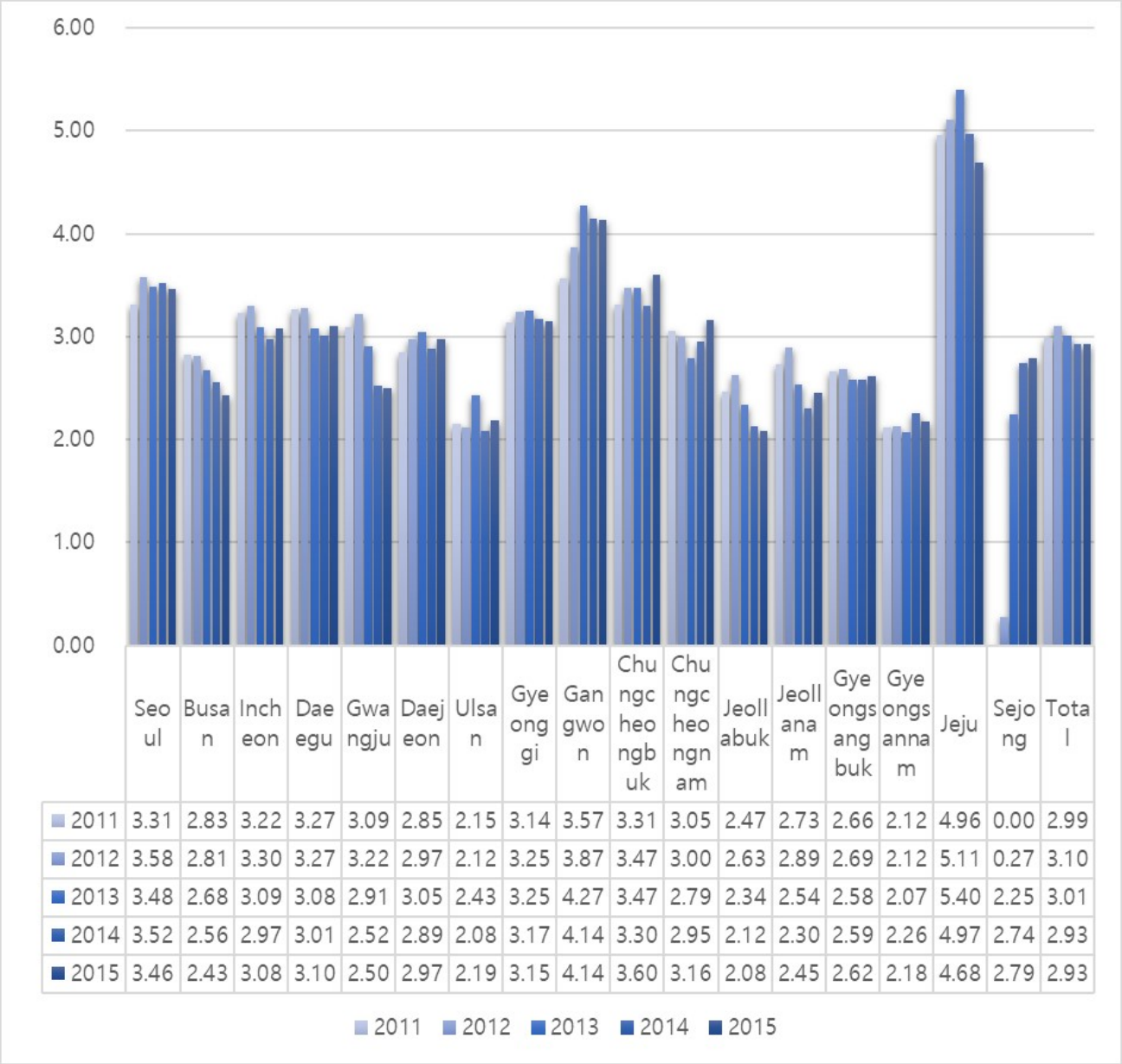
In this study, the overall IHCA incidence from 2011 to 2015 was 3.00 cases for every 1,000 hospitalizations. This is consistent with the 2007 findings of Sandroni *et al.* [2] and Nolan *et al.* [16], who reported one to five IHCA cases for every 1,000 hospitalizations. In a 2017 study by Thompson *et al.* [17] a similar IHCA incidence of four cases per 1,000 hospitalizations was observed for U.S. elderly population aged 65 and above. Harrison *et al.* [12] of the United Kingdom reported 1.5 cases in acute care hospitals, while Radeschi *et*



	2011	2012	2013	2014	2015
Tertiary Hospital	5.43	6.25	6.13	6.31	6.29
General Hospital	5.71	6.51	6.56	6.44	6.65
Hospital	1.38	1.29	1.16	1.02	0.98
Long term care Hospital	0.77	0.61	0.54	0.45	0.40
Clinics	0.05	0.05	0.07	0.10	0.10
Total	3.00	3.10	3.02	2.94	2.94

FIGURE 5. In-Hospital Cardiac Arrest Incidence Trends by Hospital Type. * Incidence unit: cases per 1,000 hospitalization.

al. [18] of Italy observed 1.51 cases. The IHCA incidences of the two countries were slightly lower than that of Korea. China's Shao *et al*. [19] declared that there were 17.5 cases for every 1,000 hospitalizations, and this was significantly higher than other countries. They also reported a low survival rate and poor prognosis. In the United States, based on the American



	Seoul	Busan	Incheon	Daegu	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungcheongbuk	Chungcheongnam	Jeollabuk	Jeollanam	Gyeongsangbuk	Gyeongsannam	Jeju	Sejong	Total
2011	3.31	2.83	3.22	3.27	3.09	2.85	2.15	3.14	3.57	3.31	3.05	2.47	2.73	2.66	2.12	4.96	0.00	2.99
2012	3.58	2.81	3.30	3.27	3.22	2.97	2.12	3.25	3.87	3.47	3.00	2.63	2.89	2.69	2.12	5.11	0.27	3.10
2013	3.48	2.68	3.09	3.08	2.91	3.05	2.43	3.25	4.27	3.47	2.79	2.34	2.54	2.58	2.07	5.40	2.25	3.01
2014	3.52	2.56	2.97	3.01	2.52	2.89	2.08	3.17	4.14	3.30	2.95	2.12	2.30	2.59	2.26	4.97	2.74	2.93
2015	3.46	2.43	3.08	3.10	2.50	2.97	2.19	3.15	4.14	3.60	3.16	2.08	2.45	2.62	2.18	4.68	2.79	2.93

FIGURE 6. In-Hospital Cardiac Arrest Incidence Trends by Region. * Incidence unit: cases per 1,000 hospitalization.

Heart Association's Get With The Guidelines-Resuscitation (GWTG-R) registry from 2008 to 2017, the incidence was estimated as 292,000 annually, or 9 to 10 IHCA per 1,000 admissions [8]. This difference between studies is speculated to be due to the method of calculation and the characteristics of the population.

There are few countries in the world that provide national health insurance for individual citizens. The Republic of Korea has a special health insurance system that allows individuals to make insurance claims for medical services based on their resident registration number. The insurance claims contain many types of information but may be a distorted representation as they are for insurance purposes. Moreover, the data are too vast to apply in clinical analysis. HIRA-NPS-2009, extracted from national health insurance claims in 2009 to be nationally representative, was utilized in some studies. Choi *et al*. [14] conducted a pilot study in 2009 using the data and found that the IHCA event rate was 2.46 cases for every 1,000 hospitalizations.

However, since most countries cannot have access to data on citizens' medical records, IHCA incidences were only reported for certain age groups or through registries of some hospitals.

The IHCA incidence according to age group showed binodal distribution. Patients aged below one year old suffered from various diseases, from which we could predict a high IHCA incidence. Those aged 60 and above showed an increasing trend from 2011 to 2015. For patients aged 60 and above, the IHCA incidence increased with age. Nonetheless, an encouraging sign was that the IHCA event rate was decreasing annually in the same age group. This can be associated with improvements in the quality of medical services and patient safety [20].

The IHCA incidence was 1.8 times higher for male patients than female patients. This trend was also observed for patients with diseases of the circulation system and cancer, with male patients having a higher rate by 1.67 and 2.17

times, respectively. The results cannot be generalized to all diseases as the difference was less significant for diseases of the nervous system. Also, there were some conditions unique to female patients, such as pregnancy, childbirth, and puerperal infections [12, 20, 21].

Historically, the most common and second most common cause of cardiac arrest have been cardiac and respiratory origins [22–24]. In this study, the high incidence in patients with diseases classified under R00-R99, that is, "symptoms, signs and abnormal clinical and laboratory findings; not elsewhere classified", is presumed to be the result of cardiac arrest occurring while trying to find the cause of symptoms. This result is thought to be because the data originated from the insurance claim data. Excluding IHCA related to neonatal period, cardiac disease, infectious disease, and respiratory disease are the next most common causes of IHCA, consistent with results from other studies.

Focusing on the several diseases that are regarded as to the leading causes of death, the IHCA rate of cardiovascular disease continues to increase, as opposed to be the decreasing trend of the IHCA incidence in other diseases, particularly infectious diseases, respiratory diseases (including pneumonia), and nervous system diseases. Even though this data is considered for insurance claim, the trends are thought to reflect the medical development of successful acute treatment of these diseases, and hospitals must exert efforts to lower cardiac arrest incidence among patients with diseases of the circulation system.

Looking at the IHCA incidence by hospital type, hospitals or long-term care hospitals where milder cases or patients requiring long-term care are hospitalized showed a decrease in the IHCA incidence, whereas tertiary hospitals displayed the opposite trend. This can be traced to the higher concentration of severe cases in general or tertiary hospitals. Harrison *et al.* [12] reported 1.5 cases for every 1,000 hospitalizations in acute care hospitals, and Radeschi *et al.* [18] found 1.51 for every 1,000 hospitalizations. The IHCA event rate in Korea's tertiary hospitals and general hospitals was about four times higher at 6.07 cases and 6.37 cases, respectively. One factor that may be relevant here is the practice of CPR on patients suffering from cancer or other diseases and who are at the end of life. To resolve this issue, the Act on Hospice and Palliative Care and Decisions on Life-sustaining Treatment for Patients at the End of Life was enacted, but further research should be conducted in this area. The overdependence on CPR alone cannot explain Korea having an almost four times higher event rate compared to developed countries, which highlights the need for in-depth analysis and countermeasures.

The provinces that showed a higher IHCA incidence than the five-year national overall were Jeju Special Self-Governing Province, Gangwon Province, and Seoul. In the case of Seoul, the high incidence can be explained by the city having major hospitals preferred by many citizens. However, the high incidence cannot be explained altogether because Jeju Special Self-Governing Province is due to the isolated environment of an island, and Gangwon Province is due to the environment with many mountainous areas. Based on data of the AHA's GWTG-R, Merchant *et al.* reported no statistically significant difference between incidence of IHCA in urban and rural areas [25]. This difference is due to the medical accessibility resulting from the geographical factors and relatively unforced health care delivery system in the nation [26].

Further research should be carried out to analyze the possibility of patients receiving treatment in other regions or moving to new regions, and to calibrate for severity of conditions.

While many cases of IHCA is irresistible, there are some cases that can be predicted and prevented. To prevent IHCA and respond to emergency situations, many hospitals have operated the Rapid Response Team (RRT) or Medical Emergency Team (MET) [27], and some researchers have even used tools of the deep learning, as a type of machine learning [28]. And their efforts make patient safety to be ensured by preventing cardiac arrest in hospitals. The results of this study would be expected to be utilized as a basic statistical data for their efforts.

This study has the following limitations.

First, insurance claims data contain information on examinations, treatment, procedures, surgeries, and medication, but do not provide results for each administration. As such, the cause of cardiac arrest could not be fully investigated.

Second, since not all patients' medical records can be accessed, it was not possible to analyze the status of patients at the time of cardiac arrest.

Third, patient status in insurance claims data is briefly described as "ongoing", "transferred", "returned", "death", "other", or "discharged", and does not provide details on specific conditions of transfer, return, or discharge. Analysis of cerebral performance category (CPC) scores, needed to determine the survival rate or prognosis evaluation of patients who have experienced cardiac arrest, could not be carried out. To assess survival rate and prognosis, it is necessary to analyze related factors based on operational definitions. This will allow a comparative analysis of survival rate and prognosis of cardiac arrest patients between hospitals that provide CPR training on a regular basis and those that do not.

5. Conclusions

The overall IHCA incidence for patients hospitalized in medical institutions of the Republic of Korea from 2011 to 2015 was found to be 3.00 cases per 1,000 hospitalizations. The IHCA incidence was also obtained by age group, gender, disease group, institution type, and regional local government. The results of this study can be used as important basic data to secure patient safety by reducing the occurrence of IHCA.

AUTHOR CONTRIBUTIONS

IHK contributed to conduct the data curation and formal analysis and funding acquisition. YC and IHK contributed to application of the research methodology. IHK drafted the manuscript as first and corresponding authors. YC reviewed and edited for completion of the manuscript. IHK visualized the figures and tables.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved as exempt from research ethics review with approval number DAUHIRB-EXP-17-110 issued by the Institutional Review Board of Dong-A University Hospital.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1372074403372646400/attachment/SV2021012701_Supplements.pdf.

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