ORIGINAL ARTICLE
Occupation & Environmental Medicine

JKMS

http://dx.doi.org/10.3346/jkms.2015.30.10.1396 • J Korean Med Sci 2015; 30: 1396-1404

Presumed Regional Incidence Rate of Out-of-Hospital Cardiac Arrest in Korea

Young Sun Ro,[1] Seung-sik Hwang,[2] Sang Do Shin,[3] Daikwon Han,[4] Sungchan Kang,[2] Kyoung Jun Song,[3] and Sung-il Cho[5]

[1]Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul; [2]Department of Social & Preventive Medicine, Inha University School of Medicine, Incheon; [3]Department of Emergency Medicine, Seoul National University College of Medicine, Seoul; [4]Department of Epidemiology & Biostatistics, Texas A&M University, College Station, TX, USA; [5]Department of Preventive Medicine, Graduate School of Public Health, Seoul National University, Seoul, Korea

Received: 3 May 2015
Accepted: 23 June 2015

Address for Correspondence:
Seung-sik Hwang, MD
Department of Social & Preventive Medicine, Inha University School of Medicine, 366 Seohae-daero, Jung-gu, Incheon 22332 Korea
Tel: +82.32-890-0972, Fax: +82.2-766-1185
E-mail: cyberdoc@inha.ac.kr

Funding: This study was financially supported by the Seoul Metropolitan City Government (2008), the Korean Centers for Disease Control and Prevention (CDC) (2009-2013) and the National Emergency Management Agency (NEMA) (2008-2013) (Grant No. 0720090210 and No. 0720100440).

The regional incidence rates of out-of-hospital cardiac arrest (OHCA) were traditionally calculated with the residential population as the denominator. The aim of this study was to estimate the true incidence rate of OHCA and to investigate characteristics of regions with overestimated and underestimated OHCA incidence rates. We used the national OHCA database from 2006 to 2010. The nighttime residential and daytime transient populations were investigated from the 2010 Census. The daytime population was calculated by adding the daytime influx of population to, and subtracting the daytime outflow from, the nighttime residential population. Conventional age-standardized incidence rates (CASRs) and daytime corrected age-standardized incidence rates (DASRs) for OHCA per 100,000 person-years were calculated in each county. A total of 97,291 OHCAs were eligible. The age-standardized incidence rates of OHCAs per 100,000 person-years were 34.6 (95% CI: 34.3-35.0) in the daytime and 24.8 (95% CI: 24.5-25.1) in the nighttime among males, and 14.9 (95% CI: 14.7-15.1) in the daytime, and 10.4 (95% CI: 10.2-10.6) in the nighttime among females. The difference between the CASR and DASR ranged from 35.4 to -11.6 in males and from 6.1 to -1.0 in females. Through the Bland-Altman plot analysis, we found the difference between the CASR and DASR increased as the average CASR and DASR increased as well as with the larger daytime transient population. The conventional incidence rate was overestimated in counties with many OHCA cases and in metropolitan cities with large daytime population influx and nighttime outflow, while it was underestimated in residential counties around metropolitan cities.

Keywords: Out-of-Hospital Cardiac Arrest; Incidence; Epidemiology

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a global health problem and incidences of OHCA vary greatly across different regions not only within countries but also between countries (1-4). Resource allocation to improve OHCA survivals targets communities with either high incidences or low survival rates. To implement effective community interventions, the true incidence rates and survival outcomes of OHCA must be evaluated.

Previous OHCA studies have extensively reported on the definite temporal variability and time-geographic distribution patterns (5-8). Epidemiological reports support the circadian variability with a daytime excess and overnight nadir in the occurrence of OHCAs (5-7, 9). Furthermore, incidence and mortality are not uniformly distributed geographically; distinct hot spots exist in which these variables are greater than expected (1, 8, 10-13). Understanding temporal variability and geographic distribution observations provides a framework that may lead to the maximization of the benefits of interventions to increase the probability of a favorable outcome (5, 9, 12-14).

The regional OHCA incidence rates were traditionally calculated with the number of incidence cases in the region as the nominator and the residential population as the denominator (population at risk during a specific period of time) (1-3, 8-13). Based on the regional OHCA incidence rates, interventions to improve OHCA outcomes, including ambulances and autonomic external defibrillators, were strategized and provided in high-risk regions. However, it is possible that certain areas may have more transient persons at risk during the daytime hours, resulting in a higher absolute number of arrests (12). For example, town centers concentrated with a large number of offices, railway stations and international airports were reported as hot spots for OHCA with an unexpected cluster attributing to the influx of daytime transient population and nonresident arrests (8, 15).

The daytime transient population who migrate inter-regions for work or school during the daytime hours should be considered to calculate the incidence rate of acute medical events such

pISSN 1011-8934
eISSN 1598-6357

as OHCA. The accurate measurement of event incidence may not be informative in determining the prevalence of chronic diseases, but it is a crucial component in effective resource allocation when developing community interventions for acute medical illness. Furthermore, because OHCAs have circadian variability and geographic distribution patterns, the daytime transient population should be considered to calculate the regional incidence rate in order to determine the true high risk population (2, 5-8, 15). To date, there have been few studies that incorporated the daytime transient population in calculations to investigate the OHCA incidence rate.

The goal of this study was to estimate the true regional incidence rate of OHCA in Korea and to investigate the characteristics of the regions with large differences between the previously reported rate and the newly calculated incidence rate that considers nighttime residential population and daytime transient population as population at risk.

MATERIALS AND METHODS

Data source and setting

The cardiovascular disease surveillance (CAVAS) database is a large-scale, nationwide, retrospective observational database of patients in Korea who have experienced confirmed OHCA (16-19). The database is population-based and contains emergency medical service (EMS)-assessed OHCAs among the entire population of the country. The cases were abstracted from the ambulance run sheets in which an OHCA was coded. For this study, data from January 2006 to December 2010 were used.

Ambulance run sheets are electronically stored in each provincial EMS headquarter, which is operated by the respective fire department. Trained medical record reviewers visited the study hospitals and reviewed the medical records to collect information related to risks and outcomes using the Utstein guidelines for reporting cardiac arrest and resuscitation data (20). All reviewers were formally trained and were provided with an operation manual to accurately abstract the data from the medical records and transcribe the data onto case report forms.

The Korean EMS system is single tiered and sponsored by the government. Basic-to-intermediate service level of ambulances are operated by 16 provincial headquarters of the national fire department. There are approximately 1,350 ambulance stations across the nation, which serve 48 million people over an area of approximately 100,000 square kilometers. The annual run volume of the prehospital service was slightly greater than 1.4 million. Two or three crew members usually ride in each ambulance.

Study population

Korea is comprised of 248 counties, the boundaries of which are defined by statute for geographical administrative purposes. The counties are classified as metropolitan (Gu), urban (Si), and rural (Gun) according to their population size. The metropolitan counties (Gu) are segmented administrative districts of a metropolitan city (for example, Seoul) with populations of more than 500,000; the urban counties (Si) are located in urban areas with populations of more than 100,000; the rural counties (Gun) are located in rural areas with populations of less than 100,000. There were 95 metropolitan, 67 urban, and 86 rural counties in 2010, and the median population sizes and population densities of each level were 298,748 residents (range: 47,260 to 640,732) and 8,873.0 people per square kilometer (range: 358.5 to 28,731.2) in metropolitan (Gu) counties, 183,673 residents (range: 41,395 to 565,201) and 531.7 people per square kilometer (range: 60.9 to 9,226.6) in urban (Si) counties, and 41,481 residents (range: 7,737 to 185,811) and 77.0 people per square kilometer (range: 19.4 to 495.7) in rural (Gun) counties (16). Each county has its own health care authorities and administrative authorities that serve the population.

Eligible patients were hospital record-confirmed OHCA patients during the five years of the study period. Each OHCA was assigned to a county according to the location of collapse because neighborhood factors including bystanders' early response, nearest autonomic external defibrillators, and prompt EMS resuscitative efforts are critical to survival outcomes. If a case was missing data on the location of collapse, the address of fire department that had the response ambulance was used. The time and date of the call received at dispatch was used as a surrogate measure for the time of OHCA occurrence (5). The time of day was divided into two 12-hr time intervals (0601-1800, 1801-0600), which were defined as daytime (0601-1800) and nighttime (1801-0600) to maintain comparability with previous reports (5).

Outcome measure

Information about the Korean population was obtained from the Korea Census data (Supplementary Table). The nighttime residential and daytime transient populations were investigated in the 2010 Census. The daytime transient population was calculated based on internal migration statistics as provided by the Korean National Statistical Office (KNSO). The KNSO reports such statistics based on survey results from 10% of the sampled population.

The nighttime population was the same as the registered residential population. The daytime population was defined by adding the daytime influx of population to the nighttime residential population and subtracting the daytime outflow. The D index (Daytime population index) was defined as the ratio of the daytime population to the nighttime population and was calculated by dividing the daytime population by the nighttime population and multiplying the result by 100.

The conventional age-standardized incidence rates (CASRs) for EMS-assessed OHCA per 100,000 person-years by gender were calculated for each county using the total nighttime popu-

lation in 2010 as the standard population. Daytime corrected age-standardized incidence rates (DASR) of EMS-assessed OHCA per 100,000 person-years were calculated with standardized daytime incidence rates and standardized nighttime incidences. To reflect the actual risk population, the daytime incidences were calculated from the OHCAs that occurred during the daytime and from the daytime population, and the nighttime incidences were calculated from the OHCAs that occurred during the nighttime and from the nighttime population.

Statistical analysis

The distributions of categorical variables are reported as percentages. The continuous variables that were not distributed normally are presented as medians with interquartile ranges. The CASRs and DASRs are presented in quintiles. Bland-Altman plots were used to compare the CASRs and DASRs by gender. The CASR, DASR, D index, the daytime and nighttime population, and the number of OHCAs during the 5 yr were used to evaluate the characteristics of the regions with the greatest and smallest differences between the CASR and the DASR by gender. Geographical maps of the CASRs and DASRs by gender were evaluated in order to identify the differences in the geographical distribution using administrative boundaries.

Ethics statement

The study was approved by the institutional review board (IRB) of the Seoul National University Hospital (IRB No. 1206-063-414). Informed consent was waived by the board.

RESULTS

There were 97,291 eligible EMS-assessed OHCA cases during

Table 1. Epidemiologic characteristics of out-of-hospital cardiac arrest patients

Parameters	Total		Male		Female		*P* value
	N	%	N	%	N	%	
	97,291		63,162		34,129		
Age							< 0.01
Years, median (IQR)	65 (49-76)		61 (48-73)		72 (55-81)		
Primary ECG							< 0.01
Shockable*	3,389	3.5	2,504	4.0	885	2.6	
Non-shockable†	93,902	96.5	60,658	96.0	33,244	97.4	
Etiology							< 0.01
Presumed cardiac	72,273	74.3	45,982	72.8	26,291	77.0	
Non-cardiac	25,018	25.7	17,180	27.2	7,838	23.0	
Year							0.02
2006	15,745	16.2	10,248	16.2	5,497	16.1	
2007	17,391	17.9	11,427	18.1	5,964	17.5	
2008	19,333	19.9	12,470	19.7	6,863	20.1	
2009	21,530	22.1	14,054	22.3	7,476	21.9	
2010	23,292	23.9	14,963	23.7	8,329	24.4	
Season							< 0.01
Spring (Mar to May)	24,226	24.9	15,746	24.9	8,480	24.8	
Summer (Jun to Aug)	23,027	23.7	15,299	24.2	7,728	22.6	
Fall (Sep to Nov)	24,677	25.4	15,933	25.2	8,744	25.6	
Winter (Dec to Feb)	25,361	26.1	16,184	25.6	9,177	26.9	
Hour							< 0.01
0001-0600	15,406	15.8	10,548	16.7	4,858	14.2	
0601-1200	33,529	34.5	21,375	33.8	12,154	35.6	
1201-1800	28,558	29.4	18,453	29.2	10,105	29.6	
1801-2400	19,798	20.3	12,786	20.2	7,012	20.5	
Arrest witnessed							< 0.01
Witnessed	37,154	38.2	24,603	39.0	12,551	36.8	
Bystander CPR							< 0.01
CPR	2,078	2.1	1,424	2.3	654	1.9	
Interval from call to EMS arrival							< 0.01
Minute, Median (IQR)	6 (5-9)		7 (5-10)		6 (5-9)		
Interval from call to hospital arrival							< 0.01
Minute, Median (IQR)	22 (16-30)		22 (16-31)		21 (16-29)		
Outcome							
ROSC	15,365	15.8	9,867	15.6	5,498	16.1	0.05
Survival to admission	9,113	9.4	5,796	9.2	3,317	9.7	< 0.01
Survival to discharge	2,937	3.0	2,061	3.3	876	2.6	< 0.01
Good CPC	831	0.9	608	1.0	223	0.7	< 0.01

*Shockable ECG, ventricular fibrillation, ventricular tachycardia; †Non-shockable ECG, asystole, pulseless electrical activity. CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; ROSC, return of spontaneous circulation; CPC, cerebral performance category scale; IQR, interquartile range.

http://dx.doi.org/10.3346/jkms.2015.30.10.1396

the study period. The characteristics of the patients, community, EMS factors, and survival outcomes for OHCAs are presented by gender in Table 1.

Of the OHCAs, 34.5% and 29.4% occurred during the daytime hours from 6 AM to noon and from noon to 6 PM, respectively, whereas 20.3% and 15.8% occurred during the nighttime hours from 6 PM to midnight and from midnight to 6 AM, respectively (Fig. 1). In Korea, the age-standardized incidence rates of OHCAs per 100,000 person-years by gender and occurrence time were 34.6 (95% CI: 34.3-35.0) during the daytime and 24.8 (95% CI: 24.5-25.1) during the nighttime among males, and 14.9 (95% CI: 14.7-15.1) during the daytime and 10.4 (95% CI: 10.2-10.6) during the nighttime among females.

The mean CASR and DASR per 100,000 person-years of each county by gender were 69.2 (range 14.0-180.7) and 66.8 (range

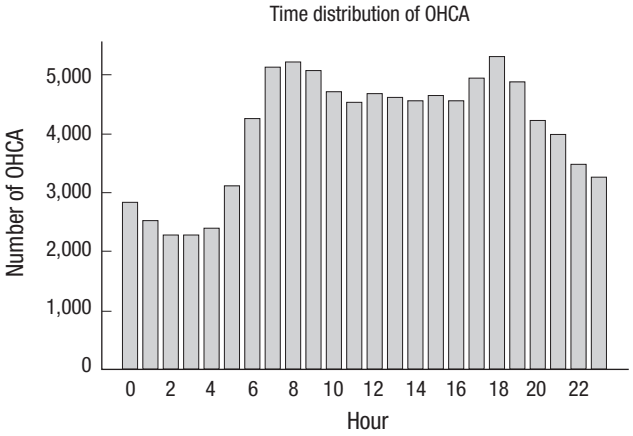

Fig. 1. Time distribution of out-of-hospital cardiac arrest. OHCA, out-of-hospital cardiac arrest.

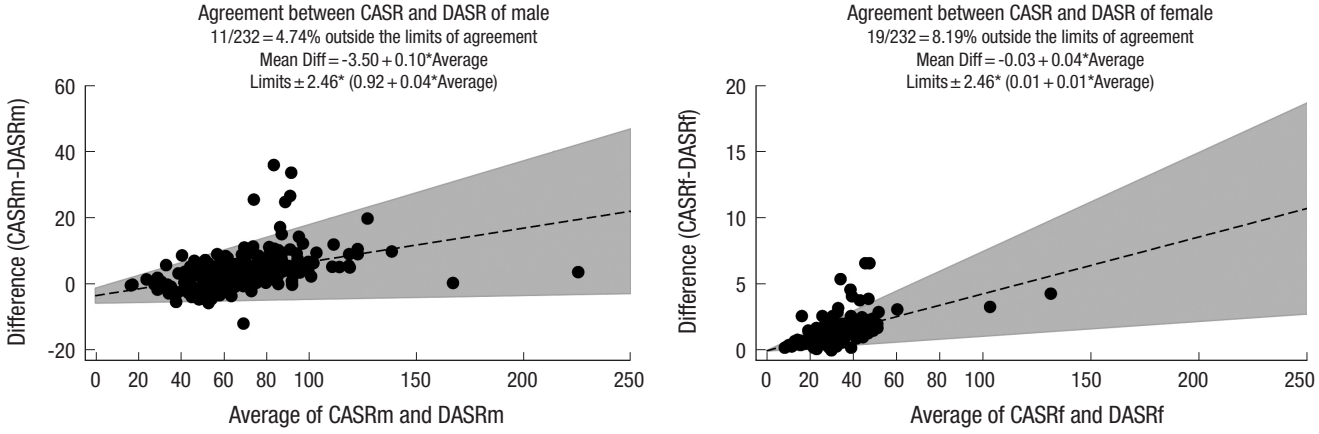

Fig. 2. Bland-Altman plots of conventional age-standardized rates and daytime corrected age-standardized rates by gender. CASR, conventional age-standardized rate per 100,000 person-years; DASR, daytime corrected age-standardized rate per 100,000 person-years.

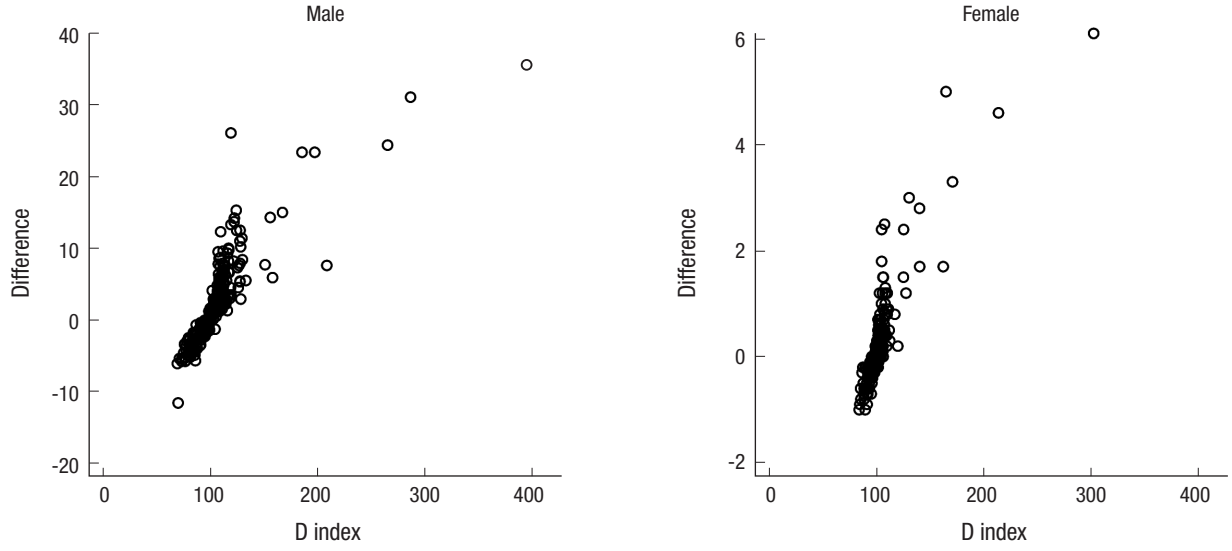

Fig. 3. Scatter plots of the D index and the difference between the conventional age-standardized rates and daytime corrected age-standardized rates. D index = daytime population/nighttime residential population *100.

Table 2. Characteristics of the highest and lowest 5 regions of differences between conventional age-standardized rates and daytime corrected age-standardized rates per 100,000 person-years

		County name*	CASR	DASR	Difference	D index†	Daytime population	Residential population	OHCA at daytime‡	OHCA at nighttime§
Male										
Highest 5										
	1	Jung-gu, Seoul	104.5	69.1	35.4	396	226,128	57,113	186	137
	2	Gangseo-gu, Busan	96.5	65.4	31.1	287	74,180	25,887	86	49
	3	Jinan-gun, Jeonbuk	180.7	154.6	26.1	119	11,333	9,489	80	19
	4	Jongno-gu, Seoul	87.0	62.6	24.4	265	192,662	72,607	210	133
	5	Jung-gu, Busan	107.9	84.5	23.4	197	44,513	22,547	89	67
Lowest 5										
	1	Jung-gu, Ulsan	56.1	67.7	-11.6	70	76,796	109,287	174	98
	2	Suji-gu, Yongin	29.3	35.4	-6.1	70	100,074	143,750	102	87
	3	Dobong-gu, Seoul	47.2	53.0	-5.8	74	122,103	165,782	212	187
	4	Yangcheon-gu, Seoul	48.7	54.5	-5.8	77	172,640	224,554	272	202
	5	Wonmi-gu, Bucheon	52.6	58.3	-5.7	78	163,030	210,326	247	198
Female										
Highest 5										
	1	Jung-gu, Seoul	51.0	44.9	6.1	302	179,850	59,518	81	73
	2	Jung-gu, Busan	49.8	44.8	5.0	165	40,076	24,338	47	28
	3	Jongno-gu, Seoul	35.3	30.7	4.6	214	164,942	77,228	84	57
	4	Jung-gu, Daegu	40.8	37.5	3.3	171	63,899	37,410	57	42
	5	Dong-gu, Gwangju	41.7	38.7	3.0	130	68,594	52,621	84	41
Lowest 5										
	1	Gwangmyoung-si, Gyonggi	31.5	32.5	-1.0	84	139,488	166,161	129	76
	2	Euiwang-si, Gyonggi	27.7	28.7	-1.0	90	64,490	72,047	56	28
	3	Hanam-si, Gyonggi	32.7	33.6	-0.9	91	62,450	68,435	54	46
	4	Jungrang-gu, Seoul	29.6	30.5	-0.9	84	171,525	203,021	150	107
	5	Dobong-gu, Seoul	28.0	28.8	-0.8	86	151,752	177,448	133	85

*County name was classified as metropolitan (-gu), urban (-si), and rural (-gun) area; †D index = daytime population/nighttime residential population *100; ‡OHCA at daytime is the number of OHCAs occurred at daytime in each gender during 5 yr; §OHCA at nighttime is the number of OHCAs occurred at nighttime in each gender during 5 yr. CASR, conventional age-standardized rate per 100,000 person-years; DASR, daytime corrected age-standardized rate per 100,000 person-years, OHCA; out-of-hospital cardiac arrest.

14.7-154.6) in males and 30.8 (range 7.8-65.2) and 30.6 (range 7.8-64.6) in females, respectively.

Bland-Altman plots of the CASRs and DASRs by gender are shown in Fig. 2. In both genders, there were positive linear trends between the average CASR and DASR and the difference between the CASR and DASR. The difference between the CASR and DASR increased as the average CASR and DASR increased.

Scatter plots of the D index and the difference between the CASR and DASR by gender are presented in Fig. 3. The difference between the CASR and DASR ranged from 35.4 to -11.6 in males and from 6.1 to -1.0 in females. There were positive linear trends between the D index and the difference between the CASR and DASR in both genders. The difference between the CASR and the DASR increased as the D index increased.

The characteristics of the 5 regions with the greatest and the 5 regions with the smallest differences between the CASR and the DASR are evaluated in Table 2. The 5 regions with the greatest differences between the CASR and the DASR had larger D index, indicating larger daytime population and smaller nighttime population, while the regions with the smallest differences had small D index for both genders. Nine of the 10 regions with the greatest differences and 7 of the 10 regions with the smallest difference between the CASR and the DASR were in metropolitan area (-gu in county name).

Fig. 4 shows the geographical distribution of the annual CASRs and DASRs of EMS-assessed OHCAs per 100,000 person-years by gender. Several metropolitan counties had large differences between the CASR and DASR.

DISCUSSION

Defining the at-risk population was essential to measure the disease burden based on the incidence rate. The incidence rates varied depending on the denominator of the at-risk population. In this study, the difference between the CASR and DASR per 100,000 person-year ranged from 35.4 to -11.6 in males and from 6.1 to -1.0 in females. Although many studies have explored the incidence of OHCA, only a few equivalent quantitative studies have elucidated the differences between the nighttime population and the daytime transient population as the denominators when measuring OHCA incidence.

There were significant temporal and geographical variations in the OHCA incidence. A daytime excess and an overnight nadir of OHCAs was observed, which is generally consistent with previous studies regardless of the characteristics of the patients and arrest circumstances (5-7, 9). In this study, 63.9% of OHCAs occurred during the daytime, comparable to the value of 59.6% reported in the ROC study (5). The greater occurrence of OHCAs

http://dx.doi.org/10.3346/jkms.2015.30.10.1396

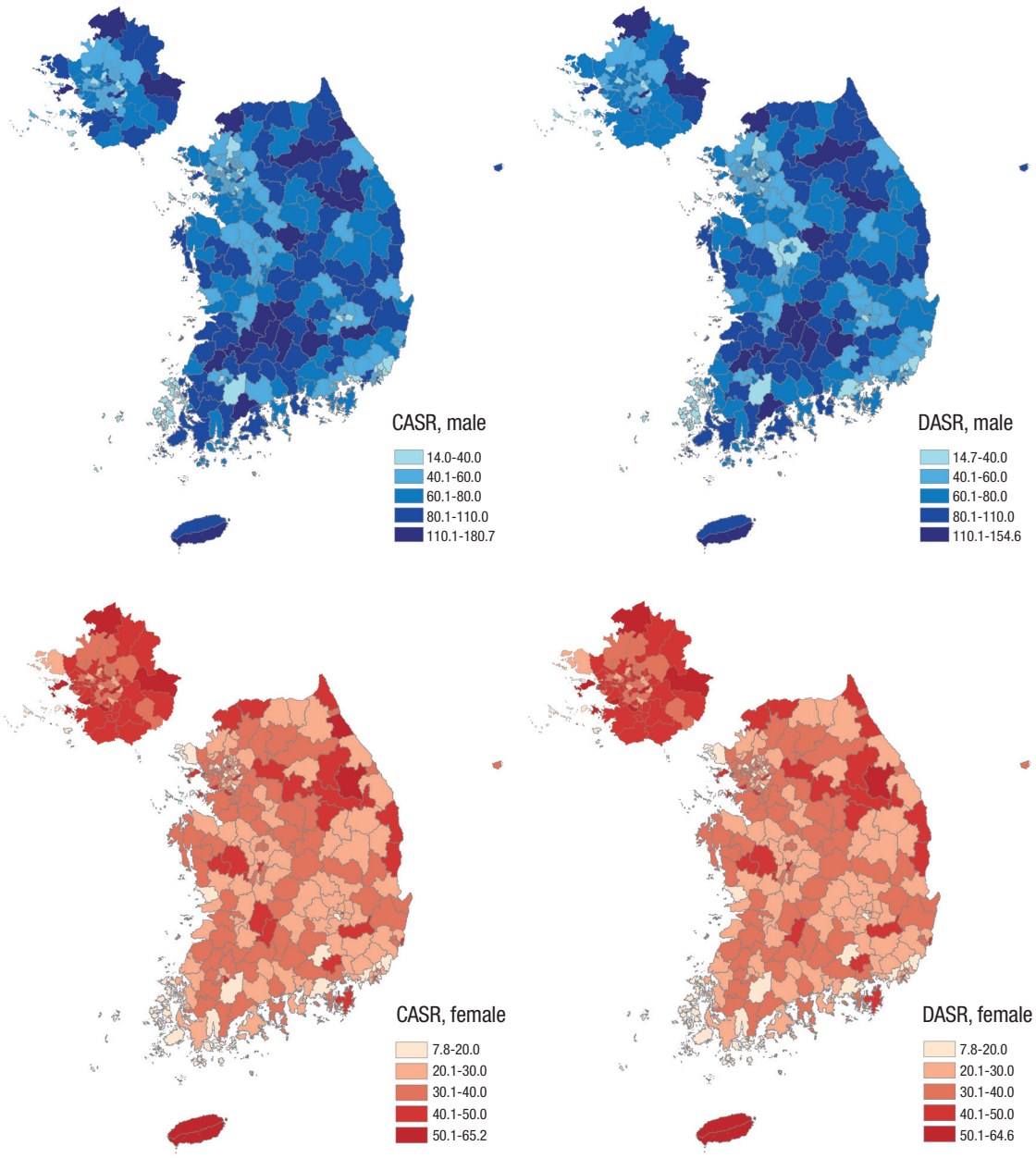

Fig. 4. Geographical maps of conventional age-standardized rates and daytime corrected age-standardized rates by gender. CASR, conventional age-standardized rate per 100,000 person-years; DASR, daytime corrected age-standardized rate per 100,000 person-years.

during the day may be associated with endogenous rhythms and environmental factors, including temperature (21, 22). Numerous epidemiological reports support the finding that there is circadian variability with a daytime excess and an overnight nadir in the occurrence of OHCA, as well as a seasonal variation with lower incidence rates in the summer and higher rates in the winter months in both hemispheres (5-7, 9, 21). Furthermore, this circadian and seasonal variability affected the survival outcomes with the lowest survival to discharge rate when the OHCA occurred during the 0001-0600 time interval and the highest during the 1201-1800 time interval, while the odds of survival to discharge were statistically lower during the winter and spring (5, 9, 23). These results may be due to an association between the survival outcomes of OHCA and temporal variability in the capabilities of EMS and hospital resources (21, 22).

The nationwide OHCA registry includes geographic and temporal information for all OHCAs. The two maps in this study show the regional OHCA incidences by gender with the different population denominators. The differences between the CASR and the DASR of OHCA were greater in counties with a larger daytime transient population. The regions with the greatest difference between the CASR and the DASR had large D index values,

indicating larger daytime population and smaller nighttime population, while the regions with the smallest differences between the CASR and the DASR had small D index values in both genders, indicating smaller daytime population and larger nighttime population. Most (16 out of 20) of the regions with the greatest and smallest differences between the CASR and the DASR in both genders were in a metropolitan area (Gu) with a large migrating population. In other words, the CASR in a commercial and industrial area of a metropolitan city with a large daytime population influx and a nighttime outflow was overestimated, whereas the CASR in a residential area of a metropolitan city with a nighttime population influx was underestimated. In addition, the Bland-Altman plots indicated that the differences between the CASRs and the DASRs tended to increase as the incidence of OHCA increased. Many studies have identified high-risk hot spots of OHCA (11, 12). A previous study reported an unexpected cluster at town centers, railway stations and international airports (8, 15). Although the incidences may have been affected by the daytime transient population and nonresident arrests, the daytime transient population was not considered due to the difficulty in measuring this population. In order to accurately estimate the burden of OHCA that integrates the characteristics of daytime excess and hot spots with daytime transient population, the denominator for calculating the OHCA regional incidences should be the true population at risk (2, 5-8, 15).

These findings have many public health implications such as resource allocation for the chain of survival including cost-effective public access automatic external defibrillator (AED) strategy, planning ambulance deployment, organizing targeted cardiopulmonary resuscitation (CPR) training, raising community awareness, and mobilizing community action (5, 8). Recognition and consideration of temporal and geographical characteristics of OHCA is crucial in developing such public health measures and would greatly increase their effectiveness. Recent studies have demonstrated that the best outcomes are achieved when devices are placed in areas with a high incidence of cardiac arrests and when there is ongoing supervision of emergency plans. However, operational decisions based on conventional incidence rate analysis can be limited. For example, AEDs had been disseminated in public places such as airports, train stations, and public buildings based on incidence rate with conventional methods (8, 24-26). However, the publicly placed AED could not cover the majority of OHCA, because the true incidence rates in residential areas were underestimated and 65% to 80% of OHCAs occur in residential areas (27, 28). In this study, the conventional incidence rate was found to be overestimated in a commercial and industrial area of a metropolitan city with a large daytime population influx and a nighttime outflow, while the conventional incidence rate was underestimated in a residential area of a metropolitan city with a nighttime population influx. Areas with a greater incidence rate of OHCA based on the true at-risk population should be allocated more resources, such as bystander CPR education programs to reduce CPR initiation time, implementation of public access AED programs to shorten the time to defibrillation, and ambulances for the fastest ambulance response times (1, 12, 29). Thus, community interventions such as neighborhood access defibrillators and community first responder programs for cardiac arrest should be considered based on the true regional incidence rate.

Our study has limitations. Temporal variability studies of OHCA are limited by their ability to accurately determine the precise time of OHCA occurrence. The daytime transient population was not confirmed of its validity, as the data was based on the internal migration statistics, which were the reported statistics of 10% sampled population provided by the Korean National Statistical Office. We accounted the daytime transient population as circadian variability into two 12-hr time intervals. The present studies are a prelude to further analysis to understand the causes of these variations as well as the implementation of targeted interventions to reduce the variability (3, 4).

In conclusion, this study was conducted in a nationwide setting to demonstrate that the regional incidence rate considering the daytime transient population is different from the conventional incidence rate of OHCA. Conventional incidence rate was found to be overestimated in counties that had many cases of cardiac arrest and in metropolitan cities with a large daytime population influx and a nighttime outflow, while the rate was underestimated in a residential area of a metropolitan city with a nighttime population influx. An accurate estimation of the burden of OHCA is essential for effective resource allocation strategies and appropriate resource planning for community support, which would enhance survival outcomes of cardiac arrest.

DISCLOSURES

All of the authors have no conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Conception and design: Ro YS, Hwang SS. Performed the experiments: Ro YS, Hwang SS, Shin SD, Kang S. Analysis of data: Ro YS, Hwang SS, Kang S. Contributed reagents/materials/analysis tools: Ro YS, Hwang SS, Kang S. Writing: Ro YS, Hwang SS. Shin SD, Han D, Song KJ, Cho SI. Agree with manuscript results and conclusions: all authors

ORCID

Young Sun Ro *http://orcid.org/0000-0003-3634-9573*
Seung-sik Hwang *http://orcid.org/0000-0002-1558-7831*
Sang Do Shin *http://orcid.org/0000-0003-4953-2916*

 http://dx.doi.org/10.3346/jkms.2015.30.10.1396

Daikwon Han *http://orcid.org/0000-0001-7509-015X*
Sungchan Kang *http://orcid.org/0000-0002-4876-3205*
Kyoung Jun Song *http://orcid.org/0000-0002-0027-6352*
Sung-Il Cho *http://orcid.org/0000-0003-4085-1494*

REFERENCES

1. Soo L, Huff N, Gray D, Hampton JR. *Geographical distribution of cardiac arrest in Nottinghamshire. Resuscitation 2001; 48: 137-47.*
2. Berdowski J, Berg RA, Tijssen JG, Koster RW. *Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation 2010; 81: 1479-87.*
3. Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, Aufderheide TP, Rea T, Lowe R, Brown T, Dreyer J, et al. *Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA 2008; 300: 1423-31.*
4. Galea S, Blaney S, Nandi A, Silverman R, Vlahov D, Foltin G, Kusick M, Tunik M, Richmond N.; Resuscitation Outcomes Consortium Investigators. *Explaining racial disparities in incidence of and survival from out-of-hospital cardiac arrest. Am J Epidemiol 2007; 166: 534-43.*
5. Brooks SC, Schmicker RH, Rea TD, Aufderheide TP, Davis DP, Morrison LJ, Sahni R, Sears GK, Griffiths DE, Sopko G, et al.; ROC Investigators. *Out-of-hospital cardiac arrest frequency and survival: evidence for temporal variability. Resuscitation 2010; 81: 175-81.*
6. Willich SN, Goldberg RJ, Maclure M, Perriello L, Muller JE. *Increased onset of sudden cardiac death in the first three hours after awakening. Am J Cardiol 1992; 70: 65-8.*
7. Thakur RK, Hoffmann RG, Olson DW, Joshi R, Tresch DD, Aufderheide TP, Ip JH. *Circadian variation in sudden cardiac death: effects of age, sex, and initial cardiac rhythm. Ann Emerg Med 1996; 27: 29-34.*
8. Ong ME, Earnest A, Shahidah N, Ng WM, Foo C, Nott DJ. *Spatial variation and geographic-demographic determinants of out-of-hospital cardiac arrests in the city-state of Singapore. Ann Emerg Med 2011; 58: 343-51.*
9. Yasunaga H, Miyata H, Horiguchi H, Tanabe S, Akahane M, Ogawa T, Koike S, Imamura T. *Population density, call-response interval, and survival of out-of-hospital cardiac arrest. Int J Health Geogr 2011; 10: 26.*
10. Lerner EB, Fairbanks RJ, Shah MN. *Identification of out-of-hospital cardiac arrest clusters using a geographic information system. Acad Emerg Med 2005; 12: 81-4.*
11. Sasson C, Keirns CC, Smith D, Sayre M, Macy M, Meurer W, McNally BF, Kellermann AL, Iwashyna TJ; CARES (Cardiac Arrest Registry to Enhance Survival) Study Group. *Small area variations in out-of-hospital cardiac arrest: does the neighborhood matter? Ann Intern Med 2010; 153: 19-22.*
12. Sasson C, Cudnik MT, Nassel A, Semple H, Magid DJ, Sayre M, Keseg D, Haukoos JS, Warden CR; Columbus Study Group. *Identifying high-risk geographic areas for cardiac arrest using three methods for cluster analysis. Acad Emerg Med 2012; 19: 139-46.*
13. Strömsöe A, Svensson L, Claesson A, Lindkvist J, Lundström A, Herlitz J. *Association between population density and reported incidence, characteristics and outcome after out-of-hospital cardiac arrest in Sweden. Resuscitation 2011; 82: 1307-13.*
14. Peberdy MA, Ornato JP, Larkin GL, Braithwaite RS, Kashner TM, Carey SM, Meaney PA, Cen L, Nadkarni VM, Praestgaard AH, et al.; *National Registry of Cardiopulmonary Resuscitation Investigators. Survival from in-hospital cardiac arrest during nights and weekends. JAMA 2008; 299: 785-92.*
15. Iwami T, Hiraide A, Nakanishi N, Hayashi Y, Nishiuchi T, Uejima T, Morita H, Shigemoto T, Ikeuchi H, Matsusaka M, et al. *Outcome and characteristics of out-of-hospital cardiac arrest according to location of arrest: A report from a large-scale, population-based study in Osaka, Japan. Resuscitation 2006; 69: 221-8.*
16. Ro YS, Shin SD, Song KJ, Lee EJ, Kim JY, Ahn KO, Chung SP, Kim YT, Hong SO, Choi JA, et al. *A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: a nationwide observational study from 2006 to 2010 in South Korea. Resuscitation 2013; 84: 547-57.*
17. Na SH, Shin SD, Ro YS, Lee EJ, Song KJ, Park CB, Kim JY. *Specific activity types at the time of event and outcomes of out-of-hospital cardiac arrest: a nationwide observational study. J Korean Med Sci 2013; 28: 320-7.*
18. Kim TH, Shin SD, Kim YJ, Kim CH, Kim JE. *The scene time interval and basic life support termination of resuscitation rule in adult out-of-hospital cardiac arrest. J Korean Med Sci 2015; 30: 104-9.*
19. Ro YS, Shin SD, Song KJ, Park CB, Lee EJ, Ahn KO, Cho SI. *A comparison of outcomes of out-of-hospital cardiac arrest with non-cardiac etiology between emergency departments with low- and high-resuscitation case volume. Resuscitation 2012; 83: 855-61.*
20. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, Cassan P, Coovadia A, D'Este K, Finn J, et al.; International Liaison Committee on Resuscitation; American Heart Association; European Resuscitation Council; Australian Resuscitation Council; New Zealand Resuscitation Council; Heart and Stroke Foundation of Canada; InterAmerican Heart Foundation; Resuscitation Councils of Southern Africa; ILCOR Task Force on Cardiac Arrest and Cardiopulmonary Resuscitation Outcomes. *Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Circulation 2004; 110: 3385-97.*
21. Deo R, Albert CM. *Epidemiology and genetics of sudden cardiac death. Circulation 2012; 125: 620-37.*
22. Empana JP, Sauval P, Ducimetiere P, Tafflet M, Carli P, Jouven X. *Increase in out-of-hospital cardiac arrest attended by the medical mobile intensive care units, but not myocardial infarction, during the 2003 heat wave in Paris, France. Crit Care Med 2009; 37: 3079-84.*
23. Arntz HR, Willich SN, Schreiber C, Brüggemann T, Stern R, Schultheiss HP. *Diurnal, weekly and seasonal variation of sudden death. Population-based analysis of 24,061 consecutive cases. Eur Heart J 2000; 21: 315-20.*
24. Caffrey SL, Willoughby PJ, Pepe PE, Becker LB. *Public use of automated external defibrillators. N Engl J Med 2002; 347: 1242-7.*
25. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. *Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med 2000; 343: 1206-9.*
26. Hallstrom AP, Ornato JP, Weisfeldt M, Travers A, Christenson J, McBurnie MA, Zalenski R, Becker LB, Schron EB, Proschan M, et al.; Public Access Defibrillation Trial Investigators. *Public-access defibrillation*

and survival after out-of-hospital cardiac arrest. N Engl J Med 2004; 351: 637-46.

27. Eisenberg MS, Mengert TJ. *Cardiac resuscitation. N Engl J Med 2001; 344: 1304-13.*
28. Norris RM; UK Heart Attack Study Collaborative Group. *Circumstances of out of hospital cardiac arrest in patients with ischaemic heart disease. Heart 2005; 91: 1537-40.*
29. Semple HM, Cudnik MT, Sayre M, Keseg D, Warden CR, Sasson C; Columbus Study Group. *Identification of high-risk communities for unattended out-of-hospital cardiac arrests using GIS. J Community Health 2013; 38: 277-84.*

 http://dx.doi.org/10.3346/jkms.2015.30.10.1396

Supplementary Table. Nighttime residential and daytime population by county

Gu code	Male				Female			
	Residential population	Daytime influx	Daytime outflow	Daytime population	Residential population	Daytime influx	Daytime outflow	Daytime population
11010	72,607	141,155	21,100	192,662	77,228	103,056	15,342	164,942
11020	57,113	184,897	15,882	226,128	59,518	131,865	11,533	179,850
11030	102,709	70,368	36,192	136,885	114,118	45,456	25,974	133,600
11040	141,147	61,906	52,133	150,920	147,169	35,025	36,391	145,803
11050	171,652	53,560	63,629	161,583	183,831	37,019	46,900	173,950
11060	165,326	77,815	55,325	187,816	171,203	57,237	36,994	191,446
11070	192,673	26,524	73,791	145,406	203,021	18,375	49,871	171,525
11080	216,596	53,926	79,522	191,000	232,015	57,124	53,559	235,580
11090	154,574	20,447	56,026	118,995	165,126	18,703	37,408	146,421
11100	165,782	19,404	63,083	122,103	177,448	17,445	43,141	151,752
11110	278,279	45,324	101,400	222,203	300,025	40,284	60,277	280,032
11120	214,058	24,491	75,146	163,403	230,020	17,523	51,498	196,045
11130	145,596	58,126	51,319	152,403	159,805	68,298	36,510	191,593
11140	171,362	93,596	61,906	203,052	189,706	62,255	47,533	204,428
11150	224,554	37,963	89,877	172,640	236,906	28,012	53,163	211,755
11160	259,300	55,823	96,351	218,772	278,602	32,444	61,945	249,101
11170	197,161	89,380	72,059	214,482	201,868	47,886	46,750	203,004
11180	114,044	68,639	36,012	146,671	114,769	32,404	22,825	124,348
11190	183,136	156,930	63,115	276,951	189,754	88,920	41,282	237,392
11200	188,704	55,757	71,667	172,794	198,568	40,589	52,274	186,883
11210	252,791	42,277	92,462	202,606	254,785	30,934	65,377	220,342
11220	183,047	172,617	66,011	289,653	202,870	100,085	44,319	258,636
11230	242,717	337,376	73,525	506,568	275,216	218,630	47,804	446,042
11240	304,457	89,598	107,585	286,470	329,905	52,605	67,084	315,426
11250	223,933	35,167	84,382	174,718	233,412	23,227	51,882	204,757
21010	22,547	28,054	6,088	44,513	24,338	20,108	4,370	40,076
21020	55,137	14,869	17,035	52,971	59,829	14,040	11,497	62,372
21030	44,475	23,082	13,304	54,253	47,831	20,742	8,656	59,917
21040	67,500	14,292	16,816	64,976	69,798	5,207	11,370	63,635
21050	179,457	49,591	58,218	170,830	195,128	45,801	33,933	206,996
21060	125,982	24,886	44,621	106,247	136,115	21,326	28,245	129,196
21070	139,637	38,978	39,669	138,946	148,348	23,028	25,588	145,788
21080	144,757	13,823	55,009	103,571	152,241	9,876	29,025	133,092
21090	192,634	27,255	63,010	156,879	210,344	22,877	32,452	200,769
21100	164,246	33,157	44,536	152,867	172,448	17,168	24,730	164,886
21110	116,963	30,661	35,011	112,613	125,587	25,456	22,198	128,845
21120	25,887	54,135	5,842	74,180	25,666	13,856	3,516	36,006
21130	95,928	25,272	33,849	87,351	104,119	20,684	22,356	102,447
21140	78,781	12,529	28,151	63,159	88,393	11,358	17,851	81,900
21150	121,528	53,325	36,630	138,223	124,340	27,423	22,230	129,533
21310	44,761	15,344	11,560	48,545	47,512	5,325	6,347	46,490
22010	34,181	32,378	9,327	57,232	37,410	32,555	6,066	63,899
22020	153,009	24,830	42,698	135,141	161,515	12,685	26,472	147,728
22030	102,020	23,136	30,818	94,338	105,419	12,500	20,921	96,998
22040	78,577	18,780	22,950	74,407	87,409	15,549	16,459	86,499
22050	219,195	49,080	55,737	212,538	225,453	26,863	29,591	222,725
22060	211,021	27,945	64,223	174,743	226,664	21,574	36,133	212,105
22070	289,817	51,790	76,358	265,249	302,229	31,934	41,430	292,733
22310	81,907	22,440	23,377	80,970	83,333	8,532	13,514	78,351
23010	40,691	42,481	7,639	75,533	40,676	21,096	4,789	56,983
23020	35,556	16,723	12,165	40,114	36,680	6,811	7,585	35,906
23030	202,316	43,011	62,134	183,193	205,369	27,588	36,300	196,657
23040	134,135	29,944	47,732	116,347	136,888	17,092	24,838	129,142
23050	219,663	65,941	62,919	222,685	229,999	32,355	34,836	227,518

(continued to the next page)

Supplementary Table. Continued

Gu code	Male				Female			
	Residential population	Daytime influx	Daytime outflow	Daytime population	Residential population	Daytime influx	Daytime outflow	Daytime population
23060	262,517	43,455	81,219	224,753	273,786	26,821	45,413	255,194
23070	162,160	22,534	53,427	131,267	168,808	16,172	30,105	154,875
23080	191,639	48,776	48,578	191,837	193,433	16,929	26,337	184,025
23310	26,698	5,123	2,238	29,583	29,059	1,782	1,383	29,458
23320	7,056	1,602	225	8,433	6,651	193	154	6,690
24010	50,387	23,998	9,916	64,469	52,621	22,765	6,792	68,594
24020	145,854	27,058	35,997	136,915	154,990	17,973	24,553	148,410
24030	101,341	12,639	27,675	86,305	110,797	13,044	18,823	105,018
24040	229,771	28,137	49,911	207,997	241,910	19,590	31,749	229,751
24050	178,838	31,668	34,412	176,094	183,259	16,282	20,574	178,967
25010	119,311	23,397	31,273	111,435	122,319	14,608	19,801	117,126
25020	121,984	21,141	32,480	110,645	129,538	19,796	19,070	130,264
25030	237,763	30,567	61,017	207,313	254,292	25,544	34,547	245,289
25040	146,502	42,244	25,691	163,055	139,860	24,770	14,136	150,494
25050	100,065	33,000	23,636	109,429	100,754	13,277	14,891	99,140
26010	109,287	8,418	40,909	76,796	109,001	6,622	18,583	97,040
26020	164,656	44,403	35,223	173,836	163,486	26,125	13,407	176,204
26030	84,044	19,186	9,708	93,522	77,741	5,512	5,289	77,964
26040	84,637	31,979	19,140	97,476	81,116	9,070	9,766	80,420
26310	92,890	36,273	22,072	107,091	91,212	10,058	11,503	89,767
31011	140,565	11,464	39,246	112,783	142,684	5,911	17,495	131,100
31012	146,132	15,142	39,828	121,446	149,390	7,721	19,013	138,098
31013	102,299	16,531	26,407	92,423	106,790	10,745	13,930	103,605
31014	128,360	31,035	32,141	127,254	127,547	12,137	14,219	125,465
31021	113,467	15,793	31,228	98,032	115,004	8,649	16,612	107,041
31022	121,673	12,723	28,288	106,108	123,106	4,821	13,685	114,242
31023	218,821	48,254	79,369	187,706	235,938	26,400	39,129	223,209
31030	199,661	27,085	63,494	163,252	211,256	18,121	32,311	197,066
31041	124,034	19,588	41,294	102,328	127,855	13,378	23,195	118,038
31042	164,754	34,299	62,222	136,831	173,572	17,425	33,155	157,842
31051	210,326	17,732	65,028	163,030	221,431	11,697	34,298	198,830
31052	105,579	10,265	35,021	80,823	110,708	6,383	19,491	97,600
31053	91,668	5,166	25,209	71,625	93,763	2,265	12,916	83,112
31060	157,492	22,985	63,875	116,602	166,161	10,532	37,205	139,488
31070	187,523	41,489	22,164	206,848	189,368	13,204	9,935	192,637
31080	43,682	6,002	10,352	39,332	45,933	3,498	5,463	43,968
31091	185,111	24,074	41,403	167,782	185,007	10,582	17,627	177,962
31092	163,880	41,204	32,092	172,992	160,693	14,863	13,983	161,573
31101	180,036	20,139	53,463	146,712	188,775	8,697	27,182	170,290
31103	120,106	15,083	34,850	100,339	131,645	7,824	18,169	121,300
31104	128,447	11,201	39,040	100,608	138,734	6,183	17,149	127,768
31110	31,729	18,681	12,585	37,825	33,777	9,996	7,660	36,113
31120	88,704	19,990	33,946	74,748	93,788	12,758	19,002	87,544
31130	255,972	27,682	77,189	206,465	265,694	10,682	40,969	235,407
31140	90,633	15,493	32,596	73,530	89,370	8,814	14,720	83,464
31150	201,324	63,999	48,483	216,840	189,303	19,090	22,216	186,177
31160	133,136	27,533	49,192	111,477	138,495	14,474	25,344	127,625
31170	69,945	16,454	28,688	57,711	72,047	8,877	16,434	64,490
31180	67,748	19,148	21,854	65,042	68,435	6,839	12,824	62,450
31191	96,821	24,689	14,052	107,458	96,923	10,800	6,327	101,396
31192	172,175	30,128	51,477	150,826	180,780	13,819	21,142	173,457
31193	143,750	9,313	52,989	100,074	151,620	6,660	22,001	136,279
31200	159,477	38,933	27,749	170,661	161,022	11,823	15,857	156,988
31210	93,047	17,605	9,586	101,066	97,626	7,703	4,325	101,004

(continued to the next page)

http://dx.doi.org/10.3346/jkms.2015.30.10.1396

Supplementary Table. Continued

Gu code	Male				Female			
	Residential population	Daytime influx	Daytime outflow	Daytime population	Residential population	Daytime influx	Daytime outflow	Daytime population
31220	87,798	20,957	8,804	99,951	86,962	9,658	4,246	92,374
31230	106,383	36,943	24,009	119,317	108,667	11,501	12,326	107,842
31240	239,202	114,637	49,986	303,853	232,544	40,868	23,442	249,970
31250	111,197	34,834	24,385	121,646	111,227	9,943	13,932	107,238
31260	90,053	19,676	22,461	87,268	91,575	8,590	12,843	87,322
31270	66,600	24,949	4,923	86,626	67,420	9,875	3,061	74,234
31320	48,158	8,133	3,782	52,509	50,873	3,846	2,285	52,434
31350	19,791	3,578	1,736	21,633	20,247	1,187	1,108	20,326
31370	24,516	4,704	1,346	27,874	25,100	1,369	848	25,621
31380	39,506	4,240	4,441	39,305	41,580	1,510	2,518	40,572
32010	131,843	6,013	8,821	129,035	139,075	3,935	3,541	139,469
32020	150,461	8,885	10,243	149,103	155,242	3,859	3,730	155,371
32030	105,051	3,917	4,949	104,019	109,276	1,835	1,989	109,122
32040	43,679	1,939	4,004	41,614	44,444	805	1,287	43,962
32050	25,836	1,155	2,219	24,772	25,060	193	718	24,535
32060	37,949	1,895	3,939	35,905	41,530	1,214	1,435	41,309
32070	32,631	3,459	1,447	34,643	33,306	1,051	674	33,683
32310	30,124	3,551	679	32,996	31,141	1,306	441	32,006
32320	18,000	4,036	947	21,089	19,098	1,868	733	20,233
32330	17,035	2,628	555	19,108	17,496	471	263	17,704
32340	18,253	2,703	326	20,630	18,743	1,009	136	19,616
32350	17,958	2,826	278	20,506	17,510	699	139	18,070
32360	20,309	1,105	925	20,489	20,920	256	399	20,777
32370	9,261	1,675	167	10,769	9,517	497	100	9,914
32380	8,816	727	87	9,456	9,122	195	39	9,278
32390	13,651	1,047	124	14,574	13,387	191	64	13,514
32400	12,202	2,690	597	14,295	12,965	837	612	13,190
32410	12,031	2,003	771	13,263	12,472	703	511	12,664
33011	116,828	6,713	18,721	104,820	121,554	4,284	8,988	116,850
33012	204,344	9,099	32,479	180,964	211,296	5,374	14,067	202,603
33020	98,102	6,811	5,424	99,489	100,689	2,737	2,099	101,327
33030	65,348	4,395	5,569	64,174	66,969	1,862	1,209	67,622
33310	70,180	32,419	13,990	88,609	70,490	14,687	7,942	77,235
33320	14,139	1,914	285	15,768	15,900	1,008	122	16,786
33330	23,585	4,314	2,009	25,890	25,181	1,479	773	25,887
33340	21,786	2,673	505	23,954	23,575	859	292	24,142
33350	30,146	11,197	2,616	38,727	28,914	3,908	1,180	31,642
33360	14,778	3,528	662	17,644	16,093	1,040	451	16,682
33370	41,830	14,002	2,324	53,508	39,560	5,114	1,302	43,372
33380	13,513	2,828	510	15,831	14,260	533	231	14,562
33390	15,145	3,940	2,980	16,105	15,611	1,968	1,717	15,862
34010	282,346	22,871	35,029	270,188	278,695	13,541	13,734	278,502
34020	57,623	7,368	4,087	60,904	61,864	4,782	2,212	64,434
34030	46,910	2,112	1,211	47,811	49,122	344	602	48,864
34040	138,025	37,276	11,688	163,613	132,960	14,092	5,921	141,131
34050	77,622	6,922	3,340	81,204	75,700	2,472	1,661	76,511
34060	55,782	8,276	3,031	61,027	60,249	4,166	1,804	62,611
34070	19,240	3,538	4,576	18,202	20,623	1,460	2,476	19,607
34310	25,219	8,338	1,327	32,230	26,855	3,555	837	29,573
34320	40,488	11,223	4,457	47,254	39,346	4,908	2,335	41,919
34330	31,506	2,908	1,355	33,059	34,974	1,286	699	35,561
34340	24,952	2,407	683	26,676	28,131	864	337	28,658
34350	13,874	1,688	524	15,038	15,390	604	315	15,679
34360	39,180	3,799	1,457	41,522	41,873	2,363	484	43,752

(continued to the next page)

Supplementary Table. Continued

Gu code	Male				Female			
	Residential population	Daytime influx	Daytime outflow	Daytime population	Residential population	Daytime influx	Daytime outflow	Daytime population
34370	36,837	3,453	2,037	38,253	39,594	1,159	1,121	39,632
34380	25,764	2,655	506	27,913	27,299	739	330	27,708
34390	69,687	11,079	1,958	78,808	64,484	2,243	827	65,900
35011	171,563	5,886	21,419	156,030	184,497	3,437	8,984	178,950
35012	138,124	7,696	19,793	126,027	144,332	4,347	7,827	140,852
35020	128,098	10,159	6,590	131,667	127,999	3,120	3,275	127,844
35030	141,903	12,320	12,879	141,344	149,003	7,017	5,338	150,682
35040	51,145	3,997	2,333	52,809	57,216	1,725	924	58,017
35050	36,516	2,087	1,129	37,474	41,117	951	475	41,593
35060	38,687	8,047	3,373	43,361	43,260	3,356	2,171	44,445
35310	40,832	17,621	6,176	52,277	40,638	7,452	4,161	43,929
35320	9,489	2,091	247	11,333	10,698	680	168	11,210
35330	10,222	1,045	177	11,090	11,352	244	75	11,521
35340	8,967	1,105	218	9,854	10,223	455	167	10,511
35350	10,755	2,983	579	13,159	12,585	1,121	338	13,368
35360	11,319	1,184	333	12,170	13,646	629	216	14,059
35370	24,506	2,126	512	26,120	28,143	771	394	28,520
35380	23,289	2,422	816	24,895	26,840	745	360	27,225
36010	121,495	5,565	22,547	104,513	124,666	3,969	8,424	120,211
36020	130,886	6,952	2,843	134,995	134,570	1,152	1,362	134,360
36030	124,232	6,233	17,954	112,511	130,443	3,462	4,367	129,538
36040	36,180	9,548	3,200	42,528	41,067	5,418	2,066	44,419
36060	68,917	13,278	3,979	78,216	66,770	2,305	2,197	66,878
36310	18,980	5,655	2,277	22,358	21,394	2,802	1,198	22,998
36320	12,128	3,700	304	15,524	14,666	1,149	204	15,611
36330	10,157	968	275	10,850	11,985	354	124	12,215
36350	28,365	1,531	288	29,608	34,304	465	263	34,506
36360	17,879	1,975	567	19,287	21,770	1,162	340	22,592
36370	28,705	4,528	4,616	28,617	32,690	2,901	2,339	33,252
36380	16,229	973	262	16,940	19,090	439	177	19,352
36390	15,418	1,111	327	16,202	18,284	422	127	18,579
36400	30,452	2,338	408	32,382	34,647	1,023	265	35,405
36410	27,807	16,756	1,190	43,373	27,378	4,047	995	30,430
36420	32,258	8,355	4,935	35,678	34,887	5,733	3,073	37,547
36430	14,112	2,379	466	16,025	16,466	930	266	17,130
36440	22,604	2,777	384	24,997	25,381	816	199	25,998
36450	17,564	5,439	1,148	21,855	19,555	2,008	820	20,743
36460	21,869	869	63	22,675	24,295	96	50	24,341
36470	12,972	547	109	13,410	15,206	122	31	15,297
36480	15,826	1,428	97	17,157	16,987	464	117	17,334
37011	125,624	6,194	3,866	127,952	120,979	1,217	2,078	120,118
37012	124,633	3,066	4,614	123,085	129,591	1,019	2,417	128,193
37020	122,090	20,028	8,251	133,867	127,880	7,443	3,559	131,764
37030	60,301	4,002	3,924	60,379	65,233	1,700	1,874	65,059
37040	78,720	3,212	4,237	77,695	84,919	1,003	1,337	84,585
37050	200,094	33,483	11,560	222,017	194,387	10,926	5,964	199,349
37060	52,055	1,913	2,441	51,527	54,999	668	678	54,989
37070	44,894	8,598	2,902	50,590	48,078	2,823	1,490	49,411
37080	46,046	3,440	1,461	48,025	50,628	1,249	897	50,980
37090	32,268	1,519	1,745	32,042	35,646	718	737	35,627
37100	128,309	41,719	21,101	148,927	129,878	27,484	11,530	145,832
37310	9,130	2,369	305	11,194	10,507	801	161	11,147
37320	23,005	2,346	396	24,955	27,491	921	204	28,208
37330	11,278	1,507	173	12,612	12,465	446	80	12,831

(continued to the next page)

http://dx.doi.org/10.3346/jkms.2015.30.10.1396

Supplementary Table. Continued

Gu code	Male				Female			
	Residential population	Daytime influx	Daytime outflow	Daytime population	Residential population	Daytime influx	Daytime outflow	Daytime population
37340	7,578	570	92	8,056	8,786	165	58	8,893
37350	16,349	1,098	297	17,150	19,582	483	204	19,861
37360	17,112	2,724	841	18,995	20,510	1,456	443	21,523
37370	14,912	5,636	1,821	18,727	15,898	1,812	981	16,729
37380	17,039	5,067	861	21,245	18,929	1,959	402	20,486
37390	56,211	17,387	16,218	57,380	55,115	8,032	6,674	56,473
37400	19,707	1,884	516	21,075	22,665	677	241	23,101
37410	14,870	1,780	416	16,234	15,964	417	287	16,094
37420	22,210	1,068	230	23,048	24,057	179	170	24,066
37430	3,860	70	2	3,928	3,759	11	20	3,750
38010	241,086	20,940	13,768	248,258	236,504	4,470	6,700	234,274
38020	190,816	7,361	14,553	183,624	197,189	3,067	4,612	195,644
38030	160,799	7,782	15,019	153,562	170,282	4,571	5,941	168,912
38040	82,164	5,219	8,790	78,593	82,336	1,026	3,000	80,362
38050	63,510	5,295	6,368	62,437	63,324	1,250	1,542	63,032
38060	51,580	8,927	5,254	55,253	53,432	2,582	2,520	53,494
38070	237,462	44,338	40,325	241,475	242,208	14,477	14,280	242,405
38080	46,053	4,010	2,643	47,420	51,467	1,290	1,022	51,735
38090	119,016	10,067	2,094	126,989	104,363	1,512	887	104,988
38100	121,707	28,478	23,971	126,214	125,505	10,274	11,173	124,606
38310	11,401	1,613	422	12,592	13,675	686	197	14,164
38320	28,666	12,013	3,503	37,176	30,270	2,866	1,815	31,321
38330	25,078	3,779	1,574	27,283	28,963	1,246	559	29,650
38340	24,803	5,884	2,243	28,444	25,813	1,338	625	26,526
38350	19,724	1,020	345	20,399	23,567	275	135	23,707
38360	19,055	2,754	930	20,879	22,225	834	371	22,688
38370	14,533	1,740	820	15,453	17,003	1,279	422	17,860
38380	17,252	852	313	17,791	20,238	322	177	20,383
38390	26,535	1,032	498	27,069	29,947	231	74	30,104
38400	19,280	1,813	335	20,758	23,788	621	231	24,178
39010	192,832	3,022	5,786	190,068	201,949	1,873	3,454	200,368
39020	62,614	5,697	2,938	65,373	65,866	3,454	1,877	67,443