

The Longitudinal Trend of Cardiac Surgery in Korea from 2003 to 2013

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Background: The purpose of this study was to investigate longitudinal changes of the utilization of operational and surgical medical care inside and outside a metropolitan area over 10 years, analyzing the residential areas of patients and the locations of medical facilities for major cardiovascular surgery. **Methods:** Data analysis was conducted by classifying the addresses of patients and the locations of medical care facilities of metropolitan cities and provinces, using data from the National Health Insurance Corporation from January 2003 to December 2013. **Results:** There is serious concentration of major heart surgery to medical facilities in Seoul; this problem has not improved over time. There were differences in percentages of surgical procedures performed in the metropolitan areas according to major diseases. In the case of Busan and Daegu provinces, at least 50% of the patients underwent surgery in medical facilities in the city, but there are other regions where the percentage is less than 50%. In the case of provinces, the percentage of surgical procedures performed in medical facilities in Seoul or nearby metropolitan cities is very high. **Conclusion:** Policies to strengthen the regional capabilities of heart surgery and to secure human resources are required to mitigate the concentration of patients in the capital area. Many regional multi-centers must be designated to minimize unnecessary competition among regional university hospitals and activate a win-win partnership model for medical services.

Key words: 1. Thoracic surgery
2. Coronary artery bypass surgery
3. Health care utilization
4. Health facilities

Introduction

Cardio-cerebrovascular disease (CCVD) is the second leading cause of death in Korea [1]. In the past 10 years, an estimated 660,000 people died of the

disease, accounting for nearly a quarter of the entire death toll, 2.5 million, during the same period. The number of people who underwent treatment for the disease increased by 58.7% from 10.23 million in 2013 to 6.44 million in 2004. In the same period,

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Table 1. Heart surgery classification code analysis

Operation	Dxcode or opcode
Coronary artery bypass	OA641, OA642, OA647 O1641(자1647가(1)가), 자1647가(1)가주) O1642(자1647가(1)나), 자1647가(1)나주) O1643, O1644, O1645(자164자(1)), O1646, O1647(자1647가(2), 자1647가(2)주), O1830
Simple congenital cardiac surgery	O1710(자171), O1711, O1721(자172가), O1722, O1723
Valvuloplasty	O1781(자178가), O1782(자178나), O1783(자178다), O1730, O1740, O1750, O1760
Complex congenital cardiac surgery	O1800(자180), O1850, O1873, O1874, O1878, O1879, O1680, O1770, O1810, O1821, O1822, O1861, O1875
Aorta operation	O2031(자203가), O2032(자203나), O2033(자203다)
Coronary intervention	M6551, M6552, M6561, M6562, M6563, M6564, M6595, M6596, M6597

treatment cost also skyrocketed by 363.2%, from 1,493 billion won to 6,915 billion won [2].

The death rate, as well as the treatment volume and cost of disease, is rapidly increasing. To address this issue, the Korean government established and implemented the first comprehensive plan on CCVDs in 2006 [3]. The second and third schemes have been planned and will be implemented by 2016. Since 2008, 11 regional cardio-cerebrovascular centers (RCCs) have been under operation [4,5]. The goal of the currently implemented RCCs include: (1) establish a system which provides treatment 3 hours within the occurrence of a CCVD case anywhere in Korea; (2) provide CCVD prevention management through community promotion activities; and (3) mitigate regional treatment gaps.

The major focus of the RCCs is on providing procedures in cardiology, neurology, and some neurosurgical operations, excluding regional support policies for cardiac surgery. To alleviate overconcentration of patients in the metropolitan areas, as well as to strengthen medical services in each region via a high-quality, multidisciplinary care approach, the Korean government established and is operating regional centers for various diseases: regional cancer centers by the comprehensive cancer strategy, regional respiratory disease centers, and regional rheumatoid arthritis disease centers.

The RCC does not offer surgery for heart and cerebrovascular diseases, so it is likely that a great share of patients who need these types of surgery still use hospitals in the metropolitan areas. Such a problem is unresolved in non-emergency surgery, in particular. The incumbent government policy to cover treatment cost for 4 major diseases has reduced the treat-

ment-cost barrier, possibly failing to alleviate the overconcentration of patients with heart or cerebrovascular diseases in metropolitan hospitals [2].

The concentrated use of hospitals in the metropolitan areas for surgery worsens the insufficient supply of heart surgeons outside those areas, causing a vicious cycle. This may lead to depletion of resources and decrease in capacity related to heart surgery in regional medical institutions. In addition, socioeconomic gaps among patients undergoing surgery in Seoul may compromise health equity. To that end, it is suggested to establish regional heart centers in the Gyeongsang, Jeolla, and Daegu provinces.

This study examined heart surgery performed in medical institutions inside and outside of metropolitan areas, based on data collected from the National Health Insurance Service (NHIS). The number of surgery performed in 17 cities and provinces was analyzed. Patients' travel status across different regions was analyzed based on their residential areas and location of the hospitals where they underwent surgery. Our results are intended to provide evidence for policy recommendations to foster regional resources and encourage the public's use of their local medical services.

Methods

Surgery data, collected from the NHIS between January 2003 and December 2013, were included in the analysis. Data for each surgery were extracted by surgery code or action code related with heart diseases. The data were classified by surgery name through expert meetings. To analyze heart surgery data, experts from different specialties reviewed the

codes by disease 3 times. Among 58 surgery codes, similar codes were combined. Less frequently occurring codes or codes that were difficult to analyze were excluded from the analysis. Finally, 6 main surgery codes were selected and data were extracted accordingly.

The data regarding medical service use were divided by region: Seoul and metropolitan areas or non-metropolitan areas. To do so, the data were analyzed by patients' residence address and the location of medical institutions in 17 cities and provinces. In case a patient's address code is consistent with the location code of the hospital, the patient was determined to have received surgery in the region. Otherwise, the patient was determined to have undergone surgery outside the region (Table 1).

A chi-square analysis was performed based on the patients' residence address and the location of the medical institution. We created a table to analyze the medical use within and without the region in different areas. Moreover, we analyzed yearly operation status by region to examine the annual medical use status and graphed the results (Figs. 1-5).

Results

1) Coronary artery bypass

The volume and percentages of the use of coronary artery bypass by region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 92.6% underwent surgery in a hospital located in Seoul. Among patients residing in Gyeonggi Province, 45.5% underwent surgery in a hospital in Gyeonggi Province, while 52.4% underwent surgery in a hospital in Seoul.

In other metropolitan cities, the percentages of patients who underwent surgery in the region of their residence ranged between 40.0% and 75.4%: 75.4% in Daegu, 59.0% in Busan, 65.4% in Ulsan, 59.3% in Gwangju, 42.4% in Daejeon, and 40.0% in Incheon. In comparison, the percentages of patients in the metropolitan cities who underwent surgery in Seoul were 50.5% in Daejeon, followed by 33.5% in Gwangju, 33.2% in Busan, 22.6% in Ulsan, and 22.1% in Daegu. Among patients living in Incheon, 32.8% went to hospitals in the Gyeonggi area for surgery.

In the metropolitan provinces, the percentage of

patients who underwent the operation in the region of their residence was 45.5% in Gyeonggi Province, followed by 37.5% in Jeonbuk and 32.1% in Jeju Province. The percentage was lowest in Chungbuk (5.2%) and Gyeongbuk (2.1%). The percentage of patients living in the metropolitan provinces undergoing surgery in Seoul were 75.7% in Chungbuk, followed by 59.1% in Jeju, 55.5% in Chungnam, and 50.7% in Jeonbuk. Patients residing in Jeonnam, Gyeongbuk, and Gyeongnam had high rates of using hospitals in the nearby metropolitan cities (Table 2).

2) Simple congenital heart surgery

The volume and percentages of the use of simple congenital heart surgery of a region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 93.9% underwent procedures or surgery in Seoul. In comparison, among patients residing in Gyeonggi Province, 34.8% underwent surgery in the region, while 63.4% underwent surgery in Seoul.

In other metropolitan cities, the percentages of patients who underwent the operation in the region of their residence ranged between 14.8% and 72.6%: 72.6% in Daegu, 59.9% in Busan, 46.2% in Gwangju, 38.5% in Daejeon, 21.6% in Incheon, and 14.8% in Ulsan. In comparison, the percentages of patients in the metropolitan cities who underwent surgery in Seoul were 53.9% in Daejeon, followed by 45.0% in Gwangju, 36.7% in Ulsan, 29.9% in Incheon, 23.3% in Daegu, and 13.5% in Busan. Among patients living in Incheon, 47.9% went to hospitals in Gyeonggi for surgery. 25.7% of the patients living in Busan as well as 16.5% of patients living in Ulsan used hospitals in Gyeongnam for surgery.

In the metropolitan provinces, the percentage of patients who underwent the operation in the region of their residence was 53.4% in Jeonbuk, followed by 36.5% in Gyeongnam and 34.8% in Gyeonggi Province. The percentage was lowest in Jeonnam (2.3%) and Gyeongbuk (0.8%). The percentages of patients living in the metropolitan provinces undergoing surgery in Seoul were 71.5% in Gangwon, followed by 70.1% in Chungbuk, 69.9% in Jeju, and 65.9% in Chungnam. Patients residing in Jeonnam, Gyeongbuk, and Gyeongnam had high rates of using hospitals in the nearby metropolitan cities (Table 3).

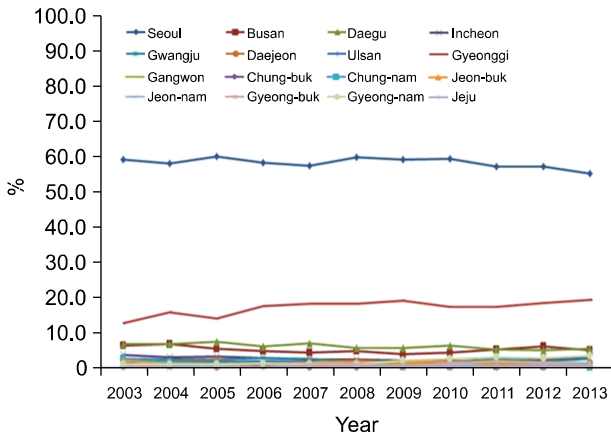


Fig. 1. Heart surgery classification code analysis.

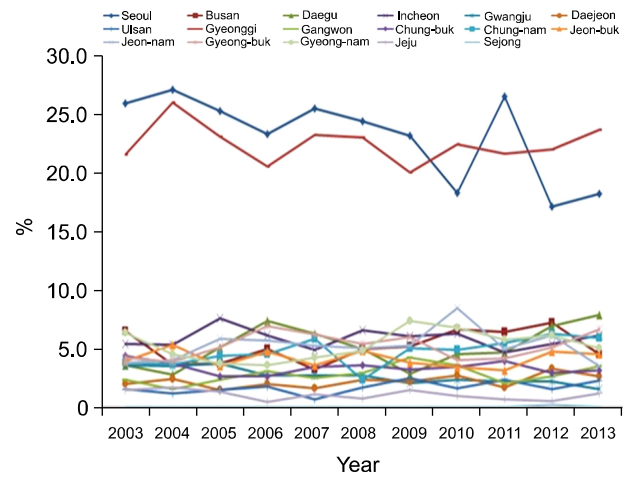


Fig. 3. Simple congenital cardiac surgery (2003-2013).

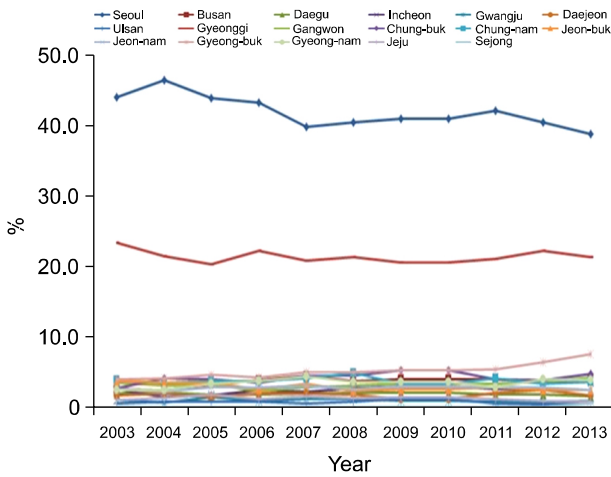


Fig. 2. Coronary artery bypass (2003-2013).

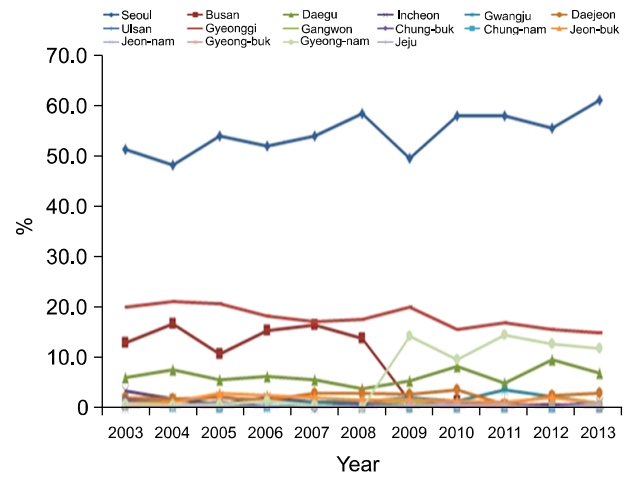


Fig. 4. Valvuloplasty (2003-2013).

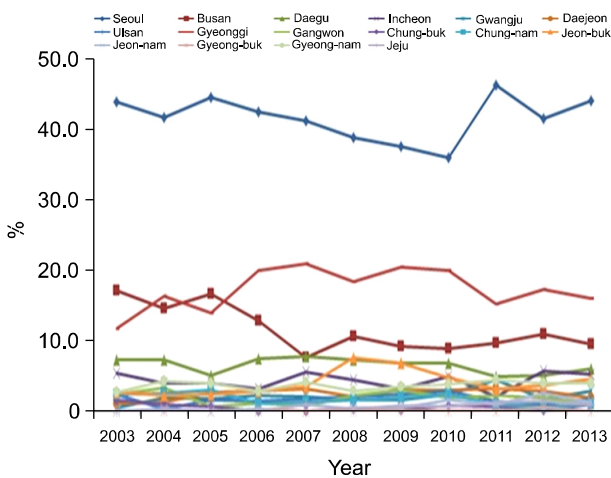


Fig. 5. Complex congenital cardiac surgery (2003-2013).

3) Valvuloplasty

The volume and percentages of the use of valvuloplasty of a region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 90.3% underwent procedures or surgery in Seoul. In comparison, among patients residing in Gyeonggi Province, 39.9% underwent surgery in the region, while 58.9% underwent surgery Seoul.

In other metropolitan cities, the percentages of patients who underwent the operation in the region of their residence ranged between 20.0% and 68.5%: 68.5%, in Daegu, 55.3% in Gwangju, 34.0% in Busan, 28.1% in Daejeon, 25.0% in Ulsan, and 20.0% in Incheon. In comparison, the percentages of patients

Table 2. Coronary artery bypass (2003–2013)

Hospital location	Region of patient residence														Total			
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Gyeongbuk		Gyeongnam	Jeju	Sejong
Seoul	9,259 (92.6)	761 (33.2)	397 (22.1)	495 (26.6)	217 (33.5)	382 (50.5)	144 (22.6)	4,727 (52.4)	699 (59.1)	910 (75.7)	839 (55.5)	627 (50.7)	572 (40.6)	1,101 (50.0)	752 (40.2)	256 (59.1)	7 (70.0)	22,145 (58.2)
Busan	6 (0.1)	1,350 (59.0)	7 (0.4)	2 (0.1)	0 (0.0)	6 (0.8)	51 (8.0)	10 (0.1)	3 (0.3)	1 (0.1)	2 (0.1)	1 (0.1)	15 (1.1)	36 (1.6)	423 (22.6)	4 (0.9)	0 (0.0)	1,917 (5.0)
Daegu	8 (0.1)	11 (0.5)	1,357 (75.4)	2 (0.1)	0 (0.0)	3 (0.4)	9 (1.4)	10 (0.1)	4 (0.3)	1 (0.1)	1 (0.1)	3 (0.2)	2 (0.1)	820 (37.2)	73 (3.9)	1 (0.2)	0 (0.0)	2,305 (6.1)
Incheon	33 (0.3)	2 (0.1)	1 (0.1)	744 (40.0)	2 (0.3)	1 (0.1)	0 (0.0)	83 (0.9)	12 (1.0)	12 (1.0)	32 (2.1)	9 (0.7)	16 (1.1)	16 (0.7)	3 (0.2)	2 (0.5)	0 (0.0)	968 (2.5)
Gwangju	7 (0.1)	1 (0.0)	1 (0.1)	0 (0.0)	384 (59.3)	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	21 (1.7)	406 (28.8)	3 (0.1)	5 (0.3)	0 (0.0)	0 (0.0)	830 (2.2)
Daejeon	9 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	321 (42.4)	0 (0.0)	9 (0.1)	1 (0.1)	56 (4.7)	163 (10.8)	19 (1.5)	3 (0.2)	3 (0.1)	0 (0.0)	0 (0.0)	2 (20.0)	587 (1.5)
Ulsan	3 (0.0)	7 (0.3)	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	416 (65.4)	5 (0.1)	0 (0.0)	0 (0.0)	1 (0.1)	0 (0.0)	3 (0.2)	50 (2.3)	16 (0.9)	0 (0.0)	0 (0.0)	503 (1.3)
Gyeonggi	656 (6.6)	46 (2.0)	30 (1.7)	610 (32.8)	39 (6.0)	41 (5.4)	14 (2.2)	4,100 (45.5)	133 (11.3)	141 (11.7)	211 (13.9)	85 (6.9)	138 (9.8)	116 (5.3)	76 (4.1)	30 (6.9)	1 (10.0)	6,467 (17.0)
Gangwon	5 (0.0)	0 (0.0)	0 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	11 (0.1)	326 (27.6)	4 (0.3)	1 (0.1)	0 (0.0)	0 (0.0)	2 (0.1)	1 (0.1)	1 (0.2)	0 (0.0)	352 (0.9)
Chungbuk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	62 (5.2)	7 (0.5)	0 (0.1)	1 (0.1)	1 (0.0)	3 (0.2)	0 (0.0)	0 (0.0)	74 (0.2)
Chungnam	7 (0.1)	0 (0.1)	1 (0.1)	2 (0.1)	1 (0.2)	1 (0.1)	0 (0.0)	51 (0.6)	2 (0.2)	10 (0.8)	232 (15.3)	6 (0.5)	2 (0.1)	2 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	318 (0.8)
Jeonbuk	3 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.6)	1 (0.1)	0 (0.0)	5 (0.1)	1 (0.1)	2 (0.2)	20 (1.3)	463 (37.5)	7 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	506 (1.3)
Jeonnam	2 (0.0)	0 (0.0)	1 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)	242 (17.2)	1 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	250 (0.7)
Gyeongbuk	1 (0.0)	0 (0.0)	0 (0.1)	1 (0.1)	0 (0.0)	1 (0.1)	0 (0.0)	1 (0.0)	0 (0.1)	1 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	47 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	53 (0.1)
Gyeongnam	4 (0.0)	110 (4.8)	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	2 (0.0)	0 (0.0)	1 (0.1)	3 (0.2)	1 (0.1)	2 (0.1)	6 (0.3)	517 (27.6)	0 (0.0)	0 (0.0)	649 (1.7)
Jeju	1 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)	0 (0.1)	0 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	139 (32.1)	0 (0.4)	143 (0.4)
Total	10,004 (26.3)	2,289 (6.0)	1,799 (4.7)	1,858 (4.9)	648 (1.7)	757 (2.0)	636 (1.7)	9,015 (23.7)	1,182 (3.1)	1,202 (3.2)	1,513 (4.0)	1,236 (3.2)	1,410 (3.7)	2,204 (5.8)	1,871 (4.9)	433 (1.1)	10 (0.0)	38,067 (100.0)

Values are presented as number (%).

Table 3. Simple congenital cardiac surgery (2003–2013)

Hospital location	Region patient residence														Total			
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Gyeongbuk		Gyeongnam	Jeju	Sejong
Seoul	4,423 (93.9)	219 (13.5)	268 (23.3)	350 (29.9)	293 (45.0)	319 (53.9)	203 (36.7)	3,206 (63.4)	398 (71.5)	380 (70.1)	575 (65.9)	297 (36.9)	358 (44.8)	507 (44.4)	404 (24.8)	153 (69.9)	11 (91.7)	12,364 (56.0)
Busan	9 (0.2)	955 (59.0)	11 (1.0)	1 (0.1)	0 (0.1)	2 (0.3)	150 (27.1)	9 (0.2)	1 (0.2)	2 (0.4)	7 (0.8)	4 (0.5)	9 (1.1)	64 (5.6)	538 (33.0)	4 (1.8)	0 (8.0)	1,766 (8.0)
Daegu	12 (0.3)	5 (0.3)	836 (72.6)	2 (0.2)	0 (0.2)	1 (0.2)	17 (3.1)	4 (0.1)	3 (0.5)	2 (0.4)	2 (0.2)	3 (0.4)	5 (0.6)	433 (37.9)	40 (2.5)	1 (0.5)	0 (6.2)	1,366 (6.2)
Incheon	6 (0.1)	0 (0.1)	0 (21.6)	253 (21.6)	0 (21.6)	2 (0.3)	1 (0.2)	35 (0.7)	4 (0.7)	17 (3.1)	4 (0.5)	3 (0.4)	12 (1.5)	4 (0.4)	1 (0.1)	8 (3.7)	0 (1.6)	350 (1.6)
Gwangju	1 (0.0)	1 (0.1)	0 (0.1)	0 (46.2)	301 (46.2)	1 (0.2)	0 (0.2)	8 (0.2)	0 (0.2)	4 (0.7)	0 (0.7)	10 (1.2)	267 (33.4)	1 (0.1)	0 (0.5)	1 (0.5)	0 (2.7)	595 (2.7)
Daejeon	3 (0.1)	0 (0.1)	0 (0.2)	2 (0.2)	0 (0.2)	228 (38.5)	0 (14.8)	3 (0.1)	2 (0.4)	24 (4.4)	52 (6.0)	3 (0.4)	3 (0.4)	2 (0.2)	2 (0.1)	0 (8.3)	1 (1.5)	325 (1.5)
Ulsan	1 (0.0)	3 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)	82 (14.8)	1 (0.1)	0 (0.2)	0 (0.6)	0 (0.6)	0 (0.6)	0 (0.6)	4 (0.4)	2 (0.1)	0 (0.4)	0 (0.4)	93 (0.4)
Gyeonggi	251 (5.3)	20 (1.2)	28 (2.4)	561 (47.9)	54 (8.3)	36 (6.1)	9 (1.6)	1,759 (34.8)	63 (11.3)	62 (11.4)	156 (17.9)	52 (6.5)	116 (14.5)	82 (7.2)	46 (2.8)	35 (16.0)	0 (15.1)	3,330 (15.1)
Gangwon	1 (0.0)	0 (0.0)	1 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	3 (0.1)	83 (14.9)	3 (0.6)	0 (0.6)	0 (0.6)	0 (0.6)	2 (0.2)	1 (0.1)	0 (0.1)	0 (0.4)	94 (0.4)
Chungbuk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.2)	47 (8.7)	2 (0.2)	0 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.2)	52 (0.2)
Chungnam	1 (0.0)	0 (0.0)	0 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	0 (0.4)	19 (0.4)	0 (0.4)	1 (0.2)	64 (7.3)	0 (0.2)	0 (0.2)	0 (0.4)	0 (0.4)	0 (0.4)	0 (0.4)	86 (0.4)
Jeonbuk	2 (0.0)	0 (0.1)	0 (0.1)	1 (0.1)	2 (0.3)	3 (0.5)	0 (0.2)	8 (0.2)	1 (0.2)	0 (0.2)	10 (1.1)	430 (53.4)	2 (0.3)	0 (0.3)	0 (2.1)	0 (2.1)	0 (2.1)	459 (2.1)
Jeonnam	0 (0.1)	1 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	1 (0.1)	18 (2.3)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	20 (0.1)
Gyeongbuk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	0 (0.2)	1 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)	9 (0.8)	1 (0.1)	0 (0.1)	0 (0.0)	11 (0.0)
Gyeongnam	1 (0.0)	416 (25.7)	7 (0.6)	0 (0.2)	1 (0.2)	0 (0.2)	91 (16.5)	3 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	2 (0.2)	9 (1.1)	33 (2.9)	594 (36.5)	1 (0.5)	0 (5.2)	1,158 (5.2)
Jeju	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	16 (7.3)	0 (0.1)	16 (0.1)
Total	4,711 (21.3)	1,620 (7.3)	1,151 (5.2)	1,171 (5.3)	651 (2.9)	592 (2.7)	553 (2.5)	5,059 (22.9)	557 (2.5)	542 (2.5)	872 (3.9)	805 (3.6)	800 (3.6)	1,141 (5.2)	1,629 (7.4)	219 (1.0)	12 (0.1)	22,085 (100.0)

Values are presented as number (%).

Table 4. Valvuloplasty (2003–2013)

Hospital location	Region patient residence													Total				
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Gyeongbuk	Jeonnam		Gyeongbuk	Gyeongnam	Jeju	Sejong
Seoul	1,837 (90.3)	195 (43.3)	131 (29.3)	125 (24.3)	81 (34.2)	120 (62.5)	72 (48.6)	1,152 (58.9)	142 (57.7)	197 (67.0)	259 (63.0)	142 (39.3)	182 (39.0)	226 (49.2)	230 (49.8)	66 (71.0)	2	5,159 (58.8)
Busan	1 (0.0)	153 (34.0)	1 (0.2)	0	0	15 (10.1)	0	0	0	0	0	4 (1.1)	5 (1.1)	6 (1.3)	69 (14.9)	1 (1.1)	0	255 (2.9)
Daegu	0	4 (0.9)	306 (68.5)	0	0	2 (1.0)	3 (2.0)	1 (0.1)	2 (0.8)	3 (1.0)	0	0	1 (0.2)	171 (37.3)	23 (5.0)	0	0	516 (5.9)
Incheon	4 (0.2)	0	0	103 (20.0)	3 (1.3)	0	0	14 (0.7)	0	4 (1.4)	8 (1.9)	4 (1.1)	5 (1.1)	1 (0.2)	0	0	1	147 (1.7)
Gwangju	2 (0.1)	0	0	2	131 (55.3)	0	0	2 (0.1)	0	1 (0.3)	0	3 (0.8)	137 (29.3)	0	0	0	0	278 (3.2)
Daejeon	0	0	0	0	0	54 (28.1)	0	0	1 (0.4)	13 (4.4)	23 (5.6)	0	0	0	1 (0.2)	0	0	92 (1.0)
Ulsan	0	2 (0.4)	0	0	0	0	37 (25.0)	0	0	0	2 (0.5)	0	0	4 (0.9)	1 (0.2)	0	0	46 (0.5)
Gyeonggi	187 (9.2)	20 (4.4)	9 (2.0)	284 (55.3)	22 (9.3)	16 (8.3)	10 (6.8)	781 (39.9)	45 (18.3)	52 (17.7)	92 (22.4)	29 (8.0)	84 (18.0)	42 (9.2)	32 (6.9)	11 (11.8)	0	1,716 (19.6)
Gangwon	0	0	0	0	0	0	0	0	56 (22.8)	2 (0.7)	1 (0.2)	0	0	0	0	0	0	59 (0.7)
Chungbuk	0	0	0	0	0	0	0	0	0	22 (7.5)	1 (0.2)	0	3 (0.6)	0	0	0	0	26 (0.3)
Chungnam	0	0	0	0	0	0	0	3 (0.2)	0	0	13 (3.2)	0	0	0	0	0	0	16 (0.2)
Jeonbuk	2 (0.1)	0	0	0	0	0	4 (0.2)	0	0	0	11 (2.7)	179 (49.6)	4 (0.9)	0	0	0	0	200 (2.3)
Jeonnam	0	0	0	0	0	0	0	0	0	0	1 (0.2)	0	46 (9.9)	0	0	0	0	47 (0.5)
Gyeongbuk	0	0	0	0	0	0	0	0	0	0	0	0	0	3 (0.7)	0	0	0	3 (0.0)
Gyeongnam	2 (0.1)	76 (16.9)	0	0	0	0	11 (7.4)	0	0	0	0	0	0	6 (1.3)	106 (22.9)	0	0	201 (2.3)
Jeju	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14 (15.1)	0	14 (0.2)
Total	2,035 (23.2)	450 (5.1)	447 (5.1)	514 (5.9)	237 (2.7)	192 (2.2)	148 (1.7)	1,957 (22.3)	246 (2.8)	294 (3.4)	411 (4.7)	361 (4.1)	467 (5.3)	459 (5.2)	462 (5.3)	93 (1.1)	2	8,775 (100.0)

Values are presented as number (%).

Table 5. Complex congenital cardiac surgery (2003–2013)

Hospital location	Region patient residence														Total			
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Gyeongbuk		Gyeongnam	Jeju	Seiong
Seoul	2,179 (93.2)	103 (14.9)	124 (28.2)	236 (41.0)	130 (56.0)	181 (59.5)	117 (44.5)	1,849 (70.8)	268 (85.6)	285 (77.0)	304 (72.6)	226 (65.3)	199 (62.6)	242 (47.9)	201 (29.8)	102 (79.1)	8 (80.0)	6,754 (64.1)
Busan	5 (0.2)	358 (51.8)	5 (1.1)	1 (0.2)	0	1 (0.3)	77 (29.3)	4 (0.2)	1 (0.3)	1 (0.3)	4 (1.0)	5 (1.4)	0	26 (5.1)	214 (31.8)	1 (0.8)	0	703 (6.7)
Daegu	0	1 (0.1)	253 (57.6)	0	0	2 (0.7)	11 (4.2)	3 (0.1)	2 (0.6)	2 (0.5)	1 (0.2)	0	0	143 (28.3)	11 (1.6)	1 (0.8)	0	430 (4.1)
Incheon	8 (0.3)	0	1 (0.2)	54 (9.4)	0	1 (0.3)	0	14 (0.5)	0	3 (0.8)	6 (1.4)	3 (0.9)	2 (0.6)	4 (0.8)	1 (0.1)	2 (1.6)	0	99 (0.9)
Gwangju	2 (0.1)	0	0	2 (0.3)	66 (28.4)	1 (0.3)	0	1 (0.0)	0	1 (0.3)	0	3 (0.9)	52 (16.4)	1 (0.2)	1 (0.1)	0	0	130 (1.2)
Daejeon	0	0	0	0	0	89 (29.3)	0	4 (0.2)	0	13 (3.5)	22 (5.3)	3 (0.9)	0	1 (0.2)	1 (0.1)	0	0	133 (1.3)
Ulsan	0	0	0	0	0	0	4 (1.5)	0	0	0	0	0	0	0	0	0	0	4 (0.0)
Gyeonggi	141 (6.0)	6 (0.9)	52 (11.8)	282 (49.0)	36 (15.5)	28 (9.2)	7 (2.7)	731 (28.0)	36 (11.5)	39 (10.5)	75 (17.9)	42 (12.1)	58 (18.2)	63 (12.5)	34 (5.0)	19 (14.7)	2 (20.0)	1,651 (15.7)
Gangwon	0	0	0	0	0	0	0	0	6 (1.9)	2 (0.5)	0	0	0	0	0	0	0	8 (0.1)
Chungbuk	0	0	0	0	0	0	0	1 (0.0)	0	21 (5.7)	0	0	0	0	0	0	0	22 (0.2)
Chungnam	0	0	0	0	0	0	0	2 (0.1)	0	1 (0.3)	5 (1.2)	0	0	0	0	0	0	8 (0.1)
Jeonbuk	0	0	0	0	0	0	0	1 (0.0)	0	1 (0.3)	1 (0.2)	63 (18.2)	1 (0.3)	0	1 (0.1)	0	0	68 (0.6)
Jeonnam	0	0	0	0	0	0	0	0	0	0	0	0	3 (0.9)	0	0	0	0	3 (0.0)
Gyeongbuk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
Gyeongnam	3 (0.1)	223 (32.3)	4 (0.9)	1 (0.2)	0	1 (0.3)	47 (17.9)	3 (0.1)	0	1 (0.3)	1 (0.2)	1 (0.3)	3 (0.9)	25 (5.0)	210 (31.2)	1 (0.8)	0	524 (5.0)
Jeju	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 (2.3)	0	3 (0.0)
Total	2,338 (22.2)	691 (6.6)	439 (4.2)	576 (5.5)	232 (2.2)	304 (2.9)	263 (2.5)	2,613 (24.8)	313 (3.0)	370 (3.5)	419 (4.0)	346 (3.3)	318 (3.0)	505 (4.8)	674 (6.4)	129 (1.2)	10 (0.1)	10,540 (100.0)

Values are presented as number (%).

Table 6. Aorta operation (2003-2013)

Hospital location	Region patient residence														Total			
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Gyeongbuk		Gyeongnam	Jeju	Sejong
Seoul	2,127 (89.8)	172 (21.5)	115 (24.6)	180 (32.8)	103 (42.7)	128 (44.3)	48 (26.4)	1,394 (59.2)	256 (65.0)	207 (63.5)	250 (51.2)	161 (38.3)	214 (48.6)	259 (42.0)	205 (29.8)	106 (67.1)	1 (33.3)	5,926 (55.0)
Busan	7 (0.3)	561 (70.0)	3 (0.6)	2 (0.4)	0 (0.0)	1 (0.3)	34 (18.7)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.9)	19 (3.1)	234 (34.0)	1 (0.6)	0 (8.0)	867 (8.0)
Daegu	7 (0.3)	1 (0.1)	325 (69.6)	1 (0.2)	1 (0.4)	2 (0.7)	5 (2.7)	2 (0.1)	1 (0.3)	1 (0.3)	1 (0.2)	0 (0.0)	1 (0.2)	276 (44.8)	29 (4.2)	1 (0.6)	0 (6.1)	654 (6.1)
Incheon	11 (0.5)	2 (0.2)	0 (0.0)	220 (40.1)	0 (0.0)	2 (0.7)	0 (0.0)	22 (0.9)	4 (1.0)	7 (2.1)	20 (4.1)	8 (1.9)	1 (0.2)	0 (0.0)	1 (0.1)	2 (1.3)	0 (2.8)	300 (2.8)
Gwangju	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	112 (46.5)	1 (0.3)	0 (0.0)	5 (0.2)	0 (0.0)	0 (0.0)	1 (0.2)	8 (1.9)	124 (28.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (2.3)	252 (2.3)
Daejeon	1 (0.0)	1 (0.1)	2 (0.4)	2 (0.4)	0 (0.0)	129 (44.6)	0 (0.0)	3 (0.1)	1 (0.3)	23 (7.1)	57 (11.7)	3 (0.7)	0 (0.0)	2 (0.3)	0 (0.0)	0 (0.0)	0 (2.1)	224 (2.1)
Ulsan	2 (0.1)	3 (0.4)	0 (0.5)	3 (0.5)	0 (0.0)	2 (0.7)	86 (47.3)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	9 (1.5)	3 (0.4)	0 (1.0)	0 (1.0)	109 (1.0)
Gyeonggi	192 (8.1)	27 (3.4)	18 (3.9)	141 (25.7)	20 (8.3)	19 (6.6)	7 (3.8)	893 (38.0)	39 (9.9)	52 (16.0)	73 (15.0)	24 (5.7)	43 (9.8)	43 (7.0)	20 (2.9)	14 (8.9)	2 (66.7)	1,627 (15.1)
Gangwon	6 (0.3)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	7 (0.3)	92 (23.4)	4 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.3)	0 (0.0)	0 (1.0)	112 (1.0)
Chungbuk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	0 (0.0)	25 (7.7)	0 (0.0)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.1)	0 (0.0)	0 (0.3)	30 (0.3)
Chungnam	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	2 (0.7)	0 (0.0)	19 (0.8)	1 (0.3)	4 (1.2)	77 (15.8)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (1.0)	105 (1.0)
Jeonbuk	4 (0.2)	2 (0.2)	0 (0.0)	0 (0.0)	2 (0.8)	2 (0.7)	0 (0.0)	2 (0.1)	0 (0.0)	1 (0.3)	9 (1.8)	214 (51.0)	6 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (2.2)	242 (2.2)
Jeonnam	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	43 (9.8)	2 (0.3)	4 (0.6)	0 (0.0)	0 (0.5)	53 (0.5)
Gyeongbuk	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.0)
Gyeongnam	9 (0.4)	32 (4.0)	1 (0.2)	0 (0.0)	0 (0.0)	1 (0.3)	2 (1.1)	3 (0.1)	0 (0.0)	2 (0.6)	0 (0.0)	0 (0.0)	3 (0.7)	1 (0.2)	190 (27.6)	0 (2.3)	0 (2.3)	244 (2.3)
Jeju	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	34 (21.5)	0 (0.3)	35 (0.3)
Total	2,368 (22.0)	801 (7.4)	467 (4.3)	549 (5.1)	241 (2.2)	289 (2.7)	182 (1.7)	2,353 (21.8)	394 (3.7)	326 (3.0)	488 (4.5)	420 (3.9)	440 (4.1)	616 (5.7)	689 (6.4)	158 (1.5)	3 (0.0)	10,784 (100.0)

Values are presented as number (%).

Table 7. Coronary intervention (2003–2013)

Hospital location	Region patient residence														Total			
	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan	Gyeonggi	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Gyeongbuk		Gyeongnam	Jeju	Sejong
Seoul	111,823 (89.7)	1,641 (2.9)	10,80 (3.8)	3,448 (12.1)	766 (4.4)	1,420 (6.2)	477 (3.1)	38,351 (30.1)	3,082 (13.7)	3,521 (15.8)	5,114 (16.4)	2,495 (9.1)	3,043 (10.4)	3,904 (10.0)	2,494 (6.3)	1,008 (12.9)	40 (9.9)	183,707 (28.7)
Busan	289 (0.2)	51,238 (90.7)	161 (0.6)	38 (0.1)	41 (0.2)	46 (0.2)	1,317 (8.5)	272 (0.2)	67 (0.3)	62 (0.3)	76 (0.2)	85 (0.3)	248 (0.8)	1,184 (3.0)	11,594 (29.4)	91 (1.2)	2 (0.5)	66,811 (10.4)
Daegu	218 (0.2)	153 (0.3)	25,948 (92.3)	38 (0.1)	5 (0.0)	38 (0.2)	99 (0.6)	209 (0.2)	46 (0.2)	74 (0.3)	39 (0.1)	26 (0.1)	29 (0.1)	13,187 (33.9)	1,607 (4.1)	9 (0.1)	2 (0.5)	41,727 (6.5)
Incheon	549 (0.4)	55 (0.1)	22 (0.1)	17,970 (63.0)	28 (0.2)	27 (0.1)	5 (0.0)	1,472 (1.2)	166 (0.7)	147 (0.7)	679 (2.2)	119 (0.4)	211 (0.7)	151 (0.4)	53 (0.1)	25 (0.3)	0 (3.4)	21,679 (3.4)
Gwangju	334 (0.3)	28 (0.0)	21 (0.1)	62 (0.2)	16,004 (92.2)	46 (0.2)	8 (0.1)	283 (0.2)	16 (0.1)	19 (0.1)	30 (0.1)	1,333 (4.9)	13,944 (47.5)	20 (0.1)	63 (0.2)	30 (0.4)	0 (5.0)	32,241 (5.0)
Daejeon	431 (0.3)	73 (0.1)	77 (0.3)	63 (0.2)	46 (0.3)	20,662 (90.3)	25 (0.2)	462 (0.4)	67 (0.3)	2,573 (11.5)	8,064 (25.9)	747 (2.7)	117 (0.4)	308 (0.8)	124 (0.3)	16 (0.2)	168 (41.7)	34,023 (5.3)
Ulsan	80 (0.1)	496 (0.9)	72 (0.3)	16 (0.1)	16 (0.1)	14 (0.1)	13,108 (84.6)	92 (0.1)	57 (0.3)	44 (0.2)	28 (0.1)	36 (0.1)	34 (0.1)	950 (2.4)	501 (1.3)	7 (0.1)	0 (2.4)	15,551 (2.4)
Gyeonggi	9,293 (7.5)	369 (0.7)	276 (1.0)	6,553 (23.0)	235 (1.4)	299 (1.3)	85 (0.5)	82,013 (64.3)	1,875 (8.3)	1,386 (6.2)	2,606 (8.4)	947 (3.5)	1,354 (4.6)	1,253 (3.2)	623 (1.6)	148 (1.9)	17 (4.2)	109,332 (17.1)
Gangwon	398 (0.3)	39 (0.1)	34 (0.1)	74 (0.3)	4 (0.0)	27 (0.1)	28 (0.2)	1,473 (1.2)	16,897 (75.1)	2,485 (11.1)	41 (0.1)	14 (0.1)	25 (0.1)	272 (0.7)	35 (0.1)	7 (0.1)	1 (0.2)	21,854 (3.4)
Chungbuk	156 (0.1)	16 (0.0)	19 (0.1)	34 (0.1)	5 (0.0)	62 (0.3)	9 (0.1)	305 (0.2)	52 (0.2)	11,695 (52.4)	376 (1.2)	42 (0.2)	33 (0.1)	111 (0.3)	39 (0.1)	6 (0.1)	108 (26.8)	13,068 (2.0)
Chungnam	316 (0.3)	54 (0.1)	33 (0.1)	84 (0.3)	8 (0.0)	107 (0.5)	8 (0.1)	1,934 (1.5)	60 (0.3)	175 (0.8)	13,270 (42.5)	103 (0.4)	73 (0.2)	72 (0.2)	59 (0.1)	6 (0.1)	56 (13.9)	16,418 (2.6)
Jeonbuk	288 (0.2)	28 (0.0)	15 (0.1)	57 (0.2)	69 (0.4)	65 (0.3)	13 (0.1)	303 (0.2)	17 (0.1)	29 (0.1)	777 (2.5)	21,250 (77.8)	184 (0.6)	16 (0.0)	35 (0.1)	10 (0.1)	1 (0.2)	23,157 (3.6)
Jeonnam	111 (0.1)	35 (0.1)	7 (0.0)	22 (0.1)	114 (0.7)	15 (0.1)	18 (0.1)	93 (0.1)	10 (0.0)	11 (0.0)	13 (0.0)	54 (0.2)	9,966 (33.9)	14 (0.0)	78 (0.2)	7 (0.1)	0 (1.7)	10,568 (1.7)
Gyeongbuk	151 (0.1)	75 (0.1)	242 (0.9)	37 (0.1)	4 (0.0)	29 (0.1)	84 (0.5)	141 (0.1)	67 (0.3)	71 (0.3)	31 (0.1)	20 (0.1)	14 (0.0)	17,276 (44.4)	116 (0.3)	5 (0.1)	2 (0.5)	18,365 (2.9)
Gyeongnam	146 (0.1)	2,175 (3.8)	83 (0.3)	19 (0.1)	10 (0.1)	26 (0.1)	204 (1.3)	142 (0.1)	24 (0.1)	28 (0.1)	39 (0.1)	21 (0.1)	89 (0.3)	197 (0.5)	21,974 (55.8)	13 (0.2)	2 (0.5)	25,192 (3.9)
Jeju	68 (0.1)	29 (0.1)	8 (0.0)	15 (0.1)	4 (0.0)	4 (0.0)	6 (0.0)	50 (0.0)	7 (0.0)	15 (0.1)	9 (0.0)	13 (0.0)	14 (0.0)	7 (0.0)	15 (0.0)	6,440 (82.3)	4 (1.0)	6,708 (1.0)
Total	124,651 (19.5)	56,504 (8.8)	28,098 (4.4)	28,530 (4.5)	17,359 (2.7)	22,887 (3.6)	15,494 (2.4)	127,595 (19.9)	22,510 (3.5)	22,335 (3.5)	31,192 (4.9)	27,305 (4.3)	29,378 (4.6)	38,922 (6.1)	39,410 (6.2)	7,828 (1.2)	403 (0.1)	640,401 (100.0)

Values are presented as number (%).

in the metropolitan cities who underwent surgery in Seoul were 62.5% in Daejeon, followed by 48.6% in Ulsan, 43.3% in Busan, 34.2% in Gwangju, 29.3% in Daegu, and 24.3% in Incheon. Among patients living in Incheon, 55.3% went to hospitals in Gyeonggi for surgery. About 10.1% of the patients living in Ulsan underwent surgery in hospitals in Busan.

In the metropolitan provinces, the percentages of patients who underwent surgery in the region of their residence were 49.6% in Jeonbuk, followed by 39.9% in Gyeonggi and 22.9% in Gyeongnam Province. The percentage was lowest in Chungbuk (7.5%), Chungnam (3.2%), and Gyeongbuk (0.7%). The percentages of patients living in the metropolitan provinces undergoing surgery in Seoul were 71.0% in Jeju, followed by 67.0% in Chungbuk, 63.0% in Chungnam, and 58.9% in Gyeonggi. 22.4% of patients in Chungnam underwent surgery in the Gyeonggi region. Patients residing in Gyeongbuk and Jeonnam had high rates of using hospitals in the nearby metropolitan cities (Table 4).

4) Complex congenital heart surgery

The volume and percentage of the use of complex congenital heart surgery of a region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 93.2% underwent procedures or surgery in Seoul. In comparison, among patients residing in Gyeonggi Province, 28.0% underwent surgery in the region, while 70.8% underwent surgery Seoul.

In other metropolitan cities, the percentages of patients who underwent the operation in the region of their residence ranged between 1.5% and 57.6%: 57.6% in Daegu, 51.8% in Busan, 29.3% in Daejeon, 28.4% in Gwangju, 9.4% in Incheon, and 1.5% in Ulsan. In comparison, the percentages of patients in the metropolitan cities who underwent surgery in Seoul were 59.5% in Daejeon, followed by 56.0% in Gwangju, 44.5% in Ulsan, 41.0% in Incheon, 28.2% in Daegu, and 14.9% in Busan. About 49.0% of the patients living in Incheon, 15.5% of patients residing in Gwangju, and 11.8% of patients living in Daegu went to hospitals in Gyeonggi for surgery. 32.3% of patients living in Busan used medical institutions in Gyeongnam and 29.3% of patients in Ulsan went to hospitals in Busan for surgery.

In the metropolitan provinces, the percentages of

patients who underwent surgery in the region of their residence were 31.2% in Gyeongnam, followed by 28.0% in Gyeonggi and 18.2% in Jeonbuk. The percentage was lowest in Chungnam (1.2%), Jeonnam (0.9%), and Gyeongnam (0.0%). The percentages of patients living in the metropolitan provinces undergoing surgery in Seoul were 85.6% in Gangwon, followed by 79.1% in Jeju, 77.0% in Chungbuk, 72.6% in Chungnam. Patients residing in Gyeongbuk and Gyeongnam had high rates of using hospitals in the nearby metropolitan cities (Table 5).

5) Aorta surgery

The volume and percentages of the use of aorta surgery of a region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 89.8% underwent procedures or surgery in Seoul. In comparison, among patients residing in Gyeonggi Province, 38.0% underwent surgery in the region, while 59.2% underwent surgery Seoul.

In other metropolitan cities, the percentages of patients who underwent the operation in the region of their residence ranged between 40.1% and 70.0%: 70.0% in Busan, 69.6% in Daegu, 47.3% in Ulsan, 46.5% in Gwangju, 44.6% in Daejeon, and 40.1% in Incheon. In comparison, the percentages of patients in the metropolitan cities who underwent surgery in Seoul were 44.3% in Daejeon, followed by 42.7% in Gwangju, 32.8% in Incheon, 26.4% in Ulsan, 24.6% in Daegu, and 21.5% in Busan. 25.7% of the patients living in Incheon went to hospitals in Gyeonggi for surgery.

In the metropolitan provinces, the percentages of patients who underwent surgery in the region of their residence were 51.0% in Jeonbuk, followed by 38.0% in Gyeonggi and 27.6% in Gyeongnam. The percentage was lowest in Chungbuk (7.7%) and Gyeongnam (0.5%). The percentages of patients living in the metropolitan provinces undergoing surgery in Seoul were 67.1% in Jeju, followed by 65.0% in Gangwon, 63.5% in Chungbuk, and 59.2% in Gyeonggi. Patients residing in Jeonnam, Gyeongbuk, and Gyeongnam had high rates of using hospitals in the nearby metropolitan cities (Table 6).

6) Coronary artery procedures and surgery

The volume and percentage of the use of coronary

artery procedures and surgery of a region between 2003 and 2013 were analyzed based on the patient's residence and location of the hospital. Among patients living in Seoul, 89.7% underwent procedures or surgery in Seoul. In comparison, among patients residing in Gyeonggi Province, 64.3% underwent surgery in the region, while 30.1% underwent surgery in Seoul.

In other metropolitan cities, the percentages of patients who underwent the surgery in the region of their residence ranged between 63.0% and 92.3%: 92.3% Daegu, 92.2% in Gwangju, 90.7% in Busan, 90.3% in Daejeon, 84.6% in Ulsan, and 63.0% in Incheon. In comparison, the percentages of patients in the metropolitan cities who underwent surgery in Seoul were 12.1% in Incheon, followed by 6.2% in Daejeon, 4.4% in Gwangju, 3.8% in Daegu, 3.1% in Ulsan, and 2.9% in Busan. 23.0% of the patients living in Incheon went to hospitals in the Gyeonggi area for surgery.

In the metropolitan provinces, the percentages of patients who underwent surgery in the region of their residence were 82.3% in Jeju, followed by 77.8% in Jeonbuk, 75.1% in Gangwon, 64.3% in Gyeonggi. The percentage was lowest in Chungnam (42.5%) and Jeonnam (33.9%). The percentages of patients living in the metropolitan provinces undergoing surgery in Seoul were 30.1% in Gyeonggi, 16.4% in Chungnam, and 15.8% in Chungbuk. Patients residing in Chungnam, Jeonnam, Gyeongbuk, and Gyeongnam had high rates of using hospitals in the nearby metropolitan cities (Table 7).

Discussion

This study analyzed surgery status of patients who underwent cardiovascular surgery, based on the data on common cardiac surgery from NHIS from January 2003 to December 2013. During the 11 years, the overconcentration of patients in medical institutions in Seoul rarely showed any change in coronary artery bypass and aorta surgery. The concentrated use of hospitals in Seoul for simple congenital heart surgery and coronary artery procedures and surgery has decreased slightly. In contrast, for complex congenital heart surgery, the rate of surgery performed in Seoul has mildly increased.

Regarding the volume of surgery during the 11

years of the study period, 12,866 and 7,941 cases of coronary artery bypass and simple congenital heart surgery, respectively, were performed in Seoul for patients living outside the metropolitan area. The figure for coronary artery bypass exceeds the number of surgery cases performed for patients living in Seoul (9,259 cases) by 3,626 cases. The figure for simple congenital heart surgery outnumbers the quantity of surgery cases performed for patients living in Seoul (4,423 cases) by 3,518 cases. These results show that overconcentration of patients who had heart surgery in hospitals in Seoul is serious. Therefore, policy measures to address the issue should be developed immediately.

A similar problem occurs in other regions outside Seoul: patients in Gyeongnam, Gyeongbuk, and Jeonnam prefer to go to Busan, Daegu, and Gwangju for heart surgery. Policies to alleviate the situation both in Seoul and other metropolitan areas should be planned. Results from a public survey [6] indicate that more than 90% of respondents agree with such a policy plan, and that public sentiment is favorable.

The Korean government employed a strategy to designate and run a single regional center in each area. However, that has caused unnecessary competition among comparable university hospitals in the same region. Moreover, the strategy failed to lead to mutually beneficial cooperation between the designated center and other university hospitals.

Such limitations have also revealed that the strategy failed to achieve its initial goal: alleviating overconcentration of patients in metropolitan cities by establishing a regional cooperative system and strengthening regional capacity in medical care. Moreover, cooperation in preventive programs, training programs, and promotion activities is weak among most regional centers, revealing limitations in gathering and organizing capabilities of the communities.

Furthermore, the decline in the number of residents and specialists in the thoracic surgery department—which performs heart surgery—is gaining momentum. In most regions, except for Seoul, human resources, facilities, and the equipment in a medical institution are subpar. Considering this situation, designation of a single regional center may not drastically enhance surgical performance of the region, possibly resulting in ineffective outcomes.

To address such challenges, we propose that the

government designate 3 or 4 centers in each region and facilitate the creation and operation of networks among them. This can minimize unnecessary competition among university hospitals in the region. Moreover, regional capacity for surgery would be enhanced and win-win cooperation among the medical institutions in selected services may occur.

In particular, for less complex cardiac surgery, a policy is needed to designate metropolitan cities and provinces as a regional unit. For heart surgery with higher complexity, regional units should be the minimum units in deploying resources and implementing support strategies. This may be an answer to solve the overconcentration of cardiac patients in Seoul at national and regional levels. Furthermore, such a strategy would be effective in strengthening regional capacity for cardiac surgery.

In conclusion, based on the results of this study, we need to address the current overconcentration of cardiac patients in the capital city as well as some metropolitan cities at the national level. To that end, fostering the necessary human resources and expanding facilities by designating and operating heart centers are needed. Moreover, at the policy level, setting multiple regional centers instead of a single one is desired to improve regional capacity for cardiac surgery.

Conflict of interest

No potential conflicts of interest relevant to this article are reported.

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