

## Original Article



# Descriptive Study on the Korean Status of Percutaneous Coronary Intervention Using National Health Insurance Service-National Sample Cohort (NHIS-NSC) Database: Focused on Temporal Trend

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### Conflict of Interest

The authors have no financial conflicts of interest.

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## ABSTRACT

**Background and Objectives:** Percutaneous coronary intervention (PCI) is an indispensable treatment modality in coronary artery disease. However, there is still inadequacy of comprehensive knowledge on the Korean status and trend of this important procedure using nation-wide and representative data.

**Methods:** National Health Insurance Service-National Sample Cohort is a database containing demographic, health insurance reimbursement for patient management and health screening data of about one million Koreans for 12 years (2002–2013). Annual procedure rate for PCI was estimated by bootstrapping as per 100,000 person-years.

**Results:** Among the whole cohort, total 12,186 PCI's were done during the study period. Mean age of subjects who underwent PCI was 57.6±11.2 years and male:female proportion was 68%:32%. Death from all cause occurred in 1,843 (15.1%), death from ischemic heart diseases in 662 (5.4%), death from all cardiovascular cause in 872 (7.2%) during the follow-up. The proportion of the primary PCI for acute myocardial infarction was estimated to be 24.0%. Estimated annual rate of PCI increased from median 29.1 (95% confidence interval [CI], 26.6–32.1) in 2002 to 107.7 (95% CI, 103.0–113.8) per 100,000 person-years in 2013. In this cohort, PCI was performed in total 180 hospitals, which annually increased from 59 in 2002 to 153 in 2013.

**Conclusions:** PCI had increased in volume from 2002 to 2013. This descriptive data may be considered in policy making and planning further direction of management of coronary artery disease in Korea.

**Keywords:** Coronary artery disease; Percutaneous coronary intervention

### Author Contributions

Conceptualization: Sung J, Hong KP. Data curation: Sung J. Formal analysis: Sung J. Funding acquisition: Sung J. Investigation: Sung J. Methodology: Sung J. Project administration: Sung J. Resources: Sung J. Software: Sung J. Supervision: Sung J, Hong KP. Validation: Sung J, Hong KP. Visualization: Sung J. Writing - original draft: Sung J. Writing - review & editing: Sung J, Hong KP.

## INTRODUCTION

Percutaneous coronary intervention (PCI) is an essential treatment modality for coronary artery disease and its indication and application have been widened along with its technical advancement. While many related studies have been done in Korea, there is paucity of descriptive data representing national status of the procedure. There are studies in United States using nation-wide sample<sup>1)</sup> or community-based population<sup>2)</sup> reporting descriptive data. In Korea, a recent study<sup>3)</sup> using 2006–2010 database of Health Insurance Review and Assessment Service reported descriptive data regarding the status of coronary revascularization, which estimated procedure rate in 2010 as 131/100,000 person-years (123.4 for PCI only). However, this study has limitations such as lack of long-term outcome except in-hospital mortality and relative restricted duration of follow-up.

The objective of this study is to report descriptive data representing national status of PCI using National Health Insurance Service-National Sample Cohort (NHIS-NSC) 2002–2013 provided by National Health Insurance Service Data Sharing Service (<http://nhiss.nhis.or.kr/bd/ab/bdaba015lv.do>) including mortality data.

## METHODS

### Subjects

Subjects of the study were extracted from NHIS-NSC 2002–2013. This cohort is provided by National Health Insurance Sharing Service (NHISS), which includes 1,025,340 participants randomly selected from 47,851,928 individuals in the Korean National Health Information Database in 2002, stratified by age group, sex, participant's eligibility status to national insurance system and income level, comprising 2.2% of the total eligible Korean population in 2002, and followed for 11 years until 2013 unless participants' eligibility was disqualified due to death or emigration. The cohort comprises four databases on participants' insurance eligibility, medical treatments, medical care institutions and general health examinations. The construction of NHIS-NSC and its profile were described elsewhere.<sup>4)</sup>

Operational definition of inclusion (PCI) and outcomes were as follows:

- 1) PCI: procedure code in NHIS-NSC M655\*–M657\*
- 2) Coronary artery bypass graft (CABG): procedure code in NHIS-NSC OA631\*–OA639\*, OB631\*–OB639\*, OA641\*, OA642\*, OA647\*, O0161\*–O0171\*, O1641\*–O1647\*
- 3) All-cause mortality: included in NHIS-NSC linked to mortality data provided by the Statistics Korea
- 4) Death from coronary artery diseases: cause of death ICD I20\*–I25\*
- 5) Cardiovascular mortality: cause of death International Classification of Diseases (ICD) I\*+R96, 98 & 99 (sudden or unobserved death or death of unknown cause)
- 6) Admission for ischemic heart diseases (IHDs): admission for ICD I20\*–I25\*
- 7) Acute myocardial infarction (AMI): admission for ICD I21\*
- 8) Primary PCI: 1)+admission via emergency room+ICD I21\*
- 9) Hypertension: ICD I10, 11, 12, 13, 15+antihypertensive medication use
- 10) Diabetes mellitus: ICD E10–E14+anti-diabetic medications or insulin use

This study was performed through retrospective analysis of the data obtained from the existing database from which identifying personal information was eliminated. It was

approved by the Institutional Review Board at the Samsung Medical Center (IRB No. 2016-04-117). Informed consent was waived given its impracticalities and the minimal risk involved in this retrospective analysis.

### Processing of data and statistical analysis

Raw data of NHIS-NSC 2002–2013 were provided by NHISS as 156 formatted text files with total size of 210.67 gigabytes and total number of records of 2,618.6 million. Raw data was converted to relational database management system (RDBMS) on the statistical workstation. Datasets for analyses were extracted through structured query language queries from RDBMS. MariaDB 10.0.21 (MariaDB Foundation, Wilmington, DE, USA) was used as RDBMS server and Python 3.4.3 (Python Software Foundation, Beaverton, OR, USA) was used as a ‘glue’ language for uploading raw data to RDBMS and extracting datasets. Statistical analysis was done by R 3.2.1 (R foundation for Statistical Computing, Vienna, Austria).

Annual procedure rates for PCI, CABG, admission for IHDs were calculated as per 100,000 person-years and 95% confidence intervals were estimated by bootstrapping.

Poisson regression model was used to test the trend of annual procedure and admission rate in which ordinal scores were assigned to calendar years. Chi-square test with ordinal score assigned to calendar years was used to test the trend of proportions, such as the proportion of primary PCI among the procedures in a year.

## RESULTS

### Demographic profile

**Tables 1** and **2** shows overall characteristics of the PCI cohort and procedures. Among 1,025,340 participants (as of year 2002) of NHIS-NSC, 9,218 cases of PCI were underwent in 7,685 patients during 2002–2013. Proportion of male was higher. During the same period,

**Table 1.** Overall statistics of PCI cohort

Variables	Values
Total	7,685
Age (years)	63.8±11.2
By age group (years; %)	
<40	7.1 (542/7,685)
40–49	26.3 (2,018/7,685)
50–59	32.8 (2,523/7,685)
60–69	22.5 (1,726/7,685)
70–79	9.9 (760/7,685)
≥80	1.5 (116/7,685)
Female (%)	32.5 (2,500/7,685)
Follow-up duration (years)	3.9 (1.6–6.8)
Overall mortality (%)	
All-cause	15.0 (1,150/7,685)
Cardiovascular	6.9 (530/7,685)
IHD	5.2 (402/7,685)
Revascularization during the follow-up (%)	17.5 (1,344/7,685)
PCI	16.3 (1,256/7,685)
CABG	1.6 (122/7,685)
Statin use (%)	90.6 (6,960/7,685)
Antiplatelet agent use (%)	96.0 (7,379/7,685)

CABG = coronary artery bypass graft; IHD = ischemic heart disease; PCI = percutaneous coronary intervention.

**Table 2.** Characteristics of PCI procedures

Variables	Values
Total number of PCI	9,218
Primary PCI for AMI (%)	31.9 (2,938/9,218)
Number of stent used (%)	
Ballooning only	10.8 (991/9,218)
1	57.3 (5,280/9,218)
2	16.6 (1,533/9,218)
≥3	7.9 (728/9,218)
Number of hospitals	180
≥500 beds	119
≥1,000 beds	28

AMI = acute myocardial infarction; PCI = percutaneous coronary intervention.

number of admission due to IHD was 35,139 cases in 39,822 patients. Primary PCI for AMI comprised 32% of all PCI cases and over half of the cases used just one stent. First generation drug-eluting stents (DES) was used since 2003 (2.7% of PCI in the year 2003) and increased rapidly (51.4% of PCI in the year 2004). Second generation DES appeared in year 2005 (14.3% of PCI in the year 2005) and increased to 71.2% in the year 2011. Polymer-free DES began to be used in the year 2010 (2.7%) and increased to 15% in the year 2013.

### Trend of PCI procedure rate

Annual PCI procedure rate showed obvious increasing tendency during 2002–2013 period. (Table 3) Procedure rate more than tripled during the 12-year period (p for linear trend <0.001), while the procedure rate for CABG did not significantly increased during the same period (Table 3). Procedure rate for PCI increased almost yearly except for the year 2009 (Figure 1). While there was significant increase in the rate of admission due to IHD and proportion of PCI performed during admission due to IHD (p for linear trend <0.001), the proportion of primary PCI among all PCI cases did not significantly increase during the year 2002–2013 (Table 3). Both admission due to IHD and annual PCI rate steadily increased with exception of year 2008–2010 period showing a ‘notch’, while the annual rate of primary PCI increased less steeply (Figure 1).

### Institutions performing PCI

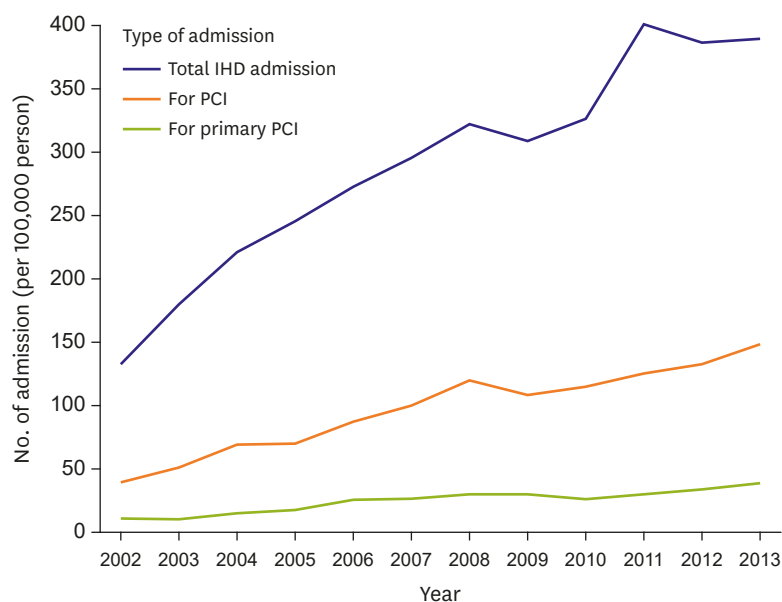
Number of institutions which performed PCI increased steadily during the year 2002–2013 period (Table 4). Again, like the annual PCI procedure rate, the year 2009 showed transient

**Table 3.** Annual procedure rate of PCI and CABG and admission due to IHD (per 100,000 person-years)

Years	Procedure rate of PCI per 100,000 person-years	Procedure rate of CABG per 100,000 person-years	Proportion of primary PCI	Rate of admission due to IHD per 100,000 person-years	PCI during admission due to IHD
2002	29.1 (26.6–32.1)	5.2 (3.9–6.7)	37.2 (32.5–42.5)	128.8 (124.9–135.1)	50.6 (48.8–52.7)
2003	43.4 (40.1–47.1)	7.7 (6.0–9.4)	30.0 (26.4–33.6)	173.9 (167.7–179.3)	52.5 (50.7–54.0)
2004	50.8 (48.0–55.1)	8.1 (6.4–9.8)	30.4 (27.3–33.5)	211.9 (206.1–219.4)	55.5 (54.2–57.5)
2005	51.4 (47.7–55.2)	7.2 (5.5–8.8)	35.0 (32.0–38.7)	234.2 (226.7–242.6)	52.0 (50.7–53.4)
2006	70.4 (66.1–75.3)	8.6 (6.8–10.5)	36.4 (33.5–39.6)	259.6 (253.1–267.5)	58.1 (56.6–59.7)
2007	79.6 (75.7–84.1)	8.2 (6.5–10.1)	32.9 (30.0–35.4)	279.5 (272.3–289.5)	61.3 (59.9–62.5)
2008	88.1 (82.0–93.2)	7.7 (5.9–9.6)	30.7 (28.1–33.5)	303.9 (294.3–312.5)	63.6 (62.2–64.9)
2009	85.6 (81.5–90.1)	7.7 (6.1–9.4)	31.0 (27.7–33.4)	292.3 (280.6–302.2)	61.4 (60.3–62.7)
2010	93.1 (87.1–97.2)	7.2 (5.6–8.9)	30.0 (27.7–32.6)	307.7 (297.9–316.1)	62.2 (60.9–63.6)
2011	103.2 (97.3–108.0)	8.7 (7.0–10.6)	29.8 (27.1–31.8)	379.4 (368.8–389.2)	58.7 (57.5–59.5)
2012	110.0 (105.7–115.4)	7.8 (5.9–9.6)	31.7 (29.4–34.2)	367.3 (357.0–373.8)	61.2 (60.0–62.3)
2013	107.7 (103.0–113.8)	6.7 (5.2–8.3)	32.8 (30.3–35.1)	362.2 (353.0–371.3)	61.5 (60.4–63.0)

Values are presented as rate or percentage (95% CI). Estimated rates, proportions, and 95% CI was obtained by bootstrapping.

CABG = coronary artery bypass graft; CI = confidence interval; PCI = percutaneous coronary intervention; IHD = ischemic heart disease.



**Figure 1.** Temporal trend of the annual rate of PCI and IHD admission during the study period. PCI = percutaneous coronary intervention; IHD = ischemic heart disease.

**Table 4.** Number of hospitals which performed percutaneous coronary intervention and its change during 2002–2013

Years	Number of hospitals	Proportion of hospitals	
		≥500 beds	≥1,000 beds
2002	59	93.2 (55/59)	40.7 (24/59)
2003	76	88.2 (67/76)	32.9 (25/76)
2004	80	90.0 (72/80)	32.5 (26/80)
2005	87	88.5 (77/87)	31.0 (27/87)
2006	97	87.6 (85/97)	27.8 (27/97)
2007	111	84.7 (94/111)	25.2 (28/111)
2008	124	83.1 (103/124)	22.6 (28/124)
2009	118	80.5 (95/118)	23.7 (28/118)
2010	127	81.1 (103/127)	22.0 (28/127)
2011	138	73.2 (101/138)	21.0 (29/138)
2012	150	74.0 (111/150)	19.3 (29/150)
2013	153	72.5 (111/153)	19.0 (29/153)

Values are presented as percentage (number of hospitals/total number of hospitals).

‘notch’ in the increasing tendency of the number of hospitals. The proportion of relatively larger hospitals decreased. The majority (93%) of hospitals had been those with ≥500 beds in 2002 and the proportion decreased to 73% in the year 2013.

### Survival of PCI cohort

**Table 5** shows 10-year survival rate of PCI cohort compared with the whole NHIS-NSC according to age group and sex. The survival rate of PCI cohort is relatively lower than age-matched NHIS-NSC and the difference seems to be larger in younger female group. Multivariable cox regression model was explored to find the predictors of all-cause mortality among PCI cohort (**Table 6**). Female sex, medications (statin and antiplatelet agents) and hypertension was associated with better survival and older age, lower socioeconomic status (SES), history of AMI, presence of diabetes mellitus predicted higher mortality. Region of the hospital was largely not a significant predictor of mortality, except that lower mortality was associated with hospitals in Jeju. Number of beds were inversely associated with

**Table 5.** Age- and sex-specific 10-year survival rate of PCI cohort, compared to the whole NHIS-NSC

Age group (years)	10-year survival (95% CI)			
	PCI cohort		NHIS-NSC	
	Male	Female	Male	Female
<40	0.981 (0.955–1.000)	0.800 (0.516–1.000)	0.993 (0.993–0.993)	0.996 (0.996–0.996)
40–49	0.942 (0.915–0.970)	0.915 (0.828–1.000)	0.962 (0.961–0.963)	0.987 (0.986–0.988)
50–59	0.880 (0.851–0.910)	0.856 (0.789–0.929)	0.919 (0.917–0.921)	0.971 (0.969–0.972)
60–69	0.760 (0.727–0.794)	0.783 (0.733–0.837)	0.795 (0.791–0.799)	0.906 (0.904–0.909)
70–79	0.491 (0.428–0.563)	0.611 (0.550–0.680)	0.544 (0.535–0.552)	0.699 (0.693–0.705)
≥80	0.243 (0.102–0.584)	0.423 (0.317–0.564)	0.228 (0.215–0.242)	0.309 (0.300–0.319)
Overall	0.759 (0.739–0.779)	0.705 (0.673–0.739)	0.953 (0.953–0.954)	0.962 (0.962–0.963)

CI = confidence interval; NHIS-NSC = National Health Insurance Service-National Sample Cohort; PCI = percutaneous coronary intervention.

**Table 6.** Multivariable-adjusted Cox proportional hazard model for all-cause mortality in PCI cohort

Explanatory variables	HR (95% CI)	p
Age (years)	1.083 (1.076–1.091)	<0.001
Sex (female)	0.745 (0.655–0.847)	<0.001
SES (reference: high)		
Middle	1.211 (1.055–1.390)	<0.01
Low	1.241 (1.066–1.444)	<0.01
AMI	1.312 (1.151–1.496)	<0.001
Region (Jeju)*	0.315 (0.117–0.851)	<0.05
Number of hospital bed (per 100)	0.990 (0.977–1.003)	0.12
Statin	0.447 (0.382–0.524)	<0.001
Antiplatelet agents	0.192 (0.158–0.233)	<0.001
Diabetes mellitus	1.437 (1.268–1.628)	<0.001
Hypertension	0.837 (0.735–0.953)	<0.01

AMI = acute myocardial infarction; CI = confidence interval; HR = hazard ratio; PCI = percutaneous coronary intervention; SES = socioeconomic status.

\*Hospital regions other than Jeju was not significant.

mortality in univariate analysis (data not shown) but only marginally in multivariable model. Because of limited clinical information, more complete exploration for the prognostic factors was not feasible.

## DISCUSSION

Though this is not the first study to report the Korean status regarding PCI, it provides additional information which the previous Korean study<sup>3)</sup> lacks. In this study, the trend of PCI during the year 2002–2013 was shown. Increasing in the number of procedures was evident and the procedure rate was more than tripled during this period while the rate of CABG was stationary. Recent report from Korean PCI registry<sup>5)</sup> from 93 hospitals reported descriptive statistics based on 2014 cohort but without information for long-term trend.

In United States, a study utilizing the Nationwide Inpatients Sample database reported that the rate for PCI increased to more than three times from 1988 to 2001 (80.3 to 244 per 100,000/person-years)<sup>6)</sup> Another study<sup>1)</sup> investigated coronary revascularization trends in the US during 2001–2008 period, which reported that there was 14% decrease in the annual rate of coronary revascularizations and the decrease was mostly explained by 39% decrease in CABG and PCI rate changed minimally (2% decrease). Further study investigated data during 2007–2011 reported decrease of annual PCI rate by 27.7% (p=0.03) and this decrease was mostly due to the decrease in PCI utilization for stable coronary artery disease.<sup>7)</sup>

In contrast to the US, annual PCI rate in Korea showed increasing trend at least until the year 2013. Increasing trend of PCI seems to be largely due to increase in the incidence of IHD, which can be estimated by the increase of admission for IHD. However, considering that the proportion of cases underwent PCI among the total admission for IHD significantly increased (from 50.6% in 2002 to 61.5% in 2013,  $p$  for trend  $<0.001$ ) and the proportion of primary PCI among all PCI cases remained the same, increased elective procedure probably for stable angina may be an important factor contributed to the increasing trend. While invasive strategy including PCI is a standard treatment in acute coronary syndrome,<sup>8)</sup> its benefit in patients with stable angina is not conclusive probably because of the influence of highly effective preventive medical therapy.<sup>9)</sup> Further study is warranted to ensure whether increasing use of elective PCI for stable coronary disease is well-justified.

While the increasing trend in both total admission for IHD and PCI was evident, there was a 'notch' during 2008–2010 and also temporary interruption of increasing trend in the number of hospitals performing PCI in 2009, while there is no such finding in the trend of the annual rate of primary PCI (**Figure 1** and **Table 4**). While the cause for this finding is uncertain, a possible explanation, though only speculative, is that the association with the global financial crisis. Financial crisis of 2008 began with a crisis in the subprime mortgage in the US and developed into an international banking crisis with the collapse of Lehman Brothers on September 2008.<sup>10)</sup> This financial crisis followed by a global economic downturn and also had impact on the Korean economy resulted in reduced gross domestic product and private consumption during 2008–2010.<sup>11)</sup> In Canada, Pilote et al.<sup>12)</sup> reported inequities in access to cardiac procedures after AMI, i.e., patients in low SES were less likely to undergo cardiac catheterization compared to those in high SES (men: 33%; compared with 47%; women: 18%; compared with 47%), even under universal health insurance coverage. The economic downturn of the period may influence the decision for PCI, especially elective procedures, both in individual and hospital levels, though this is only a speculation based on indirect evidences.

There was clear increasing trend in the number of hospitals performing PCI along with the increase of total number of PCI and also the proportion of smaller hospitals increased. Proportion of the PCI's done in the hospitals with less than 500 beds were only 7% in 2002 and increased to 27.5% in 2013. Similar findings were observed in a US study that a significant increase in the proportion of PCI's at centers without on-site cardiac surgery (from 1.8% to 12.7%) during the period of 2003–2012.<sup>13)</sup>

In our PCI cohort, regions of hospitals were largely insignificant as a predictor of mortality except Jeju region which showed lower mortality (**Table 6**). This is probably related to the disease severity of patients but further analysis was impossible due to the lack of data on clinical information. Presence of hypertension was associated with lower mortality, probably because hypertension was defined by the use of antihypertensive medication and represented well-treated group. Low personal SES is apparently associated with poor prognosis, which is consistent with previous epidemiological studies.<sup>14)15)</sup>

This study has several limitations. Because the study cohort is a retrospective cohort based on the National Health Insurance database, there are lack or insufficiencies in the clinical information such as: 1) comorbidities and especially its severity, 2) clinical events outside the range of the follow-up period, 3) clinical characteristics such as hypertension, diabetes and/or dyslipidemia and its changes over time. While some of them could be obtained from ICD codes in the insurance claims, significant over- or under-diagnoses is not avoidable because



the diagnosis should be based on the ICD codes for outpatient visit. Also there might be some inaccuracy in the diagnosis of IHD and myocardial infarction. However, diagnosis of IHD and myocardial infarction was defined by ICD codes for admission, which is known to have less errors compared to outpatient setting.<sup>16)17)</sup>

In conclusion, annual procedure rate of PCI increased more than three times during 2002–2013 period and also the number of hospitals which performed PCI. SES, either personal or national, has a significant effect on the patients' prognosis and national trend of health care. These findings should be considered in prediction of further trend and policy making.

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