Incidence of major cardiovascular disease among immigrants and native Koreans

Hunju Lee

The Graduate School
Yonsei University
Department of Public Health

Incidence of major cardiovascular disease among immigrants and native Koreans

A Dissertation Submitted
to the Department of Public Health
and the Graduate School of Yonsei University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy in Public Health

Hunju Lee

June 2024

This certifies that the Dissertation

Thesis Supervisor Hyeon Chang Kim

Thesis Committee Member Jin Ha Yoon

Thesis Committee Member Hokyou Lee

Thesis Committee Member Yeon Soon Ahn

Thesis Committee Member Sang Baek Koh

The Graduate School
Yonsei University
June 2024

Acknowledgements

First and foremost, I would like to express my heartfelt gratitude to my supervisor, Professor Hyeon Chang Kim, for the encouragement and guidance that enabled me to complete this doctoral thesis despite my many shortcomings. I am also deeply thankful to Professor Sang Baek Koh, Professor Yeon Soon Ahn, and Professor Sung Kyung Kim for their consideration of my work and for the effort they put into traveling from Wonju to Shinchon. Without their unwavering support, finishing my degree would have been far more challenging. I extend my sincere thanks to Professor Ho-Kyu Lee and Professor Jin-Ha Yoon for taking the time out of their busy schedules to serve as thesis committee members.

Reflecting on this journey, I realize that this thesis could not have been completed without the understanding and assistance of many individuals. I am particularly grateful to HJ, who always supported me and reviewed my thesis, and to SJ, who helped with my degree presentations. I also thank Mr. Kwanghyun Kim for his help when I resumed my studies after a break. Additionally, I would like to express my gratitude to Ms. Yoo Jung for helping me navigate graduate school life, which made my graduation possible.

Furthermore, I would like to thank all the professors and teachers at Wonju College of Medicine whom I could not individually mention, Professor Sei Jin Chang, Professor Chun Bae Kim, and all my friends who have always been there for me. Lastly, I want to express my gratitude and love to my family, who have always supported me and helped me complete my studies despite the difficult times.

With deepest respect,
Hunju Lee

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Incidence of major cardiovascular disease among immigrants and native Koreans

Since the employment of migrant workers in the construction industry began in the 1980s, the number of immigrants residing in Korea has steadily increased. By 2021, approximately 2 million long-term immigrants were living in Korea accounting for 4.1% of the total population. However, research on the health of immigrants, particularly cardiovascular diseases (CVD), has been lacking. Therefore, this paper aimed to calculate the incidence rates and compare the risks of major cardiovascular diseases between immigrants and Koreans.

This study used health insurance data from 77,047 foreigners and 308,188 matched Koreans who were enrolled in the National Health Insurance in 2011. The outcome measures included overall CVD, myocardial infarction (MI), ischemic heart disease (IHD), and stroke. Immigrants were further categorized by nationality, national income, and residency status. Incidence rates were calculated for all cardiovascular diseases and specific diseases within the subgroups of immigrants. Additionally, to compare the risk of cardiovascular diseases between immigrants and Koreans, the Fine-Gray sub-distributional hazard ratio was calculated. Finally, to adjust for risk factors of cardiovascular diseases, survival analysis was additionally conducted by limiting the study subjects to those who had undergone health check-ups.

The analysis showed that the incidence rate of major cardiovascular diseases among immigrants was 160.1 per 100,000 person-years (95% CI: 148.6-172.3). When age-standardized, the standardized incidence ratio was 1.08 (95% CI: 1.00-1.16), indicating a higher incidence rate of major CVD among immigrants compared to Koreans. Survival analysis results also showed that immigrants had a higher risk of CVD than Koreans (HR 1.18, 95% CI: 1.08-1.29), with a particularly higher risk of stroke. Even when limited to those who had undergone health check-ups, immigrants had a higher risk of CVD, with higher risks observed for MI, IHD, and stroke compared to Koreans.

Since immigrants have a higher risk of CVD than Koreans, public health interventions that consider the characteristics of immigrants are required to prevent the incidence of CVD.

Key words : Cardiovascular diseases, Incidence, Survival analysis, Immigrant

1. Introduction

1.1. Definition of immigrants

There is no internationally accepted definition of 'migrant'. The International Organization for Migration defines a migrant as 'a person who moves away from his or her place of usual residence, whether within a country or across an international border, temporarily or permanently, and for a variety of reasons' (1), but this definition does not imply a legal status for the migrant. The IOM's definition includes a range of migrants such as migrant workers, international students, prisoners, refugees, and undocumented migrants. However, more commonly, migrants are defined more narrowly according to the purpose of their use. For example, the United Nations Department of Economic and Social Affairs defines an 'international migrant' as 'any person who changes his or her country of usual residence' (2). This definition limits the IOM's broader definition to international migrants and excludes those whose stay is for 'recreation, holiday, visits to friends and relatives, business, medical treatment, or religious pilgrimages'.

In Korea, the definitions of migrants are primarily provided by the Ministry of Public Administration and Security's 'Status of Foreign Residents' and the Ministry of Justice's 'Annual Report on Immigration and Foreigner Policy Statistics'(3). The Ministry of Public Administration and Security defines a migrant as 'Foreign residing in the country who stay for more than 90 days', whereas the Ministry of Justice defines them as 'All foreign residing in the Republic of Korea who do not have Korean nationality'. However, the definition by the Ministry of Justice targets all foreigners who enter Korea, rather than those who have settled in the country. Therefore, in this study, immigrants are defined according to the Ministry of Public Administration and Security's definition as 'people who have left the area where they originally lived’.

1.2. The current states of immigrants in Korea

The history of migration in Korea began in the late 1980s when the labor shortages in the construction industry due to rapid industrialization were filled with workers from China and Southeast Asia. The number of immigrants workers has continuously increased since the diplomatic relations with China in 1992, and in 1993, the Industrial Trainee System was implemented to manage this institutionally. However, this system treated immigrants workers as trainees rather than workers, which led to human rights violations as they were not covered by labor laws, and increased the number of illegal residents due to trainees leaving their workplaces. To address these shortcomings, the Industrial Trainee System was replaced by the Employment Permit System in 2007, and the Visit-Employment System targeted at residents of Chinese descent was introduced(4,5).

Since 1990, the Korean government has facilitated marriages between women of Korean descent living in China and Korean men as part of efforts to reunite ethnic groups and address the decline in rural populations. The rate of international marriages has increased significantly since 2003, expanding to include countries like the Philippines and Vietnam.

As of 2021, there are 2,134,569 long-term foreign residents in Korea, accounting for 4.1% of the total population. This number has increased about fourfold from 536,627 in 2006, when the survey of foreign residents first began. Among them, 210,880 have acquired Korean nationality, making up 9.9% of the total foreign population.

Foreign residents who have not acquired Korean nationality are largely composed of foreign workers (395,175, 24.0%), foreign nationals of Korean descent (368,581, 22.3%), marriage immigrants (174,632, 10.6%), students (156,607, 9.5%), and other foreigners (554,972, 33.6%). The sex ratio is 121.9, with males outnumbering females. The majority are from China (31.7%), Vietnam (12.1%), and China (11.7%), followed by Thailand, Uzbekistan, the USA, and the Philippines. In terms of duration of stay, 38.7% have resided in Korea for more than five years, specifically 5 to less than 10 years (23.4%), 3 to less than 4 years (17.0%), and 2 to less than 3 years (16.0%).

By age, those in their 30s are the largest group, numbering 465,707 (28.2%). Among foreign workers and marriage immigrants, those in their 30s make up the highest proportion, 37.8% and 39.7% respectively, while those of foreign nationality of Korean descent aged

60 and above represent 25.3%. This is interpreted as a result of the possibility of long-term residence under the Visit-Employment System or Overseas Korean status, and the aging of the population that began migrating since the 1980s.

1.3. Healthy immigrant effects

The most widely known phenomenon related to the health of immigrants is the 'Healthy immigrant effect.' Immigrants experience physical and mental stress due to cultural acculturation during the process of leaving their home country and settling in the destination country(6). After settling, they often engage in low-wage physical labor. These conditions generally have a negative impact on an individual's health. However, because the group of immigrants consists of individuals who are healthy enough to endure the migration process, they show a better health status than the existing residents despite the adverse conditions, and this is referred to as the Healthy immigrant effect. The effect diminishes as the duration of the stay increases, and after about five years, the health status of immigrants tends to align with that of the Korean population (duration effect).

On the other hand, in Israel, which encourages the return of overseas residents, a 'Sick immigrant effect' is observed. Unlike the existing groups of immigrants primarily composed of individuals in their 20s and 30s who are capable of performing physical labor, Israel implements an immigration policy that allows all people of Jewish descent to immigrate without health restrictions. Consequently, immigrants in Israel enter the country with a lower health status than the existing residents and maintain their health through the government's health insurance and socio-economic support. Similarly, in Korea, there are instances of family-reunification immigration where elderly Chinese-Korean parents are invited to settle in Korea, which could lead to the Sick immigrant effect among elderly Chinese-Koreans(7).

1.4. Previous studies

Various studies have been conducted on the health of immigrants in Korea. Notably, these include research on the accessibility of healthcare through the use of medical institutions by immigrants, industrial accidents among immigrant workers, and studies related to childbirth and women's health among marriage immigrants. However, while early international research highlighted the difficulties immigrants face during the migration process as related to several social determinants of health and explored the relationship between migration and various diseases, domestic research on immigrant health has shown less interest in physical health.

Despite this, there are several studies related to chronic diseases. A notable study related to cardiovascular diseases (CVD) is by Provido, et al. (8), who conducted a cohort analysis revealing that Filipino women residing in Korea have higher prevalence rates of obesity and hypertension compared to Korean women. Conversely, studies by Piao, et al (9), Cho, et al (10), and Yoo, et al. (11) found higher prevalence rates of obesity and hypertension among Koreans, while Lee, et al. (12) identified a lower 10-year CVD risk among foreigners, thus confirming the presence of the Healthy Immigrant Effect within the immigrant population in Korea. Additionally, Obiang-Obounou, et al. (13) showed an increase in hypertension prevalence among foreigners as their duration of residence in Korea increased.

The significance of the studies conducted so far lies in confirming the Healthy Immigrant Effect and the duration effect among the domestic immigrant population, and in presenting the prevalence rates of major chronic diseases. However, there are several limitations. First, most studies focus on risk factors for chronic diseases such as obesity, smoking, and regular exercise, and in cases where the outcomes were obesity or hypertension prevalence, they often relied on self-reported surveys rather than objective measures like measured blood pressure. Secondly, there is a higher proportion of cross-sectional studies compared to longitudinal studies, and even in studies using cohort data such as National Health Insurance data, they tend to present trends in prevalence rates over time rather than incidence or hazard ratios. Thirdly, most studies have been conducted on specific immigrant groups such as immigrant workers or marriage immigrants, or have used convenience sampling, leading to issues with the representativeness of the overall immigrant population.

1.5. Objectives of the study

The objectives of this study are to verify the risk of major CVD occurring among immigrants compared to native Koreans by:

(1) Calculating the incidence of major CVD among immigrants residing in Korea,

(2) Comparing the risk of major CVD between immigrants and native Koreans,

(3) Comparing the incidence of major CVD between native Koreans and immigrants' subgroups based on nationality, national income and type of residency status.

2. Materials and methods

2.1. Data collection and participants

2.1.1. Data source

The National Health Insurance Service (NHIS) is the sole provider of medical insurance in South Korea, and all Korean citizens, except those receiving medical aid or medical protection, are required to enroll in the National Health Insurance. The National Health Information Database is a public data source provided by the NHIS, which includes demographic information of the insured, medical usage information, and results of health examinations. This data is available from 2002 to 2021 and can be linked using a unique identifier assigned to each individual. A more detailed description of the NHID is provided elsewhere (14).

NHIS allows foreign residents to enroll in the foreign health insurance if they meet the requirements set by the National Health Insurance Act. The eligibility criteria for foreign health insurance enrollees have changed over time, but generally, they are defined as workers and their dependents who are subject to the national health insurance, and people who have resided in Korea for a certain period or are clearly intending to reside for a long term for reasons such as study. The regulatory criteria for foreign health insurance enrollees as of the index year designated in this paper, 2011, are as follows.

Table 1. Criteria for foreign health insurance enrollment in 2011

Type	Subjetct	Mendatory
The employee	Persons who work at the workplace where the national health insurance covered Persons employed or appointed as public officials, teachers or school staff members of private school	O
Self-employed	Those who have resided in the country for more than 3 months, or possess one of the following visas - Studying, training, reporting, etc. (D-1 ~ D-9) - Teaching, research, etc. (E-1 ~ E-10) - Residency (F-1 ~ F-5) - Employment (H-1 ~ H-2)	X

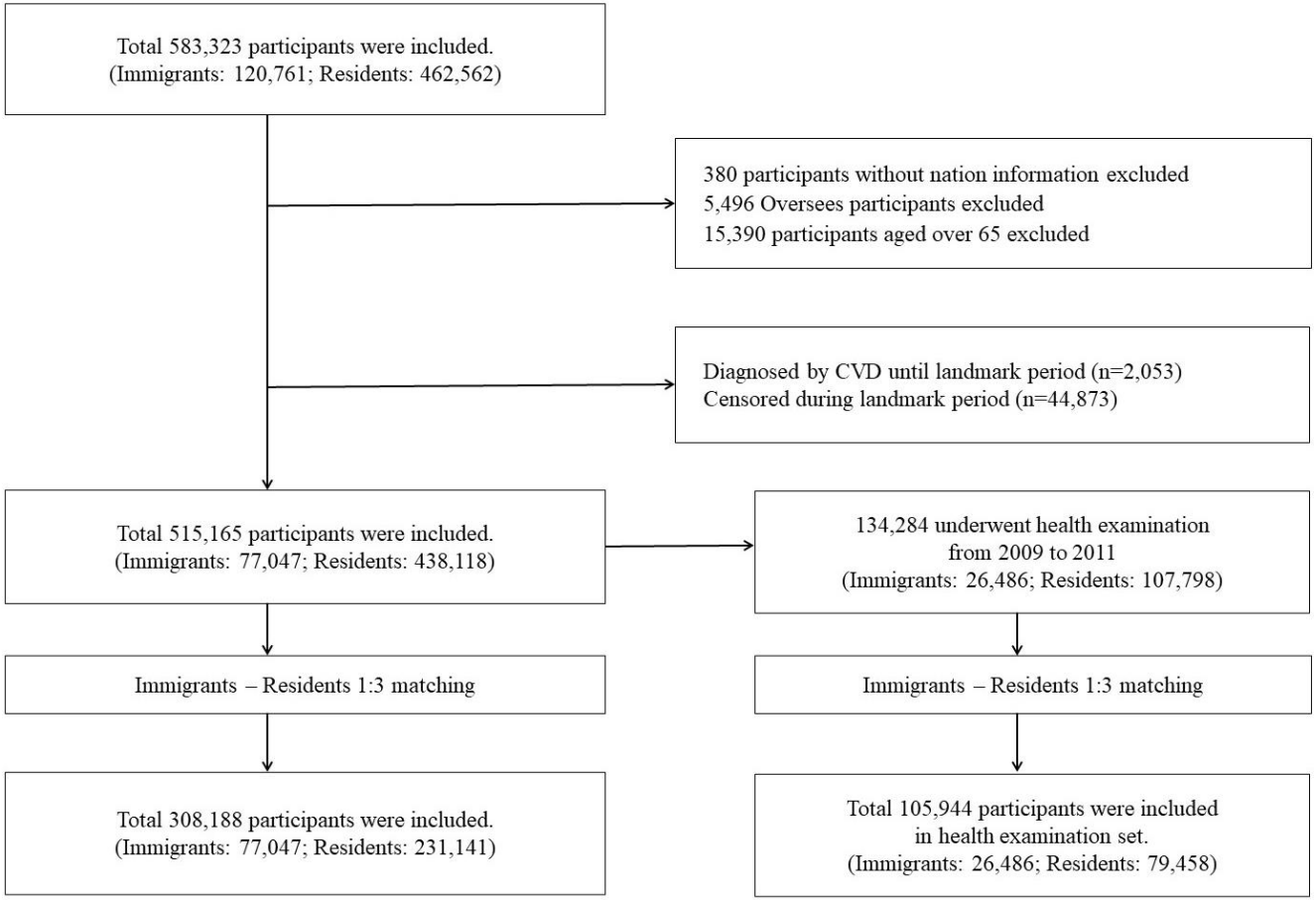
2.1.2. Study population

The study population consists of 126,761 adults aged 20 and above who were enrolled in foreign health insurance in 2011, and 462,562 Koreans enrolled in health insurance in the same year were selected as the control group. Among them, 380 individuals without nationality data, 5,496 individuals who had lost Korean nationality due to emigration or other reasons, and 15,390 individuals who were over 65 years old were excluded from the analysis. After applying a 2-year landmark to the remaining individuals, 2,053 individuals who developed CVD during the landmark period and 44,873 individuals who dropped out of follow-up were excluded. Consequently, a total of 515,165 individuals (77,047 foreigners and 438,118 Koreans) remained.

To construct the initial data set for incidence calculation and survival analysis, immigrants and Koreans were matched by gender and age in a 1:3 ratio, including a total of 308,188 individuals (immigrants: 77,047; Koreans: 231,141). Next, from the original 515,165 individuals, those who had undergone health check-ups were selected to form the health examination data set. From 134,284 individuals (immigrants: 26,486; Koreans: 107,798) who had received health check-ups between 2009 and 2011, immigrants and Koreans were matched by gender and age in a 1:3 ratio, resulting in 105,944 individuals being included in the health examination data set. Due to demographic composition issues, a 5-year bandwidth was set for age matching in the health examination data set (Figure 1).

.

Figure 1. Flow chart of the eligible participants selection



2.2. Measurements

2.2.1. Variables for immigrants

To analyze the characteristics of foreigners, variables of nationality and residency status were used. Nationality was determined based on the information provided by the foreigners at the time of their health insurance registration, using the values recorded in the 2011 eligibility data. If a nationality no longer existed in 2011 due to changes such as country name changes, it was updated to the new nationality. The final nationalities identified were classified using two categories: geographical location and the economic status of the country in 2011. Residency status was also determined using the values recorded in the 2011 eligibility data provided at the time of foreign health insurance registration.

2.2.2. Nationality

Typically, geographical classification of countries uses standards such as the World Bank Classification or the World Health Organization's division. However, since the subjects of this study are predominantly concentrated in Asia, using the above classifications might make it difficult to discern differences among Asian groups. Therefore, considering the specificity of the data, the geographical classification used was based on the criteria of the Ministry of Foreign Affairs of the Republic of Korea, which has a detailed division of Asian groups (Table 2). Countries not recognized by the Ministry or not included in a specific classification were categorized as 'ETC'. However, as an exception, nationals from Hong Kong (46 individuals) were included in Northeast Asia. Additionally, groups with fewer than 1,000 people (Europe, Latin America, Middle East, Africa) were merged into the 'ETC' category. The final geographical classifications were Northeast Asia, Southeast Asia, South West Asia-Pacific, Russia Central Asia, North America, and ETC (Table 3).

Table 2. Nation classification by Korean institutions

Institution name	Classification
World Bank Classification	East Asia-Pacific, Europe-Central Asia, Latin America-Caribbean, Middle East-North Africa, North America, South Asia, Sub-Saharan Africa
World Health Organization	Africa, Americas, South-East Asia, Europe, Eastern Mediterranean, Western Pacific
Ministry of Justice	Asia, North America, South America, Europe, Oceania, Africa, Others
Ministry of Foreign Affairs	Northeast Asia, Southeast Asia, Southwest Asia-Pacific, North America, Latin America, Russia-Central Asia, Europe, Middle East-North Africa, Sub-Saharan Africa

Table 3. Nation classification used in this study

Classification	Nations
Northeast Asia	China, Japan, Mongolia, Hongkong, Taipei
South-east Asia	Vietnam, Philippines, Malaysia, Myanmar, Thailand, etc.
South-west Asia & Pacific	India, Pakistan, Nepal, Sri Lanka, etc.
Russia & Central Asia	Russia, Uzbekistan, Kyrgyzstan, etc.
North America	United States and Canada
ETC	Bahama, Guineabisson, Gabon, etc.

2.2.3. National income

The classification based on the income of countries was made using data provided by the World Bank Classification. In 2011, the World Bank classified countries into four groups based on GNI per capita: High income (>$12,475), Upper Middle income ($4,036–$12,475), Lower Middle income ($1,026–$4,035), and Low income (≤$1,025). Countries with a population of less than 30,000 or lacking data in the World Bank were categorized as ETC (Table 4).

Table 4. National income classification used in this study

Classification	Nations
High	Japan, Hong Kong, Germany, the United States, Canada, etc.
Upper middle	Russia, China, Malaysia, Maldives, etc.
Lower middle	Mongolia, the Philippines, Uzbekistan, India, etc.
Low	Nepal, Tanzania, Afghanistan, Cambodia, etc.
ETC	Togo, Guineabisson, etc.

2.2.4. Status of stay

Residency status consists of 8 major categories and 38 subcategories, ranging from Diplomatic (A-1) to Visit-Employment (H-2). The Ministry of Public Administration and Security's 'Status of Foreign Residents' classifies residency status into foreign workers, marriage immigrants, students, compatriots by nationality, and other foreigners. In contrast, the Ministry of Justice's 'Annual Report on Immigration and Foreigner Policy Statistics' distinguishes between foreign workers with employment qualifications, marriage immigrants, students, and compatriots by nationality (Table 5). The main difference between the two classifications is whether Short-term Employment (C-4) and Visit-Employment (H-2) are included as foreign workers. In this study, we followed the classification of the Ministry of Public Administration and Security, but included Visit-Employment (H-2) in the foreign workers category, considering that it only allows simple labor. For marriage immigrants, since the Marriage Migration (F-6) visa was introduced in 2011, and before that, a Residence (F-2) visa was issued, we used the Residence (F-1 to F-3) category instead of the marriage immigrant category. Permanent residents (F-5) were

also analyzed separately. The final residency statuses were classified into six categories: foreign workers (E-1 to E-7, E-9 to E-10, H-2), Compatriots (F-4), residence (F-1 to F-3), permanent (F-5), students (D-2, D-4), and ETC (Table 6).

Table 5. Comparison of immigrants' subgroup definition

	Ministry of the Interior and Safety	Ministry of Justice
Immigrants Workers	E-1~E-7, E~9~E-10	C-4, E-1~E-7, E-9~E-10, H-2
Marriage immigrants	Individuals who are or have been married to a citizen	F-2-1, F-5-2, F-6-1, F-6-2, F-6-3
International students	D-2, D-4	D-2, D-4
Compatriots	F-4	F-4, H-2
ETC		Others

Table 6. Definition of status of stay

Status of stay	Visa
Immigrants Workers	E-1~E-7, E~9~E-10, H-2
Family relations	F-1~F-3
Permanent Residuals	F-5
International students	D-2, D-4
Compatriots	F-4
ETC	Others

2.2.5. Cardiovascular disease

The occurrence of CVD was determined using the primary ICD-10 codes, specifically for myocardial infarction (MI) (I21-I23), ischemic heart disease (IHD) (I20-I25), and stroke (I60-I64). Additionally, to prevent overestimation of CVD incidence, the analysis was limited to hospitalized patients only. The total occurrence of CVD was defined as having any one of MI, IHD, or stroke. Cases where the date of disease onset and death were the same were considered as instances of the disease occurring. The follow-up period for disease occurrence was calculated from the index date of January 1, 2011, until the date each disease occurred. The follow-up duration was calculated separately for each disease,

and if a subject died without contracting a disease, the date of death was considered the end of the follow-up. For those who neither developed a disease nor died, the follow-up was considered to continue until December 31, 2021.

2.2.6. Demographic information

The age of the subjects was used as a continuous variable and was also used as a matching variable along with gender, with a 5-year age range. For incidence calculation, age was standardized by grouping it into 10-year intervals. The health insurance premium level was based on the amount paid to the National Health Insurance Service in 2011 and was initially classified into 20 quantiles, which were then grouped into 7 quantiles including medical aid to be reclassified into three categories: Low, Middle, High. The type of insurance was categorized into three groups: Employee, Self-employed, and Dependents, with medical aids included in the Self-employed group.

Variables related to health habits were selected based on the components of the Framingham risk score (Smoking, DM, HTN, total cholesterol, HDL, BMI). Smoking was classified into smokers and non-smokers. Total cholesterol and HDL, and BMI were used as continuous variables. Hypertension was defined based on health examination results (systolic blood pressure ≥130 or diastolic blood pressure ≥90) or if the primary diagnosis was within the codes I10-I13, I15. Diabetes was defined as having a fasting blood glucose ≥126mm/dL during a health check-up or if the primary diagnosis fell under the codes E10-E14.

2.3. Statistical analysis

2.3.1. Demographic analysis

Table 1 presents the demographic information and characteristics of the foreigners and their matched native Korean control group. Gender and follow-up period are presented as continuous variables in years, with mean and standard deviation. Gender, health insurance premium level, insurance type and pre-diagnosed CVD are presented as numbers and percentages. For foreigners, the number and percentage are also provided for country classification by region, country classification by income, and type of status.

2.3.2. Incidence rate and age standardization

The incidence rate was calculated by dividing the total number of disease occurrences by the total follow-up time, expressed per 100,000 person-years. Incidence rates were calculated separately for males and females and further analyzed by nationality and residency status for foreigners. To reduce the effect of age in comparisons between groups, age standardization was performed. Both direct standardization and indirect standardization using the Standardized Mortality Ratio (SMR) were implemented. In direct standardization, the participants' ages were divided into 10-year intervals, and the matched native Korean population was used as the standard population to adjust and sum the age-specific disease occurrences. In indirect standardization, the native Korean population's rates were used as the standard, and the actual number of CVDs that occurred in the foreign population was divided by the number that would have occurred if they were part of the native Korean population to calculate the SMR.

Various methods are available for calculating confidence intervals for the standardized incidence rates. Commonly used methods include Dobson's matching method (15), Fay and Feuer method based on the gamma distribution (16), Tiwari method, and the Tiwari method based on the beta distribution (17). In this study, due to the presence of groups with very few disease occurrences or small numbers of participants, the Tiwari method based on the gamma distribution was used, which has shown stable confidence intervals even in similar simulation conditions (18). Confidence intervals for SMRs calculated using indirect

standardization were computed using Byar's method when disease occurrences were 10 or more, and directly from the Poisson distribution when fewer than 10 (19). Groups where no disease occurrence was recorded were treated as 'No data' without calculating the incidence rate and confidence interval.

2.3.3. Survival analysis

To reduce selection bias due to differences in follow-up time between immigrants and native Koreans, landmark analysis was used. The landmark period was set to 2 years, and based on the index year of 2011, individuals who dropped out of follow-up due to reasons such as death or who developed CVD between 2011 and 2012 were excluded from the analysis. Subsequently, the remaining subjects were followed for 8 years from 2013 to confirm the occurrence of CVD.

To assess the impact of immigrant status on the occurrence of CVD, survival analysis was conducted. All-cause mortality was considered as a competing risk, using the sub-distribution hazard function suggested by Fine and Gray. This method keeps individuals with competing events in the risk set instead of censoring them, thereby preventing the overestimation of incidence rates that may occur in traditional survival analysis results that do not account for competing risks. The violation of the proportional hazard assumption was checked through visual inspection of the cumulative incidence graph.

All analyses were performed using SAS version 9.4 (SAS Institute Inc, Cary, NC) and R version 4.2.2 (The R Foundation for Statistical Computing, Vienna, Austria). The ‘PHEindicatormethods’(20) and ‘asht’(21) packages were used for calculating confidence intervals for incidence, while the ‘survival’(22) and ‘cmprsk’(23) packages were utilized for survival analysis. All analyses employed a two-sided test, and confidence intervals were calculated at the 95% level.

3. Results

3.1. Baseline characteristics

A total of 385,235 individuals were selected as the final subjects for analysis, including 77,047 immigrants and 231,141 native Koreans matched by age and gender at a 3:1 ratio. The average age of the subjects was 36.9 years. The follow-up period was shorter for immigrants, averaging 5.8 years, compared to 7.9 years for native Koreans. In both the immigrant and native Korean groups, males comprised 55.6% of the population. Regarding health insurance premium levels, immigrants generally had lower economic incomes, with 43.0% in the Low category, 42.0% in the Middle, and 12.7% in the High, compared to 24.3% Low, 35.3% Middle, and 37.1% High among native Koreans. Among the immigrants, 58.9% were employed, while only 15.7% were dependents. For native Koreans, although the highest percentage was also among the employed at 38.5%, the percentages of dependents and self-employed were also significant at 27.7% and 33.8% respectively. The incidence of CVD was generally lower among immigrants than native Koreans (Table 7).

Approximately 48.2% of the immigrants were of Northeast Asian nationality, followed by Southeast Asia (27.7%). When classified by the income level of their countries, the most common was Upper middle (45.7%), followed by Lower middle (31.1%). In terms of residency status, 52.2% of the immigrants were immigrant workers, with the next largest category family relations (28.5%).

Table 7. Baseline characteristics for participants (n=308,188)

Variables	Immigrants (n= 77,047)	Native Korean (n= 231,141)
Age	36.9 ± 11.1	36.9 ± 11.1
Follow-up years (Mean)	5.8 ± 2.7	7.9 ± 0.7
Sex		
Men	42,857 (55.6)	128,571 (55.6)
Women	34,190 (44.4)	102,570 (44.4)
Insurance Premium level		
No data	1,818 (2.4)	7,695 (3.3)
Low	33,100 (43.0)	56,232 (24.3)
Middle	32,342 (42.0)	81,688 (35.3)
High	9,787 (12.7)	85,526 (37.1)
Type of Insurance		
Self employed	19,549 (25.4)	78,076 (33.8)
The employee	45,377 (58.9)	89,071 (38.5)
Dependents	12,121 (15.7)	63,994 (27.7)
Newly diagnosed disease		
All Cardiovascular diseases	714 (0.9)	2,487 (1.1)
Myocardial infarction	105 (0.1)	391 (0.2)
Ischemic heart disease	331 (0.4)	1,187 (0.6)
Stroke	384 (0.5)	1,201 (0.5)
Nationality		
North-East Asia	37,113 (48.2)	
South-East Asia	21,320 (27.7)	
South-West Asia and Oceania	7,015 (9.1)	
North America	6,146 (8.0)	
Russia and Central Asia	3,168 (4.1)	
ETC	2,285 (3.0)	
National group by income		
High	11,625 (15.1)	
Upper middle	35,228 (45.7)	
Lower middle	23,935 (31.1)	
Low	5,309 (6.9)	
ETC	950 (1.2)	
Type of stay		
Immigrant workers	40,218 (52.2)	
Compatriots	6,340 (8.2)	
Family relations	21,964 (28.5)	
Permanent Residents	3,225 (4.2)	
International students	1,670 (2.2)	
ETC	3,630 (4.7)	

The characteristics of immigrants classified by nationality are presented in Table 8. The age was youngest in the following order: ETC, South-East Asia, South-West Asia and Oceania, Russia and Central Asia, North America, and North-East Asia. The follow-up period was the shortest in South-East Asia at 4.8 years, and the longest in North-East Asia at 6.6 years. The gender ratio also varied significantly by country, with South-West Asia and Oceania having the highest proportion of males at 92.1%, and North-East Asia having the lowest proportion of males at 45.1%. The insurance premium level was mostly in the Low group; however, the Middle group was the largest in North-East Asia (46.2%), and North America was predominantly in the Middle (47.2%) and High (43.0%) groups. Regarding insurance type, most were classified as The employee. The incidence of CVD varied by country, with North-East Asia having the highest incidence at 570 cases (1.5%), and South-East Asia having the lowest incidence at 25 cases (0.1%) (Table 8).

When reclassified by national income, another immigrant classification criterion, North-East Asia was mostly in the Upper middle category, South-East Asia and Central Asia in the Lower middle category, and South-West Asia in the Lower middle and Low categories. North America was entirely in the High category. When classified by status of stay, immigrant workers were the most numerous, followed by Family relations. However, in the case of North America, the highest proportion was Compatriots at 54.6%.

Table 8. Baseline characteristics by immigrants' subgroup

Variables	North-East Asia (n=37,113)	South-East Asia (n=21,320)	Russia and Central Asia (n=3,168)	South-West Asia and Oceania (n=7,015)	North America (n=6,146)	ETC (n=2,285)
Age	42.4 ±10.9	29.1 ± 6.0	33.8 ± 8.2	31.5 ± 6.1	39.7 ± 12.2	24.8 ± 10.1
Follow-up years (mean)	6.6 ± 2.4	4.8 ± 2.7	5.0 ± 2.8	4.9 ± 2.7	5.8 ± 2.8	5.2 ± 2.8
Sex						
Male	16,750 (45.1)	12,548 (58.9)	2,194 (69.3)	6,458 (92.1)	3,297 (53.6)	1,610 (70.5)
Female	20,363 (54.9)	8,772 (41.1)	974 (30.7)	557 (7.9)	2,849 (46.4)	675 (29.5)
Insurance Premium level						
No data	1,081 (2.9)	349 (1.6)	72 (2.3)	105 (1.5)	142 (2.3)	69 (3.0)
Low	14,797 (39.9)	11,270 (52.9)	1,613 (50.9)	4,224 (60.2)	464 (7.6)	732 (32.0)
Middle	17,144 (46.2)	7,847 (36.8)	1,199 (37.9)	2,231 (31.8)	2,898 (47.2)	1,023 (44.8)
High	4,091 (11.0)	1,854 (8.7)	284 (9.0)	455 (6.5)	2,642 (43.0)	461 (20.2)
Type of insurance						
Self employed	13,111 (35.3)	4,078 (19.1)	377 (11.9)	374 (5.3)	1,258 (20.5)	351 (15.4)
The employee	16,999 (45.8)	14,270 (66.9)	2,477 (78.2)	6,407 (91.3)	3,501 (57.0)	1,723 (75.4)
Dependents	7,003 (18.9)	2,972 (13.9)	314 (9.9)	234 (3.3)	1,387 (22.6)	211 (9.2)
Newly diagnosed disease						

All CVD	570 (1.5)	25 (0.1)	25 (0.8)	21 (0.3)	60 (1.0)	13 (0.6)
Myocardial infarction	66 (0.2)	3 (0.01)	7 (0.2)	13 (0.2)	12 (0.2)	4 (0.2)
Ischemic heart disease	236 (0.6)	12 (0.1)	17 (0.5)	19 (0.3)	40 (0.7)	7 (0.3)
Stroke	335 (0.9)	13 (0.1)	8 (0.3)	2 (0.5)	20 (0.3)	6 (0.3)
National income						
High	4,183 (36.0)	15 (0.1)	-	499 (7.1)	6,146 (100.0)	782 (34.2)
Upper middle	31,871 (85.9)	2,425 (11.4)	562 (17.7)	-	-	370 (16.2)
Lower middle	1,059 (2.9)	16,742 (78.5)	2,409 (76.0)	3,571 (50.9)	-	154 (6.7)
Low	-	2,138 (10.0)	197 (6.2)	2,945 (42.0)	-	29 (1.3)
ETC	-	-	-	-	-	950 (41.6)
Status of stay						
Immigrant workers	16,208 (43.7)	12,751 (59.8)	2,239 (70.7)	5,728 (81.6)	1,937 (31.5)	1,355 (59.3)
Compatriots	2,412 (6.5)	4 (0.02)	93 (2.9)	299 (4.3)	3,353 (54.6)	179 (7.8)
Family relations	12,584 (33.9)	7,390 (34.7)	579 (18.3)	452 (6.4)	5847 (9.5)	375 (16.4)
Permanent Residents	3,018 (8.1)	65 (0.3)	52 (1.6)	6 (0.1)	60 (1.0)	24 (1.1)
International students	1,345 (3.6)	96 (0.4)	29 (0.9)	82 (1.2)	59 (1.0)	59 (2.6)
ETC	1,546 (4.2)	1,014 (4.8)	176 (5.6)	448 (6.4)	153 (2.5)	293 (12.8)

3.2. CVD incidence rate in immigrants and native Koreans

From 2011 to 2020, a total of 714 cases of CVD diagnoses occurred in the immigrant group. In crude incidence, the rate of CVD occurrence in the immigrant group was higher for all diseases compared to the native Korean group. When age was standardized using the direct standardization method, the values decreased compared to the crude incidence, but the rates for all CVDs and stroke, remained statistically significantly higher in immigrants compared to native Koreans. This trend was also observed when the analysis was limited to males. However, when the analysis was limited to females, the incidence rates for all CVDs, MI, IHD, and stroke increased but were not statistically significant (Table 9).

Table 9. Crude and age-standardized incidence rate of major cardiovascular diseases

	Native Korean	Immigrants		
	Crude incidence (95% CI)	Crude incidence (95% CI)	DSR (95% CI)	SIR (95% CI)
Total				
All CVD	136.1 (130.8 - 141.6)	160.1 (148.6 - 172.3)	145.1 (134.6 - 156.2)	1.08 (1.00 - 1.16)
MI	21.3 (19.3 - 23.5)	23.4 (19.2 - 28.4)	21.5 (17.6 - 26.1)	1.00 (0.82 - 1.21)
IHD	70.3 (66.5 - 74.2)	74.0 (66.3 - 82.4)	67.3 (60.2 – 75.0)	0.96 (0.86 - 1.07)
Stroke	65.6 (61.9 - 69.4)	85.9 (77.5 - 94.9)	77.5 (70 - 85.7)	1.21 (1.09 - 1.33)
Male				
All CVD	175.3 (167.2 - 183.6)	211.2 (193.1 - 230.4)	187.9 (171.7 - 205.2)	1.09 (1.00 - 1.19)
MI	34.3 (30.8 - 38.1)	38.0 (30.6 - 46.6)	34.7 (27.9 - 42.7)	0.99 (0.80 - 1.21)
IHD	94.6 (88.7 - 100.8)	97.9 (85.7 - 111.3)	87.8 (76.8 - 99.9)	0.93 (0.82 - 1.06)
Storke	80.2 (74.8 - 85.9)	113.0 (99.9 - 127.3)	99.7 (88.1 - 112.5)	1.28 (1.13 - 1.44)
Female				
All CVD	87.3 (81.0 – 94.0)	101.6 (88.4 - 116.3)	94.9 (82.5 - 108.7)	1.09 (0.95 - 1.24)
MI	5.1 (3.7 – 7.0)	6.7 (3.7 - 11.3)	6.1 (3.4 - 10.4)	1.21 (0.66 - 2.03)
IHD	40 (35.8 - 44.6)	46.6 (37.8 - 56.9)	43.3 (35.1 - 52.9)	1.08 (0.88 - 1.32)
Stroke	47.3 (42.7 - 52.3)	54.8 (45.2 - 65.8)	51.3 (42.3 - 61.7)	1.09 (0.90 - 1.30)

*CI: confidence interval; CVD: cardiovascular disease; DSR: direct standardized rate; IHD: ischemic heart disease; MI: myocardial infarction; SIR: standardized incidence ratio

*per 100,000 person-years

3.3. Survival analysis for CVD incidence in immigrants and native Koreans

The cumulative incidence of all CVDs and each CVD among native Koreans and immigrants was plotted using the Kaplan-Meier method (Figure 2). The incidence of all CVDs, MI, IHD, and stroke were higher among immigrants compared to native Koreans. In particular, the differences in the incidence probabilities for all CVDs ($p<0.01$) and stroke ($p<0.01$) were statistically significant according to the log-rank test results.

To compare the risk of all CVDs and each CVD between immigrants and native Koreans, the sub-distributional hazard ratio was calculated (Table 10). Model 1 includes only gender and age matching without adjusting for other variables, while Model 2 adjusts for gender and age matching, as well as health insurance type and income level. Survival analysis results showed that the risk of CVD incidence increased for all CVDs (Hazard Ratio [HR] 1.18, 95% Confidence Interval [CI] 1.08-1.29), MI (HR 1.14, 95% CI 0.91-1.43), IHD (HR 1.11, 95% CI 0.98-1.26), and stroke (HR 1.25, 95% CI 1.11-1.41) among immigrants, with the differences being statistically significant for all CVDs and stroke.

The proportional hazard assumption was visually confirmed to be valid using the Kaplan-Meier plot, and the additional ZPH test also confirmed that there were no issues with the proportional hazard assumption.

Figure 2. Cumulative incidence of major cardiovascular diseases in immigrants and native Koreans

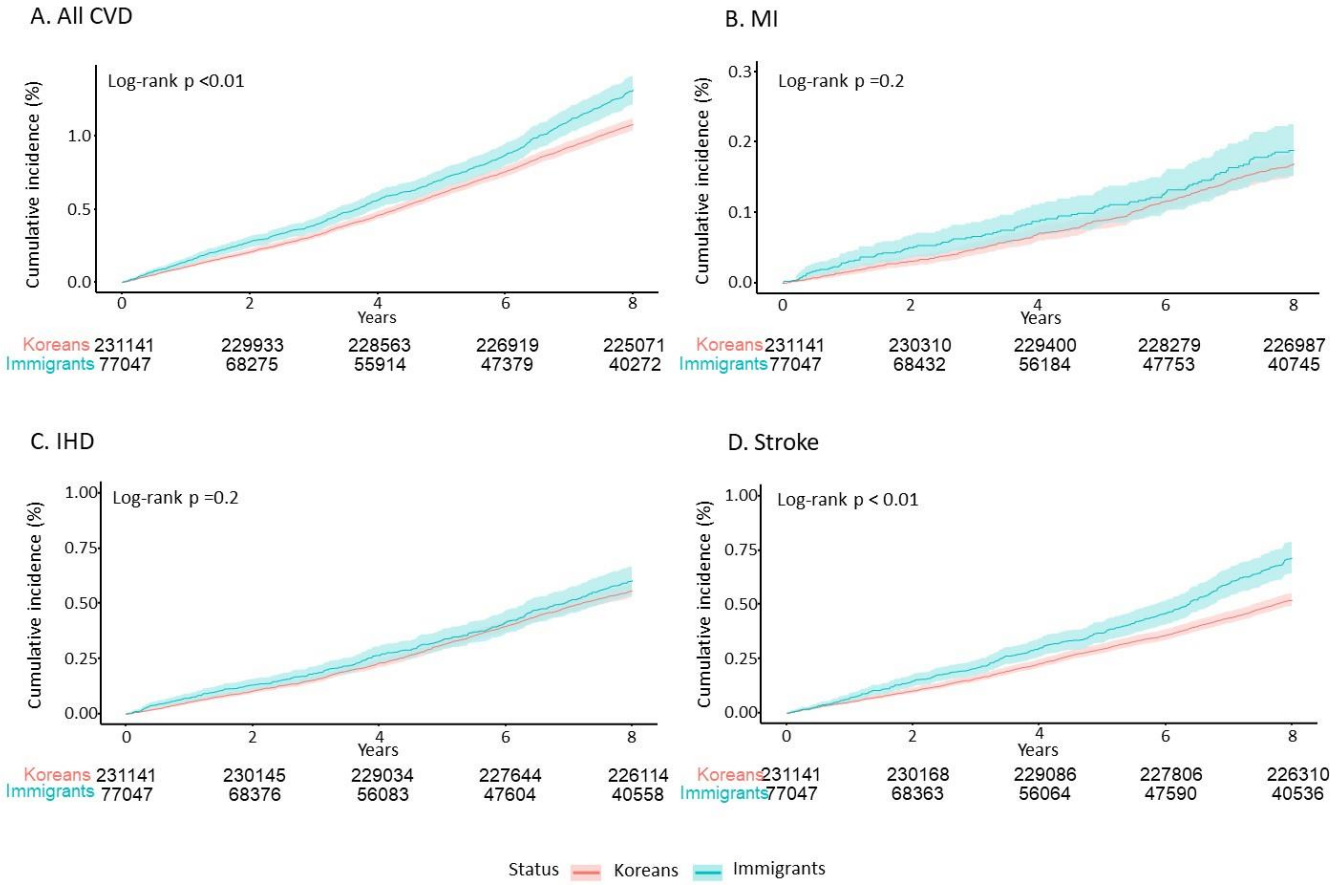


Table 10. Major cardiovascular disease risk in immigrants and native Koreans

Outcomes	No. of events	Observed person-years	Hazard ratio (95% confidence interval)	
			Model 1	Model 2
All cardiovascular disease				
Native Korean	2,487	1,827,393	Reference	Reference
Immigrants	714	445,887	1.22 (1.12-1.33)	1.18 (1.08-1.29)
Myocardial infarction				
Native Korean	391	1,834,490	Reference	Reference
Immigrants	105	447,909	1.14 (0.92-1.41)	1.14 (0.91-1.43)
Ischemic heart disease				
Native Korean	1,287	1,831,272	Reference	Reference
Immigrants	331	447,128	1.09 (0.97-1.23)	1.11 (0.98-1.26)
Stroke				
Native Korean	1,201	1,831,913	Reference	Reference
Immigrants	384	447,024	1.36 (1.21-1.53)	1.25 (1.11-1.41)

*Model1 matched by age and sex, model2 additionally adjusted by insurance premium level and insurance type.

3.4. Immigrants' subgroup analysis

To examine the differences in CVD incidence among subgroups of immigrants, the subgroups were divided by nationality, national income, and status of stay. The CVD incidence was calculated, and survival analysis for all CVDs was conducted. Each subgroup comparison used native Koreans matched to the subgroup participants as the reference.

3.4.1. CVD Incidence rate by subgroups

First, when dividing immigrants into subgroups based on nationality, the incidence rates of all CVDs in North-East Asia (SIR 1.18, 95% CI 1.08-1.28) and Russia and Central Asia (SIR 1.85, 95% CI 1.19-2.73) were higher than those of native Koreans (Table 11). On the other hand, in South-East Asia, the incidence rates of all CVDs (SIR 0.51, 95% CI 0.33-0.75), were lower than those of native Koreans. When divided by national income, most results were not statistically significant. However, in the upper middle group, the incidence rate of all CVDs (SIR 1.16, 95% CI 1.07-1.27) was higher than those of native Koreans. Finally, when divided by status of stay, all the results were not statistically significant.

Table 11. Crude and age-standardized incidence of all cardiovascular diseases in immigrants' subgroups

Diseases	Matched Koreans	Immigrants		
	Crude (95% CI)	Crude (95% CI)	DSR (95% CI)	SIR (95% CI)
Nationality				
North-East Asia	197.9 (188.4 – 207.7)	232.6 (213.9 - 252.5)	232.7 (214 - 252.7)	1.18 (1.08 - 1.28)
South-East Asia	47.8 (42.1 – 54.1)	24.3 (15.7 - 35.8)	23.2 (14.9 - 34.4)	0.51 (0.33 - 0.75)
South-West Asia and Oceania	74.7 (62.3 – 88.9)	61.1 (37.8 - 93.4)	63.0 (38.9 - 96.5)	0.86 (0.53 - 1.31)
North America	191.4 (170.6 – 213.9)	169.2 (129.1 - 217.8)	168.5 (128.3 - 217.4)	0.86 (0.66 - 1.11)
Russia and Central Asia	81.3 (62.3 – 104.2)	156.9 (101.5 - 231.7)	141.3 (90.9 - 209.4)	1.85 (1.19 - 2.73)
ETC	154.7 (123.4 – 191.6)	108.6 (57.8 - 185.7)	99.5 (52.8 - 171.6)	0.67 (0.36 - 1.15)
National group by income				
High	186.8 (172.1 – 202.4)	157.1 (129.4 - 189)	158.0 (130.1 - 190.3)	0.84 (0.69 - 1.01)
Upper middle	194.5 (184.8 – 204.6)	228.2 (209.1 - 248.7)	225.6 (206.6 - 245.8)	1.16 (1.07 - 1.27)
Lower middle	49.6 (44.2 – 55.6)	51.1 (38.8 - 66.0)	48.5 (36.7 - 62.9)	1.02 (0.77 - 1.32)
Low	67.6 (53.6 – 84.2)	56.1 (31.4 - 92.5)	57.8 (32.2 - 95.7)	0.89 (0.50 - 1.47)
ETC	99.7 (61.7 – 152.4)	117.5 (43.1 - 255.6)	94.5 (32.7 - 215.2)	0.96 (0.35 - 2.09)
Type of stay				
Immigrant workers	143.3 (135.7 – 151.3)	172.0 (155.1 - 190.3)	147.7 (133.1 - 163.6)	1.06 (0.96 - 1.17)
Compatriots	203.7 (180.0 – 229.6)	219.6 (176.8 - 269.6)	223.7 (180.0 - 274.6)	1.10 (0.88 - 1.35)
Family relations	99.1 (91.2 – 107.5)	108.5 (91.5 - 127.8)	104.0 (87.6 - 122.5)	1.05 (0.88 - 1.23)
Permanent residents	181.8 (152.3 – 215.3)	208.0 (153.9 - 275)	217.7 (161.0 - 287.8)	1.21 (0.90 - 1.60)
International students	133.3 (92.9 – 185.5)	171.7 (101.7 - 271.3)	144.9 (85.0 - 232.2)	1.12 (0.66 - 1.77)
ETC	168.3 (142.5 – 197.4)	184.5 (129.9 - 254.4)	160.2 (112.4 - 222.1)	1.06 (0.74 - 1.46)

3.4.2. Survival analysis by subgroups

The cumulative incidence of all CVDs was presented using the Kaplan-Meier method in figures, categorized by the nationality (Figure 3), national income (Figure 4), and type of status of immigrants (Figure 5). When classified by nationality, the incidence rates were highest in the order of North-East Asia, North America, Central Asia, ETC, South-West Asia, and South-East Asia. In terms of national income, there was some overlap, but the incidence rates were highest in the Upper Middle, High, and ETC groups, while the Lower Middle and Low groups had similar rates. Lastly, by type of status, the incidence rate was highest among compatriots and lowest among those with family relations and family relations.

The sub-distribution hazard ratio was calculated using native Koreans matched to each subgroup as the reference (Table 12). Model 1 matched only by age and gender without adjusting for other variables, while Model 2 additionally adjusted for insurance type and premium level.

In the nationality classification, the risk of all CVD incidence was higher in North-East Asia (HR 1.66, 95% CI 1.51-1.83) and North America (HR 1.35, 95% CI 1.04-1.74) compared to native Koreans. Conversely, the risk of all CVD incidence was lower in South-East Asia (HR 0.18, 95% CI 0.12-0.27) and South-West Asia and Oceania (HR 0.49, 95% CI 0.32-0.75) than in native Koreans. When classified by national income, the risk of all CVD incidence was higher in the High (HR 1.21, 95% CI 1.00-1.47), Upper Middle (HR 1.63, 95% CI 1.48-1.80), and ETC (HR 1.30, 95% CI 1.16-1.47) groups compared to native Koreans, whereas it was lower in the Lower Middle (HR 0.40, 95% CI 0.30-0.52) and Low (HR 0.46, 95% CI 0.15-1.44) groups than in native Koreans. Finally, in the classification by type of stay, the risk of all CVD incidence was higher in all groups except international students compared to native Koreans, but it was lower in the family relations group (HR 0.80, 95% CI 0.67-0.94).

Figure 3. Cumulative incidence of all cardiovascular diseases in nationality subgroups

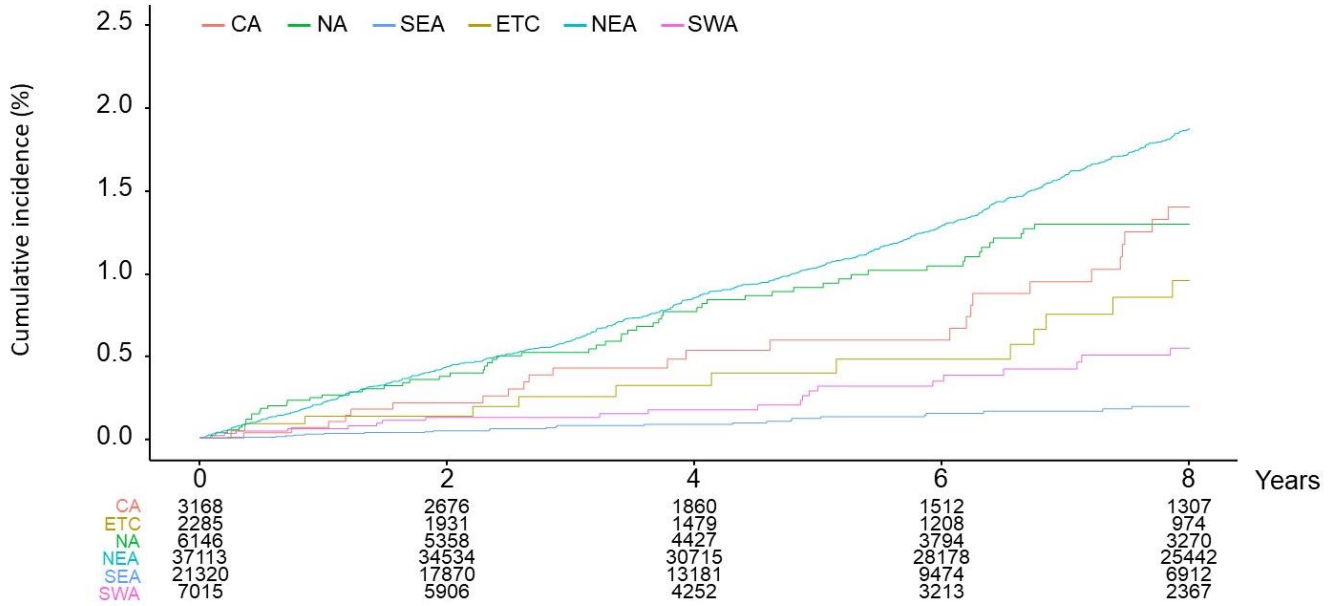


Figure 4. Cumulative incidence of all cardiovascular diseases in national income

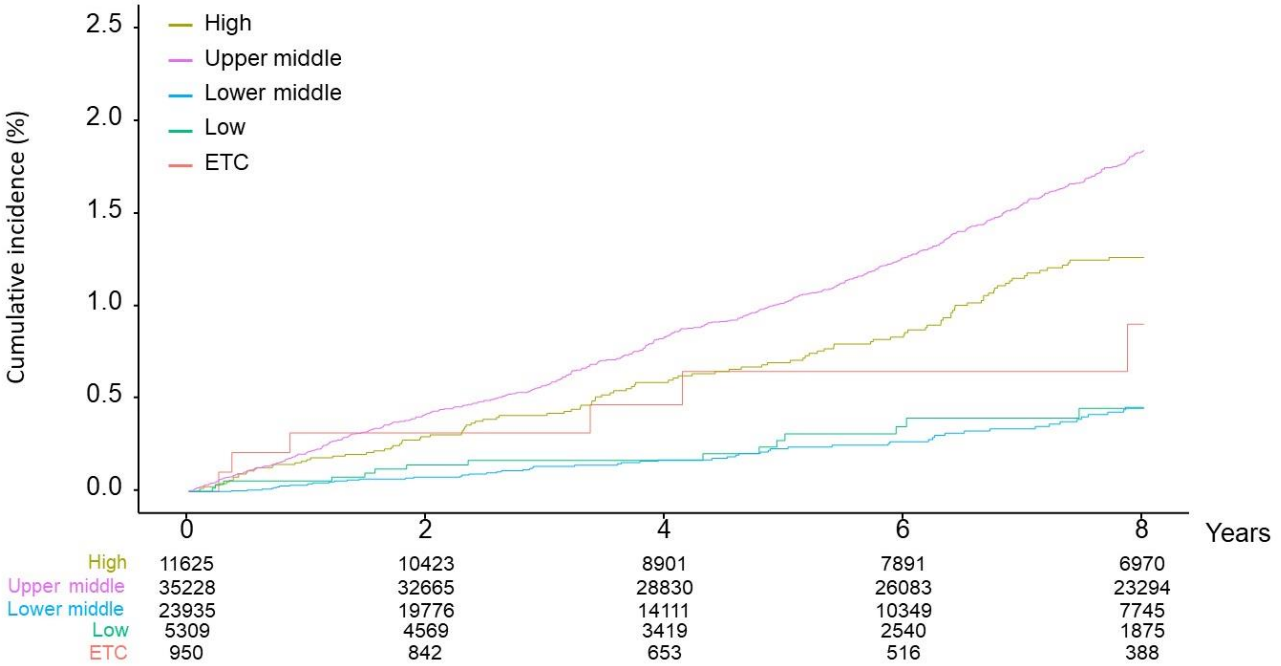


Figure 5. Cumulative incidence of all cardiovascular diseases by status of stay

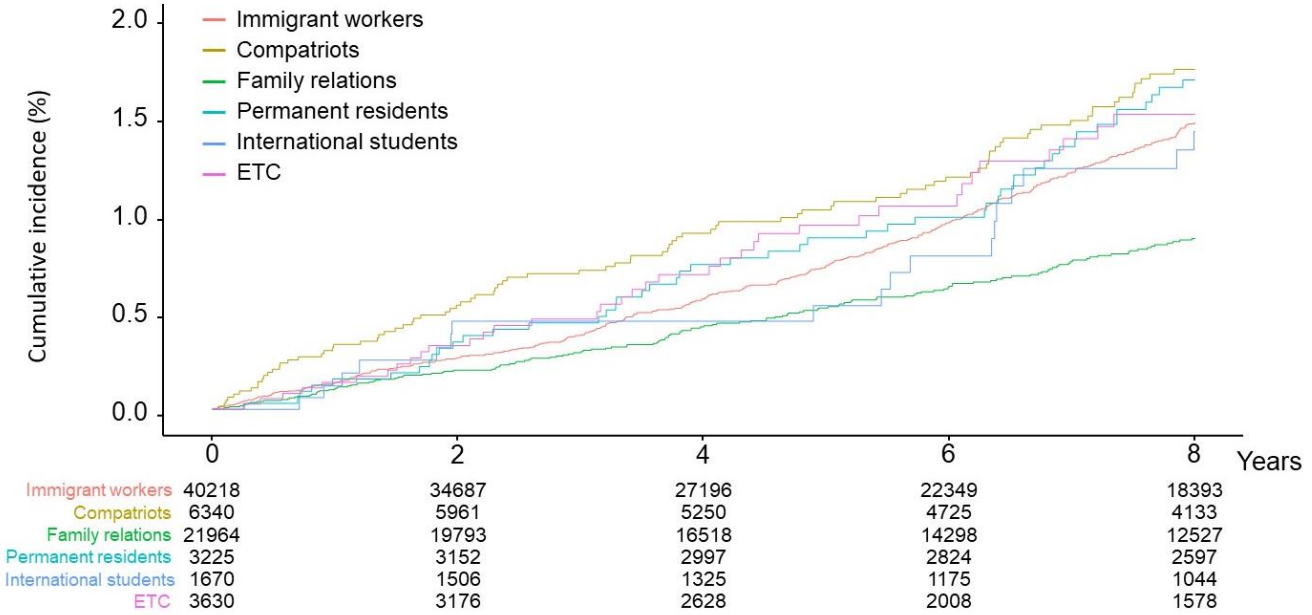


Table 12. All cardiovascular disease risk in immigrants and native Koreans

Diseases	Matched Koreans		Immigrants		Hazard ratio (95% confidence interval)	
	No. of events	Observed person-years	No. of events	Observed person-years	Model 1	Model 2
Nationality						
North-East Asia	1,650	833,620	570	245,097	1.20 (1.09-1.32)	1.15 (1.04-1.27)
South-East Asia	254	531,231	25	103,078	0.58 (0.38-0.86)	0.55 (0.36-0.84)
South-West Asia and Oceania	127	169,983	21	34,355	0.94 (0.60-1.48)	0.88 (0.52-1.49)
North America	310	162,006	60	35,459	0.90 (0.68-1.18)	1.02 (0.77-1.35)
Russia and Central Asia	62	76,265	25	15,930	2.14 (1.35-3.41)	1.83 (1.12-2.99)
ETC	84	54,288	13	11,969	0.76 (0.42-1.35)	0.60 (0.31-1.18)
National group by income						
High	594	317,997	112	71,288	0.86 (0.70-1.05)	0.91 (0.74-1.11)
Upper middle	1,493	767,624	523	229,140	1.20 (1.09-1.32)	1.16 (1.04-1.29)
Lower middle	299	602,401	58	113,608	1.16 (0.88-1.54)	1.10 (0.82-1.47)
Low	80	118,308	15	26,743	0.95 (0.56-1.61)	0.85 (0.44-1.61)
ETC	21	21,064	6	5,108	1.26 (0.53-2.99)	0.62 (0.17-2.22)
Type of stay						
Immigrant workers	1,317	918,939	376	218,588	1.27 (1.13-1.42)	1.39 (1.21-1.60)
Compatriots	268	131,581	91	41,440	1.09 (0.86-1.38)	1.10 (0.86-1.40)
Family relations	582	587,204	143	131,764	1.12 (0.94-1.35)	1.12 (0.92-1.36)
Permanent residents	134	73,700	49	23,559	1.15 (0.83-1.60)	1.07 (0.75-1.54)
International students	35	26,248	18	10,486	1.32 (0.74-2.34)	1.27 (0.71-2.29)
ETC	151	89,721	37	20,050	1.16 (0.81-1.66)	1.40 (0.96-2.04)

*Model1 matched by age and sex, model2 additionally adjusted by insurance premium level and insurance type.

3.5. Survival analysis for CVD incidence in immigrants and native Koreans undergone health examination

3.5.1. Baseline characteristics

A total of 82,304 individuals (26,486 immigrants and 79,458 native Koreans) were included in the health examination dataset (Table 13). The average age was 37.1 years, and 71.4% were male. The average follow-up time was 5.5 years for immigrants and 8.0 years for native Koreans. During the follow-up period, there were 239 new CVD cases among immigrants and 975 new cases among native Koreans. The insurance premium brackets for immigrants were mostly Low (47.8%) and Middle (42.3%), whereas for native Koreans, they were primarily Middle (40.1%) and High (37.2%). The majority of both immigrants and native Koreans were employed (immigrants: 84.0%; native Koreans: 71.9%). Among the immigrant subgroups, North-East Asia (39.2%) and South-East Asia (32.0%) were the largest groups. In terms of national income, Upper middle (38.7%) and Lower middle (37.9%) were the most common, and by type of stay, immigrant workers (68.4%) were the most numerous.

Regarding health examination results, native Koreans had higher prevalence rates of lifestyle-related diseases (Hypertension: 16.5%, Diabetes: 6.5%, Dyslipidemia: 6.7%) compared to immigrants (Hypertension: 11.6%, Diabetes: 4.4%, Dyslipidemia: 3.6%) (Table 14). Both total cholesterol and BMI averages were lower in immigrants than in native Koreans. Immigrants also had healthier smoking and drinking habits compared to native Koreans, although the proportion of individuals engaging in regular exercise was higher among native Koreans.

Table 13. Baseline characteristics of participants in health examination data set

Variables	Immigrants (n= 26,486)	Native Koreans (n= 79,458)
Age	37.1 ± 10.4	38.8 ± 9.8
Follow-up Time (Mean)	5.5 ± 2.8	8.0 ±0.5
Sex		
Men	18,899 (71.4)	56,697 (71.4)
Women	7,587 (28.6)	22,761 (28.6)
Insurance Premium level		
No data	267 (1.0)	3,403 (4.3)
Low	12,664 (47.8)	14,690 (18.5)
Middle	11,198 (42.3)	31,812 (40.1)
High	2,357 (8.9)	29,555 (37.2)
Type of Insurance		
Self employed	2,789 (10.5)	13,134 (16.5)
The employee	22,246 (84.0)	57,125 (71.9)
Dependents	1,451 (5.5)	9,199 (11.6)
Newly diagnosed disease		
All CVD	239 (0.9)	975 (1.2)
Myocardial infarction	40 (0.2)	179 (0.2)
Ischemic heart disease	114 (0.4)	542 (0.7)
Stroke	125 (0.5)	435 (0.5)
Nationality		
North-East Asia	10,392 (39.2)	
South-East Asia	8,476 (32.0)	
South-West Asia and Oceania	3,690 (13.9)	
North America	1,815 (6.9)	
Russia and Central Asia	1,319 (5.0)	
ETC	794 (3.0)	
National group by income		
High	3.563 (13.4)	
Upper middle	10,243 (38.7)	
Lower middle	10,029 (37.9)	
Low	2,211 (8.3)	
ETC	440 (1.7)	
Type of stay		
Immigrant workers	18,125 (68.4)	
Compatriots	1,743 (6.6)	
Family relations	3,941 (14.9)	
Permanent Residents	755 (2.9)	
International students	219 (0.8)	
ETC	1,703 (6.4)	

Table 14. Health examination results in immigrants and native Koreans

Variables	Immigrants (n= 26,486)	Native Koreans (n= 79,458)
Hypertension	3,084 (11.6)	13,136 (16.5)
Diabetes	1,170 (4.4)	5,161 (6.5)
Dyslipidemia	939 (3.6)	5,287 (6.7)
Smoking		
Never	17,313 (65.4)	37,797 (47.6)
Ever	1,519 (5.7)	11,374 (14.3)
Current	7,654 (28.9)	30,287 (38.1)
Alcohol consumption		
None	15,271 (57.7)	29,357 (37.0)
1-2 times/week	8,748 (33.0)	38,202 (48.1)
3 times/week	2,467 (9.3)	11,899 (15.0)
Physical exercise		
None	24,732 (93.4)	72,462 (91.2)
Regular	1,754 (6.6)	6,996 (8.8)
Total cholesterol (mg/dL)	187.1 ± 37.3	191.7 ± 36.8
BMI (kg/m^2)	23.0 ± 3.3	23.8 ± 3.4

3.5.2. Survival analysis

The sub-distributional hazard ratios for all CVDs, MI, IHD, and stroke were calculated for immigrants and Koreans through survival analysis (Table 15). In Model 1, only gender and age were matched without adjusting for other variables. Model 2 adjusted for insurance type and insurance premium level in addition to gender and age matching. Model 3 further adjusted for BMI, hypertension, diabetes, dyslipidemia, and total cholesterol in addition to the adjustments in Model 2. Finally, Model 4 included additional adjustments for lifestyle factors such as smoking, drinking, and physical activity.

The analysis results showed that in Model 1, which only matched for age and gender, the risk of incidence increased for all CVDs (HR 1.11, 95% CI 1.04-1.19) and stroke (HR 1.30, 95% CI 1.18-1.43). However, in the final model, Model 4, the risk of disease incidence for immigrants compared to Koreans increased for all CVDs by 1.37 times (95% CI 1.25-1.51), MI by 1.32 times (95% CI 1.09-1.60), IHD by 1.23 times (95% CI 1.10-1.38), and stroke by 1.53 times (95% CI 1.34-1.75).

Table 15. Major cardiovascular disease risk in health examination data set

Diseases	No. of events	Observed person-years	Hazard ratio (95% confidence interval)			
			Model 1	Model 2	Model 3	Model 4
All CVD						
Native Korean	975	629,401	Reference	Reference	Reference	Reference
Immigrants	239	146,098	1.11 (1.04-1.19)	1.16 (1.07-1.27)	1.26 (1.16-1.36)	1.37 (1.25-1.51)
MI						
Native Korean	179	632,036	Reference	Reference	Reference	Reference
Immigrants	40	146,746	1.01 (0.87-1.17)	1.04 (0.87-1.25)	1.16 (0.97-1.38)	1.32 (1.09-1.60)
IHD						
Native Korean	542	630,829	Reference	Reference	Reference	Reference
Immigrants	114	146,497	0.96 (0.88-1.05)	1.04 (0.93-1.17)	1.13 (1.02-1.26)	1.23 (1.10-1.38)
Stroke						
Native Korean	435	631,196	Reference	Reference	Reference	Reference
Immigrants	125	146,492	1.30 (1.18-1.43)	1.30 (1.16-1.47)	1.40 (1.25-1.57)	1.53 (1.34-1.75)

*MI: Myocardial infarction; IHD: Ischemic heart disease
*Model1 matched by age and sex, model2 additionally adjusted by insurance premium level and insurance type, model 3 additionally adjusted by BMI, HTN, DM, total cholesterol, model 4 additionally adjusted by smoking, drinking, physical activity

3.6. Healthcare utilization

There were differences in healthcare utilization between immigrants and native Koreans (Table 16). The average annual number of hospital days for immigrants was 2.4 days, compared to 4.2 days for native Koreans, indicating that native Koreans had longer hospital stays than immigrants. Similarly, the average annual number of outpatient visits was 2.2 times for immigrants and 2.4 times for native Koreans, showing that native Koreans had more outpatient visits than immigrants. However, in the health examination set, although the average annual number of hospital days was longer for native Koreans than for immigrants, as in the initial data set, the average annual number of outpatient visits was higher for immigrants.

We added hospitalization days and outpatient visits to the final models of each data set to check whether healthcare utilization affected the incidence of CVD (Table 17). The analysis results showed that in the initial data set, the results did not change significantly compared to the existing final model, and in the health examination set, the HR increased slightly but showed the same trend as the previous analysis.

Table 16. Healthcare utilization within one year from the index date

Variables	Immigrants	Native Koreans	p-value*
Initial data set			
Hospitalization days	2.4 ± 15.1	4.2 ± 20.0	<0.01
Outpatient visits	2.2 ± 18.3	2.4 ± 21.3	<0.01
Health examination set			
Hospitalization days	2.4 ± 11.6	3.7 ± 17.0	<0.01
Outpatient visits	3.2 ± 21.3	2.5 ± 19.9	<0.01

*p-value was calculated by Wilcoxon signed rank sum test

Table 17. Further adjustments for healthcare utilization to each final model

Variables	Hazard ratio (95% confidence interval)
Initial data set[1]	
All cardiovascular disease	1.23 (1.13-1.34)
Myocardial infarction	1.13 (0.90-1.41)
Ischemic heart disease	1.13 (0.99-1.27)
Stroke	1.33 (1.18-1.50)
Health examination set[2]	
All cardiovascular disease	1.38 (1.25-1.51)
Myocardial infarction	1.66 (1.53-1.81)
Ischemic heart disease	1.53 (1.39-1.67)
Stroke	1.56 (1.43-1.70)

[1]The model was additionally adjusted by hospitalization days and outpatient visits to model 2 in initial data set. The reference group was matched native Koreans.

[2]The model was additionally adjusted by hospitalization days and outpatient visits to model 4 in health examination set. The reference group was matched native Koreans.

4. Discussion

4.1. Main findings

Immigrants had a 1.18 times higher risk ratio (95% CI 1.08-1.29) for CVD than native Koreans (Table 10). Specifically, the risk ratio for stroke was 1.25 times higher (95% CI 1.11-1.41) for immigrants than for native Koreans. When adjusting for baseline health status and lifestyle factors among those who underwent health examinations, the risk of MI (HR 1.35, 95% CI 1.11-1.64), IHD (HR 1.24, 95% CI 1.11-1.34), and stroke (HR 1.50, 95% CI 1.32-1.71) were all higher in immigrants compared to native Koreans (Table 15).

The risk of CVD incidence varied among different subgroups of immigrants (Table 12). In the nationality classification, the risk of all CVD incidence was higher in North-East Asia (HR 1.15, 95% CI 1.04-1.27) and Russia and Central Asia (HR 1.83, 95% CI 1.12-2.99) compared to native Koreans. Conversely, the risk of all CVD incidence was lower in South-East Asia (HR 0.55, 95% CI 0.36-0.84) than in native Koreans. When classified by national income, the risk of all CVD incidence was higher in the Upper Middle (HR 1.16, 95% CI 1.04-1.29) group compared to native Koreans. Finally, in the classification by type of stay, the risk of all CVD incidence was higher in Immigrant workers group (HR 1.39, 95% CI 1.21-1.60).

4.2. Previous studies

This study is the first to compare the long-term risk of CVD incidence between native Koreans and immigrants. However, there are several studies on precursor diseases of CVD, such as the prevalence of hypertension or diabetes among immigrants.

Yoo, et al.(11) analyzed the health status of approximately 2,300 immigrants who underwent health examinations for immigrant women in 2009. The results showed that the obesity prevalence rates were lower than that of Korea (25.8%) in China (19.9%), Japan (10.4%), Vietnam (10.5%), and the Philippines (25.7%). However, Cambodia (20.6%), Mongolia (32.0%), and Thailand (36.3%) showed higher obesity prevalence rates than Korea. Additionally, when comparing these prevalence rates with WHO's obesity prevalence rates for each country, most countries recorded lower obesity prevalence rates

than in their home countries. However, the study had a limitation in that it did not separately select a control group and compared the results with external data such as the Korea National Health and Nutrition Examination Survey or WHO profiles.

Additionally, Cho et al.(10) analyzed the prevalence of type 2 diabetes among approximately 4,000 immigrants who were prescribed hypertension medication using data from the National Health Insurance Service claims from 2012 to 2015. In this analysis, the prevalence of diabetes among immigrants was found to be 3.38%, compared to 5.61% for Koreans, indicating that the prevalence of diabetes was lower among immigrants than among Koreans. However, the study is limited in that the subjects were confined to those who were prescribed hypertension medication, and the Korean comparison group was matched 1:1 with the foreigners by gender, age, and CCI (Charlson Comorbidity Index), making it difficult to interpret the results as representative of the entire immigrant population.

The most comprehensive papers on the health status and risk factors of immigrants residing in Korea are those published by Piao et al. in 2020 (24) and 2022 (9). In their 2022 paper, Piao et al. compared the health examination results of 987,214 Asian immigrants aged 20 and over with 1.7 million Koreans who underwent health examinations from 2009 to 2015. The analysis showed that male immigrants had higher rates of smoking, physical inactivity, and low income levels than Koreans, but lower rates of alcohol consumption, hypertension, and diabetes. However, for Japanese immigrants, the differences other than smoking and hypertension prevalence were not significant. Among women, smoking and alcohol consumption rates were lower compared to Korean women, but physical inactivity and low income levels were higher. Regarding obesity, the prevalence was higher among Chinese, Filipino, and ETC groups compared to Koreans, but lower in other Asian groups. Chinese immigrants had lower prevalence rates of hypertension, diabetes, and hypercholesterolemia. Additionally, a 2020 study analyzing the prevalence of type 2 diabetes in the same population showed that the odds ratio for type 2 diabetes among Asian immigrant men compared to Korean men was 0.82 (95% CI 1.10-1.20), indicating a lower risk of diabetes among Asian immigrant men compared to Korean men.

When synthesizing the above results, there are differences between the subjects and the comparison groups, but overall, immigrants tend to have lower rates of alcohol consumption and diabetes prevalence, higher rates of physical inactivity, and higher levels of low income. The risk factors such as obesity varied across studies. In this study, immigrants also showed lower diabetes prevalence, lower alcohol consumption, higher

physical inactivity, and higher low income levels, which are generally consistent with previous research findings (Table 14).

Additionally, there is a study that calculated the 10-year CVD risk from the Framingham Heart Study (FHS) (25) for 100 Chinese-Korean women who participated in a 24-week home-based walking intervention (12). The control group was selected by matching 100 Korean women from the fifth Korea National Health and Nutrition Examination Survey 2010-2012. The study found that the average 10-year CVD risk was higher for Chinese-Koreans at 6.41 points compared to 7.79 points for Koreans. This contrasts with the findings of this study, which directly followed up on CVD incidence for 10 years. The reason may be that the FHS 10-year CVD risk model predicts future CVD incidence based on baseline health status and does not adequately reflect health risk factors that occur during the immigrant life, such as acculturation.

Lastly, Cho, et al. (26) used data from the National Health Insurance Service claims from 2012 to 2015 to calculate the risk of cardio-cerebrovascular complications (CCV) for about 700 immigrants who were prescribed hypertension medication. Survival analysis showed that immigrants had a 1.39 times higher hazard ratio (HR) for CCV complications compared to Koreans (95% CI: 1.021-1.881), which is consistent with the results of this study.

4.3. Mechanism

One of the reasons cited for the increased risk of CVD among immigrants is acculturation. Immigrants experience rapid socio-cultural changes as they leave their home countries and settle in a new one. This process can act as a stressor, potentially increasing the incidence of CVD through psychosocial symptoms such as depression and anxiety (27,28). A study on South Asians living in the United States (29) found that anxiety and depression in men, and chronic stress in women, were associated with subclinical atherosclerotic disease. A study on married immigrant women living in Korea also found that they had higher levels of anxiety (30) and depression (31) compared to Korean women, which may have influenced the incidence of CVD.

Alternatively, some perspectives suggest that acculturation does not merely result from adapting to different cultures, but from exposure to 'industrialized' or 'Westernized' lifestyles. This phenomenon occurs when the host country is a high-income country, where

lifestyle changes such as high-fat and high-calorie diets, increased smoking and alcohol consumption, and increased physical inactivity can influence the incidence of CVD (32). A study on the dietary habits of married immigrant women living in Korea (33) also found that the longer the duration of immigration, the lower the dietary quality, with immigrant women recording lower scores than Korean women. Therefore, lifestyle changes that occur after immigrating to Korea may have influenced the incidence of CVD.

Furthermore, immigrants must adapt to more than just a new lifestyle. The majority of immigrant workers engage in physically demanding jobs and often hold low socioeconomic status (34), which can increase the incidence of CVD through various environmental and psychosocial mechanisms (35). Additionally, even if immigrants achieve a high socioeconomic status, they may still face social exclusion and discrimination due to their immigrant identity, which can negatively impact their health (36).

4.4. Subgroup analysis

The results of the subgroup analysis were mostly not statistically significant, but the CVD incidence rate was higher for North-East Asia and Russia and Central Asia by nationality, for Upper middle by national income, and for immigrant workers by status of stay compared to matched Koreans (Table 10). In the case of North-East Asia, the number of subjects was larger, and the follow-up years were longer than other country groups, likely providing enough cases to achieve statistical significance (Table 8). Similarly, the Upper middle group by national income was mostly comprised of members from North-East Asia, following the trend observed in North-East Asia. Despite the smaller number of subjects, Russia and Central Asia showed a higher risk of CVD incidence compared to matched Koreans, which may be due to the higher CVD incidence rates in those regions (37).

However, the South-East Asia group showed a lower risk of CVD incidence compared to matched Koreans, which may be due to several reasons. Firstly, the average age of the South-East Asia group is younger (29.1 years) and the follow-up period is shorter (4.8 years) than other country groups, possibly not providing enough time for diseases to develop. Although matched Koreans were used as the comparison group to reduce differences in population composition, the follow-up period was not adjusted. Secondly, there might be a healthy immigrant effect. Many South-East Asian males migrate as laborers and females through marriage, so only healthier individuals might have been able to migrate. Compared to North-East Asia, where a similar healthy immigrant effect might occur, the impact might

be lesser in South-East Asia because some individuals from North-East Asia may possess visit employment (H-2) visas that do not require pre-employment, reducing the healthy immigrant effect.

Finally, the CVD incidence risk for immigrant workers was observed to be higher than for native Koreans by status of stay. This is related to the sufficient number of subjects and person-years obtained, as seen in the North-East Asia group by nationality and the Upper middle group by national income. Additionally, it is likely related to the fact that the working conditions of most immigrants are more hazardous and lower-paid compared to native Koreans.

4.5. Access to care

Immigrants' use of healthcare is influenced by various factors, affecting not only the diagnosis of CVD but also the diagnosis and management of metabolic syndrome, a precursor to CVD. An analysis of the healthcare utilization patterns of foreigners using National Health Insurance Service claims data from 2013 to 2017 showed that foreign workers had a higher rate of non-utilization of healthcare services compared to Korean workers (foreigners: 23.7%, Koreans: 5.0%)(38). Additionally, while the number of outpatient visits and medical expenses per person for foreigners were lower than for Koreans, the medical expenses per hospitalization day were higher, suggesting that foreigners tend to use healthcare services in more severe conditions than Koreans.

There are various reasons for these differences in healthcare utilization between immigrants and native Koreans. According to a qualitative study conducted by Kim, et al. (39) on nine foreign workers who had lived in Korea for over a year, the most significant difficulty immigrants face when using healthcare services is the language barrier. Most immigrants rely on close acquaintances to find healthcare services, but this process can be challenging due to their limited social networks. Additionally, for immigrant workers, long working hours mean there are fewer healthcare facilities available after work, reducing their accessibility to healthcare services. Lastly, immigrants often do not recognize the need for health check-ups, may only seek pain relief rather than proper treatment, and may not fully understand their health status, likely due to the challenges of maintaining consistent healthcare utilization.

In this analysis, the initial data set showed that healthcare utilization by immigrants was lower than that of native Koreans, which is consistent with previous research findings. The low utilization of healthcare services by immigrants may mask the actual incidence of CVD in the data, making it appear that the incidence rate of CVD among immigrants is lower. However, the diseases defined as outcomes in this study, such as MI, IHD, and stroke, are severe conditions where it is difficult for individuals to opt out of using healthcare services. Therefore, the impact of low healthcare utilization rates among immigrants is expected to be minimal.

On the other hand, in the health examination set, the number of outpatient visits for immigrants was higher than for native Koreans (Table 16). Considering that hospitalization days were lower in the health examination set than in the initial set, it is presumed that most immigrants in the health examination set are employed and thus have time constraints due to work, leading to a shift from hospitalization to outpatient services.

Nonetheless, for individuals not enrolled in NHIS, such as undocumented immigrants, there is a possibility that CVD occurrences were not captured in the NHID. Considering that undocumented immigrants generally have higher CVD incidence rates due to poor working conditions and other issues, the risk of CVD incidence among immigrants may have been underestimated.

4.6. Strength and limitation

4.6.1. Strength

This paper has several strengths. Firstly, by using the National Health Insurance Data (NHID) as the data source, a large number of immigrants could be included in the analysis, thereby mitigating some of the selection bias that might arise from analyzing health examination data from specific centers. Additionally, by utilizing NHID claims data, it was possible to set objective indicators for CVD incidence and directly confirm the occurrence of CVD. As far as we know, this is the first study to calculate the incidence rate of CVD among immigrants.

Secondly, various methods were used to ensure comparability between immigrants and native Koreans. The gender and age composition of immigrants and native Koreans are very different, which can cause significant issues when calculating CVD incidence rates.

Therefore, the subjects' age was limited to 65 years, and native Koreans were matched with immigrants by gender and age. Additionally, age standardization was performed when calculating CVD incidence rates, and only native Koreans matched to the respective group were included in the subgroup analysis.

Moreover, the 2-year landmark method was used to account for the potential impact of the shorter follow-up time for immigrants compared to native Koreans. Since a short follow-up time might not provide enough time for CVD diseases to occur, only immigrants who had lived in Korea for at least two years were included in the analysis, reducing selection bias due to follow-up time.

Lastly, based on a large number of subjects, this paper conducted various subgroup analyses. Factors that could affect the health status of immigrants, such as nationality, national income, and status of stay, were used to divide the groups and calculate CVD incidence rates and risks, allowing for comparisons between individual groups.

4.6.2. Limitation

However, this paper also has several limitations. Firstly, even though NHID and the 2-year landmark method were used, it was challenging to completely control for selection bias regarding immigrants. While there are immigrant groups such as immigrant workers who are mandatorily enrolled in NHIS, regional enrollees like international students are not required to enroll in NHIS, making it difficult to claim that NHID represents all immigrants residing in Korea. Additionally, undocumented immigrants who cannot enroll in NHIS were not included in the analysis. The 2-year landmark method also has limitations in correcting for the effect of unhealthy immigrants returning to their home countries. However, if those who were censored due to such effects had a higher risk of CVD, the actual CVD risk would be higher among immigrants, and this would not change the direction of the analysis.

Moreover, nationality and status of stay are self-reported and not externally verified. However, these details were consistent for most subjects over the 10-year follow-up period. Lastly, the study did not account for the length of stay, which is an important factor in immigrant research.

5. Conclusion

In Korea, immigrants have a higher incidence rate of CVD diseases than native Koreans. Therefore, appropriate interventions tailored to the characteristics of immigrants are necessary.

References

1. Sironi, A.C. Bauloz, M. Emmanuel. Glossary on Migration. International Organization for Migration (IOM), Geneva; (International Migration Law).

2. Statistical papers. 58: Series M Recommendations on statistics of international migration. 1998.

3. Korea immigration service. Korea Immigration Service STATISTICS 2011. Ministry of Justice; 2012.

4. Jung Y. Monitoring the Status of Health Inequality in Korea and Policy Development: Migrant Worker's Health Inequality [Internet]. KIHASA; 2021 Dec [cited 2023 Jun 14]. Available from: https://doi.org/10.23060/KIHASA.A.2021.29

5. Byoun SJ. Another view of social integration: Korean Society's inclusivity as perceived by migrants [Internet]. KIHASA; 2021 Dec [cited 2023 Jun 14]. Available from: https://doi.org/10.23060/KIHASA.A.2021.37

6. Anderson NB, Bulatao RA, Cohen B, National Research Council (U.S.), editors. Critical perspectives on racial and ethnic differences in health in late life. Washington, D.C: National Academies Press; 2004. 735 p.

7. Changho Lee, Kim Yu-Mi, Yun Sung Jo, Gee-Hee Kim, Su-Nam Joung. Health Crisis of Middle-Aged and Elderly Ethnic Return Migrants: Focusing on Korean-Chinese in A Area of Gyeonggi-do. Multicult Peace. 2021 Aug;15(2):225–64.

8. Provido SMP, Abris GP, Lee H, Okekunle AP, Gironella GM, Capanzana MV, et al. Comparison of cardiovascular disease risk factors among FiLWHEL (2014-2016), NNS (2013) and KNHANES (2013-2015) women. BMC Womens Health. 2023 Mar 30;23(1):149.

9. Piao H, Yun JM, Shin A, Cho B, Kang D. Comparing Non-Communicable Disease Risk Factors in Asian Migrants and Native Koreans among the Asian Population. Biomol Ther. 2022 Nov 1;30(6):603–15.

10. Cho H, Jeong S, Kang C, Kang HJ, Jang S, Jang S. Risk Factors and the Usual Source of Care on Non-Adherence to Antihypertensive Drugs in Immigrants with Hypertension. Patient Prefer Adherence. 2020;14:2123–33.

11. Yoo S, Kim H, Cho HI. Heterogeneity in obesity status and cardiovascular risks in multiethnic Asian female immigrants in South Korea. Asia Pac J Public Health. 2015 Mar;27(2):NP448-456.

12. Lee H, Cho S, Kim YK, Kim JH. Is There Disparity in Cardiovascular Health Between Migrant Workers and Native Workers? Workplace Health Saf. 2016 Aug;64(8):350–8.

13. Obiang-Obounou BW. The Length of Residence is Associated with Cardiovascular Disease Risk Factors among Foreign-English Teachers in Korea. Behav Sci Basel Switz. 2017 Dec 26;8(1):2.

14. Cheol Seong S, Kim YY, Khang YH, Heon Park J, Kang HJ, Lee H, et al. Data Resource Profile: The National Health Information Database of the National Health Insurance Service in South Korea. Int J Epidemiol. 2016 Oct 29;dyw253.

15. Dobson AJ, Kuulasmaa K, Eberle E, Scherer J. Confidence intervals for weighted sums of poisson parameters. Stat Med. 1991 Mar;10(3):457–62.

16. Fay MP, Feuer EJ. CONFIDENCE INTERVALS FOR DIRECTLY STANDARDIZED RATES: A METHOD BASED ON THE GAMMA DISTRIBUTION. Stat Med. 1997 Apr 15;16(7):791–801.

17. Tiwari RC, Clegg LX, Zou Z. Efficient interval estimation for age-adjusted cancer rates. Stat Methods Med Res. 2006 Dec;15(6):547–69.

18. Ng HKT, Filardo G, Zheng G. Confidence interval estimating procedures for standardized incidence rates. Comput Stat Data Anal. 2008 Mar;52(7):3501–16.

19. Breslow NE, Day NE. Statistical methods in cancer research. Vol. 2: The design and analysis of cohort studies. Reprinted. Lyon: International Agency for Research on Cancer; 1996. 406 p. (IARC scientific publications; vol. 2).

20. Anderson Georgina, Fox Sebastian, Francis Matthew, Fryers Paul, Clegg Emma, Westermann Annabel, et al. Common Public Health Statistics and their Confidence Intervals. 2024.

21. Michael P. Fay. Applied Statistical Hypothesis Tests. 2023.

22. Terry M Therneau. A Package for Survival Analysis in R [Internet]. 2024. Available from: https://CRAN.R-project.org/package=survival

23. Bob Gray. cmprsk: Subdistribution Analysis of Competing Risks [Internet]. 2024. Available from: https://cran.r-project.org/web/packages/cmprsk/index.html

24. Piao H, Yun JM, Shin A, Cho B. Longitudinal Study of Diabetic Differences between International Migrants and Natives among the Asian Population. Biomol Ther. 2020 Jan 1;28(1):110–8.

25. D'Agostino RB, Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, et al. General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study. Circulation. 2008 Feb 12;117(6):743–53.

26. Cho H, Jeoung S, Kang C, Jang S. Comparative analysis of cardio-cerebrovascular complications in immigrants and native-born Koreans with diabetes: Risk factors and perspectives. Angkurawaranon C, editor. PLOS ONE. 2022 Apr 29;17(4):e0263046.

27. Dìaz Bretones F, Santos A, editors. Health, safety and well-being of migrant workers: new hazards, new workers. Cham, Switzerland: Springer; 2020. 182 p. (Aligning perspectives on health, safety and well-being).

28. Rosengren A, Hawken S, Ôunpuu S, Sliwa K, Zubaid M, Almahmeed WA, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study. The Lancet. 2004 Sep;364(9438):953–62.

29. Shah BM, Shah S, Kandula NR, Gadgil MD, Kanaya AM. Psychosocial Factors Associated with Subclinical Atherosclerosis in South Asians: The MASALA Study. J Immigr Minor Health. 2016 Dec;18(6):1317–27.

30. Lee SH, Park YC, Hwang J, Im JJ, Ahn D. Mental Health of Intermarried Immigrant Women and Their Children in South Korea. J Immigr Minor Health. 2014 Feb;16(1):77–85.

31. Kim JA, Yang SJ, Chee YK, Kwon KJ, An J. Effects of Health Status and Health Behaviors on Depression Among Married Female Immigrants in South Korea. Asian Nurs Res. 2015 Jun;9(2):125–31.

32. Delavari M, Sønderlund AL, Swinburn B, Mellor D, Renzaho A. Acculturation and obesity among migrant populations in high income countries – a systematic review. BMC Public Health. 2013 Dec;13(1):458.

33. Cho YA, Kim DY, Choue R, Lim H. Changes in Dietary Quality among Vietnamese Women Immigrants in Korea and Comparison with Korean Women. Clin Nutr Res. 2018;7(3):178.

34. Hyejin Kim, Chulhee Lee. The Immigrant Wage Gap and Assimilation in Korea. BOK Work Pap. 2021 Oct;2021(16).

35. De Mestral C, Stringhini S. Socioeconomic Status and Cardiovascular Disease: an Update. Curr Cardiol Rep. 2017 Nov;19(11):115.

36. Pascoe EA, Smart Richman L. Perceived discrimination and health: A meta-analytic review. Psychol Bull. 2009;135(4):531–54.

37. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. J Am Coll Cardiol. 2017 Jul;70(1):1–25.

38. Jinok Byeon, JeungWan Cho, JuHang Lee, JungMyun Lee. Health Care Utilization of Foreigners Entitled National Health Insurance Service of Korea. Korea Soc Policy Rev. 2019 Dec;26(4):83–100.

39. Kim S. The conception and factors that affect the utilization of health care services among foreign migrant workers in Korea. J Multi-Cult Contents Stud. 2015 Apr 30;18:255.

Appendix 1. Crude and age-standardized incidence of major cardiovascular diseases by nationality

Outcomes	North-East Asia	South-East Asia	Russia and Central Asia	South-West Asia and Oceania	North America	ETC
All CVD						
Crude	232.6 (213.9 - 252.5)	24.3 (15.7 - 35.8)	156.9 (101.5 - 231.7)	61.1 (37.8 - 93.4)	169.2 (129.1 - 217.8)	108.6 (57.8 - 185.7)
DSR	232.7 (214 - 252.7)	23.2 (14.9 - 34.4)	141.3 (90.9 - 209.4)	63.0 (38.9 - 96.5)	168.5 (128.3 - 217.4)	99.5 (52.8 - 171.6)
SIR	1.18 (1.08 - 1.28)	0.51 (0.33 - 0.75)	1.85 (1.19 - 2.73)	0.86 (0.53 - 1.31)	0.86 (0.66 - 1.11)	0.67 (0.36 - 1.15)
MI						
Crude	26.7 (20.7 - 34)	2.9 (0.6 - 8.5)	43.8 (17.6 - 90.3)	37.8 (20.1 - 64.7)	33.6 (17.4 - 58.8)	33.3 (9.1 - 85.3)
DSR	26.7 (20.7 - 34)	2.6 (0.5 - 7.9)	40.5 (16.1 - 83.7)	39.8 (21.1 - 68.2)	31.4 (16.2 - 55.3)	31.3 (8.4 - 81.5)
SIR	0.87 (0.67 - 1.11)	0.53 (0.11 - 1.55)	5.33 (2.14 - 10.99)	2.4 (1.28 - 4.11)	0.92 (0.47 - 1.6)	1.27 (0.34 - 3.24)
IHD						
Crude	95.9 (84 - 108.9)	11.6 (6 - 20.3)	106.6 (62.1 - 170.7)	55.3 (33.3 - 86.4)	112.5 (80.4 - 153.3)	58.4 (23.5 - 120.3)
DSR	96.0 (84.1 - 109)	10.5 (5.3 - 18.6)	97.7 (56.5 - 157)	56.8 (34.1 - 88.9)	109.4 (78 - 149.4)	54.1 (21.6 - 112.9)
SIR	0.92 (0.81 - 1.05)	0.52 (0.27 - 0.9)	2.46 (1.43 - 3.93)	1.25 (0.75 - 1.95)	1.21 (0.87 - 1.65)	0.71 (0.28 - 1.46)

Stroke						
Crude	136.2 (122 - 151.6)	12.6 (6.7 - 21.6)	50.1 (21.6 - 98.7)	5.8 (0.7 - 21)	56.1 (34.3 - 86.7)	50.0 (18.4 - 108.9)
DSR	136.2 (122 - 151.6)	12.7 (6.7 - 21.8)	43.1 (18.3 - 85.9)	6.2 (0.8 - 22.3)	58.5 (35.6 - 90.5)	45.4 (16.6 - 100.3)
SIR	1.46 (1.31 - 1.62)	0.50 (0.27 - 0.86)	1.21 (0.52 - 2.38)	0.22 (0.03 - 0.78)	0.55 (0.33 - 0.84)	0.64 (0.23 - 1.39)

*CVD: cardiovascular disease; DSR: direct standardized rate; MI: myocardial infarction; SIR: standardized incidence ratio

*per 100,000 person-years

Appendix 2. Crude and age-standardized incidence of major cardiovascular diseases by national income

label	High	Upper middle	Lower middle	Low	ETC
All CVD					
Crude	157.1 (129.4 - 189)	228.2 (209.1 - 248.7)	51.1 (38.8 - 66).0	56.1 (31.4 - 92.5)	117.5 (43.1 - 255.6)
DSR	158 (130.1 - 190.3)	225.6 (206.6 - 245.8)	48.5 (36.7 - 62.9)	57.8 (32.2 - 95.7)	94.5 (32.7 - 215.2)
SIR	0.84 (0.69 - 1.01)	1.16 (1.07 - 1.27)	1.02 (0.77 - 1.32)	0.89 (0.5 - 1.47)	0.96 (0.35 - 2.09)
MI					
Crude	30.7 (19.2 - 46.5)	26.4 (20.2 – 34.0)	12.3 (6.7 - 20.7)	26.2 (10.5 - 53.9)	19.5 (0.5 - 108.7)
DSR	30 (18.8 - 45.5)	26.2 (20.0 - 33.6)	12.2 (6.6 - 20.4)	27.8 (11.1 - 57.5)	21.7 (0.6 - 112.4)
SIR	1.05 (0.66 - 1.58)	0.83 (0.64 - 1.07)	2.19 (1.19 - 3.67)	1.95 (0.78 - 4.01)	0.61 (0.02 - 3.41)
IHD					
Crude	92.4 (71.4 - 117.5)	94.7 (82.6 - 108.2)	29.9 (20.7 - 41.8)	41.1 (20.5 - 73.6)	39.0 (4.7 – 141.0)
DSR	92.6 (71.6 – 118.0)	93.5 (81.5 - 106.8)	28.5 (19.7 - 40)	42.9 (21.3 - 76.9)	44.7 (5.4 - 152.5)
SIR	0.99 (0.76 - 1.26)	0.92 (0.8 - 1.05)	1.2 (0.83 - 1.67)	1.15 (0.57 - 2.05)	0.67 (0.08 - 2.43)
Stroke					
Crude	64.3 (47.1 - 85.8)	133.1 (118.6 - 148.9)	21.1 (13.5 - 31.4)	14.9 (4.1 - 38.3)	78.1 (21.3 – 200.0)
DSR	65.0 (47.5 - 86.8)	131.5 (117.2 - 147.1)	19.9 (12.7 - 29.8)	14.9 (4.1 - 38.7)	49.9 (13.4 - 141.2)
SIR	0.69 (0.5 - 0.92)	1.44 (1.28 - 1.61)	0.84 (0.54 - 1.25)	0.55 (0.15 - 1.41)	1.22 (0.33 - 3.13)

*CVD: cardiovascular disease; DSR: direct standardized rate; IHD: ischemic heart disease; MI: myocardial infarction; SIR: standardized incidence ratio

*per 100,000 person-years

Appendix 3. Crude and age-standardized incidence of major cardiovascular diseases by type of stay

label	Immigrant workers	Compatriot	Family relations	Permanent Residents	International students	ETC
All CVD						
Crude	172.0 (155.1 - 190.3)	219.6 (176.8 - 269.6)	108.5 (91.5 - 127.8)	208.0 (153.9 - 275)	171.7 (101.7 - 271.3)	184.5 (129.9 - 254.4)
DSR	147.7 (133.1 - 163.6)	223.7 (180.0 - 274.6)	104.0 (87.6 - 122.5)	217.7 (161 - 287.8)	144.9 (85 - 232.2)	160.2 (112.4 - 222.1)
SIR	1.06 (0.96 - 1.17)	1.10 (0.88 - 1.35)	1.05 (0.88 - 1.23)	1.21 (0.9 - 1.6)	1.12 (0.66 - 1.77)	1.06 (0.74 - 1.46)
MI						
Crude	24.1 (18.1 - 31.6)	33.5 (18.3 - 56.3)	11.3 (6.3 - 18.7)	54.9 (29.2 - 93.9)	38.0 (10.4 - 97.4)	29.8 (10.9 - 64.8)
DSR	21.5 (16.1 - 28.2)	33.1 (18.1 - 55.6)	10.7 (6.0 - 17.7)	57.2 (30.4 - 97.8)	36.9 (9.9 - 95)	26.6 (9.6 - 58.9)
SIR	0.84 (0.63 - 1.1)	0.92 (0.5 - 1.55)	0.88 (0.49 - 1.45)	2.15 (1.14 - 3.67)	2.15 (0.59 - 5.5)	1.58 (0.58 - 3.45)
IHD						
Crude	79.8 (68.4 - 92.6)	103.3 (74.8 - 139.2)	48.5 (37.3 - 61.9)	105.8 (68.4 - 156.1)	76.2 (32.9 - 150.1)	79.5 (45.4 - 129.1)
DSR	69.4 (59.4 - 80.6)	104.3 (75.5 - 140.6)	46.3 (35.6 - 59.2)	111.1 (71.8 - 163.9)	69.9 (29.8 - 139.4)	70.3 (39.8 - 115.3)
SIR	0.91 (0.78 - 1.06)	1.01 (0.73 - 1.36)	0.96 (0.74 - 1.22)	1.25 (0.81 - 1.84)	1.1 (0.48 - 2.17)	0.92 (0.53 - 1.5)
Stroke						
Crude	92.2 (79.9 - 105.8)	115.4 (85.1 - 153)	59.8 (47.4 - 74.6)	101.5 (65 - 151.1)	95.1 (45.5 - 174.8)	104.4 (64.6 - 159.6)

DSR	78.2 (67.7 - 89.9)	118.3 (87.2 - 156.8)	57.5 (45.5 - 71.7)	106.0 (67.9 - 157.7)	74.8 (35.4 - 141.6)	88.8 (54.8 - 137.1)
SIR	1.24 (1.07 - 1.42)	1.19 (0.87 - 1.57)	1.13 (0.89 - 1.41)	1.16 (0.74 - 1.73)	1.13 (0.54 - 2.09)	1.18 (0.73 - 1.81)

*CVD: cardiovascular disease; DSR: direct standardized rate; IHD: ischemic heart disease; MI: myocardial infarction; SIR: standardized incidence ratio

*per 100,000 person-years

Abstract in Korean

이주민과 한국인의 주요 심혈관계질환의 발생률 비교

1980 년대 건설업계에서의 이주노동자 고용을 시작으로, 한국에 체류하는 이주민의 숫자는 계속 늘어 2021 년에는 약 200 만명의 이주민이 한국에 장기 체류하고 있으며, 이는 전체 인구의 4.1%에 달한다. 그러나 이주민의 건강, 특히 심혈관계 질환에 대한 연구는 부족하였다. 따라서, 본 논문에서는 이주민과 한국인의 주요 심혈관계질환의 발생률을 산출하고 발생위험을 비교하였다.

본 논문에서는 2011 년에 국민건강보험에 가입되어 있던 외국인 77,047 명과 매칭된 한국인 308,188 명의 건강보험자료를 사용하였다. 결과 지표는 전체 심혈관계 질환, 심근경색, 허혈성 심질환, 뇌경색이며 이주민은 국적, 국적의 수입, 체류자격으로 세분화되었다. 발생률은 각 심혈관계질환 별로 전체 이주민과 이주민의 세부집단에 대해 산출되었다. 또한, 이주민과 한국인의 심혈관계질환의 발생율을 비교하기 위하여 Fine-Gray 의 Sub-distributional hazard ratio 를 계산하였다. 마지막으로 심혈관계질환의 위험요인들을 보정하기 위하여 연구대상자를 건강검진을 받은 사람으로 한정하여 생존분석을 추가적으로 시행하였다.

분석 결과 이주민의 주요 심혈관계 질환 발생률은 10 만 인년 당 160.1(95% 신뢰구간 148.6-172.3)이었으며, 연령표준화 시 표준화발생비(Standardized incidence ratio)는 1.08(95% 신뢰구간 1.00-1.16)로 한국인보다 주요 심혈관계 질환 발생률이 높았다. 생존 분석 결과에서도 한국인보다 이주민의 심혈관계질환 발생 위험이 더 높았으며(위험비 1.18, 95% 신뢰구간 1.08-1.29), 특히 뇌경색의 발생 위험이 통계적으로 유의하게 높았다. 건강검진을 받은 사람으로 한정하였을 경우에도 이주민의 심혈관계질환의 발생 위험이 높았으며, 심근경색, 허혈성 심질환, 뇌경색에서 모두 한국인보다 높은 발생위험을 보였다.

이주민은 한국인보다 심혈관계 질환 발생 위험이 높으므로, 심혈관계 질환 발생을 예방하기 위해 이주민의 특성을 고려한 보건학적 개입이 요구된다.

핵심되는 말 : 심혈관계질환, 이주민, 생존분석, 발생률