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Cardiovascular Disease & Diabetes Statistics in Korea: Nationwide Data 2010 to 2019

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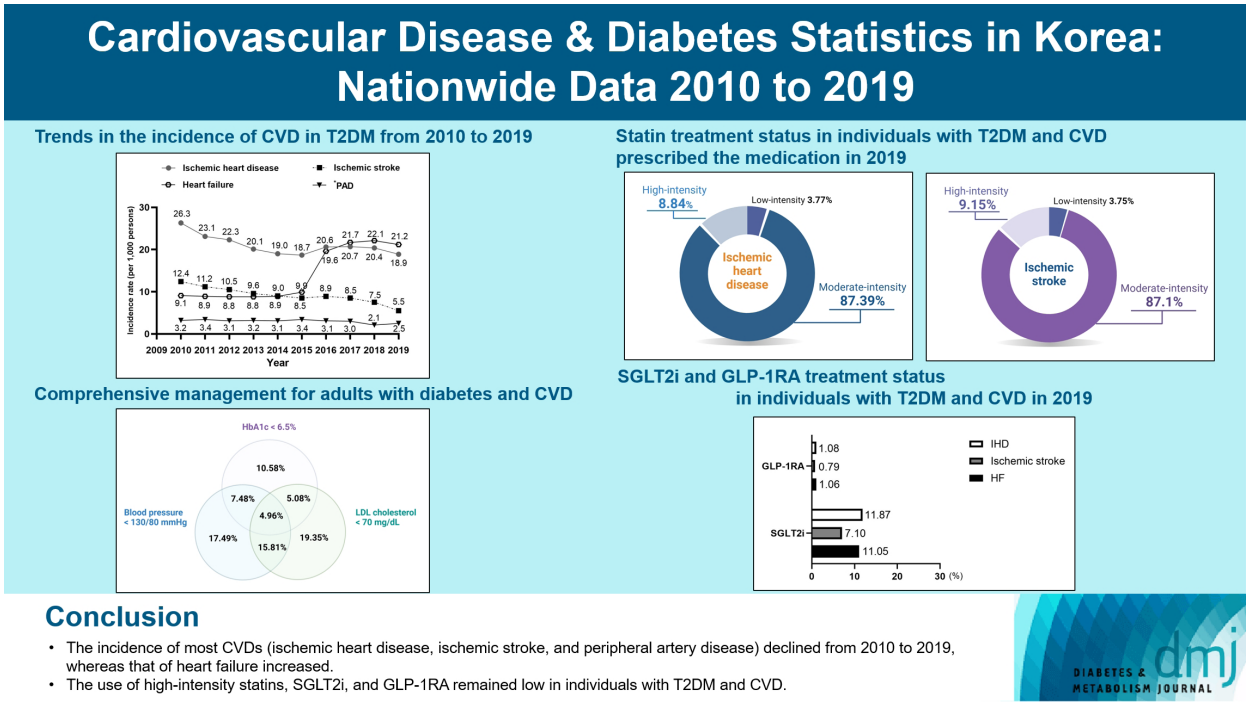

Highlights

- **From 2010 to 2019, the incidence of most CVDs decreased, but heart failure increased.**
- **Only 4.96% of adults with diabetes and CVD achieved optimal risk management.**
- **High-intensity statins, SGLT2i, and GLP-1RA use in T2DM with CVD remained suboptimal.**

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Cardiovascular Disease & Diabetes Statistics in Korea: Nationwide Data 2010 to 2019

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Background: This study aimed to provide updated insights into the incidence and management of cardiovascular disease (CVD) in Korean adults with diabetes.
Methods: Using data from the Korean National Health Insurance Service and Korea National Health and Nutrition Examination Survey, we analyzed the representative national estimates of CVD in adults with diabetes.
Results: The age- and sex-standardized incidence rate of ischemic heart disease (IHD), ischemic stroke, and peripheral artery disease (PAD) decreased from 2010 to 2019 in individuals with type 2 diabetes mellitus (T2DM). However, an increase in the incidence of heart failure (HF) was observed during the same period. Only 4.96% of adults with diabetes and CVD achieved optimal control of all three risk factors (glycemic levels, blood pressure, and lipid control). Additionally, high-intensity statin treatment rates were 8.84% and 9.15% in individuals with IHD and ischemic stroke, respectively. Treatment with a sodium-glucose cotransporter-2 inhibitor (SGLT2i) or a glucagon-like peptide-1 receptor agonist (GLP-1RA) was relatively low in 2019, with only 11.87%, 7.10%, and 11.05% of individuals with IHD, ischemic stroke, and HF, respectively, receiving SGLT2i treatment. Furthermore, only 1.08%, 0.79%, and 1.06% of patients with IHD, ischemic stroke, and HF, respectively, were treated with GLP-1RA.
Conclusion: The incidence of most CVD (IHD, ischemic stroke, and PAD) decreased between 2010 and 2019, whereas the incidence of HF increased. The overall use of high-intensity statins, SGLT2i, and GLP-1RA remained low among individuals with T2DM and CVD.

Keywords: Cardiovascular diseases; Diabetes mellitus; Epidemiology; Korea

INTRODUCTION

Diabetes is recognized as one of the most serious chronic diseases, causing life-threatening disabilities and reducing life expectancy [1]. Cardiovascular diseases (CVD) including coronary artery disease, cerebrovascular disease, heart failure (HF), and peripheral artery disease (PAD) are the leading causes of morbidity and mortality in individuals with diabetes [2]. Given the increasing prevalence of diabetes [3,4], it is crucial to emphasize the trends or changes in CVD among individuals with diabetes. However, recent nationally representative statistics on CVD in individuals with diabetes in South Korea are limit-

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ed. Jung et al. [5] and Park et al. [6] reported CVD trends in diabetes patients in Korea from 2006 to 2013 and 2006 to 2015, respectively.

Continuous evaluation of national diabetes statistics is important for supporting and advocating public health policies aimed at reducing the burden of diabetes. Furthermore, the landscape of diabetes care is rapidly evolving with the advent of new technologies, approval of novel antidiabetic medications, and adjustments in clinical practice guidelines based on recent clinical trials, all of which significantly influence diabetes care and prognosis [7,8]. In this regard, understanding population-wide trends during the recent decade and the current status of CVD in patients with diabetes has important clinical and public health implications that are critical for planning public health approaches, forecasting population-level CVD, and guiding prevention efforts.

This study aimed to provide updated national insights into and trends in the incidence and management of CVD among Korean adults with diabetes between 2010 and 2019. In this study, we analyzed data from the Korean National Health Insurance Service (NHIS) and the Korea National Health and Nutrition Examination Survey (KNHANES) to provide representative national estimates of CVD in adults with diabetes.

METHODS

Study population

This nationwide population-based observational study was conducted using the data from the Korean NHIS. Nearly all Koreans (97.2% of the Korean population) are covered by the Korean NHIS, a nonprofit, single-payer organization of the Korean government [9]. Consequently, the NHIS database contains data pertaining to almost the entire South Korean population, including claims for disease diagnosis codes from the International Classification of Diseases, 10th Revision (ICD-10), and treatment information. This study also incorporated data from the KNHANES conducted by the Korean Centers for Disease Control and Prevention from 2019 to 2021. KNHANES is an annual national health survey designed to assess the health and health-related behaviors of the Korean population. This cross-sectional, nationally representative study includes noninstitutionalized civilians and employs a stratified, multistage, clustered probability sampling design [10]. Trained investigators conduct health interviews and nutrition and health examination surveys as part of the KNHANES.

This study was approved by the Chosun University Hospital Institutional Review Board (No. CHOSUN 2024-03-007) and waived the requirement for informed consent because only anonymized and de-identified data were used.

Definitions of diabetes and CVD

The presence of type 2 diabetes mellitus (T2DM) was established using ICD-10 codes E11–14, and prescription data for antidiabetic medications were derived from the Korean NHIS. Diabetes was defined as a fasting plasma glucose level ≥126 mg/dL or glycosylated hemoglobin (HbA1c) level ≥6.5%, a prior diagnosis of diabetes by a doctor, or the use of antidiabetic medication, based on information from the KNHANES. Data were collected from individuals aged 30 years or older eligible for health insurance as well as from those within the same age group eligible for the KNHANES.

CVD comprises ischemic heart disease (IHD), ischemic stroke, HF, and PAD. IHD was identified using ICD-10 codes I20–25 with associated hospitalization. Ischemic stroke was identified using ICD codes I63–64 along with hospitalization and computed tomography/magnetic resonance imaging. HF was defined according to ICD code I50 and hospitalization. PAD was defined through hospitalization using ICD-10 and procedure codes HA633, HA651, HA652, M6597, M6605, M6612, M6613, M6620, M6632, M6633, N0571, N0572, N0573, N0574, N0575, O0161, O0162, O0163, O0164, O0165, O0166, O0167, O0168, O0169, O0170, O1710, O1711, O1643, O1644, O1645, and O1646. For PAD analysis, we used the Korean NHIS National Sample Cohort. CVD was defined as a diagnosis of myocardial infarction, angina, or stroke based on data from the KNHANES.

For the analysis of statin, sodium-glucose cotransporter-2 inhibitor (SGLT2i), and glucagon-like peptide-1 receptor agonist (GLP-1RA) prescriptions, IHD was defined using ICD-10 codes I20–25, ischemic stroke using ICD-10 codes I63,64, and HF using ICD-10 code I50.

Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease Study equation. Chronic kidney disease (CKD) was defined as an eGFR <60 mL/min/1.73 m^2.

Statistical analysis

The age- and sex-standardized incidence rate of CVD per 1,000 persons are based on data from the 2010 census of the Korean diabetes population. Statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and R ver-

Table 1. Age- and sex-standardized incidence rate per 1,000 persons of cardiovascular disease among individuals with type 2 diabetes mellitus in 2019 from the Korean NHIS

Variable	Total	Men	Women	Age <65 years		Age ≥65 years	
				Men	Women	Men	Women
IHD	18.9	19.5	18.2	16.3	12.8	27.3	24.2
Ischemic stroke	5.5	5.6	5.5	3.9	2.7	9.9	8.8
HF	21.2	20.4	22.1	14.4	12.5	35.2	33.6
PAD[a]	2.5	3.0	1.9	3.1	5.8	7.3	6.2

NHIS, National Health Insurance Service; IHD, ischemic heart disease; HF, heart failure; PAD, peripheral artery disease.
[a]Based on data from the Korean NHIS National Sample Cohort.

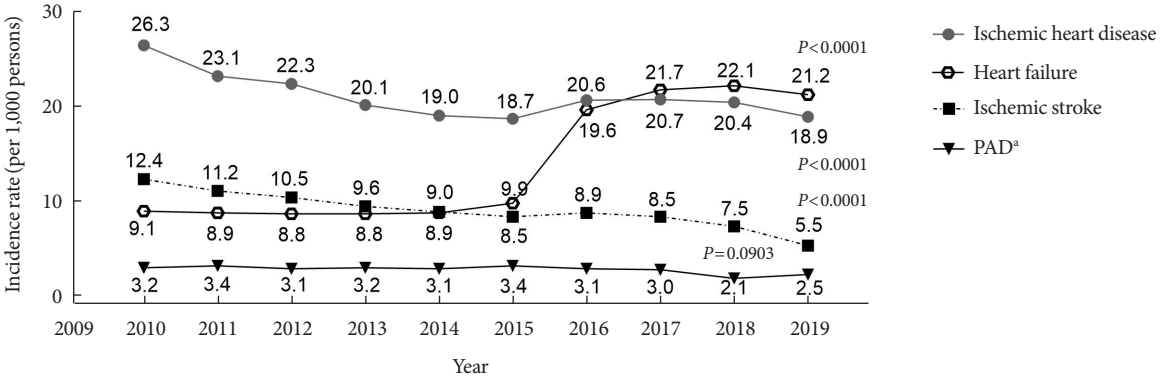

Fig. 1. Trends in age- and sex-standardized incidence of cardiovascular disease among individuals with type 2 diabetes mellitus from 2010 to 2019 based on data from the Korean National Health Insurance Service (NHIS). PAD, peripheral artery disease.
[a]Based on data from the Korean NHIS National Sample Cohort.

sion 3.2.3 (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Incidence of CVD in individuals with T2DM

In 2019, among Korean adults aged 30 years or older, the age- and sex-standardized incidence rates for CVD per 1,000 persons were 18.9 for IHD, 5.5 for ischemic stroke, 21.2 for HF, and 2.5 for PAD. CVD exhibited a higher incidence in individuals aged 65 years and older, with PAD being more prevalent in men (Table 1).

Trends of CVD in T2DM from 2010 to 2019

Among adults with T2DM, the age- and sex-standardized incidence of IHD steadily decreased from 2010 to 2015 (from 26.3 to 18.7 per 1,000 persons) and then slightly increased in 2016, persisting stably until 2018 ($P<0.0001$). This trend remained consistent regardless of sex ($P<0.0001$). The incidence of ischemic stroke steadily decreased from 2010 to 2018 (from 12.4 to 7.5 per 1,000 persons) and then sharply declined in 2019 (5.5 per 1,000 persons), irrespective of sex ($P<0.0001$). For HF, a remarkable increase was observed during 2015 to 2016, followed by a continued upward trend, resulting in an increase from 9.1 to 21.2 per 1,000 persons from 2010 to 2019 ($P<0.0001$). This trend was observed for both men and women ($P<0.0001$). The incidence of PAD exhibited a stable trend from 2010 to 2017, after which it gradually decreased (from 3.0 to 2.1 per 1,000 persons) ($P=0.0903$), consistently across sexes (men: $P=0.2237$; women: $P=0.1639$) (Fig. 1, Supplementary Figs. 1-4).

Comprehensive management of diabetes with CVD

From 2019 to 2021, only 4.96% of adults with diabetes and CVD achieved all target values, including HbA1c <6.5%, blood pressure (BP) <130/80 mm Hg, and low-density lipoprotein (LDL) cholesterol <70 mg/dL, according to KNHANES (Fig. 2). The glycemic control rates were 28.37% for HbA1c <6.5% and

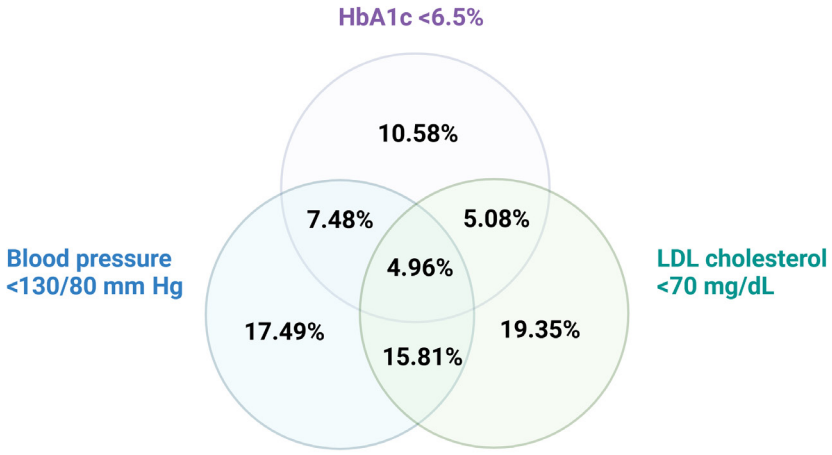

Fig. 2. Proportion of adults with diabetes and cardiovascular disease achieving target levels (2019–2021) from the Korea National Health and Nutrition Examination Survey. HbA1c, glycosylated hemoglobin; LDL, low-density lipoprotein.

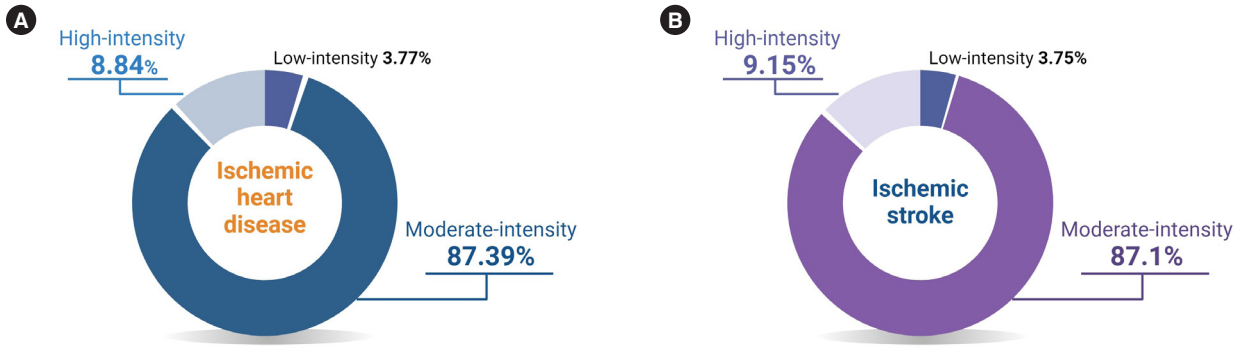

Fig. 3. Statin prescription status among individuals with type 2 diabetes mellitus and cardiovascular disease based on 2019 data from the Korean National Health Insurance Service. (A) Ischemic heart disease. (B) Ischemic stroke.

58.92% for HbA1c <7.0%. Among individuals aged ≥65 years, 33.2% had HbA1c levels <6.5%, with 62.65% achieving levels <7%. In those aged <65 years, 19.9% attained HbA1c levels <6.5%, and 52.37% reached HbA1c levels <7.0%. For adults aged <65 years, 9.2% had HbA1c levels >9.0%, whereas only 4.36% demonstrated HbA1c levels >9.0% in those aged ≥65 years (Supplementary Fig. 5).

Prescription rates for statins, SGLT2i, and GLP-1RA

The prescription rates of statins for IHD and ischemic stroke in individuals with T2DM consistently increased from 2014 to 2019 (Supplementary Fig. 6). In 2019, among individuals with T2DM and IHD who were prescribed statins, 87.39% used moderate-intensity statins, and only 8.84% used high-intensity statins. Similarly, among individuals with T2DM and ischemic stroke who were prescribed statins, 87.1% used moderate-inten-

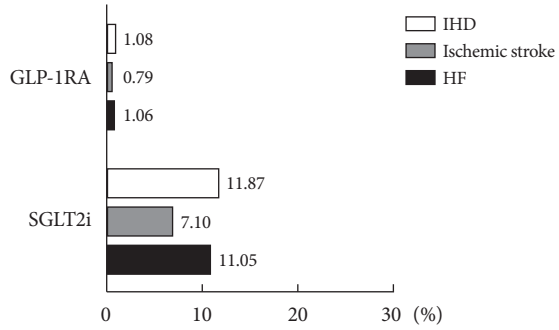

Fig. 4. Sodium-glucose cotransporter 2 inhibitor (SGLT2i) and glucagon-like peptide-1 receptor agonist (GLP-1RA) prescription status in individuals with type 2 diabetes mellitus and cardiovascular disease based on 2019 data from the Korean National Health Insurance Service. IHD, ischemic heart disease; HF, heart failure.

sity statins and only 9.15% used high-intensity statins (Fig. 3).

The rates of SGLT2i and GLP-1RA treatment were relatively low in 2019. Only 11.87%, 7.10%, and 11.05% of the patients with IHD, ischemic stroke, and HF, respectively, received SGLT2i treatment (Fig. 4). Furthermore, only 1.08%, 0.79%, and 1.06% of individuals with IHD, ischemic stroke, and HF, respectively, were treated with the GLP-1RA (Fig. 4). In patients with T2DM with IHD, ischemic stroke, and HF, individuals who were male, under 40 years of age, and without CKD were more likely to receive SGLT2i treatment. GLP-1RA were prescribed more frequently to individuals under 40 years of age (Fig. 5).

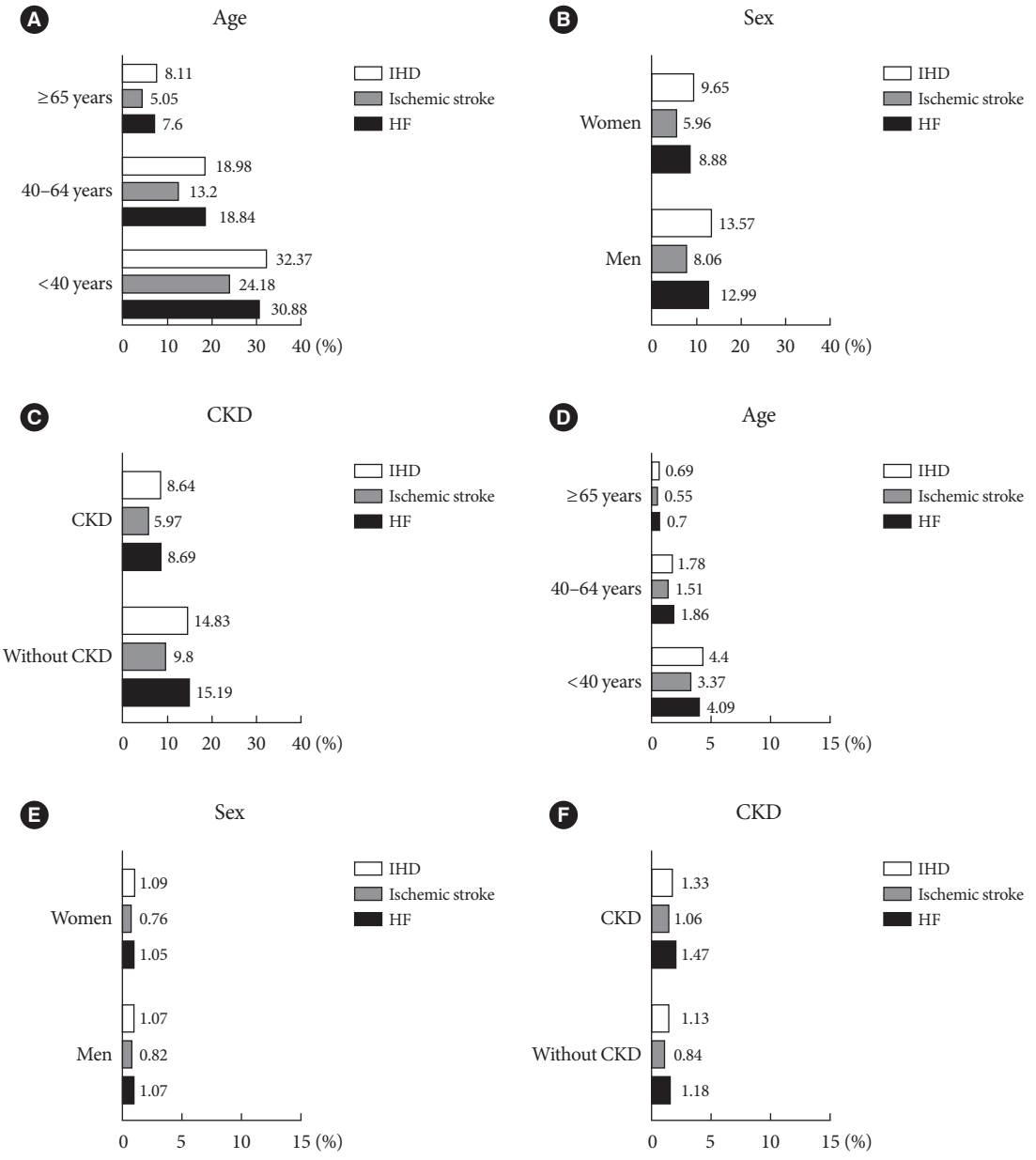

Fig. 5. The prescription pattern of sodium-glucose cotransporter 2 inhibitor (SGLT2i) and glucagon-like peptide-1 receptor agonist (GLP-1RA) according to population characteristics. (A, B, C) SGLT2i use according to age, sex, and chronic kidney disease (CKD) status, respectively. (D, E, F) GLP-1RA use by age, sex, and CKD status, respectively. IHD, ischemic heart disease; HF, heart failure.

DISCUSSION

This study revealed a consistent decline in the incidence of IHD, ischemic stroke, and PAD over the past decade in individuals with T2DM in South Korea. However, an increase in the incidence of HF has been observed during the same period. Only 4.96% of adults with diabetes and CVD achieved optimal control of all three risk factors (glycemic levels, BP, and lipid control). Glycemic control was notably superior in the population aged 65 years and older with diabetes and CVD compared to those under 65 years of age. Statin prescription rates for IHD and ischemic stroke in patients with T2DM have consistently increased over the past 6 years. However, in 2019, only 8.84% and 9.15% of patients with IHD and ischemic stroke, respectively, were prescribed high-intensity statins. The prescription rates of SGLT2i and GLP-1RA were suboptimal in 2019. Younger age was associated with higher prescription rates of both SGLT2i and GLP-1RA. Additionally, an SGLT2i is more commonly prescribed to male patients and less frequently to individuals with CKD.

Significant progress in heart disease treatment and management of cardiovascular (CV) risk factors in the past decade, along with breakthroughs in diabetes care, have significantly contributed to a noteworthy decline in the incidence of CVD in recent decades. Booth et al. [11] reported a significant reduction in the number of people affected by CVD in the diabetic population using health claims data from 1992 to 2000 in Canada. Additionally, Swedish registry data from 1998 to 2014 demonstrated a substantial reduction in CV outcomes among individuals with diabetes [12]. Additionally, based on analyses of data from the National Inpatient Sample (NIS) and NHIS between 2000 and 2016, substantial declines were observed in the age-standardized rates of hospitalization for IHD among patients diagnosed with diabetes [13].

Comparable population-level statistics for Asian countries are limited. Between 2001 and 2016, the event rates of coronary heart disease and stroke significantly declined by 69.4% and 70.3%, respectively, based on data from the Hong Kong Diabetes Surveillance Database [14]. These trends in CVD among individuals with diabetes are consistent with the findings of previous studies in Korea. Jung et al. [5] observed a 29.47% reduction in hospital admission rates for IHD and a 36.98% decrease in ischemic stroke rates among individuals with T2DM between 2006 and 2013, as reported in the Korean NHIS database. The relative decrease in CV complications was more pronounced in adults with diabetes than in those without. Park et al. [6] reported a decrease in hospitalization rates for major CV complications (IHD, ischemic stroke, and myocardial infarction), whereas the rates of HF increased from 2006 to 2015 among adults with diabetes in South Korea. This study used data from the Korean NHIS National Sample Cohort.

In this nationwide population-based study using data from the Korean NHIS database, which encompasses nearly the entire Korean population, we observed a similar trend in CVD incidence. These results are consistent with those of previous studies conducted in Korea [5,6]. Our findings suggest a consistently stable incidence rate of IHD, coupled with notable additional reductions in the incidence of ischemic stroke in subsequent years.

PAD is a critical complication of limb amputation [15]. Few population-level epidemiological studies have explored the incidence of PAD in Korea. Ryu et al. [16] observed a steadily increasing trend in 2011 and 2018 through an analysis of national claims data. They defined patients with PAD using the Korean Standard Classification of Diseases, recognizing the potential for unchanged previous diagnostic codes or selective entry of the required codes for insurance claims. Park et al. [6] noted an increase in PAD among individuals with diabetes between 2006 and 2015; however, our results suggest a stable and decreasing trend after 2016. Employing Park et al.'s [6] definition of PAD, we enhanced the diagnostic precision in claims databases, focusing on patients undergoing PAD-related procedures to prevent potential overestimation. Our study enabled us to predict decade-long trends in PAD within the diabetic population in Korea, with advances in revascularization and PAD treatment [17] and improvements in diabetes care potentially contributing to these favorable sequential trends.

In this study, the incidence of HF sharply increased from 2015 to 2016, almost doubling and subsequently demonstrating a gradual upward trend in diabetes in Korea. These findings align with those of the Korean Heart Failure Fact Sheet 2022 [18], which similarly depicted an increased incidence of HF during the same period. This observed increase may be attributed to aging and advancements in treatments that improve survival after acute heart insults or chronic cardiac abnormalities, contributing to an overall increase in the number of patients with HF. It is also possible that diagnostic codes were included in the prescription of SGLT2i to facilitate insurance coverage. Dapagliflozin, the first SGLT2i, was introduced

in the Korean market in September 2014.

Although high-intensity statin therapy is recommended for individuals with diabetes and CVD [2], our 2019 findings revealed the limited adoption of high-intensity statin treatment, as only 8.84% and 9.15% of individuals with IHD and ischemic stroke, respectively, received this therapy. A transformative shift in the management of T2DM has occurred, driven by compelling evidence of the CV benefits associated with the use of SGLT2i and GLP-1RA, as reported in CV outcome trials [19-28]. Current clinical guidelines advocate the use of SGLT2i or GLP-1RA in patients with T2DM who have established CVD or exhibit indicators of high CVD risk, including HF [29]. In our study, the prescription rates of SGLT2i were suboptimal, with only 11.87%, 7.10%, and 11.05% of the individuals diagnosed with T2DM, concomitant IHD, ischemic stroke, and HF, respectively, in 2019. Similarly, the use of GLP-1RA remained notably low, with only 1.08%, 0.8%, and 1.06% of patients with IHD, ischemic stroke, and HF, respectively. These results may be attributed to the lack of adoption of treatment guidelines advocating the prioritization of SGLT2i or GLP-1RA in patients with diabetes and CVD. The guidelines were initially published in 2019 [30,31]. Following on from our study period, a study investigating more recent prescription patterns is warranted. In a study conducted in 2019 at 13 secondary and tertiary hospitals in Korea [32], an SGLT2i was used in 31.3%, 12.6%, and 26.5% of patients with T2DM who had IHD, stroke, and HF with a preserved ejection fraction, respectively. Correspondingly, the percentages of patients in whom a GLP-1RA was used were 1.8%, 1.4%, and 1.5%, respectively. These rates are higher than those in our study. This disparity may stem from the fact that data from secondary and tertiary hospitals were analyzed in the former study, whereas our data were derived from the general population.

In a study conducted in the United States population with diabetes and CVD in 2018, only 26.8% of the individuals with CVD and diabetes received high-intensity statins. A mere 3.9% were prescribed a GLP-1RA, and 2.8% received an SGLT2i. Only 4.6% were prescribed all three classes of drugs, whereas 42.6% received none [33]. An analysis of United States health insurance databases indicated low utilization of newer cardioprotective diabetes agents between 2013 and 2019, with 0.8% (Medicare) and 1.7% (commercial insurers) using an SGLT2i and 1.0% (Medicare) and 3.5% (commercial insurers) using a GLP-1RA [34]. A national analysis using NHANES 2017 to 2018 data showed that although 52.6% of individuals with T2DM had an indication for SGLT2i and 32.8% for GLP-1RA, the actual usage was quite low, with only 4.5% treated with an SGLT2i and 1.5% with a GLP-1RA [35]. This suggests an opportunity to optimize the use of these medications to improve CVD outcomes.

In this study, younger patients had higher prescription rates of both SGLT2i and GLP-1RA. Additionally, an SGLT2i was more commonly prescribed to male patients, which may reflect physicians' concerns regarding potential side effects such as genital infections in women and volume depletion [7] in older populations when prescribing an SGLT2i. Similarly, the preference for prescribing a GLP-1RA to younger individuals could be attributed to physicians' concerns about gastrointestinal issues [7] and the initiation barrier for injectable agents [36] in older populations. A reduced prescription rate for SGLT2i in patients with CKD was also observed in our study. This finding may be attributed to the fact that, at the time of our study, the labeling for SGLT2i did not encompass patients with an eGFR <45 mL/min/1.73 m^2 until August 2019. This was done prior to the release of studies demonstrating a protective effect of SGLT2i in populations with more advanced CKD [20,23,37], as well as before the dissemination of consensus statements by the Korean Diabetes Association and the Korean Society of Nephrology regarding the utilization of SGLT2i in patients with T2DM to mitigate the decline in renal function in 2020 [38].

Our study had several limitations. First, because we analyzed cross-sectional data, establishing causality was not feasible, and the findings may not accurately reflect changes in variables over time. Second, potential discrepancies in disease diagnosis may have arisen due to the use of operational definitions for each disease. We did not investigate combination therapies making use of other drugs such as ezetimibe or proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors for lowering LDL cholesterol. Further research is required to explore these aspects. Lastly, despite standardizing the incidence rates by age and sex, it was not feasible to account for all the various confounding factors for each disease. Despite these limitations, our study, which is representative of the entire Korean population, aimed to comprehensively evaluate the incidence rates and recent trends of CVD in patients with diabetes.

In conclusion, based on information from the 2024 CVD Fact Sheet in Diabetes, there are notable findings. The incidence of most CVD (e.g., IHD, ischemic stroke, and PAD) decreased from 2010 to 2019, whereas that of HF increased. No-

tably, only 4.96% of adults with diabetes and CVD achieved optimal control of all three risk factors (glycemia, BP, and lipid control). Furthermore, in 2019, the overall use of high-intensity statins, SGLT2i, and GLP-1RA remained suboptimal among individuals with T2DM and CVD.

SUPPLEMENTARY MATERIALS

Supplementary materials related to this article can be found online at https://doi.org/10.4093/dmj.2024.0275.

CONFLICTS OF INTEREST

Hyuk-Sang Kwon has been editor-in-chief of the *Diabetes & Metabolism Journal* since 2024. He was not involved in the review process of this article. Otherwise, there was no conflict of interest.

AUTHOR CONTRIBUTIONS

Conception or design: J.H.K., J.L., K.H., H.S.K.
Acquisition, analysis, or interpretation of data: J.H.K., J.L., K.H., H.S.K.
Drafting the work or revising: J.H.K., J.L., K.H., J.T.K., H.S.K.
Final approval of the manuscript: J.H.K., J.L., K.H., J.T.K., H.S.K.

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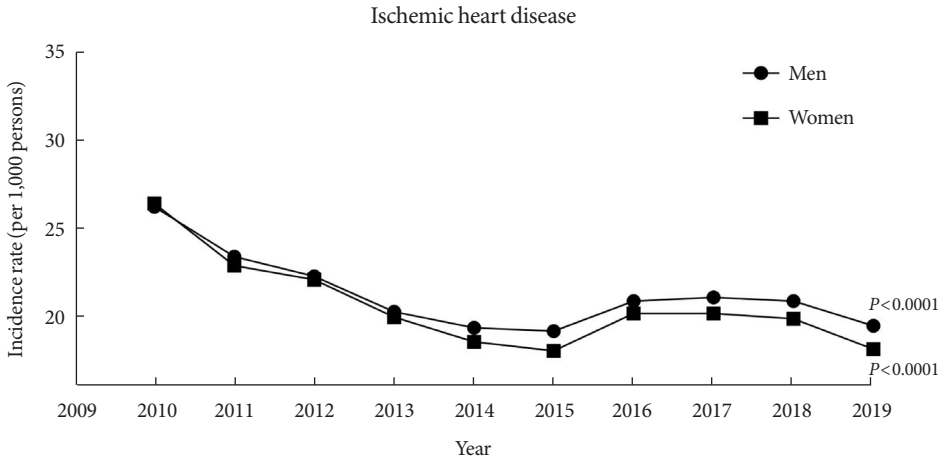
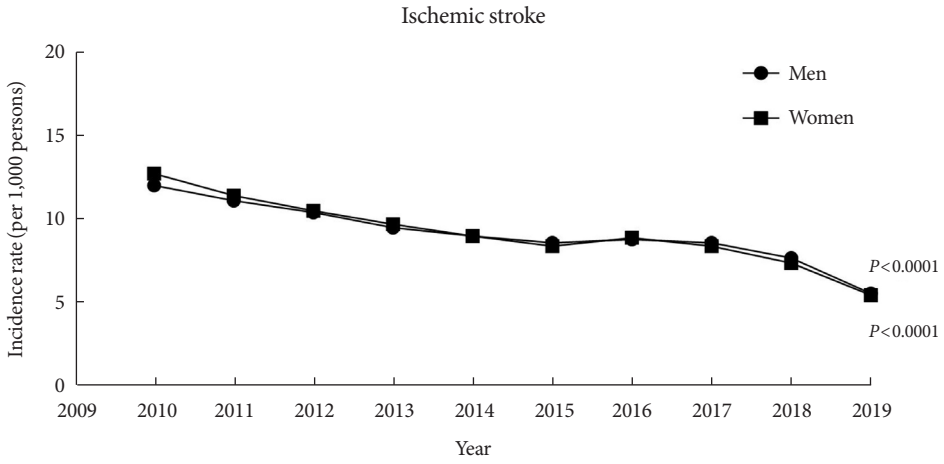
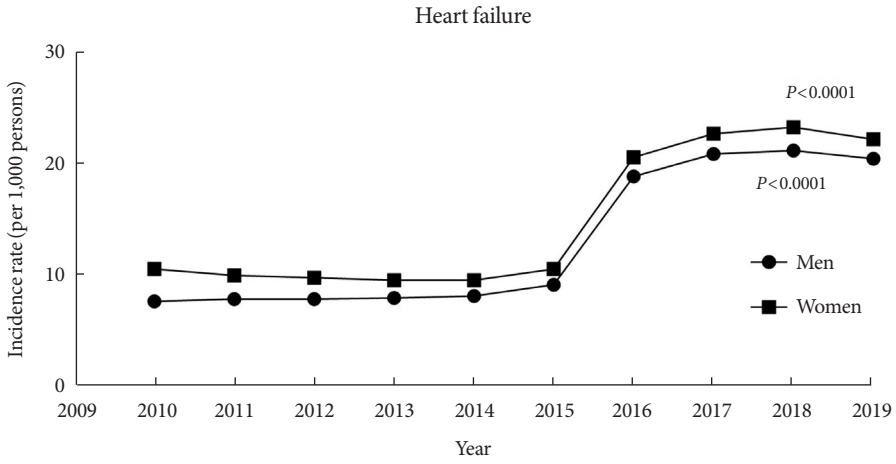


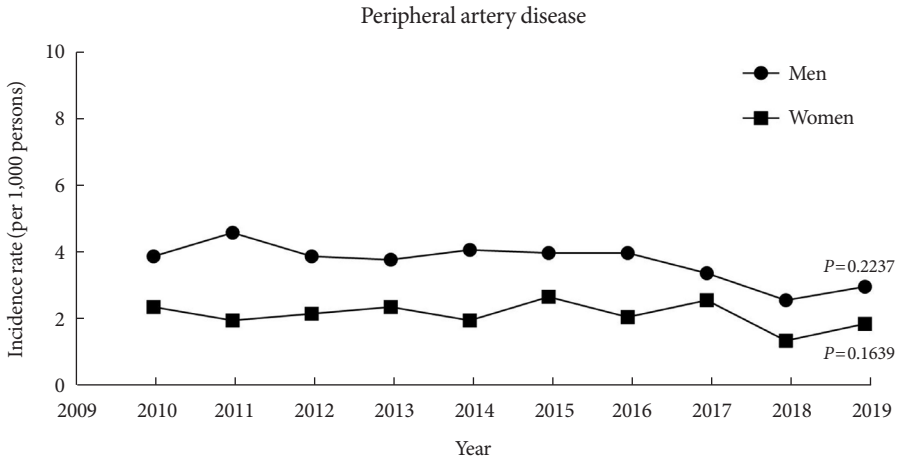
Supplementary Fig. 1. Ischemic heart disease age-standardized incidence trends in individuals with type 2 diabetes mellitus by gender: 2010 to 2019 from the Korean National Health Insurance Service.



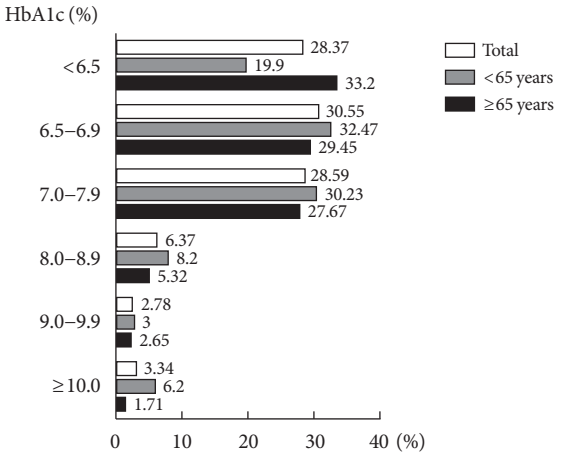
Supplementary Fig. 2. Ischemic stroke age-standardized incidence trends in individuals with type 2 diabetes mellitus by gender: 2010 to 2019 from the Korean National Health Insurance Service.



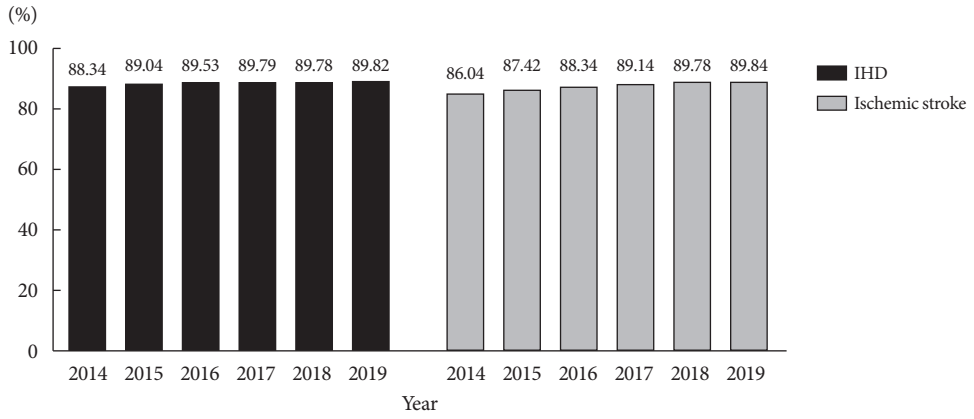
Supplementary Fig. 3. Heart failure age-standardized incidence trends in individuals with type 2 diabetes mellitus by gender: 2010 to 2019 from the Korean National Health Insurance Service.



Supplementary Fig. 4. Peripheral artery disease age-standardized incidence trends in individuals with type 2 diabetes mellitus by gender: 2010 to 2019 from the Korean National Health Insurance Service–National Sample Cohort.



Supplementary Fig. 5. Glycemic control status in individuals with diabetes and cardiovascular disease from the Korea National Health and Nutrition Examination Survey 2019 to 2021. HbA1c, glycosylated hemoglobin.



Supplementary Fig. 6. Trends in statin prescription among individuals with type 2 diabetes mellitus and cardiovascular disease: 2014 to 2019 from Korean National Health Insurance Service. IHD, ischemic heart disease.