Prevalence and Socioeconomic Burden of Diabetes Mellitus in South Korean Adults: A Population-Based Study using Administrative Data

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Abstract

Background: Diabetes leads to severe complications and imposes health and financial burdens on the society. However, currently existing domestic public health studies of diabetes in South Korea mainly focus on prevalence, and data on the nationwide burden of diabetes in South Korea are lacking. The study aimed to estimate the prevalence and economic burden of diabetes imposed on the South Korean society.

Methods: A prevalence-based cost-of-illness study was conducted using the Korean national claims database. Adult diabetic patients were defined as those aged ≥20 years with claim records containing diagnostic codes for diabetes (E10-E14) during at least two outpatient visits or one hospitalization. Direct costs included medical costs for the diagnosis and treatment of diabetes and transportation costs. Indirect costs include productivity loss costs due to morbidity and premature death and caregivers' costs. Subgroup analyses were conducted according to the type of diabetes, age (<65 vs. ≥65), diabetes medication, experience of hospitalization, and presence of diabetic complications or related comorbidities.

Results: A total of 4,472,133 patients were diagnosed with diabetes in Korea in 2017. The average annual prevalence of diabetes was estimated at 10.7%. The diabetes-related economic burden was USD 18,293 million, with an average per capita cost of USD 4,090 in 2019. Medical costs accounted for the biggest portion of the total cost (69.5%), followed by productivity loss costs (17.9%), caregivers' costs (10.2%), and transportation costs (2.4%). According to subgroup analyses, type 2 diabetes, presence of diabetic complications or related comorbidities, diabetes medication, and hospitalization represented the biggest portion of the economic burden for diabetes. As the number of complications increased from one to three or more, the per capita cost increased from USD 3,991 to USD 11,965. In inpatient settings, the per capita cost was ~10.8 times that of outpatient settings.

Conclusions: South Korea exist a slightly higher prevalence and economic burden of diabetes. These findings highlight the need for effective strategies to manage diabetic patients and suggest that policy makers allocate more health care resources to diabetes. This is the first study on this topic, conducted using a nationally representative claims database in South Korea.

Background

Diabetes mellitus has a high prevalence and imposes a substantial socioeconomic burden on individuals and the society in terms of large medical costs (1, 2). According to a global report on diabetes, published by the World Health Organization, an estimated 422 million adults were living with diabetes in 2014, compared with the 108 million adults in 1980. The worldwide prevalence of diabetes has nearly doubled since 1980, growing from 4.7–8.5% in the adult population (3). Based on cost estimates from a recent systematic review (4, 5), the estimated total global cost of diabetes is more than USD 827 billion. The International Diabetes Federation (IDF) revealed that the total costs had more than tripled during 2003–2013, with resulting increases in the prevalence of diabetes and per capita diabetes cost. The prevalence and the economic burden of diabetes are expected to continue to increase (6, 7).

Diabetes also causes suffering in humans. It leads to complications such as blindness, amputation, renal disease, and cardiovascular disease, which have become a major cause of productivity loss due to morbidities and premature mortality (3). These complications are associated with increased healthcare utilization such as having more outpatient visits and a higher probability of being hospitalized, and with increased use of more medications (8, 9). Therefore, complications associated with diabetes drive the escalating costs of diabetes management and their financial burden on the healthcare system.

Together with prevalence, morbidity, and mortality data, cost-of-illness (COI) studies have been conducted to measure the economic burden of diabetes in several countries (1, 10). However, existing domestic public health studies of diabetes in South Korea mainly focus on diabetes prevalence, and data on the nationwide economic burden of diabetes in Korea are lacking. The prevalence of diabetes among Korean adults has increased from 1.5% in 1971 to 9.9% in 2009 (11) and is expected to change more over time. There will also be changes in demographics, healthcare use patterns, and medical costs, which will affect the economic burden of diabetes as time progresses. To address these concerns, this study aimed to estimate the prevalence and the economic burden of diabetes at the population levels in 2019 by using nationally representative claims records that encompass

the entire Korean population. Identification of the nationwide burden of diabetes and the patient subgroups with a higher contribution to economic costs can aid in planning prevention and management strategies.

Methods

Study design and data sources

This study was approved by the Institutional Review Board at the Korea National Institute for Bioethics Policy (P01-201909-21-010). This COI study was conducted using a prevalence-based approach to quantify the economic burden of diabetes at a given point in time (2). The study estimates the annual cost of diabetes during 1 year for the prevalence cohort of individuals with diabetes. The 2017 Health Insurance Review and Assessment Service National Patient Sample (HIRA-NPS) was used for this study. The HIRA-NPS is an annual 3% random sample (comprising approximately 1,450,000 individuals with claims records) of the nationwide population, which includes those enrolled in both the National Health Insurance (97%) and Medical Aid (3%) programs. This dataset contains claims records including demographic information as well as diagnostic, procedural, and prescription records provided for all types of health care services (12). All diagnoses were coded using the International Classification of Diseases, 10th revision (ICD-10).

Study Population

Patients with diabetes were identified using a validated administrative data algorithm (13). We included adult patients aged ≥ 20 years and who had claim records containing the diagnostic code for diabetes (E10-E14) in at least two outpatient visits or one hospitalization between January 1, 2017, and December 31, 2017. We analyzed costs related to diabetes beyond the primary diagnosis using attributable risk approaches to estimate more accurately the costs attributed to a disease (2). Based on a literature review, patients with comorbidities unrelated to diabetes (cancer, rheumatic disease, etc.) were excluded to prevent the huge cost of these diseases from influencing the true diabetes-related costs (1, 14). Patients with missing cost-related information were excluded. The specific ICD-10 codes for these excluded diseases are listed in Additional File 1.

Estimating The Economic Burden Of Diabetes

The economic burden of diabetes was estimated from the perspective of society. The study included both direct and indirect costs. Direct costs reflected the resources used in treating the disease, including expenditure for the diagnosis and treatment of diabetes as medical costs and expenditure for transportation to medical visits as nonmedical costs. Medical costs covered by insurance were estimated using the HIRA-NPS claims data, and medical costs not covered by insurance were calculated using the ratio of out-of-pocket expense to payment for covered services (for which we used the value of 0.25) obtained from data published by the National Health Insurance Service (15). Transportation costs for patients were calculated using data from the Third Korea National Health and Nutrition Examination Survey (16). Indirect costs represented the present and future resources lost by patients and their families as a consequence of the disease. These costs included the societal costs of productivity loss due to morbidity and premature mortality, and caregivers' time costs. The productivity loss cost was calculated based on the human capital method, which estimates the lost productivity as the expected earnings lost due to a disease (17). Morbidity costs were estimated as losses of earnings due to hospitalization or outpatient visits for diabetes treatment, and mortality costs were estimated as losses of potential earnings until the age of 65 as a result of premature death caused by diabetes. The age- and gender-specific numbers of deaths attributable to diabetes were obtained from the HIRA-NPS claims data. Average daily incomes were derived from the age- and gender-specific average monthly incomes provided by the Korean Statistical Information Service (18).

Data analysis

Descriptive statistics were calculated for several characteristics of the study population. Continuous data were presented as means and standard deviation (SD), while categorical data were shown as frequencies and percentages (%). Clinical

characteristics (i.e., type of diabetes, diabetes medication use, and diabetic complications or related comorbidities) and healthcare utilization (i.e., inpatient and outpatient settings, number of outpatient visits and hospitalization, and number of hospitalization days) were examined over a 1-year period. The average annual prevalence of diabetes among the general adult population was estimated as follows. We calculated the total number of patients with diabetes in the 2017 samples, multiplied it by a sampling weight of 33.33% (i.e., the inverse of the sampling probability for the HIRA-NPS data), and then divided the result by the total population, using 2017 census data from the Korean Statistical Information Service (19). Prevalence rates were stratified by age and gender. We also evaluated the economic cost of diabetes (total cost) and the average cost per patient with diabetes (per capita cost). Per capita cost was calculated as the estimated total cost divided by the number of patients with diabetes. The total cost and the total number of patients with diabetes were extrapolated to the Korean adult population by multiplying it by a sampling weight of 33.33%. All costs are presented according to each cost component, converted to U.S. dollars using an exchange rate of 1 USD to 1,151 KRW, and are expressed in 2019 monetary values using the healthcare component of the Consumer Price Index for Korea (20).

We conducted subgroup analyses according to the type of diabetes, age group (< 65 vs. ≥65 years), diabetes medication use, experience of hospitalization, and presence of diabetic complications or related comorbidities. Previous studies revealed that the economic burden was affected by these variables (1, 2, 8). The following diabetes medications were included: insulin, biguanides, sulfonylureas, thiazolidinediones, dipeptidyl peptidase-4 inhibitors, glucagon-like peptide-1 receptor agonists, meglitinides, sodium glucose cotransporter-2 inhibitors, and alpha-glucosidase inhibitors. Complications or related comorbidities often associated with diabetes were identified from the literature (1, 14). These conditions included retinopathy, nephropathy, neuropathy, cerebrovascular disease, cardiovascular disease, peripheral vascular disease, and metabolic disease. These conditions were defined using the primary and secondary ICD-10 diagnosis codes, which are listed in Additional File 2.

Results

Prevalence of diabetes and characteristics of diabetes patients

It was estimated that a total of 4,472,133 patients were diagnosed with diabetes from the 2017 HIRA-NPS data. The average annual prevalence of diabetes in Korean adults aged 20 years and older was estimated to be 10.7%. The prevalence of diabetes was slightly higher in males (11.4%) than in females (10.1%) irrespective of the age group, which then increased gradually with age. As the patients reached their 60 s, the prevalence exceeded 50% in males and the prevalence in females doubled from 21.0% in their 50 s to 41.9% in their 60 s (Fig. 1).

The characteristics of the study population are shown in Table 1. The study included 2,357,100 (52.7%) male and 2,115,033 (47.3%) female subjects; elderly individuals (age ≥ 65 years) accounted for 45.2% of all subjects. Most diabetes patients had type 2 diabetes (88.0%) and received diabetes medication (75.8%). Based on recorded diagnoses, 57.5% of all diabetes patients had at least one diabetic complication or related comorbidity: peripheral vascular disease (24.3%) was the related disease with the highest prevalence, followed by neuropathy (18.0%), cardiovascular disease (17.8%), and nephropathy (14.8%). The proportion of diabetes patients who had been hospitalized was 23.1%: hospitalizations through emergency department visits and outpatient visits accounted for 28.9% and 71.1%, respectively. On average, diabetes patients had 9.51 outpatient visits, 0.59 hospitalizations, and 9.16 inpatient days during the 1-year period (Table 1).

Table 1
Characteristics of the study population

Characteristic	N	(%)
Total no. of patients with diabetes mellitus	4,472,133	(100.0)
Gender		
Male	2,357,100	(52.7)
Female	2,115,033	(47.3)
Age		
<65	2,449,067	(54.8)
≥65	2,023,067	(45.2)
Type of diabetes mellitus[a]		
Type 1 diabetes mellitus	172,733	(3.9)
Type 2 diabetes mellitus	3,937,200	(88.0)
Other diabetes mellitus	362,200	(8.1)
Use of diabetes medication		
One or more diabetes medications	3,391,733	(75.8)
No medication	1,080,400	(24.2)
Prevalence of diabetic complications or related comorbidities		
Retinopathy	262,933	(5.9)
Nephropathy	662,333	(14.8)
Neuropathy	806,433	(18.0)
Cerebrovascular disease	494,700	(11.1)
Cardiovascular disease	795,233	(17.8)
Peripheral vascular disease	1,088,033	(24.3)
Metabolic disease	321,533	(7.2)
Number of diabetic complications or related comorbidities		
None	1,901,667	(42.5)
1	1,569,367	(35.1)
2	727,567	(16.3)
≥3	273,533	(6.1)
Type of medical institution		
Primary	2,038,933	(45.6)
Secondary	1,678,800	(37.5)
Tertiary	754,400	(16.9)
Healthcare utilization[b]		
Had experience of hospitalization (inpatient setting)	1,033,267	(23.1)

Characteristic	N	(%)
Through emergency department visit	298,367	(6.7)
Through outpatient visit	734,900	(16.4)
Had no experience of hospitalization (outpatient setting)	3,438,867	(76.9)
No. of outpatient visits per patient, mean (SD)	9.51	(12.36)
No. of hospitalizations per patient, mean (SD)	0.59	(1.90)
Inpatient days per patient, mean (SD)	9.16	(42.20)

[a]ICD-10 codes to define type of diabetes mellitus: Type 1 diabetes mellitus (E10), Type 2 diabetes mellitus (E11), Malnutrition-related diabetes mellitus (E12), Other specified diabetes mellitus (E13), Unspecified diabetes mellitus (E14). Other diabetes mellitus included E12, E13, or E14. Among all diabetic patients, patients without a type 1 or type 2 diabetes code (E10 or E11) were classified as other diabetes mellitus.

[b]Patients admitted as outpatients and inpatients in the same year were counted as inpatients.

Socioeconomic Burden Of Diabetes Patients

The average annual cost spent by individual patients to treat diabetes was USD 4,090 in 2019 (Table 2). Direct costs were calculated to be USD 2,941 per patient (71.9%) and indirect costs to be USD 1,105 per patient (28.1%). The total economic burden of DM in South Korea was estimated to be USD 18,293 million. Medical costs accounted for the largest proportion of the total cost (69.5%), followed by productivity loss costs (17.9% = 9.9% due to premature death + 8.0% due to morbidity), caregivers' costs (10.2%), and nonmedical costs (2.4%). While only 23.1% of the diabetes patients were hospitalized (Table 1), medical costs for inpatient services accounted for 42.7% of the total economic cost.

Table 2
Total annual costs in the year 2019

	Per capita cost, USD	Total cost, million USD	(%)
Direct cost	2,941	13,151	(71.9)
Medical cost	2,842	12,710	(69.5)
Outpatient services	1,096	4,904	(26.8)
Inpatient services	1,745	7,806	(42.7)
Nonmedical cost[a]	99	442	(2.4)
Indirect cost	1,105	5,141	(28.1)
Caregivers' cost	416	1,860	(10.2)
Productivity loss cost	734	3,281	(17.9)
Due to morbidity	327	1,461	(8.0)
Due to premature mortality	407	1,820	(9.9)
Total	4,090	18,293	(100.0)

Costs converted into US dollars using an exchange rate of 1 USD = 1,151 KRW (2019)

[a]Nonmedical costs included transportation costs

The total annual per capita cost was 2.2 times higher (USD 8,891 vs. USD 4,035) for patients with type 1 diabetes than it was for those with type 2 diabetes. Particularly, indirect costs comprised a higher proportion (31.2% vs. 26.5%) for patients with type 1 diabetes than for those with type 2 diabetes (Table 3). However, the total cost was 10.3 times higher (USD 15,888 million vs. USD 1,536 million) for patients with type 2 diabetes than it was for those with type 1 diabetes, which accounted for 86.9% and 8.4% of the total economic burden of the adult diabetes patients, respectively.

Table 3
Total annual costs according to the type of diabetes mellitus in the year 2019

	Type 1 diabetes mellitus[a]		Type 2 diabetes mellitus[a]	
	Per capita cost, USD	Total cost, million USD (%)	Per capita cost, USD	Total cost, million USD (%)
Direct cost	6,117	1,057 (68.8)	2,968	11,684 (73.5)
Medical cost	5,955	1,029 (67.0)	2,864	11,278 (71.0)
Nonmedical cost[a]	162	28 (1.8)	103	407 (2.6)
Indirect cost	2,774	479 (31.2)	1,068	4,204 (26.5)
Caregiver's cost	1,062	183 (11.9)	401	1,579 (9.9)
Productivity loss cost	1,712	296 (19.3)	667	2,625 (16.5)
Due to morbidity	865	149 (9.7)	325	1,279 (8.0)
Due to premature mortality	847	146 (9.5)	342	1,346 (8.5)
Total	8,891	1,536 (100.0)	4,035	15,888 (100.0)

[a]ICD-10 codes that define the type of diabetes mellitus: Type 1 diabetes mellitus (E10), Type 2 diabetes mellitus (E11)

[b]Non-medical costs include transportation costs

Figure 2 shows the results of the analyses by subgroup such as age group (< 65 vs. ≥65), use of diabetes medication (diabetes medication and no medication), and hospital setting (inpatient and outpatient). The annual per capita cost for adult patients over the age of 65 was higher than that for those under the age of 65, and total cost was similar in the two groups. The per capita costs were similar for both individuals using and those not using medication; however, the total cost was higher for patients using diabetes medication than it was for those not using diabetes medication. For inpatient settings, the per capita cost was much higher (approximately 10.8 times) than that for outpatient settings: in particular, it was the highest for patients hospitalized through emergency department visits (USD 17,177, data not shown). The total cost was also higher for inpatient settings than for outpatient settings. Meanwhile, the total cost for patients treated in outpatient settings was dominated by direct costs, including medical costs (92%). For patients under the age of 65, those not using diabetes medication, and those treated in inpatient settings, indirect costs accounted for the highest proportion of total costs (41%, 37%, and 34%, respectively).

Adult patients with complications or related comorbidities had more outpatient visits (11.0 vs. 7.5), hospitalizations (0.8 vs. 0.3), and longer lengths of stay (12.3 vs. 5.0) for diabetes treatment in a year than did those without complications (Table 4). As the number of complications or related comorbidities per patient increased from one to three or more complications, healthcare utilization likewise increased: from 9.4 to 17.7 for outpatient visits, from 0.6 to 1.6 for hospital admission, and from 9.1 to 24.9 for length of stay. In particular, patients with three or more complications had approximately five times as many average numbers of hospitalizations and five times as long average lengths of stay as patients without complications. Further, as the number of complications or related comorbidities increased from one to three or more, the per capita cost of diabetes treatment increased from USD 3,991 to USD 11,965. The total cost was higher (USD 14,176 million vs. USD 4,117 million) for patients with

complications than for those without complications, which accounted for 77.5% and 22.5% of the total economic burden among adult diabetes patients, respectively.

Table 4
Healthcare utilization and total annual costs for diabetes patients with diabetic complications or related comorbidities

	No complication		With complications or related comorbidities							
			Total		One complication		Two complications		Three or more complications	
Total no. of patients with diabetes mellitus, n (%)	1,901,667	(42.5)	2,570,467	(57.5)	1,569,367	(35.1)	727,567	(16.3)	273,533	(6.1)
No. of outpatient visits per patient, mean (SD)	7.5	(6.5)	11.0	(15.2)	9.4	(9.9)	11.9	(16.2)	17.7	(28.9)
No. of hospitalizations per patient, mean (SD)	0.3	(1.4)	0.8	(2.2)	0.6	(1.9)	0.9	(2.4)	1.6	(3.2)
Duration of hospitalization per patient, days, mean (SD)	5.0	(32.2)	12.3	(48.0)	9.1	(42.4)	14.4	(51.4)	24.9	(63.9)
Per capita cost, USD	2,159		5,499		3,991		6,289		11,965	
Total cost, million USD	4,117		14,176		6,291		4,597		3,288	
Costs converted into US dollars using an exchange rate of 1 USD = 1,151 KRW (2019)										

Discussion

This is the first nationwide study to estimate the prevalence and socioeconomic burden of diabetes using a nationally representative claims database in South Korea. This study showed that the prevalence of diabetes in Korean adults was 10.7%. The diabetes-related economic burden was USD 18,293 million, with an average per capita cost of USD 4,090 in 2019. Our results also showed that type 2 diabetes, presence of diabetic complications or related comorbidities, diabetes medication use, and hospitalization were associated with a large economic burden of diabetes.

The estimated prevalence of diabetes in Korean adults was slightly higher than the global prevalence of diabetes in the adult population (8.5%) (3). According to the Korean National Health and Nutrition Examination Survey (2007–2009), 11.0% of males and 8.9% of females among the adult population had diabetes (11). These results are similar to ours (11.4% in males and 10.1% in females) considering the increasing trend in the prevalence of diabetes.

The economic burden of diabetes was USD 18,293 million in South Korea in 2019, which is equivalent to approximately 1.14% of Korea's gross domestic product (GDP). A study published in the U.S. showed that the estimated national cost of diabetes in 2017 (USD 327 billion) accounted for 1.69% of the GDP (1). It could be said that the relatively high percentage of GDP in the U.S. is caused by the high per capita cost for diabetes (USD 16,752), especially considering that the prevalence of diabetes in the U.S. is slightly lower (9.7% of the adult population) than it is in Korea. Additionally, the total annual cost of major diseases in Korea, such as cancer (21), liver disease (22), and cardio-cerebrovascular disease (23, 24), has been reported in the range of USD 1 billion to 3 billion, which was much lower than the total cost of diabetes. Moreover, the economic burden of diabetes was higher than the economic burden for overall cancers, at USD 15 billion (21).

Type 2 diabetes is the most common type of diabetes, accounting for approximately 90% of all cases of diabetes (7). Our study showed that 88.0% cases of all types of diabetes were type 2, which also accounted for most of the economic burden associated with diabetes (86.9%). In Korea, the direct medical costs of type 2 diabetes corresponded to 10.6% of all healthcare expenditure (USD 85.5 billion, calculated as only direct medical costs excluding out-of-pocket costs (25)). This was higher than the cost of type 2 diabetes in France, where it corresponded to ~ 5% of all healthcare expenditures (26). The economic burden makes type 2 diabetes a major clinical and public health problem in Korea (2). The type 2 diabetes are associated with overweight and obesity. Therefore, efforts to reduce the global health and economic burden of diabetes should emphasize the prevention of type 2 diabetes, or delaying its onset, by promoting healthy behavior and diet at the population level (4).

As with most other diseases, elderly patients require more healthcare resources to treat diabetes than younger patients: approximately half of all health care expenditure related to diabetes account for health resources used by those over the age of 65. Adult patients over the age of 65 in this study spent approximately 1.2 times more in annual per capita cost than those under the age of 65. Because productivity loss was assumed to be zero for people over the age of 65, indirect costs included only caregivers' costs related to hospitalization. High medical expenditures among the elderly, along with high caregivers' costs, can be partly attributed to the increased risk of hospitalization that comes with aging. The hospitalization rate of those over the age of 65 among our study subjects was approximately 1.5 times that of those under the age of 65 (28.2% vs. 18.9%).

We confirmed that hospitalization was a cost driver, which is associated with high costs for diabetes (2). Inpatient services accounted for 42.7% of the total economic costs for all diabetes patients. Diabetes incurred higher spending for inpatient services than other diseases that are common among the elderly, such as hypertension (18.3%), rheumatic arthritis (7.9%), heart failure (29.2%), and asthma (11.7%) (27–29). Furthermore, the total costs for diabetes patients with an experience of hospitalization represented 76.4% of the total economic costs for all diabetes patients, and the per capita cost in inpatient settings was much higher than that in outpatient settings, by 10.8 times. Our results show that inpatients represented a higher percentage of the elderly (55% vs. 42%) and those with complications (71.1% vs. 53.4%) than did outpatients. Patients requiring hospitalization generally had severe conditions, and because of the high cost of premature deaths from such conditions, indirect costs for inpatients accounted for a higher proportion of total costs (34% vs. 8%) than for outpatients. These findings suggest that an effective intervention to prevent hospitalization should be a critical component of a disease management strategy to minimize the economic and clinical burden of diabetes.

Because most patients with diabetes (75.8%) have been prescribed diabetes drugs, the total economic burden of patients using diabetes medication was high. However, per capita cost was similar between patients using diabetes medication and those with no use of diabetes medication, and indirect costs accounted for a higher proportion of the total for patients with no use of diabetes medication (37%) because of the higher costs incurred by diabetes complications and premature deaths than for those using diabetes medication (25%). Continuous treatment of diabetes is particularly important for preventing diabetes-related complications (30). In particular, one large cohort study found that improving antidiabetic medication adherence among newly diagnosed type 2 diabetes patients decreased the risks of macrovascular complications (31). Therefore, receiving medication reduces the clinical burden at the individual level and also reduces the socioeconomic burden by reducing indirect costs at the population level.

Our study found that per capita costs of diabetes increased with the number of complications or related comorbidities. As the number of complications increased, hospitalization also increased; in particular, the percentage of hospitalizations through emergency departments increased from 19.8–43.6% (data not shown). This result is in line with that of other studies that showed that medical costs incurred by complications led to a high economic burden in diabetic patients (8, 32). The American Diabetes Association reported how diabetes contributed to the economic costs of major complications in the healthcare system: the proportion of expenditures attributed to diabetes for peripheral vascular, neurological, renal, and cardiovascular diseases over total U.S. health care expenditures (39%, 36%, 29%, and 27%, respectively) was higher than that for other general medical conditions (8%) (1). We confirmed that peripheral vascular disease was the most common complication in Korean adult diabetic patients, followed by neurological, cardiovascular, and renal diseases. Therefore, management of diabetic patients with these major complications is expected to significantly reduce not only diabetes but also the economic burden of these diseases.

This study had several limitations. First, study subjects with diabetes were identified only based on ICD-10 codes, which potentially allowed misclassification or miscoding. Because the HIRA-NPS data do not provide information on laboratory test parameters such as fasting plasma glucose, oral glucose tolerance, and HbA1c levels, we were not able to confirm diabetes cases based on diagnostic test results. However, a previous study indicated that diabetes could be accurately identified in administrative data: The definition of diabetes, 2 physician claims within 1 years or 1 hospitalization with the ICD-10 codes E10.x–E14.x, had high validity (sensitivity 91.6%, specificity 97.2%) (13). Therefore, we consider that the administrative data can be used to establish the population-based prevalence of diabetes as a reasonable alternative to biochemical assay data (33). Second, health insurance claims data did not include information about subjects with undiagnosed or untreated diabetes; hence, the prevalence as well as the cost of diabetes might be underestimated. It was estimated that more than 50% of adults with diabetes in the Western Pacific region were undiagnosed according to the IDF Diabetes Atlas (6). Won et al. (2018) also reported that the estimated prevalence of undiagnosed or diagnosed diabetes was 13.7% during 2013–2014 in Korean adults (≥ 30 years of age) (34). However, our study was conducted among diagnosed patients who had paid for healthcare service using very comprehensive health care claims data that cover the nationwide Korean population. We regard our results to be conservative in terms of estimating COI and proper as being representative for the prevalence of diabetes in South Korea. Third, cross-sectional studies using claims data make it difficult to identify causal relationships between diabetes and its complications or related comorbidities. Thus, healthcare resource use by diabetes patients with related complications can be overestimated. To reduce the potential of overestimation in our definition of cases with complications, we excluded those for whom diabetes and complications were not diagnosed in the same prescription, although complications may occur within a certain period after the initial diagnosis of diabetes. Additionally, we mainly used diabetic complication codes (such as E10.1-E10.5 to E14.1-14.5, Additional File 2) to increase the association with diabetes, and all codes defining complications or related comorbidities were validated (1, 14). The known prevalence of diabetic complications or related comorbidities varies from one country to another; the prevalence of diabetic complications in Korea was similar or slightly lower than the average prevalence globally (7). Despite these limitations, we believe that the administrative data used in this study provide a powerful resource for a population-based evaluation of the economic burden of diabetes (33).

Conclusions

The study shows that South Korea exist a slightly higher prevalence and economic burden of diabetes. In particular, we confirmed that diabetic complications or related comorbidities and hospitalization were associated with high costs for diabetes as a cost driver. These findings highlight the need for effective strategies to manage patients with diabetic complications to reduce the use of healthcare resource and economic burden. It is expected that increased information regarding both the magnitude and the specific components of the economic burden of diabetes in Korea will influence health policy makers to prioritize its prevention and management and to allocate more health care resources to diabetes.

Abbreviations

COI
cost-of-illness
IDF
International Diabetes Federation
HIRA-NPS
Health Insurance Review and Assessment Service National Patient Sample
ICD-10
International Classification of Diseases Codes, 10th revision
SD
standard deviation
GDP
gross domestic product

Declarations

Ethical Approval and Consent to Participate

This study was approved by the Institutional Review Board at the Korea National Institute for Bioethics Policy (P01-201909-21-010). However, informed consent had not been applied due to the retrospective nature of the study.

Consent for Publication

Not applicable.

Availability of Data and Materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Competing Interests

The authors declare that they have no competing interests.

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Author Contributions

S-H O and HK conceptualized the study. S-H O designed the methodology, analyzed the study, and interpreted the results. S-H O wrote the manuscript (original draft preparation). S-H O, HK and KSP participated in the review & editing of the manuscript. KSP performed supervision. All authors read and approved the final manuscript.

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Figures

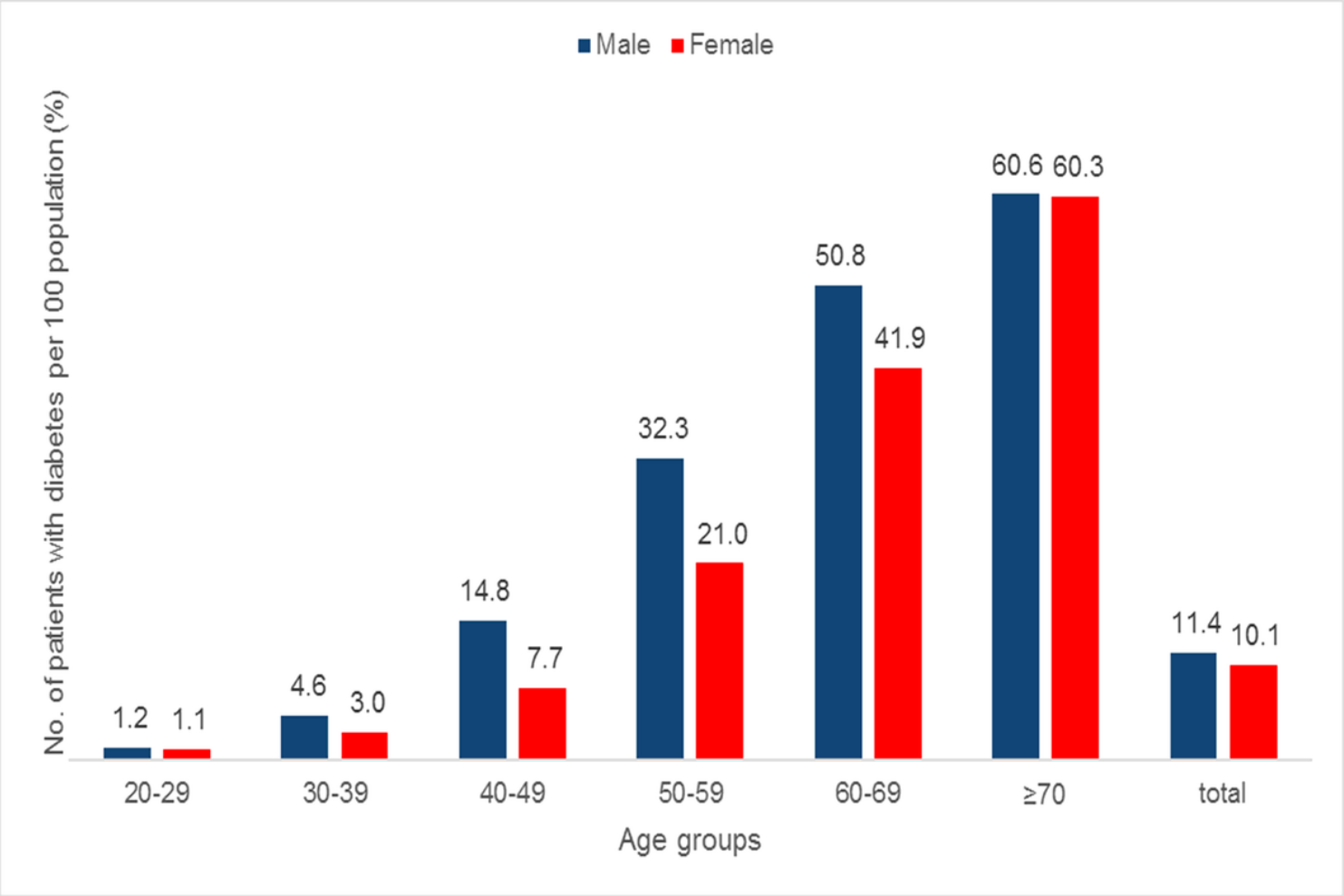
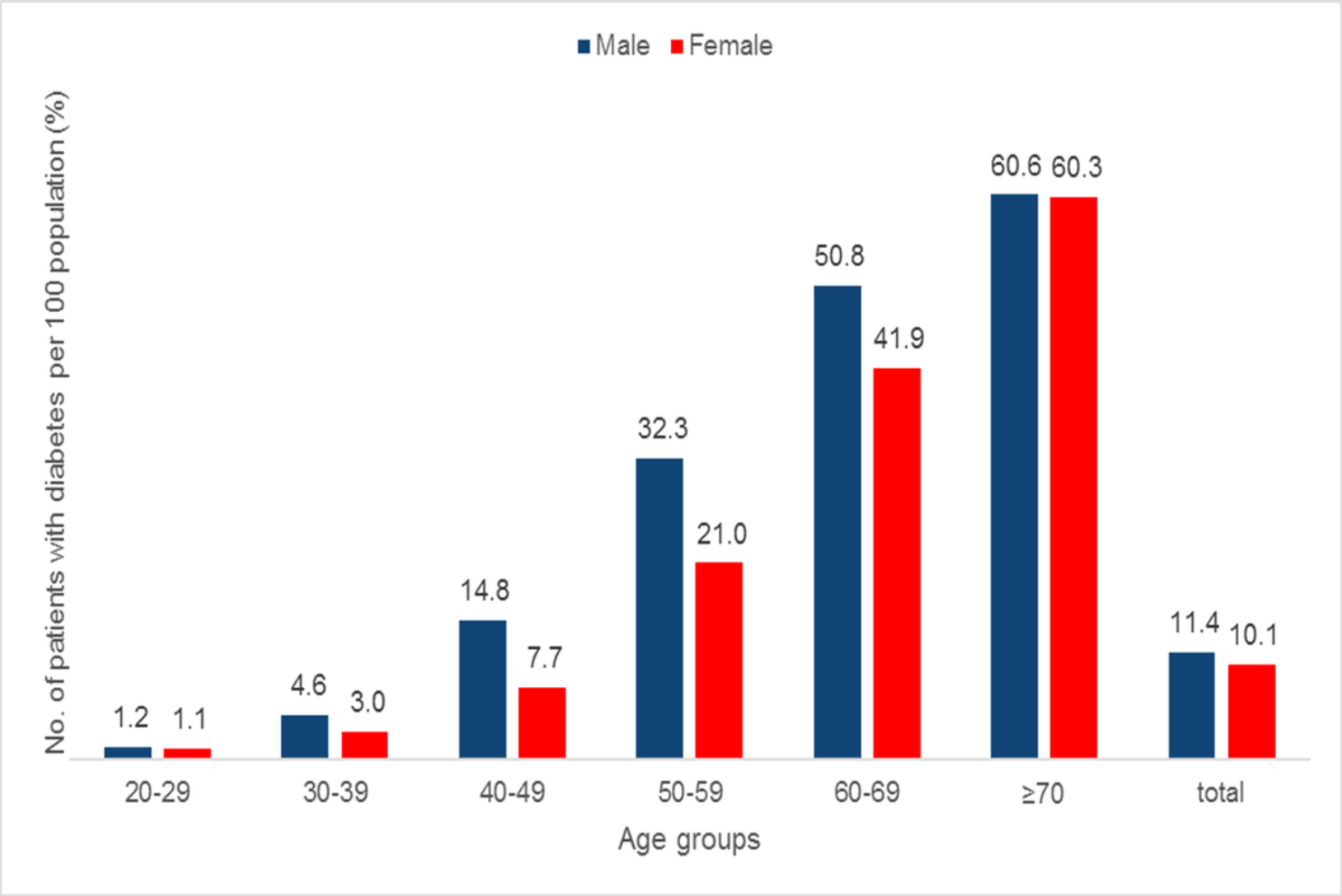


Figure 1

Age- and gender-specific prevalence of diabetes mellitus in Korean adults aged 20 years and older



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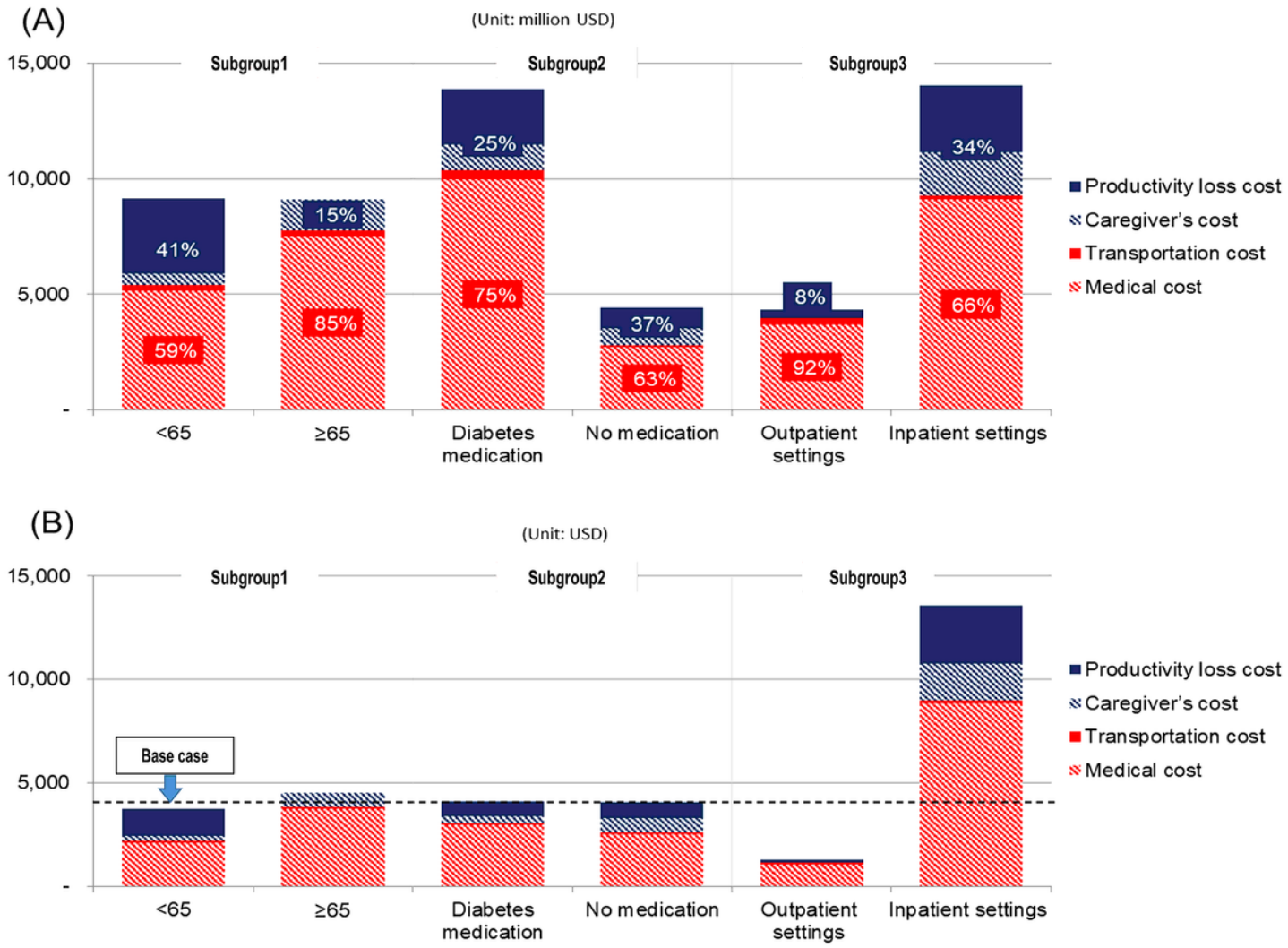
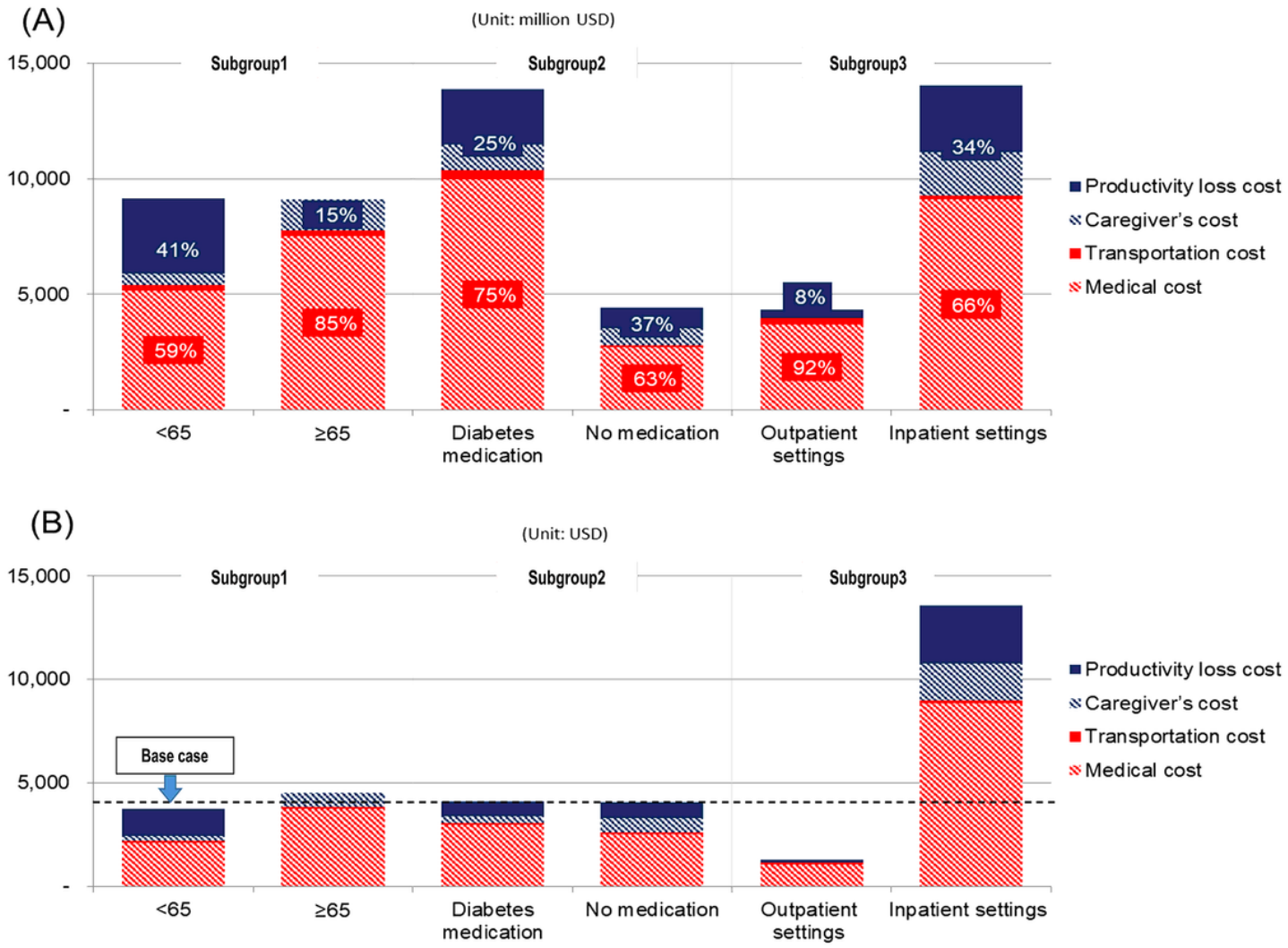


Figure 2

Total annual costs by subgroup in 2019 (A) Total cost (unit: million USD) according to subgroups 1–3. (B) Per capita cost (unit: USD) according to Subgroups 1–3. Per capita cost for base case (total diabetes patients) was USD 4,090. subgroup 1 = age group (<65 vs. ≥65), subgroup 2 = use of diabetes medication (medication vs. no medication), subgroup 3 = experience of hospitalization (inpatient vs. outpatient settings).



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