J Korean Med Sci. 2024 Feb 26;39(7):e67
https://doi.org/10.3346/jkms.2024.39.e67
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article
Medicine General & Health Policy

Check for updates

Measuring the Burden of Disease in Korea Using Disability-Adjusted Life Years (2008–2020)

Yoon-Sun Jung [1], **Young-Eun Kim** [2], **Minsu Ock** [3,4] and **Seok-Jun Yoon** [5]

[1]Artificial Intelligence and Big-Data Convergence Center, Gil Medical Center, Gachon University College of Medicine, Incheon, Korea
[2]Department of Big Data Strategy, National Health Insurance Service, Wonju, Korea
[3]Department of Preventive Medicine, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Korea
[4]Department of Preventive Medicine, University of Ulsan College of Medicine, Seoul, Korea
[5]Department of Preventive Medicine, Korea University College of Medicine, Seoul, Korea

OPEN ACCESS

Received: Jul 7, 2023
Accepted: Dec 28, 2023
Published online: Feb 6, 2024

Address for Correspondence:
Seok-Jun Yoon, MD, PhD
Department of Preventive Medicine, Korea University College of Medicine, 73 Goryeodae-ro, Seongbuk-gu, Seoul 02841, Korea.
Email: yoonsj02@korea.ac.kr

ORCID iDs
Yoon-Sun Jung
https://orcid.org/0000-0002-9379-4908
Young-Eun Kim
https://orcid.org/0000-0003-0694-6844
Minsu Ock
https://orcid.org/0000-0001-9949-9224
Seok-Jun Yoon
https://orcid.org/0000-0003-3297-0071

Funding
This study was supported by a grant from the National R&D Program for Cancer Control, Ministry of Health and Welfare, Republic of Korea (grant number: HA21C0206).

ABSTRACT

Background: The measurement of health levels and monitoring of characteristics and trends among populations and subgroups are essential for informing evidence-based policy decisions. This study aimed to examine the burden of disease in Korea for both the total population and subgroups in 2020, as well as analyze changes in disease burden from 2008 to 2020.
Methods: We employed the methodology developed in the Korean National Burden of Disease and Injuries Study to calculate disability-adjusted life years (DALYs) by sex, causes, region, and income level from 2008 to 2020. DALYs were derived by combining years of life lost and years lived with disability.
Results: In 2020, the burden of disease for the Korean population was estimated to be 25,439 DALYs per 100,000 population, reflecting a 13.8% increase since 2008. The leading causes of DALYs were diabetes mellitus, followed by low back pain and ischemic stroke. A sex-specific gap reversal was observed, with the disease burden for men surpassing that of women starting in 2017. Furthermore, variations in disease burden were identified across 250 regions and income quintiles.
Conclusion: It is imperative to establish appropriate health policies that prioritize the diseases with significantly increasing burdens and subgroups experiencing high disease burdens. The findings of this study are expected to serve as a foundation for developing healthcare policies aimed at improving the health levels of Koreans and achieving health equity.

Keywords: Disability-Adjusted Life Years; Burden of Disease; Years of Life Lost; Years Lived with Disability; Korean National Burden of Disease Study

INTRODUCTION

Measuring the health status and monitoring its characteristics and trends over time are fundamental to improving the health of a population.[1] Policymakers in the health sector rely on this data to make informed decisions and establish suitable priorities. Therefore, valid, reliable, and comparable measures of health status of populations and their subgroups are

JKMS

Disclosure
The authors have no potential conflicts of interest to disclose.

Author Contributions
Conceptualization: Jung YS, Kim YE, Ock M, Yoon SJ. Data curation: Jung YS, Kim YE. Formal analysis: Jung YS. Investigation: Ock M. Methodology: Kim YE, Ock M, Yoon SJ. Validation: Yoon SJ. Visualization: Jung YS. Writing - original draft: Jung YS. Writing - review & editing: Kim YE, Ock M, Yoon SJ.

critical components of the evidence base used for drafting health policy.[2] Hence, it is essential to obtain information on the health status of a population, commonly known as the "burden of disease."[3] The disease burden of the population can be assessed using a variety of indicators,[3] one of which is the disability-adjusted life year (DALY). DALY provides a comprehensive measure of both mortality and non-fatal health outcomes.[4] The DALY measurement methodology, developed by the influential Global Burden of Disease (GBD) projects initiated in the early 1990s, has been adapted to fit the Korean context and efforts have been made to calculate the burden of disease of Koreans using domestic data sources. The Korean National Burden of Disease (KNBD) study was first conducted in 2002 and continues to this day.[5]

In the KNBD study, disability weights (DWs) that can more appropriately reflect social preferences for diseases in Korea were calculated and applied.[6] In addition, efforts are being made to improve methods to address the limitations associated with GBD study utilization. These include use of multiple assumptions, methodological choices required to integrate various information, and timeliness of data inputs into the GBD study.[7] Moreover, a significant advantage lies in the easy accessibility and utilization of the National Health Insurance Service (NHIS) claims data, which serves as the primary source for calculating years lived with disability (YLDs). The NHIS claims data includes all information on medical service utilization (excluding non-insured service) by patients who have visited medical institutions. This wide-ranging dataset enables the generalization of analysis results. Consequently, it becomes relatively easier to calculate input parameters such as incidences and prevalences that are valid, reliable, and representative of the population's health.[5] The most recent publication of the KNBD study results was in 2021, which encompassed the measurement of the disease burden of Koreans from 2008 to 2018.[8] Subsequently, updating the measurement results is necessary to ensure their relevance and accuracy.

Meanwhile, the spread and prolonged coronavirus disease 2019 (COVID-19) pandemic, that started in 2020, caused immense human suffering; its consequences extend beyond immediate health impacts, severely affecting daily life and the overall quality of life of people worldwide.[9] The COVID-19 pandemic and its countermeasures have had a significant impact on healthcare utilization patterns and outbreaks of infectious diseases, including reduced access to prevention and treatment services.[10] To date, no comprehensive study have been conducted to ascertain the overall impact of COVID-19 on the burden of disease for all diseases and injuries, nor has the trend of DALYs according to socioeconomic levels been thoroughly examined. Furthermore, the emergence of COVID-19 as a novel disease necessitates the application of updated DWs when calculating disease burden, as the previously calculated weights may no longer be applicable. Hence, it is crucial to incorporate revised and up-to-date DWs when assessing the disease burden in 2020 and subsequent years.

Therefore, this study was conducted to understand the changes in disease burden and national health levels among Koreans by identifying its trend from 2008 to 2020 and evaluating the differences by region and income level.

METHODS

Study design and data sources

In this study, we measured the DALYs for the Korean population from 2008 to 2020, utilizing the burden of disease measurement methodology developed in the KNBD study. To adapt the

https://doi.org/10.3346/jkms.2024.39.e67

GBD-based methodology to the Korean context, modifications were made, and an incidence-based approach was employed for the calculations.[11]

The causes of mortality and morbidity were structured using a four-level classification hierarchy. At level 1, all diseases and injuries were classified into three categories: communicable, maternal, neonatal, and nutrition disease (CMNN); non-communicable diseases (NCDs); and injuries. Level 2 included 21 specific diseases, while levels 3 and 4 comprised 260 disease groups. Detailed cause hierarchies are available in previous studies.[5] Among these, the disease previously defined as chronic obstructive pulmonary disease was redefined as chronic lower respiratory diseases, excluding asthma.

To calculate the years of life lost (YLLs) due to premature death, we utilized the number of deaths and the standard life expectancy based on sex and age. Mortality rate by age, sex, and disease were calculated using the data on the cause of death from Statistics Korea for the years from 2008 to 2020. For causes that could not be determined as the primary cause of death, the garbage code redistribution method was applied.[12] To calculate the number of years lost due to premature death, we employed standard expected years of life lost. The standard life expectancy, stratified by year, sex and age, was obtained from life tables published by Statistics Korea from 2008 to 2020.[13]

For the calculation of the YLDs, we used the incidence of cases, average duration, and DWs. Epidemiological indicators such as prevalence and incidence by year and causes were obtained from the Korean National Hospital Discharge In-depth Injury Survey (KNHDIS) for injuries (2008–2019) and from the NHIS claims data for other diseases (2008–2020).[14] As the KNHDIS data for 2020 were delayed, we used the 2019 data as a substitute for calculating YLDs for injuries in 2020. Korea has a mandatory universal health coverage system. As of 2020, a total of 52,870,968 people receive health security benefits in Korea; of these, the National Health Insurance (NHI) covers 97.1% and the remaining 2.9% is covered by Medical Aid beneficiaries.[15] Health insurance claims data are generated in the process of claiming part of the patient's medical expenses to the insurer, the NHI, after the health care institution provides medical services. It is a highly representative medical use database and includes information on demographics and medical use of nearly the entire population. Therefore, it has the advantage of broadening the scope of disease burden measurement by including information such as sex, age, region, and income level of the population.

To prevent overestimation and calculate valid prevalence and incidence while using claims data, we defined criteria for each disease based on the number of hospitalization and outpatient visits (ranging from 1 to 5 times).[5] Additionally, a washout period of at least 1 year, up to a maximum of 5 years, was applied for estimating the number of incidence cases, depending on the characteristics of the disease. DW is a value that quantifies the severity of a disability or specific health states, ranging from 0 (equivalent to full health) to 1 (equivalent to death). However, the validity of DW in the past may not be suitable for the current era due to the rise of new diseases, changes in treatment, or social norms.[16] In this study, the DW values from a prior study[6] were applied for the years from 2008 to 2019, while newly update DW values after the emergence of COVID-19 were applied for 2020.[17] The duration and average age of onset for infectious diseases were calculated directly from claims data, while the DISMOD-II software was used to estimate these parameters for other causes.

https://doi.org/10.3346/jkms.2024.39.e67

Calculation of YLLs, YLDs and DALYs

The YLLs were calculated for each disease and injury category by multiplying the number of deaths by sex and year with the standard life expectancy for each age group.[4] The YLDs for each disease and injury category were calculated by multiplying the number of incidence cases, the average duration, and the assigned DW. In this study, an age-weighting rate of 4.0% and a time discount of 3.0% were applied when calculating YLLs and YLDs.[18] Finally, the YLLs and YLDs were combined to calculate the DALYs for each disease and injury category. The basic formula for DALYs is shown in Equation (1):

$$DALY = YLL + YLD = N \times L_{SL} + I \times DW \times L_D$$

where N is the number of deaths, L_{SL} is the standard life expectancy in years, I is the number of incidence cases, DW is the disability weight, and L_D is the average duration of disability. The YLLs, YLDs, and DALYs were reported per 100,000 population for each disease and injury category. The specific methodology for calculating DALYs based on the KNBD study, with some variations in data sources, is outlined in previous studies.[5,8]

Calculation of DALYs by region and income level

To examine regional disparities in health levels, the regions were classified into 250 regions, consisting of 67 cities ("Si"), 114 counties ("Gun"), and 69 districts ("Gu"), and YLLs, YLDs, and DALYs were calculated for each region. The burden of disease by region was analyzed as of 2020. The results of DALYs, YLLs, and YLDs calculations for the 250 regions were divided into deciles, with five regions with high disease burden expressed in red and five regions with low disease burden expressed in blue. Additionally, for DALYs by region, the distribution by region was expressed based on DALYs calculated for the entire population, with regions with lower and higher DALYs than the nationwide DALYs expressed in blue and yellow, respectively. The differences in health levels based on the income level of the Korean population were analyzed using the insurance premium variable for each year. Since insurance premiums in the NHIS are based on the wage and income of beneficiaries, we used insurance premium as a proxy indicator to classify the income levels of the population. The income level was determined using equivalized annual household income based on insurance premiums. For Medical Aid beneficiaries who did not pay insurance premiums, their insurance premiums were considered as zero. Consequently, the income level was divided into five quintiles for the entire population, including both NHI beneficiaries and Medical Aid beneficiaries. However, as income levels could not be confirmed from the cause-of-death data in Statistics Korea, which was the main data source for YLL calculations, we obtained the death rate distribution by income level from the claims data. By applying this distribution to the YLL calculation result, YLLs were allocated according to income levels. Meanwhile, in order to calculate YLDs for injuries according to income level, prevalence and incidence distributions by income level were obtained and applied using the Korea Community Health Survey.

Statistical analysis

SAS version 9.4 (SAS Institute, Cary, NC, USA) was used for statistical analysis. The QGIS 3.10 software was used to express regional disease burden on a map.

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Korea University (IRB No. KUIRB-2022-0093-01) who waived the need for informed consent.

RESULTS

Trends of total burden of disease and injuries (2008–2020)

From 2008 to 2020, the DALYs per 100,000 population for Koreans increased by 13.8%, with 25,439 in 2020 compared with 22,361 in 2008. The trend showed a continuous increase from 2008 to 2019, followed by a slight decrease in 2020. This pattern was observed in both sexes. In 2019, the DALYs per 100,000 population was 26,685, but decreased to 25,439 in 2020. The relative contribution of YLDs and YLLs to DALYs showed different patterns, with YLLs per 100,000 population decreasing by 4.7% in 2020 (4,176) compared with 2008 (4,384), while YLDs per 100,000 population increased by 18.3% in 2020 (21,263), compared with 2008 (17,978). In men, DALYs per 100,000 population in 2020 increased by 17.2% from 2008, with a decrease in YLLs and an increase in YLDs. In the past 12 years, YLLs per 100,000 population in men decreased by 5.2%, while YLDs per 100,000 population increased by 24.4%. The proportion of YLLs among total DALYs in men decreased from 24.2% to 19.6% in 12 years, while the proportion of YLDs increased from 75.8% to 80.4%. In women, DALYs per 100,000 population in 2020 increased by 10.4% from 2008. In the past 12 years, YLLs per 100,000 population in women decreased by 3.8% while YLDs per 100,000 population increased by 12.9%. The proportion of YLLs in total DALYs in women decreased from 15.1% to 13.1% in 12 years, while the proportion of YLDs increased from 84.9% to 86.9%. Overall DALYs and YLLs were higher in men than in women, while YLDs were higher in women than in men (**Fig. 1**).

Burden of disease and injuries in Korea according to each level in 2020

At the highest level (level 1) in 2020, CMNN accounted for 2.5% of all DALYs, while NCDs and injuries made up 88.3% and 9.2%, respectively. This composition ratio was similar for both men and women. DALYs per 100,000 population in CMNN were higher in women than in men, whereas in NCDs and injuries, they were higher in men than in women. Among the middle-level (level 2) disease groups, the DALYs per 100,000 population for diabetes, urogenital, blood, and endocrine diseases were the highest at 3,963, accounting for 15.6% of the total DALYs in Korea. This was followed by other NCDs at 3,229 (12.7%), cardiovascular and circulatory diseases at 3,096 (12.2%), musculoskeletal disorders, at 2,900 (11.4%), and neoplasms at 2,660 (10.5%). Diabetes, urogenital, blood, and endocrine diseases had the highest DALYs per 100,000 population among the middle-level (level 2) disease groups for both men and women, with 4,436 (17.1%) for men and 3,491 (14.0%) for women (**Table 1**).

In levels 3 and 4 disease groups, the highest DALYs per 100,000 population in 2020 were attributed to diabetes mellitus at 2,558 (10.1% of the total DALYs), followed by low back pain at 1,750 (6.9%), ischemic stroke at 1,077 (4.2%), ischemic heart disease at 982 (3.9%), and cirrhosis of the liver at 965 (3.8%). These top five diseases accounted for 28.8% of the total burden of disease in Korea. Examining diseases with a high proportion of YLLs among the top 30 diseases with a high disease burden, self-harm had the highest proportion at 94.7%, followed by liver cancer at 69.1%, trachea, bronchus, and lung cancers at 67.9%, overexertion and strenuous movements at 66.5%, and hemorrhagic and other non-ischemic strokes at 65.3% (**Fig. 2**). For men, the highest DALYs per 100,000 population were observed in diabetes mellitus at 3,054 (11.8%), followed by low back pain at 1,465 (5.7%), ischemic heart disease at 1,276 (4.9%), cirrhosis of the liver at 1,257 (4.9%), and ischemic stroke at 1,179 (4.5%). Among women, the highest DALYs per 100,000 population were attributed to diabetes mellitus at 2,064 (8.3%), followed by low back pain at 2,035 (8.1%), Alzheimer's disease and other dementias at 1,171 (4.7%), major depressive disorders at 1,001 (4.0%), and ischemic stroke at 977 (3.9%) (**Table 2**).

https://doi.org/10.3346/jkms.2024.39.e67

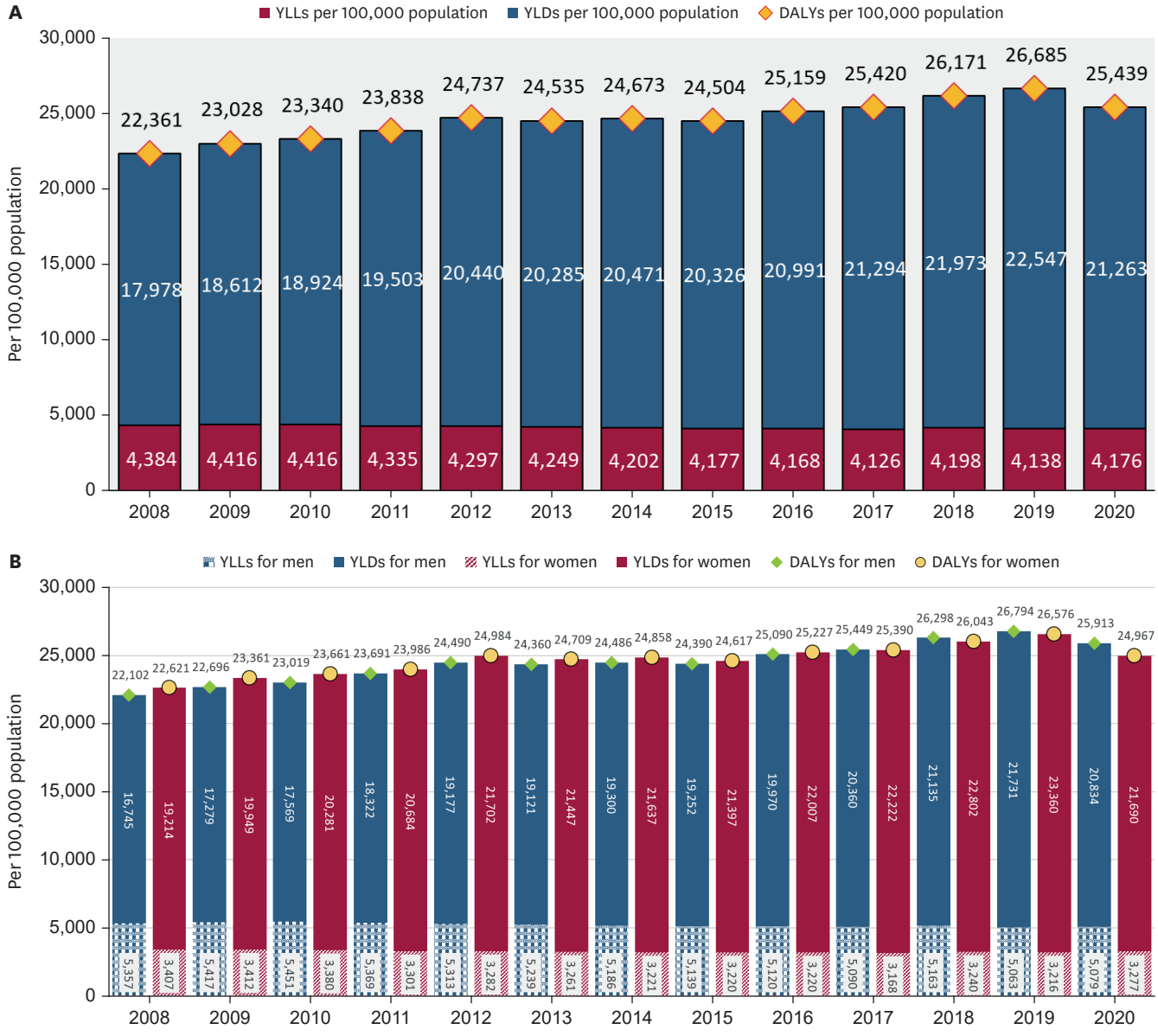


Fig. 1. DALYs per 100,000 population in Korea by year from 2008 to 2020. (**A**) Total DALYs per 100,000 population in Korea by year from 2008 to 2020, (**B**) DALYs per 100,000 population in Korea by gender from 2008 to 2020.
DALYs = disability-adjusted life years, YLLs = years of life lost, YLDs = years lived with disability.

Changes in burden of disease ranking by cause and change rate (2008–2020)

When comparing the burden of disease rankings and change rates from 2008 to 2020, several notable trends could be observed. Among the top 20 diseases with the highest DALYs per 100,000 population in 2020, Alzheimer's disease and other dementias showed the largest increase, rising by 313.4% compared with 2008. This was followed by periodontal disease, which increased by 116.9%, and benign prostatic hyperplasia (BPH) with a 103.9% increase. Psychiatric disorders such as major depressive disorders and phobic anxiety disorders also saw significant increases of 98.4% and 73.0%, respectively. On the other hand, chronic lower respiratory diseases (excluding asthma) experienced the most significant decrease, declining by 31.9%. Motorized vehicles with three or more wheels also decreased by 30.0%, and

https://doi.org/10.3346/jkms.2024.39.e67

Table 1. DALYs per 100,000 population by gender and level 2 disease groups in Korea, 2020

Level 1	Level 2	DALYs[a]		
		Total	Men	Women
Communicable, maternal, neonatal, and nutritional disorders	HIV/AIDS and tuberculosis	90 (0.4)	129 (0.5)	51 (0.2)
	Diarrhea, lower respiratory infections, meningitis, and other common infectious diseases	136 (0.5)	138 (0.5)	134 (0.5)
	Neglected tropical diseases and malaria	3 (0.0)	4 (0.0)	2 (0.0)
	Maternal disorders	294 (1.2)	0 (0.0)	586 (2.3)
	Neonatal disorders	35 (0.1)	37 (0.1)	32 (0.1)
	Nutritional deficiencies	70 (0.3)	26 (0.1)	114 (0.5)
	Other communicable, maternal, neonatal, and nutritional disorders	5 (0.0)	7 (0.0)	4 (0.0)
	Subtotal	633 (2.5)	341 (1.3)	923 (3.7)
NCDs	Neoplasms	2,660 (10.5)	2,887 (11.1)	2,434 (9.7)
	Cardiovascular and circulatory diseases	3,096 (12.2)	3,565 (13.8)	2,628 (10.5)
	Chronic respiratory diseases	1,061 (4.2)	1,096 (4.2)	1,027 (4.1)
	Cirrhosis of the liver	965 (3.8)	1,257 (4.9)	674 (2.7)
	Digestive diseases (except cirrhosis)	1,323 (5.2)	1,251 (4.8)	1,394 (5.6)
	Neurological disorders	1,300 (5.1)	938 (3.6)	1,660 (6.6)
	Mental and behavioral disorders	1,967 (7.7)	1,703 (6.6)	2,230 (8.9)
	Diabetes, urogenital, blood, and endocrine diseases	3,963 (15.6)	4,436 (17.1)	3,491 (14.0)
	Musculoskeletal disorders	2,900 (11.4)	2,391 (9.2)	3,407 (13.6)
	Other non-communicable diseases	3,229 (12.7)	3,223 (12.4)	3,236 (13.0)
	Subtotal	22,464 (88.3)	22,747 (87.8)	22,183 (88.8)
Injuries	Transport injuries	667 (2.6)	819 (3.2)	515 (2.1)
	Unintentional injuries other than transport injuries	1,068 (4.2)	1,224 (4.7)	913 (3.7)
	Self-harm and interpersonal violence	602 (2.4)	774 (3.0)	430 (1.7)
	Forces of nature, war, and legal intervention	6 (0.0)	9 (0.0)	4 (0.0)
	Subtotal	2,342 (9.2)	2,826 (10.9)	1,861 (7.5)

Values are presented as rates (%).
DALYs = disability-adjusted life years, HIV/AIDS = human immunodeficiency virus/acquired immune deficiency syndrome, NCD = non-communicable disease.
[a]DALYs per 100,000 population.

osteoarthritis decreased by 16.5%. Chronic lower respiratory diseases (excluding asthma) and osteoarthritis were also the diseases with the largest decrease in DALYs compared with 2019 among the top 20 diseases with the highest DALYs per 100,000 population in 2020.

Analyzing the changes in the top five diseases with the highest DALYs per 100,000 population in 2020 since 2008, diabetes mellitus increased by 54.2%, low back pain by 75.9%, ischemic stroke by 33.0%, ischemic heart disease by 17.5%, and cirrhosis of the liver by 16.1%. Examining the changes in the top 20 rankings over past 12 years in terms of DALYs per 100,000 population, asthma (2nd), gastritis and duodenitis (13th), hypertensive heart disease (14th), peptic ulcer disease (16th), and dental caries (18th) were ranked in the top 20 with the highest DALYs in 2008 but excluded from the top 20 in 2020 as their rankings declined. Conversely, periodontal disease, Alzheimer's disease and other dementias, phobic anxiety disorders, and BPH, which were outside the top 20 of DALYs in 2008, rose in the rankings, entering 11th, 6th, 18th, and 16th in 2020, respectively (**Fig. 3**).

Burden of disease and injuries by region and income level in 2020

When analyzing the burden of disease and injuries by region and income level in 2020, certain patterns and disparities were observed. Regions with lower overall disease burden tended to be concentrated in Seoul, Gyeonggi, and metropolitan areas. The region with the highest DALYs per 100,000 population (40,393) was 2.14 times higher than the region with the lowest DALYs (18,826). There were 165 regions with a higher burden of disease than the nationwide DALYs rate of 25,439 while 85 regions had a lower burden. In terms of YLLs per 100,000 population, the highest region (8,484) was 4.35 times higher than the lowest region (1,949). For YLDs per 100,000 population, the highest region (33,282) was 1.97 times higher

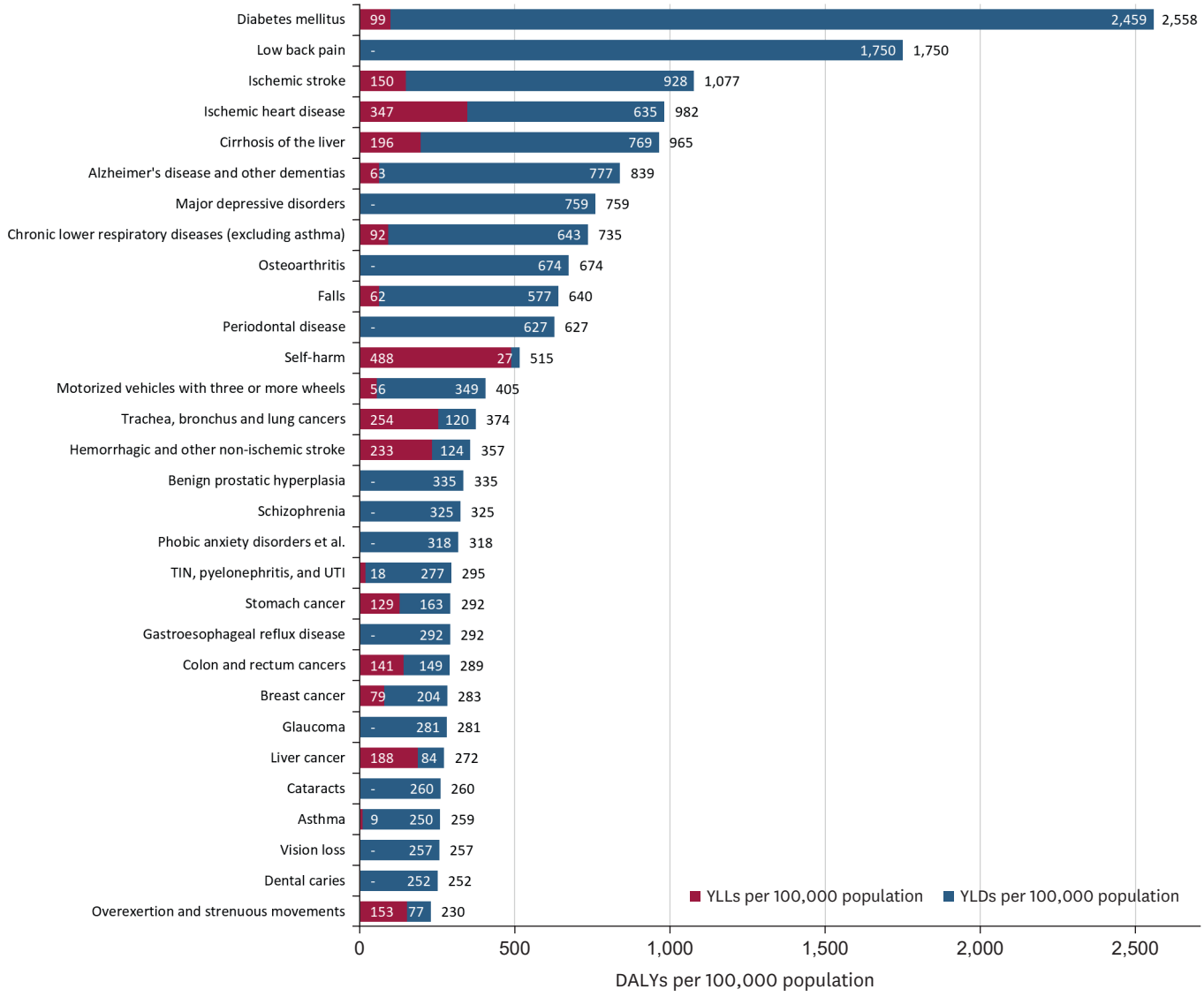


Fig. 2. Top 30 leading specific causes (levels 3 and 4) of DALYs in Korea in 2020.
DALYs = disability-adjusted life years, YLLs = years of life lost, YLDs = years lived with disability, TIN = tubulointerstitial nephritis, UTI = urinary tract infections.

than the lowest region (16,871). Disparities in disease burden between regions were more pronounced in terms of the burden of death (YLLs) compared with the burden of incidence (YLDs) (**Fig. 4**).

Examining the gap in burden of disease between the lowest income level group (Q1) and the highest income level group (Q5) from 2008 to 2020, it was found that the gap initially decreased from 2008 to 2012 but then started to increase. Generally, the lower the income level, the higher the disease burden. In 2008, the DALYs per 100,000 population of the Q1 group was 1.42 times higher than that of the Q5 group. This gap decreased to 1.31 times in 2012, but increased again to 1.40 times in 2020. In 2020, there was a significant gap in disease burden of 1.27 times between the Q1 and Q2 groups, which represents the lowest income levels among the five income groups (**Fig. 5**).

https://doi.org/10.3346/jkms.2024.39.e67

Table 2. DALYs per 100,000 population by gender and level 3 and 4 disease groups in Korea, 2020

Rank	Men			Women		
	Leading causes	DALYs[a]	% of total DALYs[a]	Leading causes	DALYs[a]	% of total DALYs[a]
1	Diabetes mellitus	3,054	11.8	Diabetes mellitus	2,064	8.3
2	Low back pain	1,465	5.7	Low back pain	2,035	8.1
3	Ischemic heart disease	1,276	4.9	Alzheimer's disease and other dementias	1,171	4.7
4	Cirrhosis of the liver	1,257	4.9	Major depressive disorders	1,001	4.0
5	Ischemic stroke	1,179	4.5	Ischemic stroke	977	3.9
6	Chronic lower respiratory diseases (excluding asthma)	774	3.0	Osteoarthritis	954	3.8
7	Periodontal disease	675	2.6	Chronic lower respiratory diseases (excluding asthma)	696	2.8
8	Benign prostatic hyperplasia	671	2.6	Ischemic heart disease	689	2.8
9	Falls	665	2.6	Cirrhosis of the liver	674	2.7
10	Self-harm	658	2.5	Falls	614	2.5
11	Major depressive disorders	515	2.0	Periodontal disease	578	2.3
12	Trachea, bronchus and lung cancers	510	2.0	Breast cancer	559	2.2
13	Alzheimer's disease and other dementias	506	2.0	Tubulointerstitial nephritis, pyelonephritis, and urinary tract infections	439	1.8
14	Motorized vehicles with three or more wheels	440	1.7	Phobic anxiety disorders, et al.	383	1.5
15	Liver cancer	416	1.6	Self-harm	373	1.5
16	Hemorrhagic and other non-ischemic stroke	395	1.5	Motorized vehicles with three or more wheels	370	1.5
17	Osteoarthritis	392	1.5	Gastroesophageal reflux disease	344	1.4
18	Stomach cancer	378	1.5	Schizophrenia	335	1.3
19	Colon and rectum cancers	345	1.3	Hemorrhagic and other non-ischemic stroke	319	1.3
20	Gout	337	1.3	Cataracts	305	1.2
21	Schizophrenia	314	1.2	Asthma	286	1.1
22	Overexertion and strenuous movements	293	1.1	Glaucoma	281	1.1
23	Glaucoma	280	1.1	Gastritis and duodenitis	269	1.1
24	Chronic kidney disease due to diabetes mellitus	260	1.0	Vision loss	266	1.1
25	Phobic anxiety disorders, et al.	252	1.0	Dental caries	264	1.1
26	Vision loss	247	1.0	Thyroid cancer	239	1.0
27	Gastroesophageal reflux disease	239	0.9	Trachea, bronchus and lung cancers	238	1.0
28	Dental caries	239	0.9	Abortion	238	1.0
29	Asthma	233	0.9	Gall bladder and bile duct disease	237	1.0
30	Abscess, impetigo, and other bacterial skin diseases	229	0.9	Colon and rectum cancers	234	0.9

DALYs = disability-adjusted life years.
[a]DALYs per 100,000 population.

DISCUSSION

The burden of disease on Koreans as measured using DALY increased by 19.8% from 2008 to 2019; however, in 2020, when COVID-19 first emerged, it decreased by 4.7% compared with the previous year, resulting in an overall increase of 13.8% over the past 12 years. Meanwhile, until 2019, before the outbreak of COVID-19, YLLs decreased and YLDs increased. However, in 2020, the opposite was observed. This shift can be attributed to the reduced accessibility of medical services due to the COVID-19 pandemic, leading to a decline in inpatient and outpatient medical usage.[19] Therefore, when analyzing the overall trend and its characteristics, it is important to interpret the results of 2020 while considering the influence of COVID-19. Furthermore, continuous monitoring of the disease burden and identifying changes in the health status of Koreans remain crucial. The increase in DALYs until 2019 was primarily driven by the increase in YLDs as opposed to the decrease in YLLs. This pattern was consistent across both men and women.

The increase in YLDs may be attributed to the reduction in the burden of medical expenses and the improvements of medical accessibility following the continuous implementation of policy on expanding health insurance coverage. In 2020, the NHI coverage rate was 65.3%.[20]

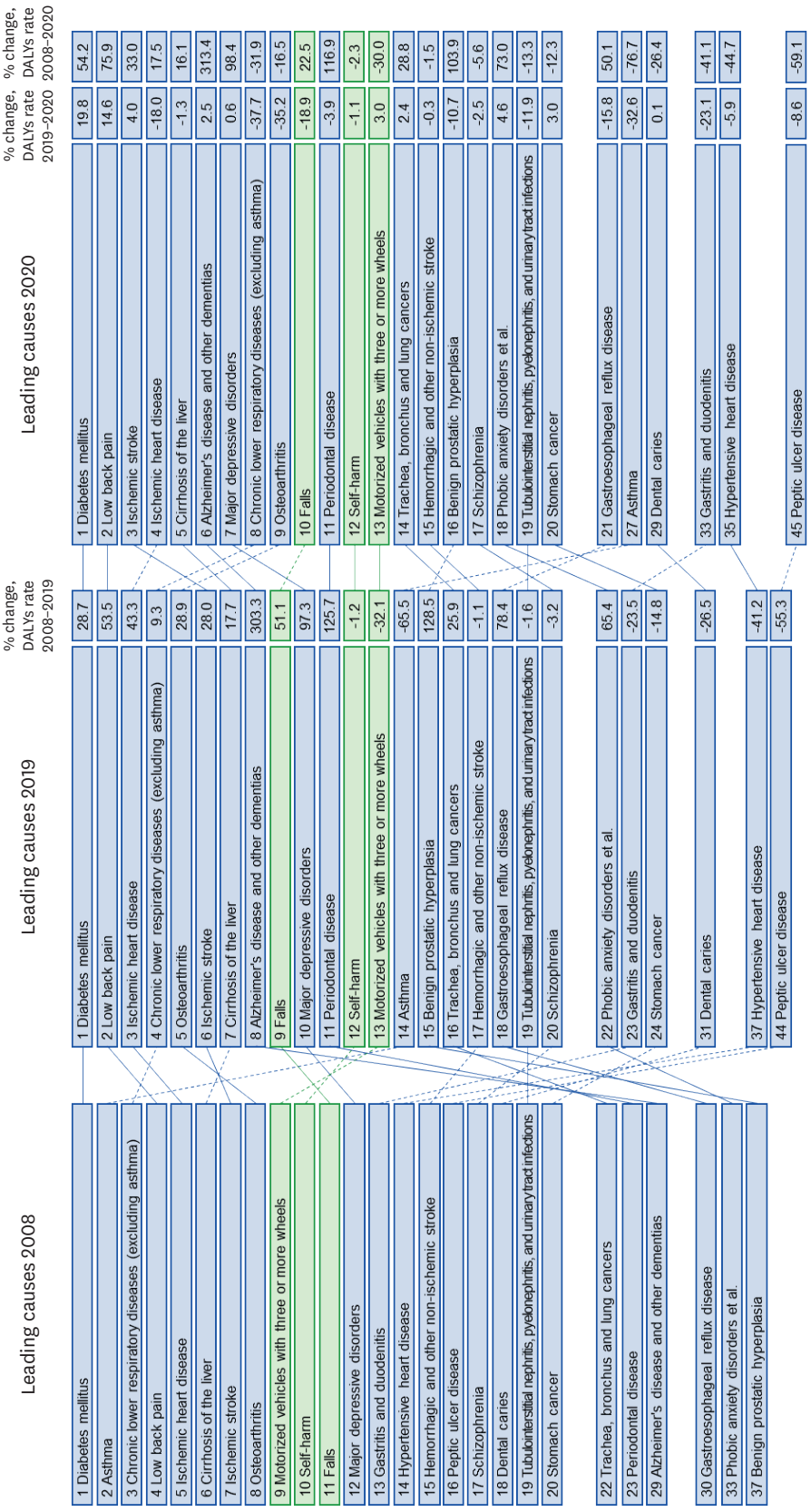


Fig. 3. Top 20 leading specific causes (levels 3 and 4) of DALYs for 2008, 2019, and 2020, with percentage change in DALYs (per 100,000).
DALYs = disability-adjusted life years.

https://doi.org/10.3346/jkms.2024.39.e67

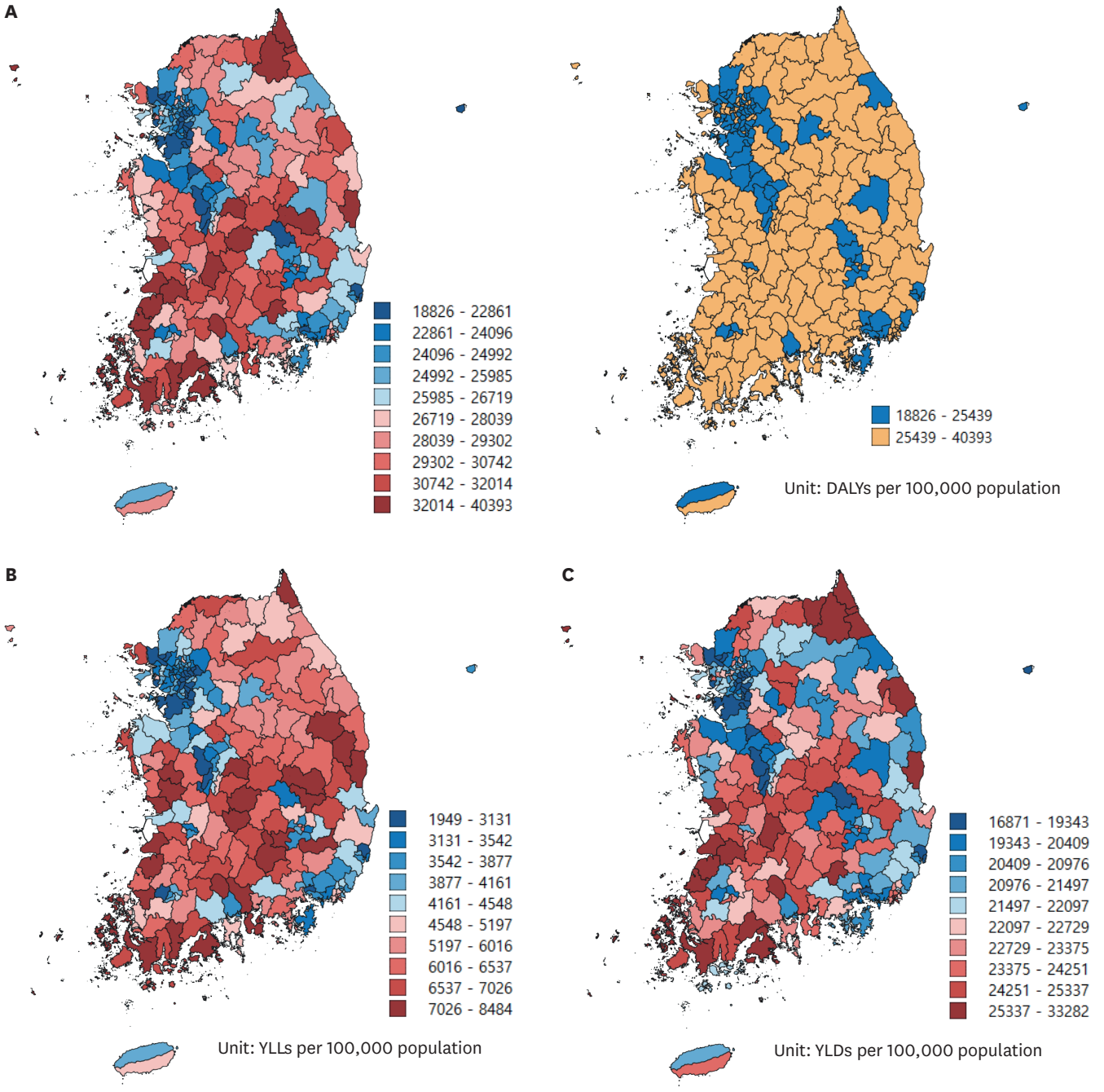
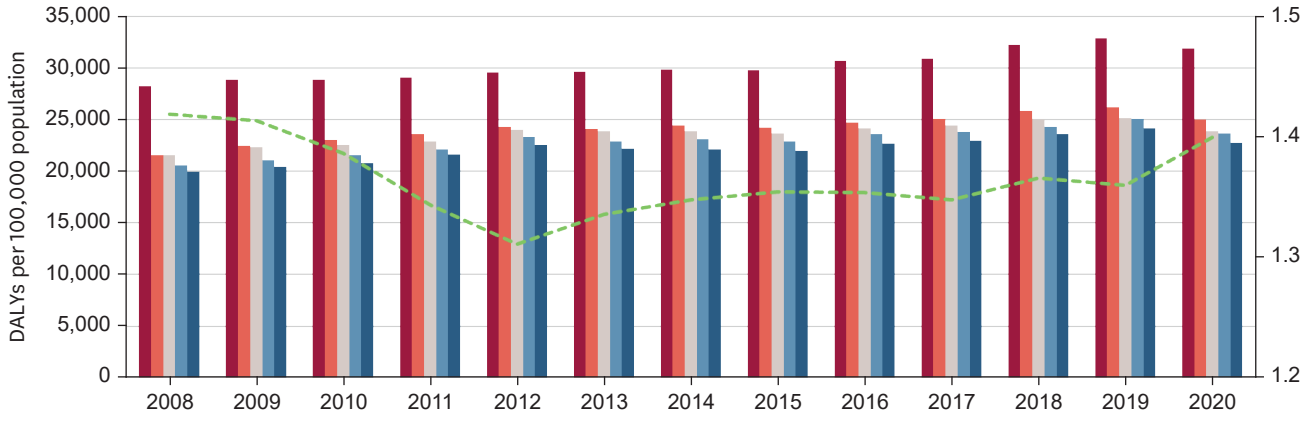


Fig. 4. DALYs per 100,000 population by region in Korea in 2020. (**A**) DALYs per 100,000 population, (**B**) YLLs per 100,000 population, (**C**) YLDs per 100,000 population.
DALYs = disability-adjusted life years, YLLs = years of life lost, YLDs = years lived with disability.

When benefits are added or the number of beneficiaries is expanded, and the out-of-pocket burden of existing benefit items is lowered, the use of medical service tends to increase. Thus, the incidences and prevalences, which are the basis of YLDs calculations, may have increased. In contrast, YLLs gradually decreased, which is primarily attributed to the improvement in overall living conditions and advancements in medical technology that have led to reduced mortality rates from diseases and non-disease-related causes.[21]

https://doi.org/10.3346/jkms.2024.39.e67



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Q1 (Lowest)	28,229	28,858	28,823	29,032	29,564	29,644	29,840	29,782	30,652	30,888	32,199	32,863	31,841
Q2	21,575	22,455	23,005	23,570	24,284	24,045	24,424	24,213	24,729	25,053	25,799	26,191	25,018
Q3	21,532	22,325	22,519	22,878	23,973	23,871	23,846	23,624	24,176	24,403	24,961	25,142	23,898
Q4	20,568	21,084	21,563	22,104	23,308	22,917	23,096	22,897	23,586	23,829	24,311	25,076	23,689
Q5 (Highest)	19,900	20,414	20,790	21,606	22,556	22,191	22,140	21,995	22,646	22,921	23,580	24,164	22,755
Q1/Q5	1.42	1.41	1.39	1.34	1.31	1.34	1.35	1.35	1.35	1.35	1.37	1.36	1.40

Fig. 5. DALYs per 100,000 population by income level in Korea by year from 2008 to 2020.
DALYs = disability-adjusted life years.

Until 2016, DALYs in women were higher than that in men; however, this was reversed in 2017 and the sex-specific gap in disease burden widened in 2020, when COVID-19 first emerged. Similar to the contribution of increased YLDs to the overall increase in DALYs for the population, the shift where DALYs in men surpassed those in women can be attributed to the higher rate of increase in YLDs in men (24.4%) compared with those in women (12.9%). To determine the reason for the increase in YLDs in men, we additionally analyzed the increase rate in YLDs by cause in men and women, respectively (**Supplementary Table 1**). We examined the increase rate in 2020 compared with 2008 for the top leading causes in 2020 for each sex. Our analysis revealed that the rate of increase in YLDs in men was higher than that of women in diseases such as ischemic stroke, ischemic heart disease, and major depressive disorder, which have a DW of 0.5 or more, as well as diabetes and low back pain, which rank first and second in YLDs. Therefore, the increase in YLDs for these diseases in men may have contributed to the reversal of DALYs by sex. Nevertheless, YLDs in women remains 1.04 times higher than that in men. Similar to the West, women use more medical services than men. These factors include not only the harsh environments due to physiological changes such as pregnancy, childbirth, and menopause, but also the traditional roles such as housework and responsibility in caring for the physical and mental health of the family members at home.[22] Hence, it is necessary to continue to monitor changes in DALYs by sex. Furthermore, for diseases with a high increase in YLDs in men, it may be meaningful to conduct research to examine the causes in relation to health risk factors.

When examining the burden of disease in 2020, diabetes mellitus emerged at the top, accounting for 10.1% of the total burden of disease. It also ranked first in both men and women, with a higher burden observed in men compared with women. Diabetes mellitus has become a prominent disease among modern populations, primarily attributed to westernized dietary habits and sedentary lifestyles. Therefore, it is imperative to proactively address this issue at the national level through active management and preventive measures. As of 2020, the population with diabetes in Korea reached 5.7 million (5.26 million over the age

https://doi.org/10.3346/jkms.2024.39.e67

of 30), with an estimated 14.97 million individuals in the pre-diabetes stage.[23] Recently, patients with obesity and diabetes are increasing, affecting not only the elderly but also the younger population due to excessive caloric intake and a lack of physical activity. Since the rate of diabetes awareness, treatment, and control in young patients is considerably low, and lifestyle management is passive,[23] this may potentially lead to serious health consequences, including the development of complications. Therefore, it is essential to take preemptive preventive measures. Moreover, there is an urgent need for national responses such as establishing an integrated diabetes care plan, promoting education and counselling centered on primary medical institutions, establishing infrastructure, and preparing relevant policies. Ultimately, to prevent or delay progression to diabetes and development of its complications in individuals with 'pre-diabetes,' countermeasures such as the identification of high-risk groups through the introduction of additional criteria[24] and development of appropriate management guidelines for early lifestyle interventions need to be promoted.

We identified diseases that ranked in the top 20 burdens of disease from 2008 to 2020. Among these, the DALYs due to Alzheimer's disease and other dementias increased the most steeply. As Korea is on the verge of becoming a super-aged society, the number of patients with dementia, a representative aging disease, is rapidly increasing, and the social cost is expected to increase accordingly. The number of patients who received treatments for dementia in 2019 was 799,000 (4 times that in 2009), and the number of patients with mild cognitive impairment was 276,000 (19 times that in 2009).[25] The National Responsibility Policy for Dementia Care was implemented to solve the problem of dementia; however, many policies emphasized the welfare aspect, and it was pointed out that the integration and organic connection between medical and care services was insufficient.[26] Considering the rapidly increasing demand for management in patients with dementia, it is necessary to emphasize the expansion and functional strength of public medical institutions.[27] In particular, since the community management rate is low in non-metropolitan areas,[28] where population aging is severe, it is necessary to strengthen the capacity to respond to the rapid increase in dementia through sufficient expansion and utilization of public medical institutions. In addition, since cardiovascular risk factors including diabetes and hypertension are related to the risk of dementia,[29] efforts are needed to effectively manage these factors to reduce the risk of cognitive impairment and dementia.

A significant increase in DALYs due to periodontal oral disease was also observed, which reflects the effect of the health insurance coverage expansion policy for dental services implemented in July 2013. The expansion of coverage to include scaling may have improved dental care access by lowering patient out-of-pocket costs and increased preventive dental care utilization.[30-33] The disease burden associated with BPH also showed a notable increase. Age has been identified as an important risk factor for BPH,[34] and higher treatment rates among the elderly[35] may contribute to this trend. However, concerns have been raised regarding unfair prescription and claims for BPH medications to treat hair loss in relation to the increase in patients with BPH. Finasteride and dutasteride are used for hair loss treatment after dosage adjustment.[36,37] Notably, while BPH is covered by health insurance, hair loss is not and considered as non-insured. Consequently, there is a concern that patients aiming to alleviate their financial burden, may be prescribed drugs for BPH, which are covered by insurance, and use them for hair loss treatment. This may have contributed to the rapid increase in the disease burden associated with BPH. The disease burden for major depressive disorders and phobic anxiety disorder also showed a significant increase over the past 12 years, and continued to increase between 2019 and 2020. This is also confirmed from the results of an

https://doi.org/10.3346/jkms.2024.39.e67

analysis of treatment trends, which showed that patients with depression increased by 35.1% and patients with anxiety disorder by 32.3% from 2017 to 2021.[38] In 2021, a significant increase in the number of patients was observed among individuals in their 20s, with a 127.1% increase in depression and an 86.8% increase in anxiety disorders. Furthermore, the prevalence of these conditions was higher among female patients compared with male patients.[38] Factors such as the intense competition for university admission,[39] job-seeking stress, and work stress,[40,41] which are unavoidable in a highly competitive society, and the impact of the COVID-19 pandemic,[42] may have contributed to mental health problems.

Meanwhile, the DALYs showed an increasing trend for chronic lower respiratory diseases (excluding asthma) and osteoarthritis from 2008 to 2019, but decreased by 37.7% and 35.2%, respectively, compared with 2020 during the COVID-19 pandemic. The decline in disease burden for these causes was substantial to the extent that the overall burden declined from 2008 to 2020. Among the top diseases with high DALYs in 2020, these diseases appear to have been most impacted by the decrease in medical utilization due to COVID-19. As of 2020, diabetes mellitus and low back pain, remained the causes with the highest disease burden among Koreans, and both causes exhibited a consistent increase even between 2019 and 2020. Over the span of 12 years, the burden for both diseases increased by more than 50%. Notably, diabetes mellitus increased by nearly 20% in disease burden from 2019 to 2020, raising awareness of the importance and necessity of management.

Asthma has experienced a substantial decline in disease burden, dropping from the second position in 2008 to the twenty-seventh position in 2020, reflecting a significant decrease of 76.7%. An analysis conducted by the Health Insurance Review and Assessment service also confirmed a 19.8% decrease in the number of patients with asthma from 2010 to 2014.[43] The exact reasons behind this decline have not been fully elucidated; however, one possible factor could be the implementation of a mild disease differential copayment policy in 2011, which aimed to improve the efficiency of the medical delivery system. This policy introduced varying coinsurance rates for prescription drugs when patients seek healthcare for a minor illness.[44] While further investigations are warranted, it is important to consider the possibility that changes in disease coding or diagnosis practices, such as assigning alternative diagnoses instead of asthma in a secondary or tertiary hospitals, could have contributed to the reduction in the burden on patients. Moreover, the sharp decrease in asthma inpatients during the COVID-19 pandemic may have also played a role.[45]

To assess the health status of different regions, this study analyzed DALYs, YLLs, and YLDs across 250 regions. The findings revealed notable health inequalities between regions, with a lower burden of disease observed in and around metropolitan cities. These health inequalities may be differences in health behaviors and health check-up rates by region. Previous studies have reported that residents living in rural areas have higher metabolic risk[46] and adult obesity rates[47] compared with those of residents living in urban areas in Korea. Additionally, it has been found that the general health check-up rate is higher in small and medium-sized cities and large cities compared with that of rural areas.[48] Because individuals who participate in regular health checkups have fewer risk factors for cardiovascular diseases than those who do not,[49] these characteristics are considered to be associated with regional health disparities. In addition, health disparities depending on residential area are caused by differences in social structural factors that are difficult to overcome at the individual level, and among them, accessibility to health care facilities needs to be considered. Geographical access to health care plays a crucial role in increasing the utilization of preventive health care

https://doi.org/10.3346/jkms.2024.39.e67

services, and consequently, improving health outcomes.[50,51] In Korea, medical facilities are predominantly concentrated in metropolitan areas and large cities[52] and the concentration of population in large cities further exacerbates the concentration of healthcare resources in these areas, resulting in disparities in medical utilization. Because insufficient primary care can contribute to poor control of chronic diseases and quality of life,[53] we suggest that a national approach to ensure an even distribution of medical institutions capable of providing primary care and early screening is needed. Considering these possibilities, future studies could explore the relationship between regional characteristics and YLLs and YLDs measurements from this study to identify geographical health risks. This approach would provide valuable information for developing region-specific policies and, ultimately, reducing health disparities between different regions.

The analysis of DALY differences across income quintiles overtime revealed a widening disparity in health levels based on income. Specifically, there was a 1.40-fold differences in disease burden between the lowest-income quantile (Q1) and the highest-income quantile (Q5). Of this difference, 1.27 times can be attributed to the gap between Q1 and Q2, highlighting the urgent need for targeted health management for individuals in the lowest income bracket. Although the disease burden decreased for all income quintiles from 2019 to 2020, the reduction rate was the lowest for Q1. To gain a better understanding of disease burden by income level, further research is necessary to analyze specific factors such as YLLs, YLDs, sex differences, and explore diseases with higher burden among each income level. By conducting more detailed analyses in future studies, it may be possible to gain insights into the specific health challenges faced by individuals in different income groups and design interventions to address the diseases that significantly contribute to the disease burden within each income category.

This study provides valuable insights into the burden of disease in Korea, considering various factors such as regional disparities and income inequality. However, some limitations need to be acknowledged. First, we did not include the calculation of DALY for COVID-19, which is an important public health issue. Future research should incorporate the disease burden of infectious diseases, including COVID-19, to provide a comprehensive assessment. Second, the estimation of YLDs may have underestimated the burden of disease that relies on over-the-counter drugs or has low medical utilization rates. Further research is needed to improve the methodology for calculating YLDs in such cases. Additionally, age standardization was not applied in calculating disease burden by region, which limits the comparability between regions. Further studies should consider age standardization to enhance regional comparability. Lastly, because this study measured DALYs based on claims data, only data of those who used medical care were included in the assessment of disease burden. As a result, YLDs decreased and YLLs increased in 2020. Changes in the disease burden of periodontal disease, asthma, and BPH over the past 12 years can also be interpreted in a similar context. As this methodology included claims data, DALYs in 2020 were measured using data reflecting changes that occurred due to COVID-19. In order to overcome these methodological limitations, follow-up studies will need to be conducted to improve the accuracy of estimating the number of prevalences and incidences of disease. Furthermore, applying a method of cross-verification with data sources other than claims data could be helpful in improving the methodology.

Despite these limitations, this study contributes to the understanding of disease burden in Korea by utilizing individual-level empirical data. The methodology employed, such as

examining disease burden by region and income level, provides valuable insights into health equity. It is crucial to explore the underlying factors that contribute to health disparities identified in the results. Furthermore, estimating the preventable disease burden by assessing the attributable burden due to health risk factors like smoking, drinking, and lack of physical activity may guide priority setting and goals establishment in health promotion efforts. It is recommended that the burden of disease in the Korean population be regularly measured and the research methodology be continuously improved. The findings from these measurements should be utilized in policymaking to promote health and address health disparities effectively.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Percentage change in YLDs (per 100,000 population) for the top 20 leading specific causes (levels 3 and 4) of YLDs

REFERENCES

1. Tulchinsky TH, Varavikova EA. Measuring, monitoring, and evaluating the health of a population. In: *The New Public Health*. Amsterdam, The Netherlands: Elsevier; 2014, 91-147.
2. Mathers CD, Murray CJ, Ezzati M, Gakidou E, Salomon JA, Stein C. Population health metrics: crucial inputs to the development of evidence for health policy. *Popul Health Metr* 2003;1(1):6. PUBMED | CROSSREF
3. Devleesschauwer B, Maertens de Noordhout C, Smit GS, Duchateau L, Dorny P, Stein C, et al. Quantifying burden of disease to support public health policy in Belgium: opportunities and constraints. *BMC Public Health* 2014;14(1):1196. PUBMED | CROSSREF
4. Murray CJ. Quantifying the burden of disease: the technical basis for disability-adjusted life years. *Bull World Health Organ* 1994;72(3):429-45. PUBMED
5. Kim YE, Park H, Jo MW, Oh IH, Go DS, Jung J, et al. Trends and patterns of burden of disease and injuries in Korea using disability-adjusted life years. *J Korean Med Sci* 2019;34(Suppl 1):e75. PUBMED | CROSSREF
6. Kim YE, Jo MW, Park H, Oh IH, Yoon SJ, Pyo J, et al. Updating disability weights for measurement of healthy life expectancy and disability-adjusted life year in Korea. *J Korean Med Sci* 2020;35(27):e219. PUBMED | CROSSREF
7. Haneef R, Schmidt J, Gallay A, Devleesschauwer B, Grant I, Rommel A, et al. Recommendations to plan a national burden of disease study. *Arch Public Health* 2021;79(1):126. PUBMED | CROSSREF
8. Jung YS, Kim YE, Park H, Oh IH, Jo MW, Ock M, et al. Measuring the burden of disease in Korea, 2008–2018. *J Prev Med Public Health* 2021;54(5):293-300. PUBMED | CROSSREF
9. Organisation for Economic Co-operation and Development (OECD). *COVID-19: Protecting People and Societies*. Paris, France: OECD; 2020.
10. Cho KS. Changes in infectious diseases, health behaviors, and medical uses during COVID-19 pandemic in the Republic of Korea, 2020. *Public Health Wkly Rep* 2021;39(39):2750-64.
11. Yoon J, Yoon SJ. Quantifying burden of disease to measure population health in Korea. *J Korean Med Sci* 2016;31(Suppl 2):S101-7. PUBMED | CROSSREF
12. Lee YR, Kim YA, Park SY, Oh CM, Kim YE, Oh IH. Application of a modified garbage code algorithm to estimate cause-specific mortality and years of life lost in Korea. *J Korean Med Sci* 2016;31(Suppl 2):S121-8. PUBMED | CROSSREF
13. Statistics Korea. Life table. http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B42&conn_path=I3. Updated 2021. Accessed April 19, 2022.
14. National Health Insurance Sharing Service (KR). Customized DB. https://nhiss.nhis.or.kr/bd/ab/bdaba000eng.do. Updated 2023. Accessed June 25, 2023.
15. National Health Insurance Service (KR). *National Health Insurance Statistical Yearbook, 2020*. Wonju, Korea: National Health Insurance Service; 2021.

16. Ock M, Ko S, Lee HJ, Jo MW. Review of issues for disability weight studies. *Health Policy Manag* 2016;26(4):352-8. CROSSREF
17. Im D, Mahmudah NA, Yoon SJ, Kim YE, Lee DH, Kim YH, et al. Updating disability weights for causes of disease: adopting an add-on study method. *J Prev Med Public Health* 2023;56(4):291-302. PUBMED | CROSSREF
18. Yoon J, Oh IH, Seo H, Kim EJ, Gong YH, Ock M, et al. Disability-adjusted life years for 313 diseases and injuries: the 2012 Korean burden of disease study. *J Korean Med Sci* 2016;31(Suppl 2):S146-57. PUBMED | CROSSREF
19. Kang E, Yun J, Hwang SH, Lee H, Lee JY. The impact of the COVID-19 pandemic in the healthcare utilization in Korea: analysis of a nationwide survey. *J Infect Public Health* 2022;15(8):915-21. PUBMED | CROSSREF
20. National Health Insurance Service (KR). *2020 Survey on the Benefit Coverage Rate of National Health Insurance*. Wonju, Korea: National Health Insurance Service; 2021.
21. Organisation for Economic Co-operation and Development (OECD). Premature mortality. In: *Health at a Glance 2009: OECD Indicators*. Paris, France: OECD Publishing; 2009. CROSSREF
22. Choi SH, Cho YT. Sex differentials in the utilization of medical services by marital status. *Korea J Popul Stud* 2006;29(2):143-66.
23. Korean Diabetes Association. *Diabetes Fact Sheet in Korea, 2022*. Seoul, Korea: Korean Diabetes Association; 2023.
24. Kim HK, Bae SJ, Choe J. Impact of HbA1c criterion on the detection of subjects with increased risk for diabetes among health check-up recipients in Korea. *Diabetes Metab J* 2012;36(2):151-6. PUBMED | CROSSREF
25. Health Insurance Review and Assessment Service. One in 10 elderly people have dementia, and early screening is essential to prevent dementia. https://www.hira.or.kr/bbsDummy.do?pgmid=HIRAA020041000100&brdScnBltNo=4&brdBltNo=10146#none. Updated 2023. Accessed June 19, 2023.
26. Kim MK, Seo KH. A comparative study on the national dementia policy. *Public Policy Rev* 2017;31(1):233-60. CROSSREF
27. Yim J. Conceptual reconstruction and challenges of public health care. *Public Health Aff* 2017;1(1):109-27. CROSSREF
28. Kwon HS, Suh J, Kim MH, Yoo B, Han M, Koh IS, et al. Five-year community management rate for dementia patients: a proposed indicator for dementia policies. *J Clin Neurol* 2022;18(1):24-32. PUBMED | CROSSREF
29. Fillit H, Nash DT, Rundek T, Zuckerman A. Cardiovascular risk factors and dementia. *Am J Geriatr Pharmacother* 2008;6(2):100-18. PUBMED | CROSSREF
30. Lee JH, Lee JS, Choi JK, Kweon HI, Kim YT, Choi SH. National dental policies and socio-demographic factors affecting changes in the incidence of periodontal treatments in Korean: a nationwide population-based retrospective cohort study from 2002-2013. *BMC Oral Health* 2016;16(1):118. PUBMED | CROSSREF
31. Park HJ, Lee JH, Park S, Kim TI. Changes in dental care access upon health care benefit expansion to include scaling. *J Periodontal Implant Sci* 2016;46(6):405-14. PUBMED | CROSSREF
32. Yun SH, Suh CJ. The effects of the scaling health insurance coverage expansion policy on the use of dental services among patients with gingivitis and periodontal diseases. *Korean J Health Econ Policy* 2016;22(2):143-62.
33. Kim WJ, Shin YJ. Evaluation of the effectiveness of the policy to expand the scope of national health insurance dental scaling service benefits. *J Korean Acad Oral Health* 2022;46(4):192-206. CROSSREF
34. Hong J, Kwon S, Yoon H, Lee H, Lee B, Kim HH, et al. Risk factors for benign prostatic hyperplasia in South Korean men. *Urol Int* 2006;76(1):11-9. PUBMED | CROSSREF
35. Kang JY, Min GE, Son H, Kim HT, Lee HL. National-wide data on the treatment of BPH in Korea. *Prostate Cancer Prostatic Dis* 2011;14(3):243-7. PUBMED | CROSSREF
36. Ekman P. Finasteride in the treatment of benign prostatic hypertrophy: an update. New indications for finasteride therapy. *Scand J Urol Nephrol Suppl* 1999;33(203):15-20. PUBMED | CROSSREF
37. Jones MC. Treatment options for androgenetic alopecia. *US Pharm* 2018;43(8):12-6.
38. Health Insurance Review and Assessment Service (KR). Analysis of treatment status for depression and anxiety disorders over the past 5 years (2017–2021). https://www.hira.or.kr/bbsDummy.do?pgmid=HIRAA020041000100&brdScnBltNo=4&brdBltNo=10627. Updated 2023. Accessed June 19, 2023.
39. Kim ML, Shin K. Exploring the major factors affecting generalized anxiety disorder in Korean adolescents: based on the 2021 Korea youth health behavior survey. *Int J Environ Res Public Health* 2022;19(15):9384. PUBMED | CROSSREF
40. Melchior M, Caspi A, Milne BJ, Danese A, Poulton R, Moffitt TE. Work stress precipitates depression and anxiety in young, working women and men. *Psychol Med* 2007;37(8):1119-29. PUBMED | CROSSREF

41. Yoon Y, Ryu J, Kim H, Kang CW, Jung-Choi K. Working hours and depressive symptoms: the role of job stress factors. *Ann Occup Environ Med* 2018;30(1):46. PUBMED | CROSSREF
42. COVID-19 Mental Disorders Collaborators. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet* 2021;398(10312):1700-12. PUBMED | CROSSREF
43. Health Insurance Review and Assessment Service (KR). The number of people receiving asthma treatment was 1.87 million (2014), a decrease of 19.8% compared to 5 years ago. https://www.hira.or.kr/bbsDummy.do?brdBltNo=8946&brdScnBltNo=4&pgmid=HIRAA020041000100. Updated 2023. Accessed June 19, 2023.
44. Jo S, Jun DB, Park S. Impact of differential copayment on patient healthcare choice: evidence from South Korean National Cohort Study. *BMJ Open* 2021;11(6):e044549. PUBMED | CROSSREF
45. Huh K, Kim YE, Ji W, Kim DW, Lee EJ, Kim JH, et al. Decrease in hospital admissions for respiratory diseases during the COVID-19 pandemic: a nationwide claims study. *Thorax* 2021;76(9):939-41. PUBMED | CROSSREF
46. Kim JM, Bae YJ. Regional differences in metabolic risk in the elderly in Korea. *Int J Environ Res Public Health* 2022;19(18):11675. CROSSREF
47. Kim B. Regional disparity in adult obesity prevalence, and its determinants. *J Health Inform Stat* 2021;46(4):410-9. CROSSREF
48. Park HH, Chun IA, Ryu SY, Park J, Han MA, Chio SW, et al. Social disparities in utilization of preventive health services among Korean women aged 40-64. *J Health Inform Stat* 2016;41(4):369-78. CROSSREF
49. Park BH, Lee BK, Ahn J, Kim NS, Park J, Kim Y. Association of participation in health check-ups with risk factors for cardiovascular diseases. *J Korean Med Sci* 2021;36(3):e19. PUBMED | CROSSREF
50. Harrington DW, Wilson K, Bell S, Muhajarine N, Ruthart J. Realizing neighbourhood potential? The role of the availability of health care services on contact with a primary care physician. *Health Place* 2012;18(4):814-23. PUBMED | CROSSREF
51. Daly MR, Mellor JM, Millones M. Do avoidable hospitalization rates among older adults differ by geographic access to primary care physicians? *Health Serv Res* 2018;53(Suppl 1):3245-64. PUBMED | CROSSREF
52. Hong E, Ahn BC. Income-related health inequalities across regions in Korea. *Int J Equity Health* 2011;10(1):41. PUBMED | CROSSREF
53. Kim MS, Kim KH, Park SM, Lee JG, Ko YS, Cho AR, et al. Comparison of health status in primary care underserved area residents and the general population in Korea. *Korean J Fam Med* 2020;41(2):119-25. PUBMED | CROSSREF