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Updating Korean Disability Weights for Causes of Disease: Adopting an Add-on Study Method

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Objectives: Disability weights require regular updates, as they are influenced by both diseases and societal perceptions. Consequently, it is necessary to develop an up-to-date list of the causes of diseases and establish a survey panel for estimating disability weights. Accordingly, this study was conducted to calculate, assess, modify, and validate disability weights suitable for Korea, accounting for its cultural and social characteristics.

Methods: The 380 causes of disease used in the survey were derived from the 2019 Global Burden of Disease Collaborative Network and from 2019 and 2020 Korean studies on disability weights for causes of disease. Disability weights were reanalyzed by integrating the findings of an earlier survey on disability weights in Korea with those of the additional survey conducted in this study. The responses were transformed into paired comparisons and analyzed using probit regression analysis. Coefficients for the causes of disease were converted into predicted probabilities, and disability weights in 2 models (model 1 and 2) were rescaled using a normal distribution and the natural logarithm, respectively.

Results: The mean values for the 380 causes of disease in models 1 and 2 were 0.488 and 0.369, respectively. Both models exhibited the same order of disability weights. The disability weights for the 300 causes of disease present in both the current and 2019 studies demonstrated a Pearson correlation coefficient of 0.994 ($p=0.001$ for both models). This study presents a detailed add-on approach for calculating disability weights.

Conclusions: This method can be employed in other countries to obtain timely disability weight estimations.

Key words: Disability weight, Burden of disease, Republic of Korea, Add-on study method

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INTRODUCTION

A disability weight (DW) is a measure that represents the severity of specific health states or causes of disease, in contrast to a utility weight. DW values range from 0, indicating full health, to 1, representing a disability equivalent to death [1]. DW is a critical component in calculating disability-adjusted life years (DALYs) and disability-adjusted life expectancy (DALE), which are used to determine summary measures of popula-

tion health [2,3]. Therefore, it is essential to ensure the validity of DW, as it impacts the validity of the DALY and DALE calculations. An overestimated DW for a particular disease would lead to an overestimation of the burden of that disease, while the opposite would occur if the DW were underestimated.

DW validity cannot be guaranteed by a single instance of validity verification. The emergence of new diseases, as well as changes in conditions, treatments, or societal perceptions, may render previously valid DWs inapplicable in the current era. Therefore, it is necessary to assess the validity of past DWs and determine whether modifications are required. The Global Burden of Disease Study has been updating DWs to reflect their current relevance [4-6]. The emergence of coronavirus disease 2019 (COVID-19) has further underscored the importance of revising DWs. While some studies have temporarily replaced COVID-19 with another disease for DW measurement [7,8], COVID-19 should be incorporated into DW evaluations given the disease's expected persistence.

Two DW measurement approaches are used according to the DALY calculation method [3]. One is an incidence-based approach involving the cause of disease, while the other is a prevalence-based approach focused on the health state. After determining which strategy to use, it is necessary to categorize the cause of disease or health state in order to construct a survey panel and to modify or create a health state description if needed [1]. Subsequently, a survey must be initiated, taking into account the valuation method and time presentation, as its results will be incorporated into DW calculations and validated. Due to cultural and social differences across countries, care should be taken when applying DWs to other nations. The 2010 Global Burden of Disease Report demonstrated relatively few discrepancies in health state preferences among countries [4]; however, it is challenging to assert that no differences were present in cultural perceptions of health states or diseases, as the 2010 survey exhibited bias in the number of participating countries and cultures. Therefore, DWs must be appropriately measured for the Korea, with their validity evaluated and their calculations adjusted as needed [1].

In this study, we estimated DWs using an incidence-based approach with an updated list of disease causes. The validity of these DWs was assessed in consideration of Korea's cultural and social characteristics. In particular, the DW survey results from previous studies employing an incidence-based approach were utilized through an add-on study method to refine the DWs [9,10].

METHODS

Study Design and Participants

A web-based self-administered survey was conducted, drawing from a previous study [10]. The survey took place between August 1, 2022, and August 30, 2022. Eligible participants were restricted to medically licensed physicians in Korea, with nurses and Korean medical doctors excluded due to improper response patterns observed in previous studies [10]. Furthermore, since the survey did not offer detailed descriptions of diseases, medical expertise was necessary to determine the cause of each disease based on its apparent value and severity level. Participants were recruited through advertisements on medical institution-related web boards, word of mouth, and snowball sampling, with participants who had completed the survey recommending other qualified individuals to join the study.

Valuation Method and Causes of Disease

The questionnaire consisted of 4 socio-demographic characteristics—age, sex, specialty, and occupation—as well as 20 questions regarding the ranking of causes of disease, in line with methods used in previous studies [9,10]. Of 378 causes of disease (excluding "full health" and "death"), 5 causes of disease were randomly selected for each question. Participants ranked these causes of disease in order of good health based on severity and face value [11]. "Full health" and "death" served as valuation anchor points to ensure the validity of survey responses and the participants' full comprehension of the survey content. Specifically, "full health" was the first fixed alternative for questions 5, 10, 15, and 20, while "death" was the first fixed alternative for questions 9-12. Questions 9-12 were designed to include at least 1 of the new causes of disease as the second alternative for each question, increasing the likelihood of newly added causes of disease appearing in the questionnaire. An example of a ranking method question can be found in Supplemental Material 1.

The list of causes of diseases used in the survey required modification, as previously measured DWs needed to be reviewed and validated to ensure their relevance to the current era considering new disease outbreaks such as COVID-19, changes in treatment, and shifts in social judgment regarding specific diseases [4-6]. A total of 380 causes of disease were identified for the study in the following manner. First, the list of causes of disease used in the 2019 Global Burden of Disease Collaborative Network was evaluated to incorporate global DW

trends. In total, 281 causes of disease were selected, excluding those that could be further classified by severity. Next, 99 additional causes of disease were included after examining the causes of disease lists from the 2016, 2019, and 2020 Korean DW measurements to reflect the cultural characteristics of Korea [9,10,12]. Specifically, common causes of diseases from those 3 years, such as "hemorrhagic and other non-ischemic strokes" and "Asperger syndrome and other autistic spectrum disorders," were added. Other common causes of diseases from 2016 and 2019, such as "influenza and intestinal infection," and from 2019 and 2020, such as "stomach cancer" and "breast cancer stages 1-4," were also included. From the 2020 list, "unintentional suffocation," "COVID-19" with severity classification, "ischemic heart disease," and others were added. The researchers and a DW expert reviewed each selection process and the English-to-Korean translation of disease terminology.

Statistical Analysis

During the data cleaning process, incomplete surveys and incorrect anchor-point answer data related to "full health" were removed. To enhance the validity of the results, raw data for measuring DW by the cause of disease from the 2019 [9] and 2020 [10] studies were utilized. Specifically, raw data from 430 participants in the 2019 study [9] and 685 participants in the 2020 study [10] were included after eliminating any data that did not meet the present participation eligibility criteria and any data derived from a set of questions with at least 1 cause of disease that did not overlap with the present list of causes of disease. For instance, in the 2019 study [9], 71 participants who did not complete the survey were initially removed from the data, followed by the exclusion of 175 participants who were either medical students, nurses, or Korean medical doctors; data derived from a set of questions that included 38 causes of diseases were also removed. Additionally, "human immunodeficiency virus disease resulting in mycobacterial infection" and "typhoid and paratyphoid fevers" were excluded, as they did not match the current list and were subdivided into 2 separate entities, respectively. In the 2020 study [10], 95 participants who did not complete the survey were initially removed, and 157 participants who did not meet the eligibility criteria were excluded; data resulting from any questions that included 11 disease causes were also withdrawn. Chronic kidney disease due to diabetes mellitus was excluded due to its subdivision in the current list. Subsequently, the labeling of the extracted data with cause of disease numbers was converted to match the present labeling system.

First, a descriptive analysis of the participants' socio-demographic characteristics was conducted using the complete dataset. The 5 alternatively ranked datasets were then transformed into a paired comparison format to adapt a precedent method [9,10]. Specifically, if a participant responded to a ranking questionnaire in the order of C1-C2-C3-C4-C5, this was transformed into C1-C5, C1-C4, C1-C3, C1-C2, C2-C5, C2-C4, C2-C3, C3-C5, C3-C4, and C4-C5. Probit regression analysis was performed using 2 models, in line with previous studies [12,13]. The cause of disease was treated as a dummy variable and set as an independent variable, while preference was set as a dependent variable. The regression coefficient for each cause of disease was then converted to a predicted probability. The value was rescaled based on the estimated DW of "death" (1), with this rescaled value considered the DW. The DWs were rescaled using a normal distribution and natural logarithm in models 1 and 2, respectively.

Stata version 13.1 (StataCorp., College Station, TX, USA) was utilized for all statistical analyses. A p-value <0.05 was considered to indicate statistical significance.

Ethics Statement

The Korea University Institutional Review Board (IRB No. KUIRB-2022-0221-02) granted approval for this study. Prior to the survey, participants were informed about the study's objectives and procedures. Only those who consented to the terms participated in the study and were given coffee coupons valued at 10 000 Korean won upon completion of the survey.

RESULTS

For this study, 211 participants began and completed the survey. Of these, 205 participants who correctly ranked "full health" first for the anchor point questions 5, 10, 15, and 20 were selected for analysis. As an add-on, 685 and 430 participants were chosen from the 2020 and 2019 studies [9,10], respectively. Table 1 displays the socio-demographic characteristics of the participants across the 3 years. Most participants during this period were male specialists in their 30s. In the current study and the 2019 study, most participants' specialties were neither medical nor surgical, while participants from the 2020 study primarily specialized in medicine.

Table 2 displays the DWs for the 2 models. The mean DWs for model 1 and model 2 were 0.488 and 0.369, respectively.

Table 1. Characteristics of study participants

Characteristics	Present	2020[1]	2019[2]
Age (y)			
19-29	17 (8.3)	100 (14.6)	52 (12.1)
30-39	126 (61.5)	569 (83.1)	374 (87.0)
≥40	62 (30.2)	16 (2.3)	4 (0.9)
Sex			
Male	143 (69.8)	540 (78.8)	401 (93.3)
Female	62 (30.2)	145 (21.2)	29 (6.7)
Occupation			
General practitioner	12 (5.9)	76 (11.1)	56 (13.0)
Resident	19 (9.3)	65 (9.5)	6 (1.4)
Specialist	169 (82.4)	527 (76.9)	358 (83.3)
Other	5 (2.4)	17 (2.5)	10 (2.3)
Specialty			
Medical	71 (34.6)	259 (37.8)	153 (35.6)
Surgical	44 (21.5)	190 (27.7)	60 (14.0)
Other	90 (43.9)	236 (34.4)	217 (50.5)
Total	205 (100.0)	685 (100.0)	430 (100.0)

Values are presented as number (%).
[1]Source from: Kim YE, et al. J Korean Med Sci 2020;35(27):e219 [10].
[2]Source from: Ock M, et al. J Korean Med Sci 2019;34(Suppl 1):e60 [9].

Both models identified the same disease as having the highest DW: "trachea, bronchus, and lung cancers (stage 4)," with DWs of 0.922 in model 1 and 0.696 in model 2. Similarly, the lowest DW in both models was attributed to the same disease: "acne vulgaris," with DWs of 0.055 in model 1 and 0.223 in model 2. The 2 models also shared the same ranking of diseases by DW.

Following "trachea, bronchus, and lung cancers (stage 4)," the diseases with the highest DWs in descending order were "pancreatic cancer," "kidney cancer (stage 4)," and "liver cancer secondary to alcohol use (stage 4)." Conversely, the diseases with the lowest DWs in ascending order were "acne vulgaris," "caries of deciduous teeth," "allergic rhinitis," and "urticaria."

Figure 1 illustrates the DW distributions for models 1 and 2. Model 1 displays a relatively normal distribution, whereas model 2 exhibits a left-skewed distribution. In model 1, the highest number of causes of disease, 61, was found in the DW range of 0.3 to 0.4. Meanwhile, in model 2, no causes of disease were identified with DW values less than 0.2 or greater than 0.7.

Figure 2 displays the correlation between the DWs for causes of disease in the current and previous models [10]. The causes of disease from the 2020 study [10] were compared word by word with those in the present study, and 300 causes of disease were selected for correlation analyses. Both model 1 and

Table 2. Disability weights for each analysis model by cause of disease

No.	Cause of disease	Model 1[1]	Model 2[2]
1	HIV/AIDS - Drug-susceptible tuberculosis	0.724	0.470
2	HIV/AIDS - Multidrug-resistant tuberculosis without extensive drug resistance	0.787	0.519
3	HIV/AIDS - Extensively drug-resistant tuberculosis	0.806	0.537
4	HIV/AIDS resulting in other diseases	0.752	0.491
5	Syphilis	0.432	0.326
6	Chlamydial infection	0.327	0.292
7	Gonococcal infection	0.315	0.289
8	Trichomoniasis	0.330	0.293
9	Genital herpes	0.255	0.271
10	Other sexually transmitted disease	0.356	0.301
11	Latent tuberculosis infection	0.241	0.268
12	Drug-susceptible tuberculosis	0.388	0.312
13	Multidrug-resistant tuberculosis without extensive drug resistance	0.657	0.427
14	Extensively drug-resistant tuberculosis	0.677	0.439
15	Upper respiratory infections	0.207	0.259
16	Lower respiratory infections	0.329	0.293
17	Otitis media	0.191	0.255
18	Influenza	0.220	0.262
19	Pneumococcal pneumonia	0.418	0.322
20	H influenza type B pneumonia	0.442	0.330
21	Respiratory syncytial virus pneumonia	0.331	0.293
22	COVID-19 (mild)	0.110	0.235
23	COVID-19 (moderate)	0.642	0.419
24	COVID-19 (severe)	0.755	0.493
25	Diarrhoeal diseases	0.176	0.251
26	Typhoid fever	0.315	0.289
27	Paratyphoid fever	0.388	0.311
28	Invasive non-typhoidal Salmonella	0.389	0.312
29	Other intestinal infectious diseases	0.273	0.276
30	Cholera	0.415	0.321
31	Other Salmonella infections	0.318	0.290
32	Shigellosis	0.372	0.306
33	Enteropathogenic E. coli infection	0.323	0.291
34	Enterotoxigenic E. coli infection	0.306	0.286
35	Campylobacter enteritis	0.299	0.284
36	Amoebiasis	0.422	0.323
37	Cryptosporidiosis	0.531	0.365
38	Rotaviral enteritis	0.211	0.260
39	Intestinal infection	0.262	0.273
40	Malaria	0.436	0.328
41	Chagas disease	0.548	0.373
42	Visceral leishmaniasis	0.416	0.321

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Table 2. Continued from the previous page

No.	Cause of disease	Model 1[1]	Model 2[2]
43	Cutaneous and mucocutaneous leishmaniasis	0.394	0.313
44	African trypanosomiasis	0.475	0.342
45	Schistosomiasis	0.391	0.313
46	Cysticercosis	0.393	0.313
47	Cystic echinococcosis	0.395	0.314
48	Lymphatic filariasis	0.480	0.344
49	Onchocerciasis	0.322	0.291
50	Trachoma	0.387	0.311
51	Dengue	0.427	0.325
52	Yellow fever	0.505	0.354
53	Rabies	0.696	0.451
54	Ascariasis	0.225	0.263
55	Trichuriasis	0.326	0.292
56	Hookworm disease	0.234	0.266
57	Food-borne trematodiases	0.313	0.288
58	Leprosy	0.601	0.398
59	Tsutsugamushi fever	0.450	0.333
60	Typhus fever	0.435	0.328
61	Hantaan virus disease	0.539	0.369
62	Ebola virus disease	0.764	0.500
63	Zika virus disease	0.509	0.356
64	Guinea worm disease	0.352	0.300
65	Other neglected tropical diseases	0.383	0.310
66	Pneumococcal meningitis	0.600	0.397
67	H influenzae type B meningitis	0.607	0.401
68	Meningococcal infection	0.546	0.372
69	Other meningitis	0.583	0.389
70	Encephalitis	0.699	0.453
71	Diphtheria	0.362	0.303
72	Whooping cough	0.319	0.290
73	Tetanus	0.539	0.369
74	Measles	0.305	0.286
75	Varicella and herpes zoster	0.276	0.277
76	Legionnaire disease	0.366	0.304
77	Leptospirosis	0.424	0.324
78	Rubella	0.362	0.303
79	Mumps	0.245	0.269
80	Acute hepatitis A	0.365	0.304
81	Acute hepatitis B	0.433	0.327
82	Acute hepatitis C	0.529	0.364
83	Acute hepatitis E	0.501	0.353
84	Other unspecified infectious diseases	0.267	0.275
85	Maternal hemorrhage	0.576	0.386
86	Maternal sepsis and other maternal infections	0.678	0.440
87	Maternal hypertensive disorders	0.414	0.320

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Table 2. Continued

No.	Cause of disease	Model 1[1]	Model 2[2]
88	Maternal obstructed labor and uterine rupture	0.654	0.426
89	Maternal abortion and miscarriage	0.365	0.304
90	Ectopic pregnancy	0.395	0.314
91	Indirect maternal deaths	0.780	0.513
92	Late maternal deaths	0.834	0.566
93	Maternal deaths aggravated by HIV/AIDS	0.904	0.663
94	Other maternal disorders	0.365	0.304
95	Neonatal preterm birth complications	0.581	0.388
96	Neonatal encephalopathy due to birth asphyxia and trauma	0.818	0.549
97	Neonatal sepsis and other neonatal infections	0.708	0.459
98	Hemolytic disease and other neonatal jaundice	0.491	0.349
99	Other neonatal disorders	0.520	0.360
100	Protein-energy malnutrition	0.421	0.323
101	Iodine deficiency	0.225	0.263
102	Vitamin A deficiency	0.194	0.255
103	Iron-deficiency anemia	0.181	0.252
104	Other nutritional deficiencies	0.225	0.263
105	Lip and oral cavity cancer	0.774	0.509
106	Nasopharynx cancer	0.818	0.549
107	Other pharynx cancer	0.797	0.528
108	Esophageal cancer	0.885	0.632
109	Stomach cancer (stage 1)	0.457	0.336
110	Stomach cancer (stage 2)	0.615	0.405
111	Stomach cancer (stage 3)	0.794	0.526
112	Stomach cancer (stage 4)	0.905	0.664
113	Colon and rectum cancers (stage 1)	0.489	0.348
114	Colon and rectum cancers (stage 2)	0.646	0.421
115	Colon and rectum cancers (stage 3)	0.814	0.545
116	Colon and rectum cancers (stage 4)	0.888	0.637
117	Liver cancer secondary to hepatitis B	0.759	0.496
118	Liver cancer secondary to hepatitis C	0.786	0.519
119	Liver cancer secondary to alcohol use (stage 1)	0.598	0.396
120	Liver cancer secondary to alcohol use (stage 2)	0.722	0.468
121	Liver cancer secondary to alcohol use (stage 3)	0.815	0.546
122	Liver cancer secondary to alcohol use (stage 4)	0.911	0.675
123	Liver cancer due to NASH	0.774	0.508
124	Liver cancer due to other causes	0.786	0.519
125	Gallbladder and biliary tract cancer	0.830	0.562
126	Pancreatic cancer	0.919	0.690
127	Larynx cancer	0.868	0.607

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Table 2. Continued from the previous page

No.	Cause of disease	Model 1[1]	Model 2[2]
128	Trachea, bronchus and lung cancers (stage 1)	0.585	0.390
129	Trachea, bronchus and lung cancers (stage 2)	0.715	0.464
130	Trachea, bronchus and lung cancers (stage 3)	0.847	0.581
131	Trachea, bronchus and lung cancers (stage 4)	0.922	0.696
132	Malignant skin melanoma	0.824	0.555
133	Non-melanoma skin cancer (squamous-cell carcinoma)	0.636	0.416
134	Non-melanoma skin cancer (basal cell carcinoma)	0.656	0.427
135	Breast cancer (stage 1)	0.459	0.336
136	Breast cancer (stage 2)	0.592	0.393
137	Breast cancer (stage 3)	0.769	0.504
138	Breast cancer (stage 4)	0.880	0.625
139	Cervical cancer (stage 1)	0.419	0.322
140	Cervical cancer (stage 2)	0.592	0.393
141	Cervical cancer (stage 3)	0.764	0.500
142	Cervical cancer (stage 4)	0.880	0.624
143	Uterine cancer	0.704	0.456
144	Ovarian cancer	0.804	0.535
145	Prostate cancer (stage 1)	0.473	0.342
146	Prostate cancer (stage 2)	0.601	0.397
147	Prostate cancer (stage 3)	0.728	0.473
148	Prostate cancer (stage 4)	0.863	0.601
149	Testicular cancer	0.746	0.486
150	Kidney cancer (stage 1)	0.539	0.369
151	Kidney cancer (stage 2)	0.729	0.473
152	Kidney cancer (stage 3)	0.854	0.589
153	Kidney cancer (stage 4)	0.916	0.684
154	Bladder cancer (stage 1)	0.534	0.366
155	Bladder cancer (stage 2)	0.630	0.412
156	Bladder cancer (stage 3)	0.790	0.522
157	Bladder cancer (stage 4)	0.863	0.600
158	Other urinary organ cancers	0.737	0.479
159	Brain and nervous system cancer	0.875	0.618
160	Thyroid cancer (stage 1)	0.276	0.277
161	Thyroid cancer (stage 2)	0.467	0.339
162	Thyroid cancer (stage 3)	0.619	0.407
163	Thyroid cancer (stage 4)	0.802	0.533
164	Mesothelioma	0.785	0.518
165	Hodgkin lymphoma	0.712	0.462
166	Non-Hodgkin lymphoma	0.711	0.461
167	Multiple myeloma	0.740	0.481
168	Acute lymphoid leukemia	0.811	0.542
169	Chronic lymphoid leukemia	0.748	0.488
170	Acute myeloid leukemia	0.827	0.558
171	Chronic myeloid leukemia	0.769	0.504

(*Continued to the next*)

Table 2. Continued

No.	Cause of disease	Model 1[1]	Model 2[2]
172	Other leukemia	0.829	0.561
173	Bone and connective tissue cancer	0.768	0.503
174	Benign neoplasm of brain and other parts of central nervous system	0.507	0.355
175	Other malignant neoplasms	0.778	0.512
176	Myelodysplastic, myeloproliferative, and other hematopoietic neoplasms	0.751	0.490
177	Benign and in situ intestinal neoplasms	0.279	0.278
178	Benign and in situ cervical and uterine neoplasms	0.366	0.304
179	Other benign and in situ neoplasms	0.216	0.261
180	Rheumatic heart disease	0.627	0.411
181	Stable ischemic heart disease	0.521	0.361
182	Unstable angina	0.630	0.412
183	Ischemic stroke (mild)	0.527	0.363
184	Ischemic stroke (moderate)	0.782	0.515
185	Ischemic stroke (severe)	0.828	0.559
186	Hemorrhagic and other non-ischemic stroke	0.798	0.530
187	Hypertensive heart disease	0.462	0.338
188	Non-rheumatic calcific aortic valvular heart disease	0.652	0.425
189	Non-rheumatic degenerative mitral valvular heart disease	0.605	0.399
190	Other non-rheumatic valvular heart diseases	0.637	0.416
191	Myocarditis	0.649	0.423
192	Alcoholic cardiomyopathy	0.629	0.412
193	Other cardiomyopathy	0.671	0.436
194	Atrial fibrillation and flutter	0.543	0.370
195	Aortic aneurysm	0.728	0.472
196	Peripheral vascular disease	0.415	0.321
197	Endocarditis	0.684	0.444
198	Other cardiovascular and circulatory diseases	0.543	0.371
199	Hemorrhoid	0.132	0.240
200	Varicose veins of lower extremities	0.143	0.243
201	Chronic obstructive pulmonary disease (mild)	0.444	0.331
202	Chronic obstructive pulmonary disease (moderate)	0.669	0.434
203	Chronic obstructive pulmonary disease (severe)	0.771	0.506
204	Silicosis	0.669	0.435
205	Asbestosis	0.659	0.429
206	Coal workers' pneumoconiosis	0.671	0.435
207	Other pneumoconiosis	0.594	0.394
208	Asthma	0.409	0.318
209	Interstitial lung disease and pulmonary sarcoidosis	0.707	0.459
210	Other chronic respiratory diseases	0.503	0.354

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Table 2. Continued from the previous page

No.	Cause of disease	Model 1[1]	Model 2[2]
211	Cirrhosis and other chronic liver diseases due to hepatitis B	0.674	0.437
212	Cirrhosis and other chronic liver diseases due to hepatitis C	0.680	0.441
213	Cirrhosis and other chronic liver diseases due to alcohol use (mild)	0.512	0.357
214	Cirrhosis and other chronic liver diseases due to alcohol use (moderate)	0.640	0.418
215	Cirrhosis and other chronic liver diseases due to alcohol use (severe)	0.683	0.443
216	Cirrhosis and other chronic liver diseases due to NAFLD	0.540	0.369
217	Cirrhosis and other chronic liver diseases due to other causes	0.629	0.412
218	Peptic ulcer disease	0.247	0.269
219	Gastritis and duodenitis	0.144	0.243
220	Gastroesophageal reflux disease	0.126	0.239
221	Appendicitis	0.246	0.269
222	Paralytic ileus and intestinal obstruction	0.427	0.325
223	Inguinal, femoral, and abdominal hernia	0.254	0.271
224	Inflammatory bowel disease	0.461	0.337
225	Vascular intestinal disorders	0.524	0.362
226	Gallbladder and biliary diseases	0.432	0.327
227	Pancreatitis	0.454	0.335
228	Other digestive diseases	0.198	0.256
229	Alzheimer disease and other dementias	0.660	0.429
230	Parkinson disease	0.699	0.453
231	Idiopathic epilepsy	0.613	0.403
232	Multiple sclerosis	0.674	0.437
233	Motor neuron disease	0.712	0.461
234	Migraine	0.186	0.253
235	Tension-type headache	0.180	0.252
236	Other neurological disorders	0.483	0.346
237	Schizophrenia	0.695	0.451
238	Major depressive disorder (mild)	0.312	0.288
239	Major depressive disorder (moderate)	0.544	0.371
240	Major depressive disorder (severe)	0.585	0.390
241	Dysthymia	0.239	0.267
242	Bipolar disorder	0.457	0.336
243	Anxiety disorders	0.309	0.287
244	Panic disorder	0.384	0.310
245	Obsessive-compulsive disorder	0.320	0.290
246	Post-traumatic stress disorder	0.392	0.313
247	Anorexia nervosa	0.402	0.316
248	Bulimia nervosa	0.371	0.306
249	Autism spectrum disorders	0.520	0.361
250	Asperger syndrome and other autistic spectrum disorders	0.488	0.348

(*Continued to the next*)

Table 2. Continued

No.	Cause of disease	Model 1[1]	Model 2[2]
251	Attention-deficit/hyperactivity disorder	0.230	0.265
252	Conduct disorder	0.314	0.288
253	Idiopathic developmental intellectual disability	0.458	0.336
254	Borderline personality disorder	0.433	0.327
255	Other mental disorders	0.486	0.347
256	Alcohol use disorders	0.428	0.325
257	Opioid use disorders	0.491	0.349
258	Cocaine use disorders	0.516	0.359
259	Amphetamine use disorders	0.483	0.346
260	Cannabis use disorders	0.384	0.310
261	Other drug use disorders	0.322	0.291
262	Diabetes mellitus type 1 without complications	0.394	0.314
263	Diabetes mellitus type 1 with complications	0.632	0.413
264	Diabetes mellitus type 2 without complications	0.322	0.291
265	Diabetes mellitus type 2 with complications	0.665	0.432
266	Metabolic syndrome	0.272	0.276
267	Chronic kidney disease due to diabetes mellitus type 1	0.692	0.448
268	Chronic kidney disease due to diabetes mellitus type 2	0.660	0.429
269	Chronic kidney disease due to hypertension	0.610	0.402
270	Chronic kidney disease due to glomerulonephritis	0.639	0.417
271	Chronic kidney disease due to other and unspecified causes	0.631	0.413
272	Acute glomerulonephritis	0.464	0.338
273	Eczema	0.134	0.241
274	Atopic dermatitis	0.224	0.263
275	Contact dermatitis	0.109	0.235
276	Seborrheic dermatitis	0.122	0.238
277	Psoriasis	0.242	0.268
278	Cellulitis	0.231	0.265
279	Pyoderma	0.320	0.290
280	Scabies	0.181	0.252
281	Fungal skin diseases	0.226	0.264
282	Viral skin diseases	0.197	0.256
283	Acne vulgaris	0.055	0.223
284	Alopecia areata	0.131	0.240
285	Pruritus	0.104	0.234
286	Urticaria	0.102	0.233
287	Decubitus ulcer	0.494	0.350
288	Other skin and subcutaneous diseases	0.135	0.241
289	Glaucoma	0.399	0.315
290	Cataract	0.281	0.279
291	Age-related macular degeneration	0.404	0.317
292	Refraction and accommodation disorders	0.207	0.259
293	Near vision loss	0.279	0.278

(*Continued to the next page*)

Table 2. Continued from the previous page

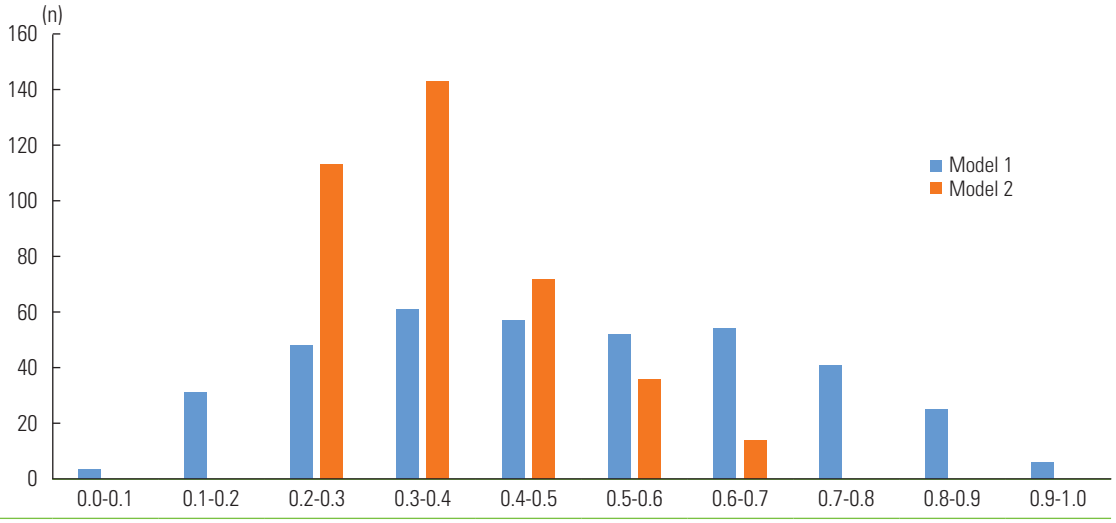
No.	Cause of disease	Model 1[1]	Model 2[2]
294	Other vision loss	0.601	0.398
295	Age-related and other hearing loss	0.274	0.277
296	Allergic rhinitis	0.084	0.229
297	Other sense organ diseases	0.323	0.291
298	Rheumatoid arthritis	0.423	0.323
299	Osteoarthritis, hip	0.353	0.300
300	Osteoarthritis, knee	0.277	0.277
301	Osteoarthritis, hand	0.242	0.268
302	Osteoarthritis, other	0.282	0.279
303	Low back pain (mild)	0.132	0.240
304	Low back pain (moderate)	0.304	0.285
305	Low back pain (severe)	0.393	0.313
306	Neck pain	0.125	0.238
307	Gout	0.341	0.296
308	Other musculoskeletal disorders	0.194	0.255
309	Systemic lupus erythematosus	0.619	0.407
310	Neural tube defects	0.765	0.501
311	Congenital heart anomalies	0.690	0.447
312	Orofacial clefts	0.491	0.349
313	Down syndrome	0.652	0.424
314	Turner syndrome	0.563	0.379
315	Klinefelter syndrome	0.558	0.377
316	Other chromosomal abnormalities	0.650	0.423
317	Congenital musculoskeletal and limb anomalies	0.640	0.418
318	Urogenital congenital anomalies	0.520	0.360
319	Digestive congenital anomalies	0.530	0.365
320	Other congenital anomalies	0.590	0.392
321	Interstitial nephritis and urinary tract infections	0.409	0.319
322	Urolithiasis	0.261	0.273
323	Benign prostatic hyperplasia	0.208	0.259
324	Male infertility	0.296	0.283
325	Urinary incontinence	0.233	0.265
326	Other urinary diseases	0.182	0.252
327	Uterine fibroids	0.201	0.257
328	Polycystic ovarian syndrome	0.382	0.310
329	Female infertility	0.305	0.286
330	Endometriosis	0.317	0.289
331	Genital prolapse	0.379	0.308
332	Premenstrual syndrome	0.154	0.245
333	Other gynecological diseases	0.251	0.270
334	Thalassemias	0.484	0.346
335	Thalassemia trait	0.479	0.344
336	Sickle cell disorders	0.543	0.371
337	Sickle cell trait	0.496	0.351
338	G6PD deficiency	0.520	0.360
339	G6PD trait	0.526	0.363

(*Continued to the next*)

Table 2. Continued

No.	Cause of disease	Model 1[1]	Model 2[2]
340	Other hemoglobinopathies and hemolytic anemias	0.470	0.340
341	Endocrine, metabolic, blood, and immune disorders	0.438	0.329
342	Caries of deciduous teeth	0.067	0.225
343	Caries of permanent teeth	0.129	0.239
344	Periodontal disease	0.204	0.258
345	Edentulism and severe tooth loss	0.465	0.339
346	Other oral disorders	0.193	0.255
347	Sudden infant death syndrome	0.865	0.604
348	Pedestrian road injuries	0.453	0.334
349	Cyclist road injuries	0.290	0.281
350	Motorcyclist road injuries	0.527	0.364
351	Motor vehicle road injuries	0.508	0.356
352	Other road injuries	0.318	0.289
353	Other transport injuries	0.418	0.322
354	Falls	0.415	0.321
355	Drowning	0.527	0.363
356	Fire, heat, and hot substances	0.399	0.315
357	Poisoning by carbon monoxide	0.776	0.510
358	Poisoning by other means	0.655	0.426
359	Unintentional firearm injuries	0.469	0.340
360	Unintentional suffocation	0.686	0.445
361	Other exposure to mechanical forces	0.301	0.285
362	Adverse effects of medical treatment	0.302	0.285
363	Venomous animal contact	0.398	0.315
364	Non-venomous animal contact	0.107	0.234
365	Pulmonary aspiration and foreign body in airway	0.569	0.382
366	Foreign body in eyes	0.117	0.237
367	Foreign body in other body part	0.161	0.247
368	Environmental heat and cold exposure	0.247	0.269
369	Exposure to forces of nature	0.249	0.270
370	Other unintentional injury	0.249	0.270
371	Self-harm by firearm	0.574	0.384
372	Self-harm by other specified means	0.548	0.372
373	Physical violence by firearm	0.531	0.365
374	Physical violence by sharp object	0.276	0.277
375	Sexual violence	0.520	0.360
376	Physical violence by other means	0.265	0.274
377	Conflict and terrorism	0.516	0.359
378	Police conflict or execution	0.550	0.373
Mean		0.488	0.369

HIV/AIDS, human immunodeficiency virus/acquired immune deficiency syndrome; COVID-19, coronavirus disease 2019; NASH, nonalcoholic fatty liver disease; NAFLD, nonalcoholic fatty liver disease; G6PD, glucose 6-phosphate dehydrogenase.
[1]Based on a normal distribution.
[2]Based on the natural logarithm.



	0.0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Model 1	3	31	48	61	57	52	54	41	25	6
Model 2	0	0	113	143	72	36	14	0	0	0

Figure 1. Distribution of disability weights in each analytical method adopted from the previous study [10]. Model 1: Based on a normal distribution.; Model 2: Based on the natural logarithm.

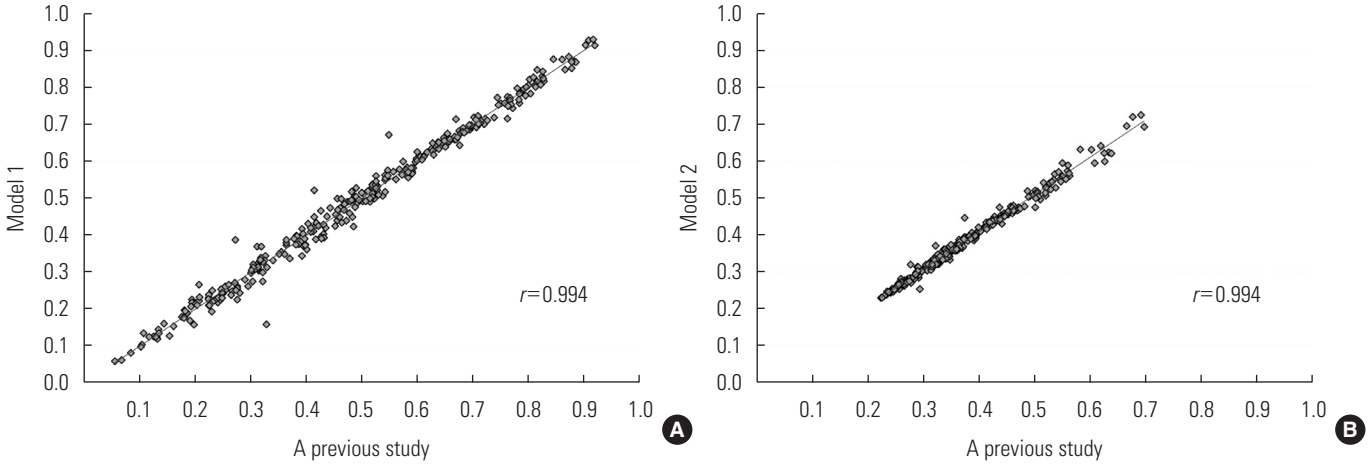


Figure 2. Correlation of disability weights between previous [10] and present studies. Model 1: Based on a normal distribution (A). Model 2: Based on the natural logarithm (B).

model 2 had a Pearson correlation coefficient of 0.994 with a *p*-value of 0.001. Among the 300 overlapping causes of disease, 155 DWs increased in model 1 relative to the DWs in the previous study, while 137 DWs decreased (Supplemental Material 2). Eight DWs remained the same as in the previous study: "other meningitis" (0.583), "liver cancer secondary to alcohol use (stage 1)" (0.598), "asthma" (0.409), "Alzheimer disease and other dementias" (0.660), "conduct disorder" (0.314), "pruritus" (0.104), "other skin and subcutaneous diseases" (0.135), and "drowning" (0.527). In model 2, 145 DWs increased and 148 DWs decreased relative to the DWs in the previous study. Seven DWs remained unchanged: "latent tuberculosis infection" (0.268), "breast cancer (stage 2)" (0.393), "other drug use disorders" (0.291), "glaucoma" (0.315), "age-related and other hearing loss" (0.277), "physical violence by firearms" (0.365), and "physical violence by other means" (0.274).

DISCUSSION

This study presents the findings of an add-on study approach for revising DWs. We combined the results of a present DW survey involving approximately 200 physicians with data from

previous studies (430 and 685 participants in 2019 and 2020, respectively) to update the DWs for 380 causes of disease. In earlier DW studies, independent surveys were conducted to introduce new causes of disease or refine existing ones, and the outcomes were analyzed to generate DWs. The central importance of this study is its demonstration of the potential to revise DWs using an add-on study method.

The importance of an add-on study for determining DWs stems from the fact that recent DW studies have primarily employed ordinal methods, such as paired comparison and ranking methods [14]. Estimating the DW is relatively straightforward when using cardinal methods like person trade-off, time trade-off, and standard gamble, as they allow for direct comparison with an anchor point, such as death, and can easily incorporate newly added causes of diseases. However, to calculate DW using ordinal methods, a new cause of disease must be compared to an existing cause. Therefore, if additional causes of disease are introduced without a major reorganization of the disease classification system, it is feasible to use an add-on study method for calculating DWs with ordinal methods. This approach is also applicable to DW studies focusing on health states.

The strength of the add-on study method also underscores the difficulty in recruiting physicians, who frequently serve as participants for estimating DWs related to causes of disease. Numerous DW estimation studies have been conducted reflecting the preferences of the public [13,15,16]; however, this approach is limited, as this population can only evaluate the DW of health states. Consequently, if DWs are to be calculated based directly on the cause of disease, the opinions of health professionals must be incorporated. It is essential to adapt to the anticipated expertise of these professionals to ensure valid paired comparison results, which ultimately affects the sample size for analysis due to the low number of survey participants. In fact, DW studies involving experts tend to have fewer participants than those involving the public [17]. Therefore, updating DWs by merging the results of existing surveys with data from more recent ones, as in the add-on study method, is a promising approach to enhance the efficiency of the DW estimation process.

It is not uncommon for DWs to require revision, particularly when a new cause of disease emerges, such as COVID-19, which has recently led to a high global disease burden. The calculation of DWs for this cause of disease is in high demand. However, studies calculating DALYs, including those for COVID-19, have replaced DWs with existing causes of disease or health states rather than adding COVID-19 as a specific new disease [18-20]. In the present study, the severity of COVID-19 was subdivided into mild, moderate, and severe. The respective DWs were calculated as 0.110, 0.642, and 0.755 for model 1 and 0.235, 0.419, and 0.493 for model 2. The DWs for COVID-19 in this study were slightly higher than those in previous studies. However, the DW obtained in this study, derived from analyzing physicians' responses through the direct comparison of COVID-19 to other diseases, is expected to have higher validity.

When comparing the revised DWs to those found in previous research, the values and patterns observed were generally similar (Pearson correlation, 0.994). The differences between the 2 values were mainly within 0.02, although some were model-specific. Extreme changes in DW can lead to major alterations in years lived with disability, ultimately compromising the ability to obtain a valid DALE measurement. This add-on study method demonstrated the benefit of utilizing existing survey results to obtain the DWs of new causes of disease without causing abrupt changes in the current cause of disease values during DW revision. This finding suggests that DWs can be fine-tuned based on the collective opinions of multiple health professionals, rather than implementing dramatic DW revisions influenced by the preferences or judgments of a limited number of experts.

Notably, the revised leading causes of disease in the present study were more likely to have DWs segmented by severity. Previous studies typically utilized 3 or 4 levels of severity for primary diseases such as cancer or chronic obstructive pulmonary disease [11]. In the present study, DWs were measured not only for COVID-19 but also by subdividing the severity of kidney and bladder cancer. For diabetes, DWs were calculated by categorizing the severity of each complication type. Preventing chronic diseases entirely is becoming increasingly difficult. It may be more rational to manage a disease at a lower severity and reduce the burden of a specific cause of disease, such as by preventing the development of complications. The severity-disaggregated DWs and severity distributions from this study can be used to calculate years lived with disability more accurately for specific causes of disease [21]. Additionally, monitoring will enable the evaluation of the effectiveness of interventions aimed at preventing disease complications [22,23].

The limitations of this study include the inherent challenges of surveying experts and the surveyed physicians' inability to fully represent the views of all physicians in Korea. This recent

survey involved approximately 200 physicians, whose insights may have been particularly valuable in determining the DWs for additional or revised disease causes. It is crucial to involve physicians with diverse expertise in future DW surveys to identify the valid causes of disease-related DWs.

CONCLUSION

This study presents a detailed add-on methodology for revising the DWs of 380 existing causes of disease and estimating DWs of additional causes. This research approach is applicable in Korea and other countries to generate timely DWs. The DWs obtained in this study can be utilized to determine a reasonable disease burden by choosing an appropriate DALE calculation method. Additionally, these DWs can serve as a fundamental variable in calculating healthy life expectancy.

SUPPLEMENTAL MATERIALS

Supplemental materials are available at https://doi.org/10.3961/jpmph.23.192.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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