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Updating Disability Weights for Measurement of Healthy Life Expectancy and Disability-adjusted Life Year in Korea

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ABSTRACT

Background: The present study aimed to update the methodology to estimate cause-specific disability weight (DW) for the calculation of disability adjusted life year (DALY) and health-adjusted life expectancy (HALE) based on the opinion of medical professional experts. Furthermore, the study also aimed to compare and assess the size of DW according to two analytical methods and estimate the most valid DW from the perspective of years lost due to disability and HALE estimation.
Methods: A self-administered web-based survey was conducted ranking five causes of disease. A total of 901 participants started the survey and response data of 806 participants were used in the analyses. In the process of rescaling predicted probability to DW on a scale from 0 to 1, two models were used for two groups: Group 1 (physicians and medical students) and Group 2 (nurses and oriental medical doctors). In Model 1, predicted probabilities were rescaled according to the normal distribution of DWs. In Model 2, the natural logarithms of predicted probabilities were rescaled according to the asymmetric distribution of DWs.
Results: We estimated DWs for a total of 313 causes of disease in each model and group. The mean of DWs according to the models in each group was 0.490 (Model 1 in Group 1), 0.378 (Model 2 in Group 1), 0.506 (Model 1 in Group 2), and 0.459 (Model 2 in Group 2), respectively. About two-thirds of the causes of disease had DWs of 0.2 to 0.4 in Model 2 in Group 1. In Group 2, but not in Group 1, there were some cases where the DWs had a reversed order of severity.
Conclusion: We attempted to calculate DWs of 313 causes of disease based on the opinions of various types of medical professionals using the previous analysis methods as well as the revised analysis method. The DWs from this study can be used to accurately estimate DALY and health life expectancy, such as HALE, in the Korean population.

Keywords: Disability Weight; Burden of Disease; Republic of Korea; Ranking Method

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Disclosure

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Kim YE, Jo MW, Park H, Oh IH, Yoon SJ, Pyo J, Ock M. Data curation: Kim YE, Jo MW, Pyo J, Ock M. Formal analysis: Jo MW, Ock M. Validation: Kim YE, Jo MW, Park H, Oh IH, Yoon SJ, Ock M. Methodology: Jo MW, Ock M. Writing - original draft: Kim YE, Jo MW, Ock M. Writing - review & editing: Kim YE, Jo MW, Park H, Oh IH, Yoon SJ, Pyo J, Ock M.

INTRODUCTION

In healthcare policy and research, summary measures regarding the burden of disease and injuries are needed for priority setting and rational allocation of limited resources (including budget).[1,2] In this context, during the 1990s, Alan D Lopez and Christopher J.L. Murray developed disability adjusted life year (DALY), an indicator that can comprehensively measure the health status of a population. DALY is the sum of years of life lost due to premature death (YLL) and years lost due to disability (YLD).[2] DALY is meaningful in that it expresses the health status of a population as a comprehensive quantitative indicator, rather than segmenting it by morbidity and mortality. It is being used as the representative indicator for measuring the global burden of disease in the Global Burden of Disease (GBD) study. In particular, the World Health Organization used YLD, a component of DALY, to estimate health-adjusted life expectancy (HALE), which is used as key evidence when prioritizing policies or allocating budget.

To combine YLL and YLD into the indicator of DALY, YLD must be estimated by the disability weight (DW). DW represents a measured value of specific health status and severity of the disease, with values ranging between 0 (perfect health) and 1 (equivalent to death). Therefore, DW acts as a bridge between disease morbidity and mortality.[3] In this context, DW of a specific disease must be set to accurately reflect the average characteristics of that disease. In other words, the relative severity of diseases must be well reflected in DW.

Research on DW has evolved along with the GBD study. In the 1990 GBD study, investigation using visual analogue scale (VAS) and person trade off (PTO) with 10 public health specialists produced DWs for 483 health conditions corresponding to 131 diseases and injuries.[4] Since 1996, several studies have been conducted to estimate DW in a variety of countries.[3,5-8] However, the methodology, validity, and universality of DW estimation are not adequately clear.[9,10] DWs used in the 2010 GBD study were estimated based on a household questionnaire and online surveys administered to 30,230 people in 5 countries (the United States, Peru, Tanzania, Bangladesh, and Indonesia). Paired comparison and population health equivalence (modified from a PTO) were used as valuation methodologies.[11] As an upgrade, the 2013 GBD study used DWs that reflected those from studies conducted in 4 European countries (the Netherlands, Sweden, Hungary, and Italy).[12] However, despite such attempts at a methodological upgrade, many scholars still question the validity of methodology for estimating DWs.[13-15] Nord[13] criticized that the agreement between countries for DWs used in the 2010 GBD study was exaggerated. The DW associated with each health condition is currently fixed across all social, cultural, and environmental contexts.[16]

In this context, there is an ongoing effort since 2000 to estimate DW that reflects the unique social and cultural context of Korea.[3,17-19] Most DW studies conducted in Korea have targeted people who received medical education to allow more objective and broader assessment of disease characteristics.[3,17,18] Although reflecting preferences of the general population is required for priority setting and rational allocation of limited resources, the general population may have biases about disease status and may not be able to determine the severity of the diseases that are not very well-known. Therefore, careful consideration of the target population for estimating DWs is important.

Moreover, the issue of the size of DW needs to be studied as well. Although a direct comparison may be difficult, the DWs used in the 2015 Korean National Burden of Disease (KNBD) study

showed regular distribution around the value of 0.5 (normal distribution), whereas the DWs used in the GBD study were lower than those of the 2015 KNBD study. For example, Alzheimer disease and other dementias had DW of 0.069, 0.377, and 0.449 for mild, moderate, and severe cases in the GBD study,[12] respectively, whereas the DW used in the 2015 KNBD study had the value of 0.736.[18] Such a difference can significantly affect the size of YLD and even influence HALE.

The present study aimed to estimate cause-specific DWs based on the opinion of medical professional experts and discuss the differences found. Furthermore, the study also aimed to compare and assess the size of DW according to two analytical methods and estimate the most reasonable DW from the YLD and HALE estimation perspective. Accordingly, the study aimed to derive the Korean version DW update by estimating DWs according to the severity of major diseases.

METHODS

Study design and participants

A self-administered web-based survey was conducted based on the methodology of previous studies for estimating DWs.[3,18] The survey was performed from November 2018 to December 2018. In order to explore the possibility of expanding the participants in the survey, we included nurses and oriental medical doctors as well as physicians and medical students (third or fourth grade of a regular course). Participants were recruited through the promotion of the survey in the online community site for medical professionals and by word-of-mouth from other participants.

Valuation method and causes of disease

First, participants responded to their age group, sex, occupation, and specialty. Next, the participants assessed the severity of the causes of disease by using a ranking method. We used the complete ranking method listing five alternatives in view of the effectiveness and feasibility demonstrated in previous studies.[3,18,20] The participants ranked the five listed causes of disease in order of good health, considering the seriousness of the physical and mental problems caused by the diseases. The descriptions of the causes of disease were not presented to the participants and they judged the severity by looking at the names of the presented causes of disease.

A total of 313 causes of disease were used in this survey. The list of causes of disease utilized in this study is based on the GBD 2016 study.[21] In the GBD 2016 study, DALY and YLD were calculated for 333 and 328 causes of disease, respectively. After reviewing the list of the causes of disease from GBD 2016 study, 277 causes of disease were selected after considering duplication of causes of disease and the possibility of emerging causes of disease in Korea. Among the 277 causes of disease, 14 causes of diseases were subdivided by the degree of severity. For example, major depressive disorder was subdivided into 'major depressive disorder (mild),' 'major depressive disorder (moderate),' and 'major depressive disorder (severe).' In the case of diabetes mellitus, the severity was classified as the presence ('diabetes mellitus with complications') or absence of complications ('diabetes mellitus without complications'). Furthermore, 'allergic rhinitis,' 'atopic dermatitis,' and 'metabolic syndrome,' which were not included in the GBD 2016 study, were included in the list to calculate the magnitude of the problem in Korean National Burden of Disease study. 'Full health' and 'being dead' were also included in the list to identify participants who made illogical responses and to use them as anchor points in the analyses.

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Participants conducted a total of 20 ranking methods to evaluate five alternatives. Among the 311 causes of disease (excluding 'full health' and 'being dead'), 5 randomly selected causes of disease were given to participants in each ranking method question. However, 'full health' was fixed as the first cause of disease in question 1 and the fifth cause of disease in question 11. Similarly, 'being dead' was fixed as the first cause of disease in question 5, fifth cause of disease in question 10, the first cause of disease in question 15, and the fifth cause of disease in question 20.

Analysis

Descriptive analyses were performed to determine the socio-demographic characteristics of the participants. Before proceeding with the analyses of DWs, only the responses of participants who answered 'full health' in questions 1 and 11 with the best health state were included in the analyses. Then, the ranked data were converted into paired comparison data in accordance with previous studies.[3,18,20] For example, if the response of a participant was in the order of C1-C2-C3-C4-C5, it was converted to C1-C2, C1-C3, C1-C4, C1-C5, C2-C3, C2-C4, C2-C5, C3-C4, C3-C5, and C4-C5. Thus, paired comparison data were obtained by ranking method listing five alternatives. Probit regression analysis was conducted with these paired comparison data. The stated preference of the first cause of disease in the paired comparison was regarded as the dependent variable. The two causes of disease that were compared were considered as independent variables and 'being dead' was treated as a reference of the dummy variable. Using the coefficient estimates of the probit regression, the predicted probabilities of causes of disease were calculated.

In the process of rescaling predicted probability to DW on a scale from 0 to 1, two models were used. Model 1 was to rescale considering the normal distribution of DWs as in previous studies.[3,18] In Model 2, predicted probabilities taking the natural logarithm were rescaled considering the asymmetric distribution of DWs. 'Being dead (1)' and 'full health (0)' were used as anchor points in both Models. Subgroup analyses were also performed according to the occupation of participants. Group 1 comprised physicians and medical students as in the previous studies,[3,18] whereas Group 2 comprised nurses and oriental medical doctors. We determined the frequency distributions of the DWs from the models and calculated the Pearson correlation coefficients to compare the DWs from the models to those obtained in the most recent Korean DWs study.[18]

We used Stata 13.1 software (StataCorp, College Station, TX, USA) for all statistical analyses. In this study, *P* value less than 0.05 was regarded as statistically significant.

Ethics statement

This study was approved by the Institutional Review Board (IRB) of the Ulsan University Hospital (IRB No. 2018-11-034). All participants were informed about the purpose and process of the study and only those who agreed to participate joined this survey. Each participant received a 9,000 won coffee coupon.

RESULTS

A total of 901 participants started the survey and 872 participants completed the survey. Among 872 participants, 66 participants were excluded from the analyses due to illogical responses such as 'full health' was not listed as the best health state. **Table 1** summarized the details of the socio-demographic characteristics of 806 participants used in the analyses. Most

Table 1. Characteristics of the study participants

Characteristics	Values, No. (%)
Age, yr	
19–29	164 (20.3)
30–39	621 (77.0)
≤ 40	21 (2.6)
Sex	
Male	561 (69.6)
Female	245 (30.4)
Occupation	
Medical student	12 (1.5)
General practitioner	76 (9.4)
Resident	65 (8.1)
Specialist	529 (65.6)
Nurse	115 (14.3)
Oriental medical doctors	9 (1.1)
Specialty	
Medical part	384 (47.6)
Surgical part	136 (16.9)
Others	286 (35.5)
Total	806 (100.0)

participants were in the 30s and about 70% were male. About two-thirds of the participants were specialists and there were more medical specialists than surgical specialists. Group 1 comprised only physicians and medical students and group 2 comprised only nurses and oriental medical doctors and included were 682 and 124 participants, respectively.

Table 2 shows the DWs by the model of analysis for each group. The mean of the DWs according to the models in each group was 0.490 (Model 1 in Group 1), 0.378 (Model 2 in Group 1), 0.506 (Model 1 in Group 2), and 0.459 (Model 2 in Group 2), respectively. In all analyses, 'Pancreatic cancer' had the highest DW as follows: 0.929 (Model 1 in Group 1), 0.724 (Model 2 in Group 1), 0.996 (Model 1 in Group 2), and 0.986 (Model 2 in Group 2). On the other hand, the cause of the disease with the lowest DW was acne vulgaris in Model 1 in Group 1 (0.059) and Model 2 in Group 1 (0.229). Cause of disease with the lowest DW differed according to the analysis method. Acne vulgaris, caries of deciduous teeth, and allergic rhinitis had low DWs overall.

Table 2. Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
1	Drug-susceptible tuberculosis	0.385	0.318	0.522	0.444
2	Multidrug-resistant tuberculosis without extensive drug resistance	0.651	0.434	0.632	0.504
3	Extensively drug-resistant tuberculosis	0.682	0.453	0.672	0.529
4	Latent tuberculosis infection	0.218	0.268	0.212	0.324
5	Drug-susceptible HIV/AIDS - tuberculosis	0.715	0.474	0.669	0.527
6	Multidrug-resistant HIV/AIDS - tuberculosis without extensive drug resistance	0.784	0.529	0.850	0.688
7	Extensively drug-resistant HIV/AIDS - tuberculosis	0.783	0.527	0.803	0.636
8	HIV/AIDS resulting in other diseases	0.756	0.505	0.791	0.624
9	Diarrhoeal diseases	0.179	0.258	0.246	0.335
10	Typhoid fever	0.325	0.299	0.310	0.356
11	Paratyphoid fever	0.376	0.315	0.438	0.406
12	Other intestinal infectious diseases	0.266	0.281	0.420	0.398
13	Lower respiratory infections	0.387	0.319	0.420	0.398
14	Upper respiratory infections	0.159	0.253	0.286	0.348
15	Otitis media	0.169	0.256	0.137	0.302
16	Pneumococcal meningitis	0.606	0.410	0.518	0.442

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
17	H influenzae type B meningitis	0.613	0.413	0.551	0.458
18	Meningococcal infection	0.554	0.385	0.544	0.455
19	Other meningitis	0.583	0.398	0.651	0.516
20	Encephalitis	0.693	0.460	0.673	0.529
21	Diphtheria	0.348	0.306	0.468	0.418
22	Whooping cough	0.339	0.303	0.279	0.346
23	Tetanus	0.506	0.364	0.570	0.468
24	Measles	0.321	0.298	0.320	0.360
25	Varicella and herpes zoster	0.262	0.280	0.403	0.391
26	Malaria	0.420	0.331	0.467	0.418
27	Chagas disease	0.575	0.394	0.604	0.487
28	Visceral leishmaniasis	0.424	0.332	0.520	0.443
29	Cutaneous and mucocutaneous leishmaniasis	0.373	0.315	0.466	0.418
30	African trypanosomiasis	0.490	0.357	0.511	0.438
31	Schistosomiasis	0.383	0.318	0.421	0.399
32	Cysticercosis	0.417	0.329	0.558	0.462
33	Cystic echinococcosis	0.404	0.325	0.506	0.436
34	Lymphatic filariasis	0.492	0.358	0.588	0.478
35	Onchocerciasis	0.275	0.284	0.429	0.402
36	Trachoma	0.376	0.316	0.556	0.461
37	Dengue	0.395	0.322	0.461	0.416
38	Yellow fever	0.512	0.366	0.463	0.416
39	Rabies	0.685	0.455	0.656	0.518
40	Ascariasis	0.231	0.272	0.306	0.355
41	Trichuriasis	0.332	0.301	0.377	0.381
42	Hookworm disease	0.222	0.269	0.330	0.363
43	Food-borne trematodiases	0.309	0.294	0.398	0.389
44	Leprosy	0.602	0.408	0.692	0.543
45	Ebola virus disease	0.774	0.520	0.844	0.681
46	Zika virus disease	0.493	0.358	0.403	0.391
47	Guinea worm disease	0.349	0.307	0.451	0.411
48	Other neglected tropical diseases	0.399	0.323	0.398	0.389
49	Maternal haemorrhage	0.599	0.406	0.374	0.380
50	Maternal sepsis and other pregnancy related infections	0.643	0.430	0.600	0.485
51	Maternal hypertensive disorders	0.410	0.327	0.416	0.396
52	Maternal obstructed labour and uterine rupture	0.668	0.444	0.674	0.531
53	Maternal abortion, miscarriage, and ectopic pregnancy	0.379	0.316	0.219	0.326
54	Other maternal disorders	0.387	0.319	0.256	0.338
55	Neonatal preterm birth complications	0.577	0.396	0.520	0.443
56	Neonatal encephalopathy due to birth asphyxia and trauma	0.815	0.558	0.785	0.618
57	Neonatal sepsis and other neonatal infections	0.691	0.458	0.621	0.497
58	Hemolytic disease and other neonatal jaundice	0.488	0.356	0.409	0.394
59	Other neonatal disorders	0.513	0.367	0.520	0.443
60	Protein-energy malnutrition	0.428	0.334	0.261	0.340
61	Iodine deficiency	0.210	0.266	0.325	0.362
62	Vitamin A deficiency	0.226	0.270	0.164	0.310
63	Iron-deficiency anaemia	0.179	0.258	0.210	0.323
64	Other nutritional deficiencies	0.239	0.274	0.184	0.316
65	Syphilis	0.403	0.325	0.574	0.470
66	Chlamydial infection	0.344	0.305	0.335	0.365
67	Gonococcal infection	0.304	0.293	0.504	0.435
68	Trichomoniasis	0.313	0.295	0.398	0.389
69	Genital herpes	0.252	0.278	0.324	0.362
70	Other sexually transmitted diseases	0.355	0.309	0.461	0.416
71	Acute hepatitis A	0.373	0.315	0.589	0.478
72	Hepatitis B	0.393	0.321	0.273	0.344
73	Hepatitis C	0.521	0.370	0.629	0.502
74	Acute hepatitis E	0.515	0.368	0.396	0.388

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
75	Other infectious diseases	0.249	0.277	0.219	0.326
76	Lip and oral cavity cancer	0.743	0.495	0.699	0.548
77	Nasopharynx cancer	0.847	0.594	0.741	0.580
78	Other pharynx cancer	0.777	0.523	0.669	0.527
79	Oesophageal cancer	0.870	0.623	0.808	0.641
80	Stomach cancer (stage 1)	0.440	0.338	0.535	0.450
81	Stomach cancer (stage 2)	0.617	0.416	0.570	0.468
82	Stomach cancer (stage 3)	0.796	0.540	0.913	0.779
83	Stomach cancer (stage 4)	0.914	0.694	0.963	0.883
84	Colon and rectum cancers (stage 1)	0.476	0.352	0.587	0.477
85	Colon and rectum cancers (stage 2)	0.650	0.434	0.786	0.619
86	Colon and rectum cancers (stage 3)	0.807	0.550	0.873	0.718
87	Colon and rectum cancers (stage 4)	0.868	0.620	0.941	0.831
88	Liver cancer due to hepatitis B	0.757	0.506	0.722	0.565
89	Liver cancer due to hepatitis C	0.757	0.506	0.712	0.558
90	Liver cancer secondary to alcohol use (stage 1)	0.598	0.406	0.500	0.433
91	Liver cancer secondary to alcohol use (stage 2)	0.700	0.465	0.811	0.644
92	Liver cancer secondary to alcohol use (stage 3)	0.801	0.544	0.827	0.662
93	Liver cancer secondary to alcohol use (stage 4)	0.927	0.719	0.963	0.882
94	Liver cancer due to other causes	0.782	0.527	0.750	0.588
95	Gallbladder and biliary tract cancer	0.816	0.559	0.702	0.550
96	Pancreatic cancer	0.929	0.724	0.996	0.986
97	Larynx cancer	0.848	0.594	0.758	0.594
98	Trachea, bronchus and lung cancers (stage 1)	0.556	0.385	0.710	0.556
99	Trachea, bronchus and lung cancers (stage 2)	0.703	0.467	0.832	0.666
100	Trachea, bronchus and lung cancers (stage 3)	0.876	0.631	0.851	0.689
101	Trachea, bronchus and lung cancers (stage 4)	0.913	0.692	0.848	0.686
102	Malignant skin melanoma	0.807	0.550	0.784	0.618
103	Non-melanoma skin cancer (squamous-cell carcinoma)	0.645	0.431	0.566	0.466
104	Non-melanoma skin cancer (basal-cell carcinoma)	0.675	0.449	0.716	0.560
105	Breast cancer (stage 1)	0.451	0.342	0.519	0.442
106	Breast cancer (stage 2)	0.572	0.393	0.650	0.515
107	Breast cancer (stage 3)	0.771	0.517	0.817	0.651
108	Breast cancer (stage 4)	0.851	0.598	0.905	0.766
109	Cervical cancer (stage 1)	0.433	0.335	0.627	0.501
110	Cervical cancer (stage 2)	0.567	0.390	0.572	0.469
111	Cervical cancer (stage 3)	0.715	0.474	0.783	0.617
112	Cervical cancer (stage 4)	0.869	0.621	0.956	0.866
113	Uterine cancer	0.719	0.477	0.757	0.593
114	Ovarian cancer	0.821	0.564	0.831	0.665
115	Prostate cancer (stage 1)	0.439	0.337	0.396	0.388
116	Prostate cancer (stage 2)	0.602	0.408	0.568	0.467
117	Prostate cancer (stage 3)	0.710	0.471	0.845	0.682
118	Prostate cancer (stage 4)	0.875	0.630	0.798	0.631
119	Testicular cancer	0.772	0.518	0.809	0.643
120	Kidney cancer	0.771	0.517	0.796	0.629
121	Bladder cancer	0.787	0.531	0.709	0.555
122	Brain and nervous system cancer	0.882	0.640	0.802	0.635
123	Thyroid cancer (stage 1)	0.257	0.279	0.474	0.421
124	Thyroid cancer (stage 2)	0.472	0.350	0.556	0.461
125	Thyroid cancer (stage 3)	0.624	0.419	0.688	0.540
126	Thyroid cancer (stage 4)	0.805	0.549	0.926	0.802
127	Mesothelioma	0.766	0.513	0.639	0.508
128	Hodgkin lymphoma	0.719	0.477	0.749	0.587
129	Non-Hodgkin's lymphoma	0.722	0.479	0.616	0.494
130	Multiple myeloma	0.718	0.477	0.677	0.532
131	Acute lymphoid leukaemia	0.827	0.570	0.785	0.618
132	Chronic lymphoid leukaemia	0.752	0.502	0.770	0.605

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
133	Acute myeloid leukaemia	0.830	0.573	0.822	0.656
134	Chronic myeloid leukaemia	0.764	0.512	0.843	0.679
135	Other leukaemia	0.823	0.566	0.863	0.705
136	Other neoplasms	0.574	0.394	0.540	0.453
137	Rheumatic heart disease	0.634	0.424	0.721	0.565
138	Ischaemic heart disease	0.703	0.466	0.728	0.570
139	Ischemic stroke (mild)	0.560	0.387	0.454	0.412
140	Ischemic stroke (moderate)	0.797	0.541	0.793	0.626
141	Ischemic stroke (severe)	0.843	0.588	0.716	0.560
142	Hemorrhagic stroke	0.800	0.543	0.856	0.696
143	Hypertensive heart disease	0.474	0.351	0.646	0.512
144	Myocarditis	0.663	0.441	0.550	0.458
145	Alcoholic cardiomyopathy	0.649	0.433	0.674	0.531
146	Other cardiomyopathy	0.714	0.474	0.612	0.492
147	Atrial fibrillation and flutter	0.549	0.382	0.711	0.556
148	Peripheral vascular disease	0.449	0.341	0.407	0.393
149	Endocarditis	0.690	0.458	0.603	0.487
150	Other cardiovascular and circulatory diseases	0.562	0.388	0.511	0.438
151	Chronic obstructive pulmonary disease (mild)	0.474	0.351	0.617	0.494
152	Chronic obstructive pulmonary disease (moderate)	0.658	0.438	0.577	0.472
153	Chronic obstructive pulmonary disease (severe)	0.753	0.503	0.812	0.646
154	Silicosis	0.666	0.443	0.624	0.499
155	Asbestosis	0.653	0.436	0.656	0.519
156	Coal workers pneumoconiosis	0.658	0.438	0.745	0.584
157	Other pneumoconiosis	0.582	0.398	0.669	0.527
158	Asthma	0.409	0.327	0.330	0.364
159	Interstitial lung disease and pulmonary sarcoidosis	0.712	0.473	0.803	0.637
160	Other chronic respiratory diseases	0.492	0.358	0.532	0.449
161	Cirrhosis and other chronic liver diseases due to hepatitis B	0.665	0.443	0.588	0.478
162	Cirrhosis and other chronic liver diseases due to hepatitis C	0.676	0.449	0.662	0.522
163	Cirrhosis and other chronic liver diseases due to alcohol use (mild)	0.519	0.369	0.518	0.442
164	Cirrhosis and other chronic liver diseases due to alcohol use (moderate)	0.633	0.424	0.682	0.536
165	Cirrhosis and other chronic liver diseases due to alcohol use (severe)	0.679	0.451	0.551	0.458
166	Cirrhosis and other chronic liver diseases due to other causes	0.628	0.421	0.517	0.441
167	Peptic ulcer disease	0.238	0.274	0.319	0.360
168	Gastritis and duodenitis	0.161	0.254	0.131	0.300
169	Appendicitis	0.225	0.270	0.317	0.359
170	Paralytic ileus and intestinal obstruction	0.466	0.347	0.699	0.548
171	Inguinal, femoral, and abdominal hernia	0.261	0.280	0.454	0.413
172	Inflammatory bowel disease	0.449	0.341	0.360	0.375
173	Vascular intestinal disorders	0.499	0.361	0.498	0.432
174	Gallbladder and biliary diseases	0.429	0.334	0.307	0.355
175	Pancreatitis	0.456	0.344	0.537	0.451
176	Other digestive diseases	0.158	0.253	0.178	0.314
177	Alzheimer's disease and other dementias	0.660	0.440	0.724	0.566
178	Parkinson's disease	0.697	0.462	0.566	0.466
179	Epilepsy	0.612	0.413	0.730	0.571
180	Multiple sclerosis	0.665	0.442	0.621	0.497
181	Motor neuron disease	0.701	0.465	0.571	0.468
182	Migraine	0.189	0.261	0.197	0.320
183	Tension-type headache	0.176	0.257	0.198	0.320
184	Other neurological disorders	0.495	0.359	0.303	0.354
185	Schizophrenia	0.698	0.463	0.735	0.575
186	Alcohol use disorders	0.391	0.321	0.326	0.362
187	Opioid use disorders	0.504	0.363	0.528	0.446
188	Cocaine use disorders	0.490	0.357	0.416	0.396
189	Amphetamine use disorders	0.518	0.369	0.646	0.512
190	Cannabis use disorders	0.397	0.322	0.519	0.442

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
191	Other drug use disorders	0.299	0.291	0.289	0.349
192	Major depressive disorder (mild)	0.369	0.313	0.417	0.397
193	Major depressive disorder (moderate)	0.554	0.385	0.509	0.437
194	Major depressive disorder (severe)	0.570	0.392	0.668	0.527
195	Dysthymia	0.229	0.271	0.243	0.334
196	Bipolar disorder	0.499	0.361	0.536	0.450
197	Anxiety disorders	0.308	0.294	0.317	0.359
198	Anorexia nervosa	0.361	0.311	0.249	0.336
199	Bulimia nervosa	0.337	0.303	0.353	0.372
200	Autism	0.537	0.377	0.490	0.429
201	Asperger syndrome and other autistic spectrum disorders	0.505	0.363	0.560	0.463
202	Attention-deficit/hyperactivity disorder	0.193	0.262	0.258	0.339
203	Conduct disorder	0.314	0.296	0.323	0.361
204	Idiopathic developmental intellectual disability	0.469	0.349	0.524	0.445
205	Other mental and substance use disorders	0.423	0.332	0.428	0.402
206	Diabetes mellitus without complications	0.324	0.299	0.332	0.364
207	Diabetes mellitus with complications	0.534	0.376	0.745	0.584
208	Acute glomerulonephritis	0.498	0.360	0.446	0.409
209	Chronic kidney disease due to diabetes mellitus	0.699	0.464	0.665	0.524
210	Chronic kidney disease due to hypertension	0.604	0.409	0.570	0.468
211	Chronic kidney disease due to glomerulonephritis	0.652	0.435	0.587	0.477
212	Chronic kidney disease due to other causes	0.617	0.415	0.591	0.479
213	Interstitial nephritis and urinary tract infections	0.420	0.331	0.634	0.505
214	Urolithiasis	0.266	0.282	0.480	0.424
215	Benign prostatic hyperplasia	0.232	0.272	0.258	0.339
216	Male infertility	0.262	0.281	0.320	0.360
217	Other urinary diseases	0.195	0.262	0.209	0.323
218	Uterine fibroids	0.214	0.267	0.243	0.334
219	Polycystic ovarian syndrome	0.374	0.315	0.223	0.328
220	Female infertility	0.313	0.295	0.341	0.367
221	Endometriosis	0.330	0.301	0.344	0.369
222	Genital prolapse	0.390	0.320	0.495	0.431
223	Premenstrual syndrome	0.128	0.246	0.103	0.292
224	Other gynecological diseases	0.243	0.275	0.281	0.346
225	Thalassemias	0.449	0.341	0.411	0.395
226	Thalassaemias trait	0.459	0.345	0.470	0.420
227	Sickle cell disorders	0.517	0.368	0.589	0.478
228	Sickle cell trait	0.495	0.359	0.533	0.449
229	G6PD deficiency	0.536	0.376	0.586	0.477
230	G6PD trait	0.536	0.377	0.577	0.472
231	Other hemoglobinopathies and hemolytic anaemias	0.484	0.355	0.543	0.454
232	Endocrine, metabolic, blood, and immune disorders	0.451	0.342	0.488	0.427
233	Rheumatoid arthritis	0.425	0.332	0.422	0.399
234	Osteoarthritis (mild)	0.257	0.279	0.303	0.354
235	Osteoarthritis (moderate)	0.394	0.322	0.440	0.407
236	Osteoarthritis (severe)	0.494	0.359	0.549	0.457
237	Low back pain (mild)	0.119	0.243	0.051	0.278
238	Low back pain (moderate)	0.275	0.284	0.368	0.378
239	Low back pain (severe)	0.344	0.305	0.296	0.352
240	Neck pain	0.126	0.245	0.154	0.307
241	Gout	0.332	0.301	0.405	0.392
242	Other musculoskeletal disorders	0.218	0.268	0.207	0.322
243	Neural tube defects	0.749	0.499	0.700	0.549
244	Congenital heart anomalies	0.682	0.453	0.670	0.528
245	Orofacial clefts	0.528	0.373	0.605	0.488
246	Down's syndrome	0.639	0.427	0.457	0.414
247	Turner syndrome	0.551	0.383	0.449	0.410
248	Klinefelter syndrome	0.572	0.393	0.617	0.495

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
249	Other chromosomal abnormalities	0.655	0.437	0.550	0.458
250	Congenital musculoskeletal and limb anomalies	0.651	0.434	0.573	0.470
251	Urogenital congenital anomalies	0.530	0.374	0.539	0.452
252	Digestive congenital anomalies	0.533	0.375	0.552	0.459
253	Other congenital anomalies	0.582	0.398	0.488	0.428
254	Eczema	0.145	0.250	0.128	0.299
255	Psoriasis	0.231	0.272	0.064	0.282
256	Cellulitis	0.250	0.277	0.362	0.375
257	Pyoderma	0.369	0.313	0.355	0.373
258	Scabies	0.197	0.263	0.290	0.349
259	Fungal skin diseases	0.210	0.266	0.179	0.314
260	Viral skin diseases	0.217	0.268	0.297	0.352
261	Acne vulgaris	0.059	0.229	-	-
262	Alopecia areata	0.125	0.245	0.123	0.298
263	Pruritus	0.104	0.240	0.018	0.270
264	Urticaria	0.098	0.238	0.142	0.303
265	Decubitus ulcer	0.488	0.356	0.390	0.386
266	Other skin and subcutaneous diseases	0.135	0.247	0.145	0.304
267	Glaucoma	0.375	0.315	0.274	0.344
268	Cataract	0.244	0.275	0.237	0.332
269	Macular degeneration	0.431	0.334	0.465	0.417
270	Refraction and accommodation disorders	0.222	0.269	0.255	0.338
271	Age-related and other hearing loss	0.251	0.277	0.213	0.325
272	Other vision loss	0.625	0.420	0.468	0.419
273	Other sense organ diseases	0.327	0.300	0.445	0.409
274	Caries of deciduous teeth	0.062	0.230	0.053	0.279
275	Caries of permanent teeth	0.125	0.245	0.076	0.285
276	Periodontal disease	0.211	0.266	0.212	0.324
277	Edentulism and severe tooth loss	0.434	0.335	0.525	0.445
278	Other oral disorders	0.207	0.265	0.260	0.339
279	Pedestrian road injuries	0.425	0.332	0.389	0.386
280	Cyclist road injuries	0.280	0.286	0.223	0.328
281	Motorcyclist road injuries	0.546	0.381	0.492	0.429
282	Motor vehicle road injuries	0.492	0.358	0.321	0.360
283	Other road injuries	0.333	0.302	0.462	0.416
284	Other transport injuries	0.389	0.320	0.454	0.413
285	Falls	0.521	0.370	0.555	0.460
286	Drowning	0.527	0.372	0.414	0.396
287	Fire, heat, and hot substances	0.373	0.314	0.350	0.371
288	Poisonings	0.508	0.365	0.527	0.446
289	Unintentional firearm injuries	0.468	0.348	0.485	0.426
290	Unintentional suffocation	0.677	0.450	0.773	0.608
291	Other exposure to mechanical forces	0.298	0.291	0.304	0.354
292	Adverse effects of medical treatment	0.305	0.293	0.412	0.395
293	Venomous animal contact	0.390	0.320	0.458	0.414
294	Non-venomous animal contact	0.135	0.247	0.185	0.316
295	Pulmonary aspiration and foreign body in airway	0.578	0.396	0.557	0.461
296	Foreign body in eyes	0.125	0.245	0.086	0.288
297	Foreign body in other body part	0.154	0.252	0.256	0.338
298	Environmental heat and cold exposure	0.254	0.278	0.292	0.350
299	Other unintentional injuries	0.230	0.272	0.282	0.347
300	Self-harm by firearm	0.563	0.389	0.657	0.519
301	Self-harm by other specified means	0.561	0.388	0.541	0.453
302	Assault by firearm	0.509	0.365	0.411	0.395
303	Assault by sharp object	0.226	0.270	0.258	0.339
304	Sexual violence	0.503	0.362	0.594	0.481
305	Assault by other means	0.238	0.274	0.365	0.376
306	Exposure to forces of nature	0.244	0.275	0.339	0.367

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Table 2. (Continued) Disability weights from each model for the subgroups

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2
307	Conflict and terrorism	0.500	0.361	0.520	0.443
308	Executions and police conflict	0.671	0.446	0.760	0.596
309	Allergic rhinitis	0.082	0.235	0.111	0.294
310	Atopic dermatitis	0.227	0.271	0.159	0.308
311	Metabolic syndrome	0.271	0.283	0.232	0.330
-	Mean	0.490	0.378	0.506	0.459

HIV/AIDS = Human immunodeficiency virus infection and acquired immune deficiency syndrome.

The DWs of causes of disease that were classified by severity are shown in **Table 3**. Furthermore, **Table 3** also shows the DWs calculated from a previous study for comparison.[3] In the results of Group 1, there was no case where the DWs were reversed according to severity. However, in Group 2, there were some cases in which DWs were reversed according to severity. For example, among the results of 'Model 2 in Group 2,' the DW of 'Ischemic stroke (moderate)' was 0.626, but that of 'Ischemic stroke (severe)' was 0.560. In addition, the results of Model 2 showed that the DWs were generally low in causes of disease with high severity, compared with those from a previous study. For example, in the case of 'trachea, bronchus, and lung cancers (stage 4),' the DW of the previous study was 0.906, but that of 'Model 2 in Group 1' was estimated to be 0.692.

Fig. 1 shows the distributions of DWs in all analyzes. The distributions of DWs for 'Model 1 in Group 1' and 'Model 1 in Group 2' were close to normal distribution. However, the distributions of DWs for 'Model 2 in Group 1' and 'Model 2 in Group 2' were right skewed. About two-thirds of the causes of disease had DWs of 0.2 to 0.4 in 'Model 2 in Group 1.' Furthermore, in 'Model 2 in Group 1,' there was no cause of disease with a DW of more than 0.8 or less than 0.2.

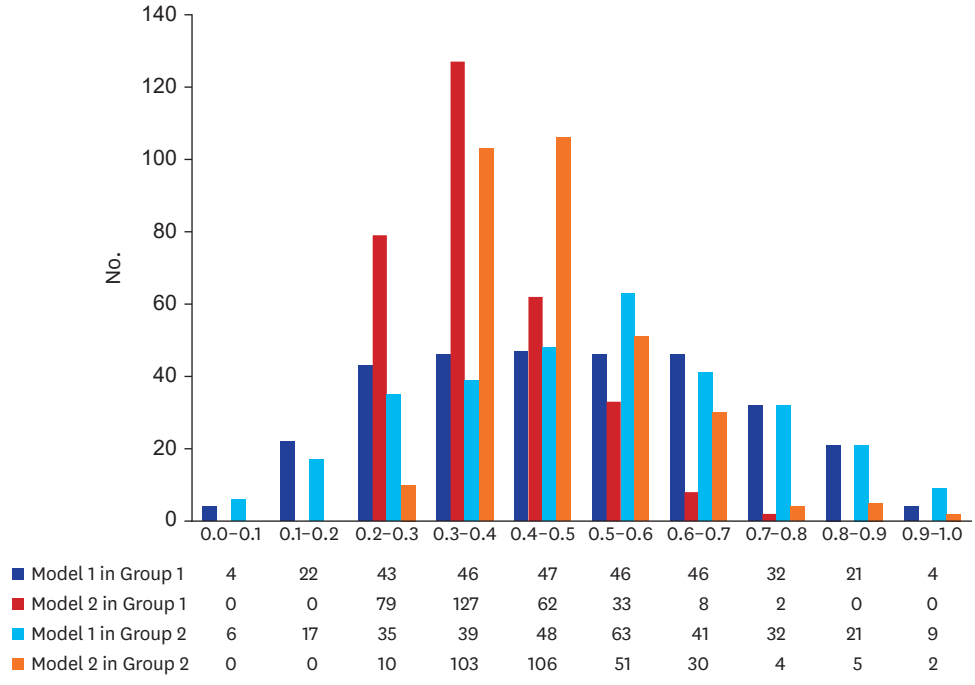

Fig. 1. Distribution of disability weights in each analytical method.

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Table 3. Comparison of disability weights among causes of disease subdivided by severity

No.	Cause of disease	Model 1 in Group 1	Model 2 in Group 1	Model 1 in Group 2	Model 2 in Group 2	A previous study
80	Stomach cancer (stage 1)	0.440	0.338	0.535	0.450	0.462
81	Stomach cancer (stage 2)	0.617	0.416	0.570	0.468	0.669
82	Stomach cancer (stage 3)	0.796	0.540	0.913	0.779	0.823
83	Stomach cancer (stage 4)	0.914	0.694	0.963	0.883	0.880
84	Colon and rectum cancers (stage 1)	0.476	0.352	0.587	0.477	0.496
85	Colon and rectum cancers (stage 2)	0.650	0.434	0.786	0.619	0.689
86	Colon and rectum cancers (stage 3)	0.807	0.550	0.873	0.718	0.841
87	Colon and rectum cancers (stage 4)	0.868	0.620	0.941	0.831	0.870
90	Liver cancer secondary to alcohol use (stage 1)	0.598	0.406	0.500	0.433	0.603
91	Liver cancer secondary to alcohol use (stage 2)	0.700	0.465	0.811	0.644	0.718
92	Liver cancer secondary to alcohol use (stage 3)	0.801	0.544	0.827	0.662	0.785
93	Liver cancer secondary to alcohol use (stage 4)	0.927	0.719	0.963	0.882	0.876
98	Trachea, bronchus and lung cancers (stage 1)	0.556	0.385	0.710	0.556	0.600
99	Trachea, bronchus and lung cancers (stage 2)	0.703	0.467	0.832	0.666	0.738
100	Trachea, bronchus and lung cancers (stage 3)	0.876	0.631	0.851	0.689	0.758
101	Trachea, bronchus and lung cancers (stage 4)	0.913	0.692	0.848	0.686	0.906
105	Breast cancer (stage 1)	0.451	0.342	0.519	0.442	0.439
106	Breast cancer (stage 2)	0.572	0.393	0.650	0.515	0.597
107	Breast cancer (stage 3)	0.771	0.517	0.817	0.651	0.724
108	Breast cancer (stage 4)	0.851	0.598	0.905	0.766	0.864
109	Cervical cancer (stage 1)	0.433	0.335	0.627	0.501	0.431
110	Cervical cancer (stage 2)	0.567	0.390	0.572	0.469	0.553
111	Cervical cancer (stage 3)	0.715	0.474	0.783	0.617	0.813
112	Cervical cancer (stage 4)	0.869	0.621	0.956	0.866	0.855
115	Prostate cancer (stage 1)	0.439	0.337	0.396	0.388	0.458
116	Prostate cancer (stage 2)	0.602	0.408	0.568	0.467	0.613
117	Prostate cancer (stage 3)	0.710	0.471	0.845	0.682	0.742
118	Prostate cancer (stage 4)	0.875	0.630	0.798	0.631	0.838
123	Thyroid cancer (stage 1)	0.257	0.279	0.474	0.421	0.301
124	Thyroid cancer (stage 2)	0.472	0.350	0.556	0.461	0.484
125	Thyroid cancer (stage 3)	0.624	0.419	0.688	0.540	0.639
126	Thyroid cancer (stage 4)	0.805	0.549	0.926	0.802	0.779
139	Ischemic stroke (mild)	0.560	0.387	0.454	0.412	0.540
140	Ischemic stroke (moderate)	0.797	0.541	0.793	0.626	0.787
141	Ischemic stroke (severe)	0.843	0.588	0.716	0.560	0.840
151	Chronic obstructive pulmonary disease (mild)	0.474	0.351	0.617	0.494	0.408
152	Chronic obstructive pulmonary disease (moderate)	0.658	0.438	0.577	0.472	0.703
153	Chronic obstructive pulmonary disease (severe)	0.753	0.503	0.812	0.646	0.722
163	Cirrhosis and other chronic liver diseases due to alcohol use (mild)	0.519	0.369	0.518	0.442	0.484
164	Cirrhosis and other chronic liver diseases due to alcohol use (moderate)	0.633	0.424	0.682	0.536	0.668
165	Cirrhosis and other chronic liver diseases due to alcohol use (severe)	0.679	0.451	0.551	0.458	0.717
192	Major depressive disorder (mild)	0.369	0.313	0.417	0.397	0.279
193	Major depressive disorder (moderate)	0.554	0.385	0.509	0.437	0.528
194	Major depressive disorder (severe)	0.570	0.392	0.668	0.527	0.569
206	Diabetes mellitus without complications	0.324	0.299	0.332	0.364	0.334
207	Diabetes mellitus with complications	0.534	0.376	0.745	0.584	0.663
234	Osteoarthritis (mild)	0.257	0.279	0.303	0.354	0.216
235	Osteoarthritis (moderate)	0.394	0.322	0.440	0.407	0.415
236	Osteoarthritis (severe)	0.494	0.359	0.549	0.457	0.575
237	Low back pain (mild)	0.119	0.243	0.051	0.278	0.138
238	Low back pain (moderate)	0.275	0.284	0.368	0.378	0.310
239	Low back pain (severe)	0.344	0.305	0.296	0.352	0.456

The correlations between the DWs for 200 overlapping causes of disease from a previous study[18] and this study are shown in **Fig. 2**. The Pearson correlation coefficient was highest in 'Model 1 in Group 1 (0.975)' and lowest in 'Model 2 in Group 2 (0.867).' When the DWs of Model 1 in Group 1 were compared with those of the previous study, a total of 96 causes

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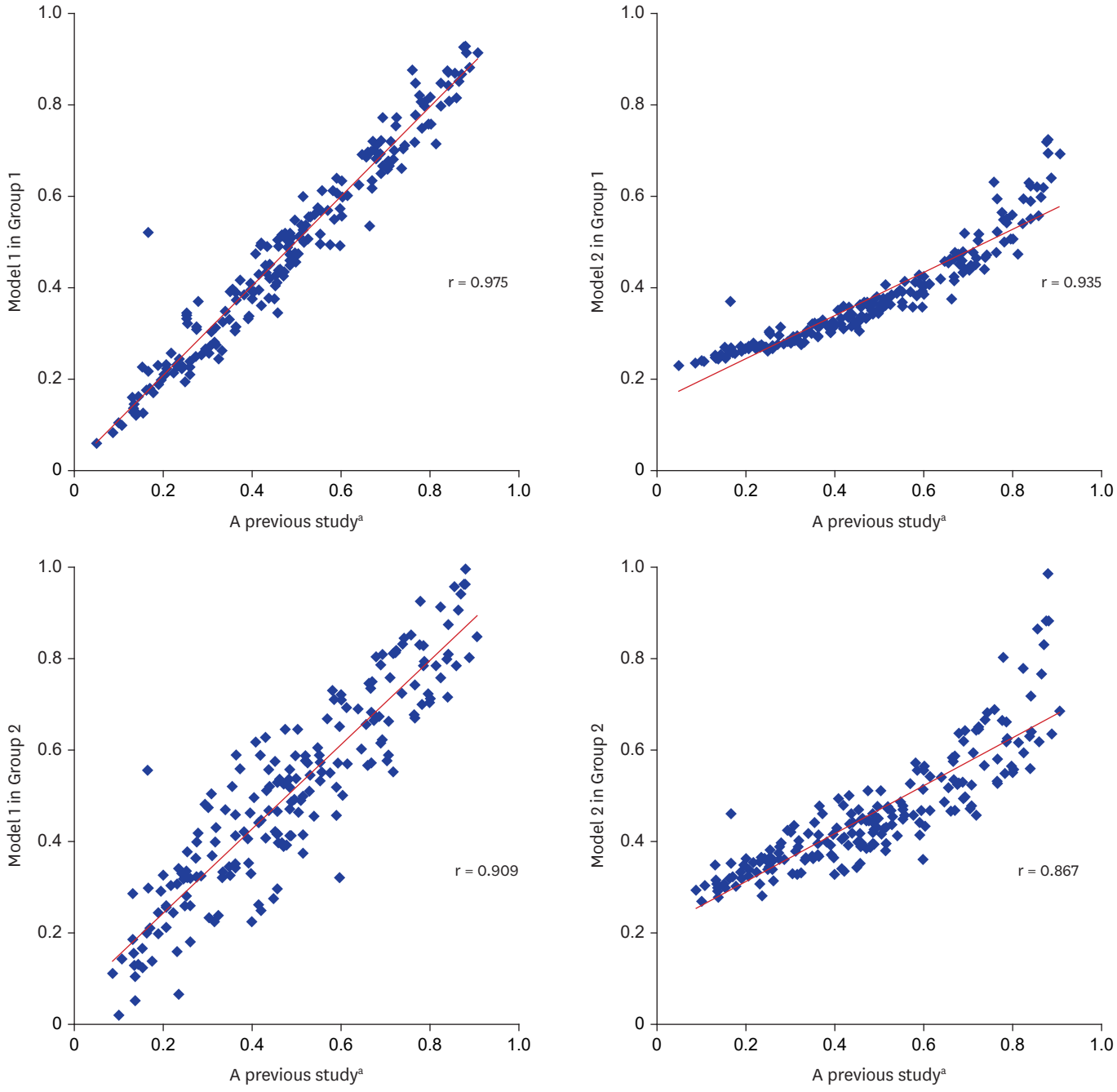

Fig. 2. Correlation of disability weights between a previous study and this study.
[a]Data from the most recent Korean disability weights study.[18]

of disease had decreased DW, but 104 causes had increased DW (**Supplementary Table 1**). However, when the DWs of 'Model 2 in Group 1' were compared to the previous study, a total of 155 causes had decreased the DW, but 45 causes had increased DW. In particular, the DW of the 'Cervical cancer (stage 3)' in 'Model 2 in Group 1 (0.474)' decreased by 0.338 compared to the previous study (0.813). However, the DW of 'Falls' in 'Model 2 in Group 1 (0.370)' increased by 0.205 compared to the previous study (0.165).

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DISCUSSION

In this study, we updated the methodology to obtain reasonable DWs for the calculation of DALY and HALE. Specifically, we attempted to determine whether DWs could be calculated for physicians and medical students as well as nurses and oriental medical doctors. In addition, we attempted to identify an optimal model for calculating valid DWs through evaluating the size and distribution of DWs as well as correlation with previous research results and reversal of DW according to the severity of diseases. The survey method and the analytical model for the calculation of DWs, which have been proved through this study, can be used in the calculation of the DW in other countries.

Above all, it is significant because a large number of medical professionals participated in this DW study. Most of the studies on DW conducted for medical professionals were performed by dozens of participants.[22] A total of 901 medical professionals participated in the survey and responses of 806 medical professionals were utilized in the analyses. The number of participants was higher than that in the most recent DW study in Korea involving 605 physicians and medical students. Although healthcare professionals have a wealth of knowledge about a variety of health conditions and diseases and can objectively compare and evaluate diseases, questions can arise as to whether they can objectively compare and evaluate diseases as the area of expertise of healthcare professionals becomes increasingly fragmented.[23] This limitation may be overcome by more healthcare professionals with diverse specializations participating in DW survey.

In this study, we included nurses and oriental medical doctors as participants of this study. A total of 115 nurses and 9 oriental medical doctors participated in the survey and the results of these responses were analyzed in Group 2. In Group 2, there were some cases in which DWs were reversed according to severity, while there was no case where the DWs were reversed according to the severity in Group 1. Nurses and oriental medical doctors who participated in this study were still unfamiliar with the DW study and seem to have an inconsistent response. In previous studies, healthcare professionals or medical experts have been used extensively in DW studies, but few have specifically identified who will be healthcare professionals or medical experts.[22,23] Based on the results of this study, it is difficult to make a quick judgment on whether nurses or oriental medicine doctors are not worthy of participating in DW study. However, careful attention should be paid to including medical professionals unconditionally in DW survey, simply because they have medical qualifications. In the DW study, it will be important to educate participants to understand the significance of DW and to make a consistent assessment of the disease during the survey.[24]

In this study, we attempted to revise the analysis method to obtain valid DWs. The DWs estimated in the previous KNBD studies showed normal distribution,[3,18] whereas the DWs calculated in the GBD studies showed right-skewed distribution. Accordingly, the estimated DWs in KNBD studies were somewhat higher than those in the GBD study. For example, the DWs for 'anorexia nervosa' and 'bulimia nervosa' were 0.224 and 0.223 in the GBD 2013 study,[12] respectively, but 0.420 and 0.392 in the most recent KNBD study,[18] respectively. In fact, it is not easy to assess which DWs are valid, but such difference can significantly affect the size of YLD and even influence HALE in KNBD studies. Therefore, this study attempted to revise the method of calculating the DWs considering the distribution assumption of the DWs in the GBD study. In other words, we compared the results of the analytical model assuming a normal distribution of DWs (Model 1) and the results of an analytical model assuming a right-skewed distribution of DWs (Model 2).

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As a result, it was confirmed that the DWs in Model 2 was estimated to be smaller than those in Model 1. For example, the DW of 'Pancreatic cancer' was 0.929 in Model 1 (Group 1), but 0.724 in Model 2 (Group 1). In Model 2 (Group 1), however, most of the DWs were distributed between 0.2 and 0.4, and there was no cause of disease with DWs of more than 0.8 or less than 0.2. For example, the DW of 'Otitis media' was 0.169 in Model 1 (Group 1) but 0.256 in Model 2 (Group 1). It was confirmed that the variance of the DWs between causes of disease estimated in Model 2 was smaller than that of Model 1. Therefore, efforts should continue to be made to produce valid disability weights that can increase the discrimination between causes of disease while meeting distribution assumptions. It is necessary to try to have multiple anchor points and to give constant values using data from health-related quality of life.

Assessing the validity of DWs is not an easy task.[22,24] This is because there is no gold standard for DWs, and we estimate DWs for hundreds of causes of disease at once. Therefore, in this study, various methods were used to evaluate the validity of DWs. We examined whether there was a reversal in DWs of causes of disease with other severity levels and we also checked the distribution of DWs and compared them with previous results. Although not used in this study, it is also possible to compare EQ-5D's DWs with utility weights.[19,25] Considering these points together, we conclude that 'Model 2 in Group 1' has several advantages over others. However, due to the emergence of new diseases, changes in characteristics of the disease, development of new drugs and treatment techniques, and changes in social perspectives on disability, the DWs calculated in the past may not be valid presently, so that it is necessary to evaluate and revise DWs continuously.

One limitation of this study is that the number of participating nurses or oriental medical doctors was relatively small compared to physicians. Although the number of participants does not seem to be small compared to other studies, the participation of more people in the DW survey can help to reasonably estimate the DWs of a variety of causes of disease. Future studies should include a higher number of nurses and oriental medical doctors for examining the possibility of calculating the DW.

In conclusion, we attempted to calculate DWs by surveying various types of medical professionals using the previous analysis methods as well as the revised analysis method. Finally, we estimated DWs for a total of 313 causes of disease for the KNBD study. The DWs from this study can be used to estimate accurate DALY and health life expectancy, such as HALE, in Korea.

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SUPPLEMENTARY MATERIAL

Supplementary Table 1

Comparison of disability weights between a previous study and the present study

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