Disability Weights Measurement for 228 Causes of Disease in the Korean Burden of Disease Study 2012

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Disability weight for each disease plays a key role in combining years lived with disability and years of life lost in disability adjusted life year. For the Korean Burden of Disease 2012 study, we have conducted a re-estimation of disability weights for causes of disease by adapting the methodology of a recent Global Burden of Disease study. Our study was conducted through a self-administered web-based survey using a paired comparison (PC) as the main valuation method. A total of 496 physicians and medical college students who were attending in third or fourth grade of a regular course conducted the survey. We applied a probit regression on the PC data and computed the predicted probabilities of each cause of disease from the coefficient estimates of the probit regression. We used 'being dead (1)' and 'full health (0)' as anchor points to rescale the predicted probability of each cause of disease on a scale of 0 to 1. By this method, disability weights for a total of 228 causes of disease were estimated. There was a fairly high correlation between the disability weights of overlapping causes of disease from this study and a previous South Korean study despite the differences in valuation methods and time periods. In conclusion, we have shown that disability weights can be estimated based on a PC by including 'full health' and 'being dead' as anchor points without resorting to a person trade-off. Through developments in the methodology of disability weights estimation from this study, disability weights can be easily estimated and continuously revised.

Keywords: Disability Weight; Burden of Disease; Republic of Korea; Paired Comparison

INTRODUCTION

Disability adjusted life year (DALY) has become a standard summary measure reflecting disease burden (1). The DALY aggregates the total burden of diseases into a single index by combining years lived with disability (YLD) and years of life lost (YLL) (2). With this measure, we can estimate the magnitude of disease burden and compare these values between diseases, so that we can prioritize policies and interventions to reduce the burden of disease (3). In DALY, the disability weight for each disease plays a key role in combining YLDs and YLLs (4). The level of disability for each disease is converted into a disability weight that rates a disease's disability from 0 (equivalent to full health) to 1 (equivalent to being dead).

Since 1996, there have been several studies that have tried to estimate the disability weights and to develop the methodology in response to criticisms about the methods for measuring disability weights (4-8). In the global burden of disease (GBD) 1990 study, the judgments of ten healthcare professionals were used to establish disability weights using a visual analogue scale (VAS) and a person trade-off (PTO) (5). Most recently, a disability weights measurement study for the GBD 2010 was conducted in-

volving the general public to elicit judgments about disability due to many causes of disease through two valuation techniques: a paired comparison (PC) and a population health equivalence (PHE, modified from a PTO) (4). The results from a PC were hybridized with that from a PHE in the GBD 2010 disability weights measurement study.

In the GBD 2013 study, the disability weights were revised from previous versions by adding the results from a European disability weight study (9). The European disability weight study adapted the approach of the GBD 2010 disability weights measurement study by using a web-based sample survey with same valuation techniques (PC and PHE) (10). Likewise, the studies have been revising disability weights and methodology to effectively determine a valid and timely outcome and to efficiently elicit preferences about causes of diseases. However, several issues still remain as follows: the appropriateness of the health state or disease classification and valuation method, selection of survey participants to elicit preferences, validation of disability weights, and cross-cultural variability of disability weights (11-15). In particular, the problem of using PTO or PHE was questioned in terms of the lack of theoretical basis (16,17).

In the case of South Korea, the results for a disability weight

measurement study were published for the first time in 2000, in which disability weights of major cancers were estimated by using the Delphi method (18). An addition and amendments to these disability weights were performed in 2002 (published in 2003) (19-21). A total of 16 indicator diseases' disability weights were calculated with a PTO, and the disability weights for 123 health states of diseases were interpolated using the disability weights for the indicator diseases (20). Although disability weights for 24 major cancers were recently evaluated based on a VAS, disability weights for the Korean Burden of Disease (KBD) 2012 study needed to be amended to reflect the latest changes (22). The disability level of diseases can change as medical technology advances the treatment and management of disease. Furthermore, a more efficient recent method to estimate disability weights, such as in the GBD 2010 or GBD 2013 studies, is required as the number of diseases to be considered increases in burden of disease studies.

For the KBD 2010 study, we have conducted a re-estimation of disability weights adapting the methodology of the recent GBD study. Specifically, in this study we asked medical professionals to evaluate disability weights for 228 causes of diseases using a PC and a PHE. We also attempted to determine a simple method of modifying the method based on a PC, rather than depending on a PTO.

MATERIALS AND METHODS

Study design and participants

The study was conducted through two types of self-administered web-based surveys in South Korea, adapting the methodology of a preceding disability weights measurement study (4). The two types of surveys were designed differently for the valuation methods. The first type (type A survey) used a PC and a PTO, while the second type (type B survey) used only a PC as a valuation method. The type A survey was performed on November 13 2014 and February 3 2015, and the type B survey was performed between November 18 2014 and October 21 2015.

A purposive sampling technique was utilized to select the participants who had knowledge of the causes of diseases. Accordingly, the participants in the survey differed between the two types of surveys. The participants in the type A survey were all specialists, but those in the type B survey were physicians and medical college students who were attending in the third or fourth grade of a regular course. The participants in the type A survey were delegated to represent various clinical departments and those of the type B survey were recruited from promotion of the survey in medical colleges and hospitals and an announcement at medical conferences and meetings.

Valuation method and causes of disease

In both types of surveys, participants were asked about their age, gender, and specialty at the beginning of the survey. Next, each participant evaluated the causes of diseases using a PC and a PHE. In the PC, the participants were requested to choose the healthier option between two causes of disease, which were randomly selected among the 230 causes of diseases. Among the 230 causes of disease, 228 causes of disease were taken from the disease classification of the KBD 2010 study. The remaining two causes of disease were 'full health' and 'being dead,' which were included to utilize them as anchor points. Each participant in the type A and B surveys carried out a total of 60 PCs.

In the PTO, the participants were asked to make a trade-off between two different health programs. The first health program (program A) prevented 1,000 people from suffering a fatal disease causing rapid death. The second one (program B) prevented 10,000 people from being afflicted with a certain cause of disease, which was randomly selected from the 40 causes of disease. If program A was regarded as the worthier program, the number of people for program B was increased by 1,000. On the other hand, if program A was chosen as worthier program, the number of people for program B was decreased by 1,000. The questions were continued until the participants thought that the two health programs had the same or nearly the same worth. That is, the questions stopped at the point at which the participant did not have any differences in their preference for the two health programs. The number of people in program B ranged from 1,000 to 20,000, and the number of people changed by 500 or 1,000 depending on the participant's response. Each participant in the type A survey conducted a total of 40 iterations of PTO about 40 causes of disease, such as diabetes mellitus, ischemic stroke, and stomach cancer. The 40 causes of disease had a high disease burden in South Korea based on the scale from the GBD 2010 study (23).

Analysis

First, we conducted descriptive analyses for socio-demographic factors of the participants. Then, the disability weights for the cause of disease for each participant were computed in a PC and a PTO, respectively. In the PTO, the disability weights of causes of disease for each participant were estimated by the following formula: 1,000/final number of people in program B (19). The disability weights of causes of disease for all participants in the PTO were summarized using the mean, standard deviation, and median. In the case of the PC, we applied a probit regression that has been utilized in the analysis of discrete choice experimental data (24). We regarded the stated choice between the two causes of disease in the PC as the dependent variable. Furthermore, we treated the 230 causes of disease as independent variables and created them as dummy variables with 'being dead' as the reference. We computed the predicted probabilities for each cause of disease from the coefficient estimates of the probit regression. We took advantage of 'being dead

(1)' and 'full health (0)' as anchor points to rescale the predicted probability of each cause of disease on a scale of 0 to 1. The 95% confidence interval of disability weight for each cause of disease in the PC was estimated using the 95% confidence interval of the predicted probabilities.

We compared the disability weights from this study to those estimated in a previous South Korean disability weight study (20). All statistical analyses were performed using Stata 13.1 software (StataCorp, College Station, TX, USA). *P* values less than 0.05 were considered statistically significant in this study.

Ethics statement

This study was approved by the institutional review board of the Asan Medical Center (S2014-1396-0002). Informed consent was waived by the board.

RESULTS

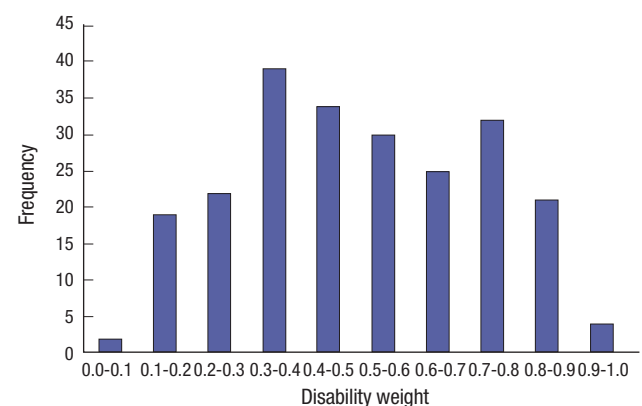A total of 40 and 456 participants conducted type A and type B

Table 1. Characteristics of the study participants by type of survey

Demographic parameters	Type A survey		Type B survey	
	No.	%	No.	%
Age, yr				
19-29	0	0.0	360	79.0
30-39	27	67.5	89	19.5
40-49	13	32.5	5	1.1
50-59	0	0.0	1	0.2
60-	0	0.0	1	0.2
Gender				
Male	30	75.0	284	62.3
Female	10	25.0	172	37.7
Specialty				
Family medicine	1	2.5	10	2.2
Internal medicine	10	25.0	23	5.0
Anesthesiology	0	0.0	9	2.0
Radiation oncology	1	2.5	6	1.3
Pathology	1	2.5	10	2.2
Urology	2	5.0	1	0.2
Obstetrics and gynecology	0	0.0	2	0.4
Plastic surgery	0	0.0	2	0.4
Pediatrics	3	7.5	1	0.2
Neurology	1	2.5	3	0.7
Neurosurgery	2	5.0	1	0.2
Ophthalmology	2	5.0	0	0.0
Radiology	1	2.5	12	2.6
Preventive medicine	6	15.0	11	2.4
General surgery	2	5.0	4	0.9
Emergency medicine	2	5.0	3	0.7
Otolaryngology	1	2.5	13	2.9
Rehabilitation medicine	1	2.5	4	0.9
Psychiatry	1	2.5	6	1.3
Orthopedics	1	2.5	8	1.8
Dermatology	1	2.5	14	3.1
Nuclear medicine	1	2.5	4	0.9
Cardiothoracic surgery	0	0.0	1	0.2
General practitioner	0	0.0	15	3.3
Medical student	0	0.0	293	64.3
Total	40	100.0	456	100.0

surveys, respectively. Table 1 lists the details of the participants' characteristics for each survey. Participants aged 30 to 39 were predominant in the type A survey; whereas, participants aged 19 to 29 were highest in the type B survey. The male respondents outnumbered female respondents in both surveys. In terms of the number of specialties involved in the surveys, 19 versus 22 specialties were involved in the type A and type B surveys, respectively.

Supplementary Fig. 1 shows the box plot of estimated disability weights for the 40 causes of disease from the PTO. On the basis of the mean, the majority of disability weights (27, 67.5%) from the PTO were located between 0.1 and 0.3. Furthermore, all disability weights from the PTO had a value less than 0.4. The cause of disease with the highest disability weight from the PTO was 'Pancreatic cancer (0.400)', followed by 'Gallbladder and biliary tract cancer (0.277)' and 'Hemorrhagic and other non-ischemic stroke (0.258)'. In contrast, the cause of disease with lowest disability weight from the PTO was 'Migraine (0.058)', followed by 'Neck pain (0.059)' and 'Dysthymia (0.061)'. An exact figure for the mean, standard deviation, and median of the disability weights from the PTO is presented in Supplementary Table 1.

Table 2 presents the disability weights and their 95% confidence intervals for 228 causes of disease from the PC. Fig. 1 shows the frequency distribution of disability weights for causes of disease from the PC. Approximately half of the causes of disease (50.9%) had a disability weight less than 0.5. Furthermore, disability weights for approximately one third of causes of disease (65.8%) were located between 0.2 and 0.7. The cause of disease with the highest disability weight from the PC was 'Pancreatic cancer (0.938)', followed by 'Trachea, bronchus, and lung cancers (0.917)' and 'Neonatal encephalopathy (birth asphyxia and birth trauma) (0.911)'. On the other hand, the cause of disease with the lowest disability weight from the PC was 'Urticaria (0.084)', followed by 'Upper respiratory infections (0.088)' and 'Acne vulgaris (0.106)'.

Fig. 1. Distribution of disability weights for cause of disease from a paired comparison.

Table 2. Disability weights for 228 causes of disease from a paired comparison

Causes of disease	Disability weight	95% confidence interval
Tuberculosis	0.464	0.367-0.563
HIV disease resulting in mycobacterial infection	0.837	0.770-0.891
HIV disease resulting in other specified or unspecified diseases	0.794	0.717-0.859
Cholera	0.324	0.237-0.421
Other *Salmonella* infections	0.283	0.199-0.381
Shigellosis	0.372	0.278-0.475
Enteropathogenic *E. coli* infection	0.257	0.174-0.357
Enterotoxigenic *E. coli* infection	0.347	0.255-0.449
Campylobacter enteritis	0.206	0.133-0.298
Amoebiasis	0.461	0.364-0.561
Cryptosporidiosis	0.583	0.486-0.676
Rotaviral enteritis	0.152	0.091-0.233
Intestinal infection	0.155	0.091-0.243
Typhoid and paratyphoid fevers	0.347	0.252-0.452
Influenza	0.131	0.075-0.211
Pneumococcal pneumonia	0.385	0.288-0.490
H. influenza type B pneumonia	0.309	0.215-0.418
Respiratory syncytial virus pneumonia	0.260	0.177-0.360
Upper respiratory infections	0.088	0.045-0.154
Otitis media	0.138	0.078-0.222
Pneumococcal meningitis	0.551	0.458-0.642
H. influenza type B meningitis	0.523	0.427-0.620
Meningococcal infection	0.598	0.500-0.691
Encephalitis	0.721	0.636-0.798
Diphtheria	0.389	0.291-0.495
Whooping cough	0.256	0.176-0.351
Tetanus	0.524	0.425-0.623
Measles	0.279	0.192-0.383
Varicella	0.223	0.147-0.316
Malaria	0.471	0.373-0.573
Chagas disease	0.647	0.550-0.739
Leishmaniasis	0.411	0.317-0.512
African trypanosomiasis	0.515	0.416-0.616
Schistosomiasis	0.340	0.253-0.435
Cysticercosis	0.471	0.370-0.577
Echinococcosis	0.354	0.264-0.454
Lymphatic filariasis	0.564	0.465-0.661
Onchocerciasis	0.357	0.268-0.455
Trachoma	0.431	0.333-0.535
Dengue	0.428	0.331-0.530
Yellow fever	0.496	0.392-0.602
Rabies	0.797	0.718-0.864
Ascariasis	0.256	0.175-0.352
Trichuriasis	0.320	0.229-0.422
Hookworm disease	0.302	0.211-0.407
Food-borne trematodiases	0.329	0.238-0.430
Tsutsugamushi fever	0.317	0.230-0.417
Typhus fever	0.435	0.341-0.533
Hantaan virus disease	0.479	0.382-0.580
Intestinal helminth	0.341	0.250-0.443
Maternal hemorrhage	0.514	0.415-0.613
Maternal sepsis	0.825	0.755-0.881
Hypertensive disorders of pregnancy	0.508	0.405-0.610
Obstructed labor	0.471	0.374-0.572
Abortion	0.455	0.358-0.556
Preterm birth complications	0.678	0.584-0.763
Neonatal encephalopathy (birth asphyxia and birth trauma)	0.911	0.858-0.949

(Continued to the next page)

Table 2. Continued

Causes of disease	Disability weight	95% confidence interval
Sepsis and other infectious disorders of the newborn baby	0.758	0.677-0.829
Protein-energy malnutrition	0.362	0.270-0.465
Iodine deficiency	0.166	0.101-0.253
Vitamin A deficiency	0.223	0.146-0.317
Iron-deficiency anemia	0.122	0.067-0.199
Syphilis	0.519	0.422-0.617
Sexually transmitted chlamydial diseases	0.413	0.317-0.516
Gonococcal infection	0.345	0.252-0.448
Trichomoniasis	0.346	0.253-0.448
Herpes genitalia	0.442	0.344-0.545
Acute hepatitis A	0.346	0.254-0.448
Acute hepatitis B	0.483	0.384-0.583
Acute hepatitis C	0.646	0.548-0.738
Acute hepatitis E	0.462	0.369-0.558
Leprosy	0.815	0.740-0.878
Legionnaires' disease	0.447	0.348-0.550
Leptospirosis	0.362	0.270-0.464
Rubella	0.366	0.270-0.470
Mumps	0.193	0.123-0.282
Esophageal cancer	0.875	0.809-0.924
Stomach cancer	0.724	0.640-0.799
Liver cancer secondary to hepatitis B	0.857	0.791-0.909
Liver cancer secondary to hepatitis C	0.819	0.745-0.881
Liver cancer secondary to alcohol use	0.824	0.748-0.885
Larynx cancer	0.872	0.812-0.919
Trachea, bronchus, and lung cancers	0.917	0.864-0.953
Breast cancer	0.704	0.614-0.787
Cervical cancer	0.744	0.659-0.819
Uterine cancer	0.745	0.659-0.820
Prostate cancer	0.701	0.609-0.783
Colon and rectum cancers	0.759	0.673-0.834
Mouth cancer	0.883	0.824-0.929
Nasopharynx cancer	0.816	0.739-0.879
Cancer of other parts of pharynx and oropharynx	0.890	0.837-0.931
Gallbladder and biliary tract cancer	0.827	0.757-0.886
Pancreatic cancer	0.938	0.891-0.968
Malignant melanoma of skin	0.790	0.706-0.860
Non-melanoma skin cancer	0.634	0.534-0.728
Ovarian cancer	0.791	0.713-0.856
Testicular cancer	0.799	0.721-0.865
Kidney cancer	0.777	0.698-0.846
Other urinary organ cancers	0.754	0.668-0.828
Bladder cancer	0.792	0.714-0.857
Brain and nervous system cancers	0.874	0.809-0.924
Thyroid cancer	0.466	0.369-0.564
Hodgkin's disease	0.718	0.631-0.795
Non-Hodgkin's lymphoma	0.754	0.672-0.827
Multiple myeloma	0.768	0.690-0.836
Leukemia	0.845	0.770-0.904
Bone and connective tissue cancer	0.816	0.744-0.876
Benign neoplasm of brain and other parts of central nervous system	0.571	0.472-0.667
Rheumatic heart disease	0.685	0.592-0.769
Ischemic heart disease	0.790	0.714-0.856
Ischemic stroke	0.809	0.734-0.872
Hemorrhagic and other non-ischemic stroke	0.864	0.796-0.917
Hypertensive heart disease	0.575	0.472-0.675
Cardiomyopathy and myocarditis	0.753	0.667-0.828

Table 2. Continued

Causes of disease	Disability weight	95% confidence interval
Atrial fibrillation and flutter	0.551	0.451-0.650
Aortic aneurysm	0.727	0.644-0.803
Peripheral vascular disease	0.530	0.432-0.627
Endocarditis	0.668	0.576-0.752
Hemorrhoids	0.171	0.103-0.260
Varicose veins of lower extremities	0.232	0.154-0.327
Chronic obstructive pulmonary disease	0.690	0.593-0.779
Pneumoconiosis	0.733	0.647-0.809
Asthma	0.367	0.269-0.477
Interstitial lung disease and pulmonary sarcoidosis	0.701	0.617-0.778
Cirrhosis of the liver secondary to hepatitis B	0.716	0.630-0.792
Cirrhosis of the liver secondary to hepatitis C	0.748	0.660-0.826
Cirrhosis of the liver secondary to alcohol use	0.614	0.517-0.706
Peptic ulcer disease	0.375	0.282-0.477
Gastritis and duodenitis	0.181	0.111-0.272
Appendicitis	0.133	0.077-0.212
Paralytic ileus and intestinal obstruction without hernia	0.491	0.390-0.594
Inguinal or femoral hernia	0.208	0.133-0.302
Crohn's disease	0.720	0.631-0.800
Ulcerative colitis	0.664	0.568-0.751
Vascular disorders of intestine	0.542	0.443-0.638
Gall bladder and bile duct disease	0.389	0.299-0.487
Pancreatitis	0.513	0.411-0.615
Gastroesophageal reflux disease	0.214	0.139-0.307
Alzheimer's disease and other dementias	0.854	0.784-0.911
Parkinson's disease	0.780	0.703-0.847
Epilepsy	0.778	0.698-0.846
Multiple sclerosis	0.778	0.696-0.848
Migraine	0.314	0.227-0.413
Tension-type headache	0.165	0.099-0.253
Schizophrenia	0.885	0.824-0.931
Alcohol use disorders	0.436	0.338-0.539
Opioid use disorders	0.453	0.354-0.555
Cocaine use disorders	0.441	0.343-0.544
Amphetamine use disorders	0.461	0.364-0.562
Cannabis use disorders	0.318	0.231-0.415
Major depressive disorders	0.606	0.508-0.700
Dysthymia	0.194	0.122-0.286
Bipolar affective disorder	0.610	0.515-0.700
Panic disorder	0.526	0.424-0.628
Obsessive-compulsive disorder	0.391	0.294-0.495
Post-traumatic stress disorder	0.435	0.338-0.538
Anorexia nervosa	0.488	0.392-0.586
Bulimia nervosa	0.411	0.316-0.513
Autism	0.758	0.672-0.832
Asperger's syndrome	0.685	0.591-0.771
Attention-deficit hyperactivity disorder	0.379	0.288-0.480
Conduct disorder	0.502	0.399-0.606
Idiopathic intellectual disability	0.676	0.586-0.760
Borderline personality disorder	0.603	0.504-0.698
Diabetes mellitus	0.593	0.496-0.686
Acute glomerulonephritis	0.445	0.345-0.550
Chronic kidney disease due to diabetes mellitus	0.837	0.769-0.893
Chronic kidney disease due to hypertension	0.748	0.662-0.823
Tubulointerstitial nephritis, pyelonephritis, and urinary tract infections	0.483	0.384-0.584
Urolithiasis	0.283	0.199-0.382
Benign prostatic hyperplasia	0.289	0.205-0.387

Table 2. Continued

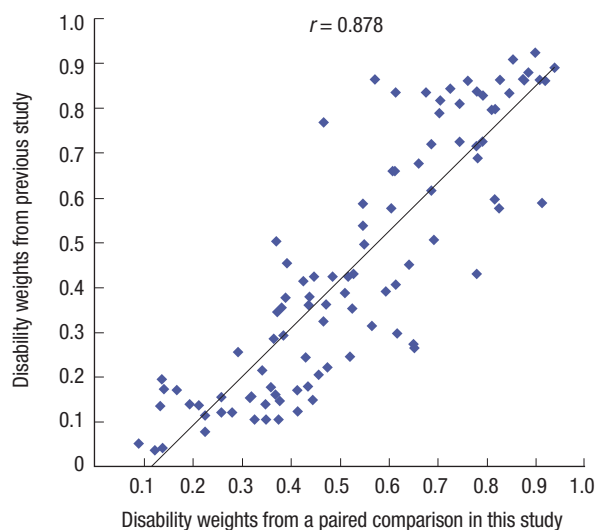| Causes of disease	Disability weight	95% confidence interval
Male infertility	0.588	0.494-0.680
Urinary incontinence	0.343	0.250-0.445
Uterine fibroids	0.242	0.163-0.338
Polycystic ovarian syndrome	0.439	0.338-0.544
Female infertility	0.561	0.466-0.655
Endometriosis	0.413	0.318-0.514
Genital prolapse	0.458	0.364-0.555
Premenstrual syndrome	0.142	0.082-0.225
Thalassemias	0.501	0.403-0.600
Sickle cell disorders	0.509	0.415-0.604
G6PD deficiency	0.679	0.588-0.763
Rheumatoid arthritis	0.549	0.449-0.647
Osteoarthritis	0.370	0.276-0.474
Low back pain	0.315	0.225-0.417
Neck pain	0.213	0.137-0.308
Gout	0.395	0.299-0.499
Systemic lupus erythematosus (SLE)	0.634	0.538-0.726
Neural tube defects	0.897	0.837-0.940
Congenital heart anomalies	0.686	0.596-0.769
Cleft lip and cleft palate	0.424	0.332-0.522
Down's syndrome	0.908	0.845-0.951
Eczema	0.162	0.098-0.248
Psoriasis	0.280	0.196-0.377
Cellulitis	0.302	0.214-0.404
Abscess, impetigo, and other bacterial skin diseases	0.205	0.133-0.295
Scabies	0.197	0.128-0.285
Fungal skin diseases	0.283	0.198-0.382
Viral skin diseases	0.240	0.159-0.337
Acne vulgaris	0.106	0.057-0.180
Alopecia areata	0.237	0.157-0.335
Pruritus	0.174	0.109-0.258
Urticaria	0.084	0.042-0.151
Decubitus ulcer	0.431	0.334-0.535
Glaucoma	0.640	0.545-0.727
Cataracts	0.384	0.294-0.483
Macular degeneration	0.576	0.480-0.669
Refraction and accommodation disorders	0.428	0.332-0.528
Dental caries	0.137	0.078-0.219
Periodontal disease	0.209	0.137-0.299
Edentulism	0.651	0.556-0.738
Pedestrian injury by road vehicle	0.534	0.437-0.629
Pedal cycle vehicle	0.357	0.266-0.458
Motorized vehicle with two wheels	0.529	0.428-0.630
Motorized vehicle with three or more wheels	0.588	0.487-0.685
Falls	0.613	0.513-0.708
Drowning	0.660	0.568-0.745
Fire, heat, and hot substances	0.545	0.443-0.645
Poisonings	0.546	0.447-0.644
Mechanical forces (firearm)	0.634	0.534-0.728
Adverse effects of medical treatment	0.385	0.286-0.494
Animal contact (venomous)	0.398	0.300-0.505
Animal contact (non-venomous)	0.107	0.059-0.176
Self-harm	0.614	0.517-0.706
Assault by firearm	0.611	0.516-0.701
Assault by sharp object	0.300	0.215-0.399
Exposure to forces of nature	0.389	0.292-0.494
Collective violence and legal intervention	0.613	0.520-0.702

Fig. 2. Comparison of disability weights between this study and a previous study.

The Pearson correlation coefficient between the disability weights for the overlapping causes of disease from this study and a previous South Korean study was 0.878 (Fig. 2) (20). Among 100 overlapping causes of disease, the disability weights for 26 causes of disease from this study, such as 'Thyroid cancer' and 'Stomach cancer', were estimated to be lower than that from the previous study; whereas, the disability weights for 74 causes of disease from this study, such as 'Self-harm' and 'Low back pain', were determined to be higher than that from the previous study. The difference in disability weight between the two studies was largest for 'Edentulism (0.384)', followed by 'Chagas disease (0.371)', and 'Epilepsy (0.346)'. However, disability weights of some causes of disease (e.g., 'Schizophrenia' and 'Influenza') showed little change. Supplementary Table 2 shows detailed comparisons between the disability weights for causes of disease from this study and the previous study (20).

DISCUSSION

In our present study, we re-estimated 228 disability weights for causes of disease by adapting the methodology of the recent GBD study. The disability weights were estimated by a survey with a PC and a PTO, involving physicians and medical college students. However, we suggest that the results from the PTO were not suitable to apply to estimation of disability weights, considering the span of values from the PTO. Furthermore, we showed that disability weights can be estimated from PC data alone by adding 'full health' and 'being dead' as anchor points. By using this simplified method in estimating disability weights, the problems on PTO or PHE could be overcome.

The PTO, including PHE, has been used to estimate disability weights in previous studies (4-6,9,19). The original purpose of a PTO was to anchor the results from a PTO and other valuation

methods, such as a VAS or a PC. That is, the results from a VAS or a PC were interpolated into the values from a PTO. However, values from the PTO displayed little variation in the known severity of causes of disease, especially considering the result that majority of disability weights (67.5%) from the PTO in this study ranged between 0.1 and 0.3. Such a phenomenon also occurred in the European disability weight study (10). In that study, the responsiveness to the variation in the severity of health states was low, so the authors used the PHE data from the GBD 2010 disability weights measurement study to anchor the results from the PC on a scale from 0 to 1. We suspect that the poorer discrimination of values between causes of disease by the PTO might be due to the number of cause of disease applied to the PTO. In general, a PTO has been applied to only a few causes of disease or health states (5,6,19), but in this study we asked participants to evaluate 40 causes of disease using a PTO. To evaluate the disability weights for causes of disease might be hard for participants, considering the disability level between the causes of diseases. If the number of causes of disease or health states increases, a PTO may not be suitable to ascertain the differences of disability level between causes or health states.

As the number of causes of disease or health states compared increases, ordinal methods, such as a PC or a ranking method, would be more appropriate than cardinal methods, such as a PTO or a time trade-off (TTO). Understanding the methodology of cardinal methods is easier for a participant than ordinal methods (25). Consequently, in ordinal methods, participants can elicit preferences for causes of disease or health states more easily than cardinal methods, by comparing preferences between causes of diseases and health states. However, rescaling the values from ordinal methods on a certain scale is crucial to use the results from cardinal methods as continuous data. We overcame this issue by adding 'full health' and 'being dead' to the list of causes of disease used in the PC. Generally, 'being dead' is used as reference for eliciting preferences in other valuation methods, such as the TTO and the standard gamble (26). Furthermore, the 'best imaginable health state' and the 'worst imaginable health state' are defined as the top and bottom anchors in the VAS (27). By including 'full health' and 'being dead' as in these other valuation methods, disability weights can be estimated based on a PC without resorting to a PTO.

We recruited physicians and medical college students, who were attending in third or fourth grade of a regular course, as study participants rather than the general public. Although the preferences in economic evaluation of the general public have more significance than those of healthcare professionals or patients (28), completely capturing the preferences of the general public is not an easy task. When evaluating the preferences of the general public, health states or diseases need to be explained in a manner that can be understood by all, especially people with a low level of education. Therefore, health states explain-

ing various aspects of causes of disease should be carefully developed and repeatedly reviewed. The GBD 2010 disability weights measurement study conducted surveys of the general public (4), but the disability weights from that study were revised by adding additional results from the European disability weight study, in which the lay descriptions of 33 health states were modified to fully reflect the key manifestations of the causes of disease (10). The disability weights from the general public are sensitive to specific descriptions of health states (9). To deflect this issue in this study, we conducted surveys involving physicians and medical college students who are assumed to possess sufficient experience and knowledge in the causes of disease. Furthermore, conducting surveys of healthcare professionals ensured comparability between the results from this study and a previous South Korean study that targeted medical experts as survey participants. For the KBD 2010 study, the Korean disability weights study aimed at the South Korean general public was also performed and is described in detail elsewhere (29).

Because we estimated a large number of disability weights for causes of disease on a scale from 0 to 1, some disability weights might seem counterintuitive in terms of degree and ranking compared to others. However, evaluating the validity of disability weights is difficult due to the absence of a gold standard (11). Consequently, comparing the ranking of disability weights between similar studies and detecting inversion of disability weights in specific diseases with different severity levels have been suggested to confirm the validity of disability weights (11). Furthermore, increasing the sample size of survey participants and including diverse specialists among the survey participants are additional options that can enhance the validity of disability weights. Although a relatively large number of physicians and medical college students conducted the survey in this study, further studies will be required to ensure the validity of disability weights.

When comparing disability weights for overlapping causes of disease from this study and the previous South Korean study (20), there is a fairly high correlation between the two studies despite their differences in valuation methods and time periods. However, change in perception of healthcare professionals about particular causes of disease is predictable. For example, the disability weights of 'Thyroid cancer' and 'Stomach cancer' were lower than those of previous studies. On the other hand, the disability weights of 'Self-harm' and 'Low back pain' were higher than those of previous studies. The outcome of medical treatments, prognosis of causes of disease, and recent changes in epidemiologic data are expected to affect participants' evaluation of the disability level for causes of disease (30,31). Therefore, disability weights must periodically be revised to reflect the up-to-date advances in medical science and epidemiological changes.

One limitation of our current study design is that the severity levels of causes of disease were not considered. The disability weights of 'Trachea, bronchus, and lung cancers (0.917)' and 'Pancreatic cancer (0.938)' were estimated with high values in this study. If these cancers were divided up into different disease stages, the results might be more valid because they would reflect the severity levels of causes of disease. Further disability weight studies that consider the stages of causes of disease will be required in the near future.

In conclusion, we re-estimated 228 disability weights for causes of disease based on the responses of a large number of medical experts. We showed that disability weights can be estimated based on a PC without resorting to a PTO by including 'full health' and 'being dead' as anchor points. Disability weights can be easily estimated and continuously revised through new methodology developed from this study in the estimation of disability weights.

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DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Study conception and design: Jo MW, Ock M. Acquisition of data: all authors. Data analysis: Jo MW, Ock M, Lee JY. Manuscript preparation: Ock M, Jo MW. Revision and approval of manuscript: all authors.

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Supplementary Table 1. Means, standard deviations, and medians of disability weights for causes of disease from a person trade-off

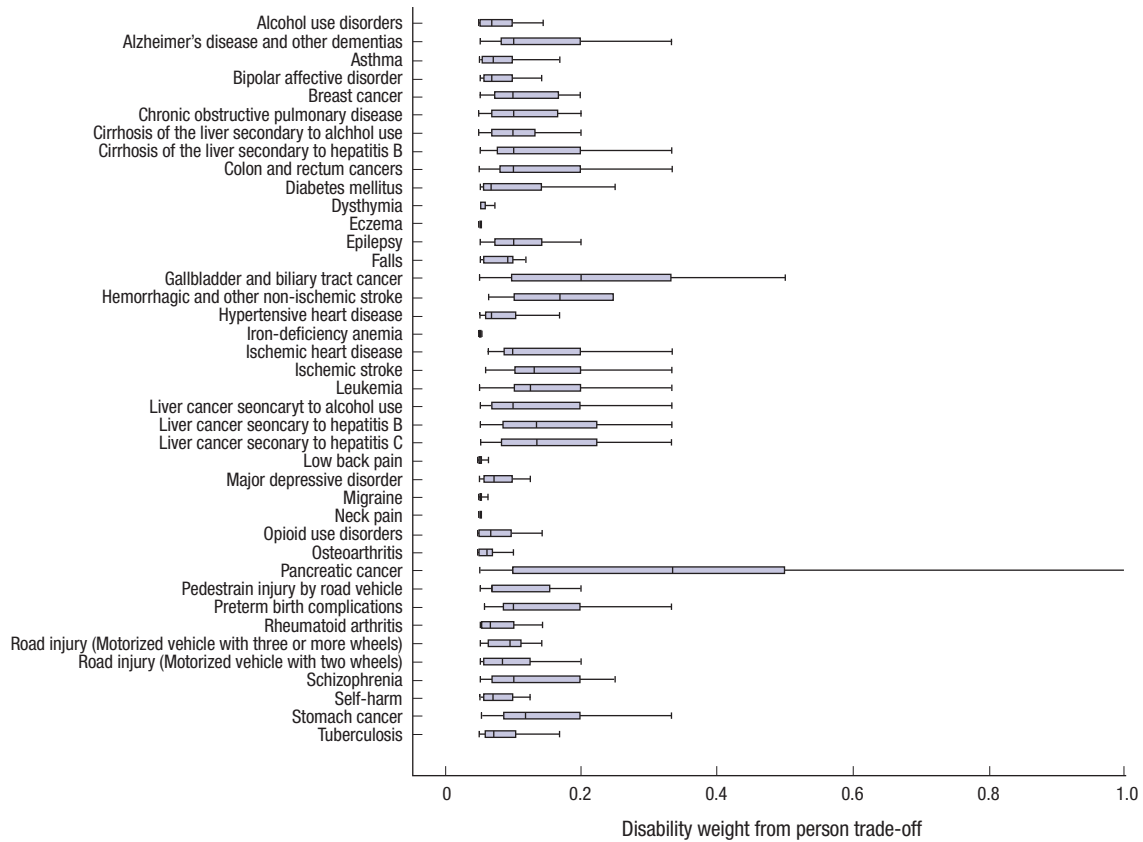| Cause of disease	Mean	Standard deviation	Median
Migraine	0.058	0.017	0.050
Neck pain	0.059	0.021	0.050
Dysthymia	0.061	0.020	0.050
Eczema	0.061	0.029	0.050
Low back pain	0.065	0.040	0.050
Osteoarthritis	0.069	0.034	0.050
Iron-deficiency anemia	0.080	0.150	0.050
Opioid use disorders	0.080	0.043	0.065
Self-harm	0.091	0.066	0.069
Rheumatoid arthritis	0.092	0.081	0.066
Asthma	0.094	0.059	0.069
Major depressive disorder	0.099	0.071	0.071
Tuberculosis	0.101	0.080	0.071
Hypertensive heart disease	0.110	0.152	0.067
Bipolar affective disorder	0.112	0.154	0.067
Alcohol use disorders	0.114	0.166	0.067
Cirrhosis of the liver secondary to alcohol use	0.114	0.080	0.100
Falls	0.122	0.114	0.091
Chronic obstructive pulmonary disease	0.136	0.161	0.100
Epilepsy	0.136	0.160	0.100
Road injury (motorized vehicle with two wheels)	0.142	0.177	0.083
Diabetes mellitus	0.145	0.185	0.067
Ischemic heart disease	0.159	0.154	0.100
Cirrhosis of the liver secondary to hepatitis B	0.162	0.164	0.100
Road injury (motorized vehicle with three or more wheels)	0.169	0.247	0.095
Alzheimer's disease and other dementias	0.169	0.173	0.100
Breast cancer	0.169	0.213	0.100
Liver cancer secondary to hepatitis B	0.175	0.158	0.134
Colon and rectum cancers	0.181	0.206	0.100
Pedestrian injury by road vehicle	0.194	0.278	0.100
Liver cancer secondary to alcohol use	0.195	0.246	0.100
Ischemic stroke	0.197	0.201	0.129
Schizophrenia	0.201	0.252	0.100
Liver cancer secondary to hepatitis C	0.203	0.216	0.134
Stomach cancer	0.208	0.244	0.118
Preterm birth complications	0.218	0.277	0.100
Leukemia	0.227	0.247	0.125
Hemorrhagic and other non-ischemic stroke	0.258	0.256	0.167
Gallbladder and biliary tract cancer	0.277	0.275	0.200
Pancreatic cancer	0.400	0.328	0.333

Supplementary Table 2. Comparison of disability weights for causes of disease between this study and a previous study

Cause of disease	Disability weight		Difference
	From this study	From previous study	
Schizophrenia	0.885	0.882	0.003
Influenza	0.131	0.135	-0.004
Iodine deficiency	0.166	0.172	-0.006
Poisonings	0.546	0.540	0.006
Leukemia	0.845	0.836	0.009
Brain and nervous system cancers	0.874	0.865	0.009
Cleft lip and cleft palate	0.424	0.414	0.010
Diphtheria	0.389	0.378	0.011
Esophageal cancer	0.875	0.863	0.012
Ischemic stroke	0.809	0.796	0.013
Bone and connective tissue cancer	0.816	0.800	0.016
Cervical cancer	0.744	0.727	0.017
Drowning	0.660	0.677	-0.017
Acute glomerulonephritis	0.445	0.424	0.021
Attention-deficit hyperactivity disorder	0.379	0.356	0.023
Osteoarthritis	0.370	0.346	0.024
Borderline personality disorder	0.603	0.577	0.026
Neural tube defects	0.897	0.927	-0.030
Benign prostatic hyperplasia	0.289	0.257	0.032
Congenital heart anomalies	0.686	0.721	-0.035
Upper respiratory infections	0.088	0.052	0.036
Otitis media	0.138	0.175	-0.037
Gallbladder and biliary tract cancer	0.827	0.865	-0.038
Bladder cancer	0.792	0.831	-0.039
Ovarian cancer	0.791	0.831	-0.040
Down's syndrome	0.908	0.866	0.042
Fire, heat, and hot substances	0.545	0.588	-0.043
Pancreatic cancer	0.938	0.892	0.046
Bipolar affective disorder	0.610	0.660	-0.050
Rheumatoid arthritis	0.549	0.497	0.052
Mumps	0.193	0.140	0.053
Trachea, bronchus, and lung cancers	0.917	0.864	0.053
Major depressive disorder	0.606	0.660	-0.054
Alcohol use disorders	0.436	0.382	0.054
Alzheimer's disease and other dementias	0.854	0.911	-0.057
Tubulointerstitial nephritis, pyelonephritis, and urinary tract infections	0.483	0.424	0.059
Kidney cancer	0.777	0.839	-0.062
Appendicitis	0.133	0.195	-0.062
Multiple sclerosis	0.778	0.716	0.062
Ischemic heart disease	0.790	0.727	0.063
Obsessive-compulsive disorder	0.391	0.457	-0.066
Uterine cancer	0.745	0.812	-0.067
Rheumatic heart disease	0.685	0.616	0.069
Periodontal disease	0.209	0.138	0.071
Post-traumatic stress disorder	0.435	0.362	0.073
Protein-energy malnutrition	0.362	0.287	0.075
Iron-deficiency anemia	0.122	0.037	0.085
Maternal hemorrhage	0.514	0.425	0.089
Prostate cancer	0.701	0.791	-0.090
Parkinson's disease	0.780	0.690	0.090
Cataracts	0.384	0.293	0.091
Dental caries	0.137	0.044	0.093
Panic disorder	0.526	0.433	0.093
Whooping cough	0.256	0.157	0.099
Colon and rectum cancers	0.759	0.863	-0.104
Varicella	0.223	0.117	0.106

(Continued to the next page)

Supplementary Table 2. Continued

Cause of disease	Disability weight		Difference
	From this study	From previous study	
Obstructed labor	0.471	0.363	0.108
Breast cancer	0.704	0.819	-0.115
Hypertensive disorders of pregnancy	0.508	0.389	0.119
Stomach cancer	0.724	0.847	-0.123
Schistosomiasis	0.340	0.215	0.125
Ascariasis	0.256	0.122	0.134
Asthma	0.367	0.504	-0.137
Tuberculosis	0.464	0.325	0.139
Vitamin A deficiency	0.223	0.079	0.144
Measles	0.279	0.123	0.156
Low back pain	0.315	0.154	0.161
Idiopathic intellectual disability	0.676	0.838	-0.162
Trichuriasis	0.320	0.157	0.163
Tetanus	0.524	0.354	0.170
Onchocerciasis	0.357	0.179	0.178
Chronic obstructive pulmonary disease	0.690	0.508	0.182
Dengue	0.428	0.245	0.183
Glaucoma	0.640	0.451	0.189
Diabetes mellitus	0.593	0.394	0.199
Rubella	0.366	0.162	0.204
Falls	0.613	0.409	0.204
Gonococcal infection	0.345	0.139	0.206
Cholera	0.324	0.106	0.218
Leprosy	0.815	0.597	0.218
Collective violence and legal intervention	0.613	0.835	-0.222
Peptic ulcer disease	0.375	0.151	0.224
Typhoid and paratyphoid fevers	0.347	0.106	0.241
Sexually transmitted chlamydial diseases	0.413	0.172	0.241
Maternal sepsis	0.825	0.579	0.246
Malaria	0.471	0.224	0.247
Lymphatic filariasis	0.564	0.316	0.248
Abortion	0.455	0.207	0.248
Trachoma	0.431	0.179	0.252
Shigellosis	0.372	0.106	0.266
Syphilis	0.519	0.247	0.272
Leishmaniasis	0.411	0.126	0.285
Herpes genitalia	0.442	0.151	0.291
Benign neoplasm of brain and other parts of central nervous system	0.571	0.865	-0.294
Thyroid cancer	0.466	0.771	-0.305
Self-harm	0.614	0.299	0.315
Neonatal encephalopathy (birth asphyxia and birth trauma)	0.911	0.590	0.321
Epilepsy	0.778	0.432	0.346
Chagas disease	0.647	0.276	0.371
Edentulism	0.651	0.267	0.384

Supplementary Fig. 1. Box plot of disability weights of 40 causes of disease from a person trade-off.