

Methods and Application

Online Pairwise Comparisons Survey on Disability Weight for Chronic Cadmium Poisoning — Shenyang City, Liaoning Province, China, June–August 2022

He Jiang^{1,2,&}; Fei Wang^{1,3,&}; Shuhao Nie^{1,&}; Qinyue Tan¹; Qihao Wang¹; Xing Yang¹; Le Yan¹; Ziqi Guo¹; Kun Song¹; Yuan Gao¹; Lingjun Yan^{1,4,5}; Haijiao Yu¹; Guowei Pan^{1,4,5}; Wei Sun^{1,4,5,#}

ABSTRACT

Introduction: Currently, the disease burden of chronic cadmium poisoning remains unquantifiable due to the absence of disability weights (DWs). This study aimed to derive DWs for mild and severe chronic cadmium poisoning.

Methods: Adopting the pairwise comparison (PC) method from the Global Burden of Disease (GBD) study, health state descriptions for mild and severe chronic cadmium poisoning were developed, and a severity spectrum of 13 health states was constructed based on GBD 2023. Questionnaires collecting demographic information and PC task questionnaires were distributed to the general population ($n=552$) and medical professionals ($n=488$).

Results: Heatmaps confirmed response consistency. Probit regression and Loess modeling revealed that DWs for mild and severe chronic cadmium poisoning were 0.099 and 0.363, respectively, in the general population, and 0.102 and 0.397, respectively, among medical professionals. Spearman correlation coefficients comparing DWs values with reference studies (GBD 2023 study and a Chinese national study) ranged from 0.64 to 0.95.

Conclusion: To our knowledge, this is the first study to successfully establish DW parameters for chronic cadmium poisoning. No significant differences were observed between DWs derived from the general population and those derived from medical professionals. This study provides a methodological reference for establishing DWs of environmental pollutants to assess their indirect disease burden.

Cadmium is a toxic heavy metal and environmental pollutant that accumulates in soil and enters the food chain (1). Chronic exposure damages multiple organs

and systems (2), but its public health burden remains unquantified.

Since 1993, disability-adjusted life years (DALYs) have been the main indicators of disease burden (3). The Global Burden of Disease Study 2023 (GBD 2023) has established DWs covering 590 health states (4). However, the use of DALYs to assess the burden of chronic cadmium poisoning is limited due to the lack of disability weights (DWs). Limited exposure can cause severe, multi-organ damage, demonstrating the phenomenon of “one cause and multiple effects.” The presence of any more health impairments also defines more severe poisoning. Consequently, the actual disease burden of chronic cadmium poisoning remains unclear.

This study aimed to establish DWs of mild and severe chronic cadmium poisoning. Given the expertise of medical professionals in disease recognition (5), they were included alongside the general population.

METHODS

Health States and Severity Spectrum

Disease-specific descriptions of mild and severe chronic cadmium poisoning were developed following China’s National Occupational Health Standards and validated by occupational disease experts. Generic terms were established using the EuroQol 5-dimension plus cognition 3-level (EQ-5D+C-3L) instrument (6) (Supplementary Table S1, available at <https://weekly.chinacdc.cn/>). Both disease-specific and generic descriptions were validated by occupational disease experts.

With reference to the design for determining the DWs of chronic mercury poisoning (7), a severity spectrum of health states was constituted with consideration on methodological requirement and performable feasibility. A severity spectrum of 13

health states was established based on current parameters of DWs for mild vision disorder, diabetes mellitus, breast cancer (disease-free stage without permanent sequelae), mild dementia, severe asthma, coronary heart disease (stage at diagnosis and primary therapy), human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS; seropositive, asymptomatic), colorectal cancer, stroke moderate impairments (acute incident plus rehabilitation phase), chronic low back pain, quadriplegia, severe depression, and deafness that has cross-cultural/regional stability (8). Disease-specific descriptions were identified through literature reviews and converted to generic descriptions using the EQ-5D+C-3L (6) in consultation with clinical experts (Supplementary Table S1, available at <https://weekly.chinacdc.cn/>).

Descriptions were compared with the lay descriptions used in GBD 2023 (4). Consistency was assessed using the Delphi method (Supplementary Material, available at <https://weekly.chinacdc.cn/>). A mean value ≥ 3 and coefficient of variation ≤ 0.35 (9) were considered a consensus. In this study, 12 health states, excluding HIV/AIDS, matched the corresponding descriptions in the GBD 2023 study and were used as anchors for a locally weighted regression model (Supplementary Table S2, available at <https://weekly.chinacdc.cn/>).

Questionnaire and Participants

The pairwise comparison (PC) method (Supplementary Material) was used as described in previous GBD studies (10). Each PC question presented a brief narrative of the main characteristics of disease-specific and generic descriptions. Demographic data included sex, age, household income, and education level.

The survey was conducted from June 2022 to August 2022 in Shenyang City, China. Sample size ($n=375$) was calculated based on the PC method used in the GBD studies (10), which requires 25 responses per health state; the number was increased to 480 to achieve an 80% response rate.

A total of 552 questionnaires were distributed to the general population, of which 444 (effective response rate: 80.43%) were included for analysis. A total of 488 questionnaires were distributed to the medical professionals, of which 429 (effective response rate: 87.91%) were included for analysis. Sampling and quality control details are in Supplementary Method.

Statistical Analysis

Analyses were performed using R (version 4.1.2; R Foundation for Statistical Computing, Vienna, Austria). Heatmaps were generated to validate the consistency of the data. With reference to the calculation on DWs of chronic mercury poisoning based on the GBD DW scales (7), probit regression analysis, the Loess model, and the Monte Carlo model (Supplementary Method) were performed to derive parameters of the DWs and their 95% uncertainty intervals (UIs) (7). Spearman rank correlation analysis was conducted to assess the consistency of the DWs of the general population, medical professionals, GBD 2023 study (4), and Chinese national study (11).

RESULTS

Participant Characteristics

Mean age was 39.75 ± 12.44 years (general population) and 33.97 ± 8.41 years (medical professionals). Average response times were 8.92 ± 5.64 min and 11.61 ± 6.73 min, respectively (Table 1).

Response Probabilities

The response probabilities for PCs of the general population and medical professionals are presented as heatmaps (Figure 1). For both populations, the relatively smooth transition in colors from low to high probabilities between the upper left and lower right corners indicated a limited measurement error and a high degree of internal consistency.

Disability Weights

Estimated DWs for chronic cadmium poisoning are presented in Table 2. Based on the fitting curve of the Loess model (Supplementary Figure S1, available at <https://weekly.chinacdc.cn/>), DWs of mild and severe chronic cadmium poisoning for the general population were 0.099 (95% UI: 0.051, 0.184) and 0.363 (95% UI: 0.196, 0.572), respectively. For medical professionals, DWs of mild and severe chronic cadmium poisoning were 0.102 (95% UI: 0.052, 0.189) and 0.397 (95% UI: 0.215–0.611), respectively. The overlapping areas of the 95% UIs were large for DWs for both mild and severe chronic cadmium poisoning in the two populations. DWs for severe chronic cadmium poisoning were significantly higher than those for mild chronic cadmium poisoning and ranked between colorectal cancer and severe depression.

TABLE 1. Sociodemographic characteristics of survey respondents (general population and medical professionals), Shenyang City, Liaoning Province, China, June–August 2022.

Variables	General population		Medical professionals	
	n	Proportion (%)	n	Proportion (%)
Age (years)				
18–29	131	29.50	145	33.80
30–49	180	40.54	258	60.14
50–70	133	29.95	26	6.06
Sex				
Male	152	34.23	46	10.72
Female	292	65.77	383	89.28
Education level				
Below senior high school	89	20.05	14	3.26
College/university and above	355	79.95	415	96.74
Annual income (CNY)				
<30,000	62	13.96	43	10.02
30,000–150,000	286	64.41	283	65.97
>150,000	96	21.62	103	24.01
Total	444	100.00	429	100.00

Abbreviation: CNY=Chinese Yuan.

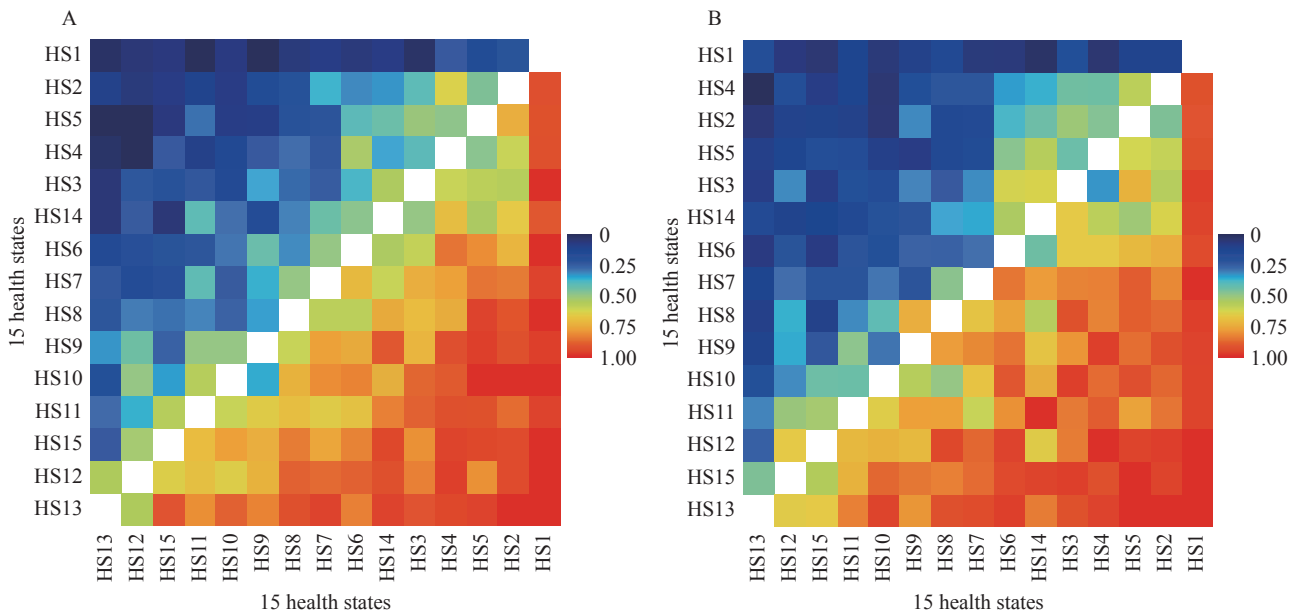


FIGURE 1. Response probabilities for pairwise comparisons of health states. (A) General population; (B) Medical professionals.

Note: Each cell shows the response probability for one pair of states. The colors correspond to the probability that the first health state in pairwise comparison was chosen as the healthier outcome. HS1–HS15 represent the following health states: mild vision disorder, chronic low back pain, breast cancer (disease-free stage without permanent sequelae), deafness, diabetes mellitus, mild dementia, severe asthma, coronary heart disease (stage at diagnosis and primary therapy), stroke moderate impairments (acute incident plus rehabilitation phase), colorectal cancer, HIV/AIDS (seropositive, asymptomatic), severe depression, quadriplegia, mild chronic cadmium poisoning, and severe chronic cadmium poisoning.

Abbreviation: HS=health state; HIV/AIDS=human immunodeficiency virus/acquired immunodeficiency syndrome.

TABLE 2. Estimated disability weights and 95% uncertainty intervals for each health state — general population, medical professionals, and reference studies (the GBD 2023 and a Chinese national study), Shenyang City, Liaoning Province, China, June–August 2022.

Health state	General population			Medical professionals			GBD 2023 study		Chinese national study	
	Rank1	Coef*	DWs (95% UI)	Rank2	Coef*	DWs (95% UI)	Rank3	DWs (95% UI)	Rank4	DWs (95% UI)
Mild vision disorder	1	2.308	0.012 (0.002–0.068)	1	2.500	0.012 (0.002–0.066)	1	0.011 (0.005–0.020)	1	0.016 (0.001–0.081)
Chronic low back pain	2	0.671	0.095 (0.044–0.194)	3	0.709	0.096 (0.044–0.194)	10	0.325 (0.219–0.446)	8	0.180 (0.089–0.311)
Breast cancer (disease-free stage without permanent sequelae)	4	0.405	0.100 (0.051–0.186)	6	0.494	0.107 (0.054–0.200)	2	0.049 (0.031–0.072)	2	0.045 (0.006–0.153)
Deafness	5	0.621	0.102 (0.048–0.205)	5	0.621	0.106 (0.051–0.208)	7	0.215 (0.144–0.307)	6	0.151 (0.065–0.287)
Diabetes mellitus	6	0.600	0.104 (0.049–0.206)	7	0.498	0.108 (0.054–0.202)	2	0.049 (0.031–0.072)	2	0.045 (0.006–0.153)
Mild dementia	7	0.174	0.112 (0.058–0.206)	2	0.338	0.094 (0.048–0.175)	4	0.069 (0.046–0.099)	4	0.047 (0.007–0.157)
Severe asthma	8	-0.050	0.152 (0.076–0.281)	8	-0.140	0.154 (0.075–0.293)	5	0.133 (0.086–0.192)	9	0.227 (0.136–0.346)
Coronary heart disease (stage at diagnosis and primary therapy)	9	-0.154	0.170 (0.084–0.316)	9	-0.280	0.177 (0.084–0.334)	6	0.167 (0.110–0.240)	7	0.163 (0.074–0.297)
Stroke moderate impairments (acute incident plus rehabilitation phase)	10	-0.487	0.244 (0.123–0.426)	10	-0.512	0.224 (0.109–0.404)	9	0.316 (0.206–0.437)	5	0.111 (0.036–0.247)
Colorectal cancer	11	-0.530	0.256 (0.131–0.440)	11	-0.659	0.262 (0.134–0.449)	8	0.288 (0.193–0.399)	11	0.264 (0.176–0.371)
HIV/AIDS (seropositive, asymptomatic)	12	-0.550	0.261 (0.134–0.446)	12	-0.788	0.300 (0.159–0.492)	–	–	–	–
Severe depression	14	-0.921	0.389 (0.208–0.607)	14	-1.122	0.422 (0.225–0.648)	12	0.658 (0.477–0.807)	12	0.699 (0.608–0.777)
Quadriplegia	15	-1.358	0.575 (0.210–0.873)	15	-1.491	0.581 (0.228–0.867)	11	0.402 (0.268–0.545)	10	0.262 (0.174–0.370)
Mild chronic cadmium poisoning	3	0.283	0.099 (0.051–0.184)	4	0.205	0.102 (0.052–0.189)	–	–	–	–
Severe chronic cadmium poisoning	13	-0.856	0.363 (0.196–0.572)	13	-1.058	0.397 (0.215–0.611)	–	–	–	–

Note: “–”: incomparability.

Abbreviation: DW=disability weight; UI=uncertainty interval; GBD=global burden of disease; HIV/AIDS=human immunodeficiency virus/acquired immunodeficiency syndrome; coef=coefficient.

* The probability regression coefficients.

Severity Spectrum Disability Weights

Estimated DWs (95% UI) of the general population and medical professionals are presented in Table 2. The DWs of the 13 health states were similar between the two populations, especially in the last 7 health states. Among the 13 health states between the two populations, 10 had differences in DWs of less than 0.010, with the largest difference for HIV/AIDS (seropositive, asymptomatic) (0.039). In this study, mild vision disorder had the lowest DWs for the general population and medical professionals [0.012 (95% UI: 0.002, 0.068) and 0.012 (95% UI: 0.002,

0.066), respectively], whereas quadriplegia had the highest [0.575 (95% UI: 0.210, 0.873) and 0.581 (95% UI: 0.228, 0.867), respectively].

Comparisons with Other Studies

In comparison to the GBD 2023 study (4), DWs for 5 of the 12 health states of the general population and 6 of the 12 health states of medical professionals were within the 95% UIs of the GBD 2023 study. DWs of chronic low back pain, deafness, and severe depression were below the lower limit of the corresponding 95% UIs of the GBD 2023 study, with absolute differences

of 0.113 to 0.269 and 0.109 to 0.236 for the two populations, respectively. DWs of breast cancer (disease-free stage without permanent sequelae), diabetes mellitus, and quadriplegia were above the upper limit of the corresponding 95% UIs of the GBD 2023 study, with absolute differences of 0.051 to 0.173 and 0.058 to 0.179, respectively. In addition, DWs of mild dementia was also above the level of the GBD 2023 with an absolute difference of 0.043 for the general population.

Compared with the Chinese national study (11), DWs for 10 of the 12 health states were within the corresponding 95% UIs of the Chinese national study for the two populations. DW values of severe depression were well below the lower limit of the corresponding 95% UI of the Chinese national study, with absolute differences of 0.310 and 0.277, respectively, and DWs values of quadriplegia were above the upper limit of the 95% UI of the Chinese national study, with an absolute difference of 0.310 for both the general population and medical professionals.

Correlation Analysis

Correlations between the DWs drawn from the two populations in the present study, the GBD 2023 study (4), and the Chinese national study (11) are shown in Table 3. Spearman's rank correlation coefficient for DWs between the general population and medical professionals was 0.95 ($P<0.001$). Their correlations for DWs between the general population and the GBD 2023 study and between medical professionals and the GBD 2023 study were 0.64 ($P<0.05$) and 0.67 ($P<0.05$), respectively. In contrast, their correlations with the Chinese national study were 0.72 ($P<0.001$) and 0.73 ($P<0.001$), respectively.

DISCUSSION

To our knowledge, this study is the first to derive

DW parameters for chronic cadmium poisoning. Test-retest reliability (0.80 and 0.79) exceeded European estimates (0.72 to 0.78) (12). Heatmaps indicated low measurement error and high consistency. These findings demonstrate the relatively high credibility of this study.

DWs for mild and severe poisoning were 0.099 and 0.363 in the general population, and 0.102 and 0.397 in medical professionals, respectively. In the two populations, the DWs of mild chronic cadmium poisoning ranked between chronic low back pain and breast cancer, whereas those of severe chronic cadmium poisoning ranked between colorectal cancer and severe depression. Previous studies used only kidney impairment DWs (0.091) to calculate DALYs due to the lack of available DWs, underestimating health damage (13–14). Bone damage of severe poisoning exceeded moderate musculoskeletal problems (moderate generalized) in the GBD 2023 study (4) but were lower than severe musculoskeletal problems. Existing DWs inadequately reflect chronic cadmium poisoning, highlighting the need for condition-specific DWs.

Comparisons of DW severity spectrum with those of other studies revealed interesting findings. Of the DWs of the 12 health states in this study, only 5 were within the corresponding 95% UIs of the GBD 2023 study (4), while 10 were within the corresponding 95% UIs of the Chinese national study (11). Moreover, their correlations with the GBD 2023 study were smaller than those with the Chinese national study. With regard to deafness, an indicator of the reliability of the results (8), the variation intensity to the Chinese national study is lower than that to the GBD 2023 study, suggesting that the present study was localized and representative of the Chinese population. As suggested by Nomura et al. (15), there may be contextual differences in rating the severity of health states across countries with different cultures and income levels, and country-specific DWs should be

TABLE 3. Correlation analysis of disability weights between survey respondents (general population and medical professionals), the GBD 2023 study, and a Chinese national study; Shenyang City, Liaoning Province, China, June–August 2022.

Study populations	General population	Medical professionals	GBD 2023 study	Chinese national study
General population	1			
Medical professionals	0.95**	1		
GBD 2023 study	0.64*	0.67*	1	
Chinese national study	0.72**	0.73**	0.83**	1

Abbreviation: GBD=global burden of disease.

* $P<0.05$; ** $P<0.001$.

applied in future studies.

Piao et al. (5) found that DWs were higher for medical professionals than the general population. In contrast, the present study found no significant difference in DWs between the two populations, inversely confirming the health state descriptions of the EQ-5D+C-3L (6) and representativeness of the general population in the GBD study.

The findings in this report are subject to at least two limitations. First, the survey was conducted only in Shenyang, limiting the generalizability of these findings. A national survey covering all regions should be conducted to enhance the representativeness of DW values. Second, the web-based survey method introduced a sample bias toward younger and more educated participants. However, this limitation led to enhanced response quality due to the participants' stronger comprehension.

In conclusion, this study derived DWs for mild and severe chronic cadmium poisoning based on the PC method. There were no significant differences in DWs between the general population and medical professionals, providing a basis for measuring health damage due to environmental risks.

Conflicts of interest: No conflicts of interest.

Ethical statements: Approved by the ethics committee of the China Medical University (Shenyang City, Liaoning Province, China).

Funding: Supported by the National Key Research and Development Project of China [grant number 2018YFC1801205], the Science and Technology Innovation Team Project of China Medical University 2022 [grant number CXTD2022006], and the Science and Technology Plan Project of Shenyang City 2023 [grant number 23-506-3-01]. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

doi: 10.46234/ccdcw2026.095

Corresponding author: Wei Sun, wsun@cmu.edu.cn.

¹ Research Center for Universal Health, School of Public Health, China Medical University, Shenyang City, Liaoning Province, China; ² Quality Management and Accreditation Department, the University of Hong Kong-Shenzhen Hospital, Shenzhen City, Guangdong Province, China; ³ Public Health Center, Gumei Community Health Center, Minhang District, Shanghai, China; ⁴ Key Laboratory of Environmental Stress and Chronic Disease Control & Prevention, Ministry of Education (China Medical University), Shenyang City, Liaoning Province, China; ⁵ Liaoning Provincial Key Laboratory of Early Warning, Intervention Technology and Countermeasure Research for Major Public Health Events (China Medical University), Shenyang City, Liaoning Province, China.

^{8c} Joint first authors.

Copyright © 2026 by Chinese Center for Disease Control and Prevention & Chinese Academy of Preventive Medicine. All content is distributed under a Creative Commons Attribution Non Commercial License 4.0 (CC BY-NC).

Submitted: November 17, 2025

Accepted: March 31, 2026

Issued: May 08, 2026

REFERENCES

- Wang P, Chen HP, Kopittke PM, Zhao FJ. Cadmium contamination in agricultural soils of China and the impact on food safety. *Environ Pollut* 2019;249:1038 – 48. <https://doi.org/10.1016/j.envpol.2019.03.063>.
- Liu JL, Li YL, Li D, Wang YBN, Wei S. The burden of coronary heart disease and stroke attributable to dietary cadmium exposure in Chinese adults, 2017. *Sci Total Environ* 2022;825:153997. <https://doi.org/10.1016/j.scitotenv.2022.153997>.
- Gao TT, Wang XC, Chen R, Ngo HH, Guo WS. Disability adjusted life year (DALY): a useful tool for quantitative assessment of environmental pollution. *Sci Total Environ* 2015;511:268 – 87. <https://doi.org/10.1016/j.scitotenv.2014.11.048>.
- GBD 2023 Disease and Injury and Risk Factor Collaborators. Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet* 2025;406(10513):1873 – 922. [https://doi.org/10.1016/S0140-6736\(25\)01637-X](https://doi.org/10.1016/S0140-6736(25)01637-X).
- Piao XD, Tsugawa S, Takemura Y, Ichikawa N, Kida R, Kunie K, et al. Disability weights measurement for 17 diseases in Japan: a survey based on medical professionals. *Econ Anal Policy* 2021;70:238 – 48. <https://doi.org/10.1016/j.eap.2021.02.010>.
- Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: past, present and future. *Appl Health Econ Health Policy* 2017;15(2):127 – 37. <https://doi.org/10.1007/s40258-017-0310-5>.
- Steckling N, Devleeschauwer B, Winkelkemper J, Fischer F, Ericson B, Krämer A, et al. Disability weights for chronic mercury intoxication resulting from Gold Mining Activities: results from an online pairwise comparisons survey. *Int J Environ Res Public Health* 2017;14(1):57. <https://doi.org/10.3390/ijerph14010057>.
- Manchaiah V, Danermark B, Ahmadi T, Tomé D, Zhao F, Li Q, et al. Social representation of "hearing loss": cross-cultural exploratory study in India, Iran, Portugal, and the UK. *Clin Interv Aging* 2015;10:1857 – 72. <https://doi.org/10.2147/cia.S91076>.
- Ruan Y, Song SJ, Yin ZF, Wang M, Huang N, Gu W, et al. Comprehensive evaluation of military training-induced fatigue among soldiers in China: a Delphi consensus study. *Front Public Health* 2022;10:1004910. <https://doi.org/10.3389/fpubh.2022.1004910>.
- Salomon JA, Vos T, Hogan DR, Gagnon M, Naghavi M, Mokdad A, et al. Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2129 – 43. [https://doi.org/10.1016/S0140-6736\(12\)61680-8](https://doi.org/10.1016/S0140-6736(12)61680-8).
- Liu XX, Wang F, Zhou MG, Yu Y, Qi JL, Yin P, et al. Eliciting national and subnational sets of disability weights in mainland China: findings from the Chinese disability weight measurement study. *Lancet Reg Health West Pac* 2022;26:100520. <https://doi.org/10.1016/j.lanwpc.2022.100520>.
- Haagsma JA, Maertens de Noordhout C, Polinder S, Vos T, Havelaar AH, Cassini A, et al. Assessing disability weights based on the responses of 30,660 people from four European countries. *Popul Health Metr* 2015;13(1):10. <https://doi.org/10.1186/s12963-015-0042-4>.
- Chatham-Stephens K, Caravanos J, Ericson B, Sunga-Amparo J,

- Susilorini B, Sharma P, et al. Burden of disease from toxic waste sites in India, Indonesia, and the Philippines in 2010. *Environ Health Perspect* 2013;121(7):791 – 6. <https://doi.org/10.1289/ehp.1206127>.
14. Hernández-Cruz EY, Amador-Martínez I, Aranda-Rivera AK, Cruz-Gregorio A, Pedraza Chaverri J. Renal damage induced by cadmium and its possible therapy by mitochondrial transplantation. *Chem Biol Interact* 2022;361:109961. <https://doi.org/10.1016/j.cbi.2022.109961>.
15. Nomura S, Yamamoto Y, Yoneoka D, Haagsma JA, Salomon JA, Ueda P, et al. How do Japanese rate the severity of different diseases and injuries? —An assessment of disability weights for 231 health states by 37,318 Japanese respondents. *Popul Health Metr* 2021;19(1):21. <https://doi.org/10.1186/s12963-021-00253-4>.

SUPPLEMENTARY MATERIAL

The Delphi Method

Twenty clinical experts from general hospitals were invited to evaluate the degree of matching consistency using the Delphi method. Scores were assigned to the degree of consistency of the health state descriptions based on a 5-point Likert scale. The mean and the coefficient for each question were calculated after expert scoring.

The degree of authority of each expert is expressed as the coefficient of reliability (Cr), which is calculated as the mean score of the self-assessment questionnaire. A Cr value ≥ 0.7 was considered a reliable counselling result.

Pairwise Comparison Method

The pairwise comparison (PC) method was used, as described in the GBD studies. Each PC question presented a pair of randomized health states with a brief narrative of the main characteristics of disease-specific and generic descriptions. Respondents were asked to compare the health states of two individuals selected at random and choose the healthier pair. All health states (2 health states of chronic cadmium poisoning and 13 health states in the severity spectrum) were matched, yielding a total of 210 (15 health states \times 14) possible combinations. Each questionnaire contained 15 pairwise PC questions randomly selected by the survey platform, *Wenjuanxing* from a pool of pairwise health state questions.

Subject Sampling

A multistage stratified random sampling method was used to randomly select two urban districts, two subdistricts in each district, one neighborhood committee for each subdistrict, and 120 potential respondents from each committee, which constituted the general population of this study.

Using a two-stage stratified sampling method based on the size of the clinical register, two primary, secondary, and tertiary hospitals were randomly selected, and 480 clinicians practicing at the selected hospitals were selected as the study population of medical professionals.

All potential participants were recruited online, and the questionnaires were distributed through the survey platform *Wenjuanxing* among WeChat groups of selected communities. Our research team was also included in WeChat groups to supervise the survey implementation. The study declaration about the aim of this survey, the specific requirements of questionnaires, and the confirmation of the voluntary nature of participation were also collected through WeChat groups.

Quality Control

A study team was established in response to quality control. Each question was answered in a self-administered questionnaire. In order to improve data quality, the following scales were performed with reference to the web-based DW survey of GBD study and the European study: 1) each respondent was allowed to complete the questionnaire only once; 2) participation was limited to respondents aged 18–70 years; 3) questionnaires with a response time < 3 min or any invalid response were excluded; and 4) responses with uniform selection such as all 'A' or all 'B' or perfectly alternating selection (e.g. A, B, A, B, etc) across the 15 PC questions were excluded. Finally, the logical validity was verified uniformly. In addition, for some participants, the same PC question was repeated, but in reverse order, to check test-retest reliability. In this study, 186 general and 182 medical professionals were randomly selected to assess the test-retest reliability. The test-retest reliability was 0.80 for the general population and 0.79 for the medical professionals.

Heatmaps Analysis

The horizontal axis represents the first health state and the vertical axis represents the second health state in each pairwise PC question. Each cell in the heat map indicates the response probability for one pairwise PC question, and its color corresponds to the probability that the first health state in a pairwise PC question was selected as a healthier outcome.

SUPPLEMENTARY TABLE S1. Specific and generic descriptions of health states for chronic cadmium poisoning and severity spectrum of health states used in the survey; Shenyang City, Liaoning Province, China, June–August 2022.

Serial number	Disease label	Professional description	Generic description
1	Mild vision disorder	Person experiencing some difficulty to read small newspaper print, despite sufficient correction with glasses, and no difficulty in recognizing faces at 4 m distance.	EQ-5D+C-3L: 112111 Can walk around. Can take care of themselves. Some difficulty in performing daily activities. Not having any pain or discomfort. Not feeling anxious or depressed. Does not have any difficulty with cognition. EQ-5D+C-3L: 212221 Some mobility problems. Can take care of himself/herself.
2	Chronic low back pain	Person with radiating pain low in the back, limited in sitting and to a smaller extent in walking; patient is generally restricted in all physical activities.	Some difficulty in carrying out daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any difficulty with cognition. EQ-5D+C-3L: 111221 Can walk around.
3	Breast cancer (disease-free stage without permanent sequelae)	Person who has undergone breast conserving therapy and local radiotherapy because of breast cancer more than one year ago, and who only experiences some discomfort; there are no signs of tumor recurrence.	Can take care of themselves. Can perform daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any cognitive difficulties. EQ-5D+C-3L: 112122 Can walk around.
4	Deafness	Person with severe congenital or early acquired hearing disorder.	Can take care of themselves. Some difficulty in performing daily activities. Not having any pain or discomfort. Having some degree of anxiety or depression. Having some difficulty with cognition. EQ-5D+C-3L: 111221 Can walk around.
5	Diabetes mellitus	Person with poor glycemic control despite careful adherence to insulin and diet, resulting in unexpected hypoglycemic attacks.	Can take care of themselves. Can perform daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any cognitive difficulties. EQ-5D+C-3L: 112122 Can walk around.
6	Mild dementia	Person with mild loss of recent memory and some problems in planning and organizing daily activities; the person is aware of the deterioration in cognitive function; the person is still capable of living independently.	Can take care of themselves. Some difficulty in performing daily activities. Not having any pain or discomfort. Having some degree of anxiety or depression. Having some difficulty with cognition. EQ-5D+C-3L: 112221 Can walk around.
7	Severe asthma	Person with recurrent attacks of severe shortness of breath, despite adequate therapy and careful adherence to therapy; these attacks limit the daily activities.	Can take care of themselves. Having some difficulty in performing daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any difficulty with cognition. EQ-5D+C-3L: 212321 Some mobility problems. Can take care of himself.
8	Coronary heart disease (stage at diagnosis and primary therapy)	Person with recurrent attacks of severe chest pain, typically provoked by mild exertion (such as walking up a short flight of stairs) or by cold weather. Attacks usually end within minutes with rest and medication.	Having some difficulty in carrying out daily activities. Feeling extreme pain or discomfort. Having some degree of anxiety or depression. Does not have any difficulty with cognition.

The Probit Regression Analysis and the Loess Model Calculation

For all pairwise problems, a value of 1 was assigned to a healthier state and a value of 0 was assigned to a less healthy state. A probability regression coefficient for each health state was calculated to reflect the relative severity compared with all other health states. We then focused on the 12 health states in the severity spectrum with a matching description between the GBD 2023 and the present study. Probability regression coefficients were used as

Continued

Serial number	Disease label	Professional description	Generic description
			EQ-5D+C-3L: 222222 Some mobility problems.
9	Stroke moderate impairments (acute incident plus rehabilitation phase)	Person with permanent impairments in movement, speech and memory after incomplete recovery from a stroke more than one year ago.	Some difficulty in washing face, brushing teeth, bathing or dressing. Some difficulty in carrying out daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any difficulty with cognition. EQ-5D+C-3L: 222221 Some mobility problems.
10	Colorectal cancer	Person after uneventful resection of the colon or bowel after colorectal cancer, still experiencing some pain from the wound; the patient has problems with stool requiring a dietary regimen and medication, and adaptive behaviour in social life.	Some difficulty in washing face, brushing teeth, bathing or dressing. Some difficulty in carrying out daily activities. Having some degree of pain or discomfort. Having some degree of anxiety or depression. Does not have any difficulty with cognition. EQ-5D+C-3L: 111131 Can walk around
11	HIV/AIDS (seropositive, asymptomatic)	Healthy person who knows that an incurable disease is acquired.	Can take care of themselves. Can perform daily activities. Not having any pain or discomfort. Feeling extremely anxious or depressed. Does not have any difficulty with cognition. EQ-5D+C-3L: 113233 Can walk around.
12	Severe depression	Person with strong feelings of emptiness and sadness, who has lost all interest, pleasure and energy, and has severe disturbances of sleep, appetite, concentration and cognition, despite treatment; daily activities can not be performed.	Can take care of themselves. Unable to perform daily activities. Having some degree of pain or discomfort. Feeling extremely anxious or depressed. Having severe cognitive functioning problems. EQ-5D+C-3L: 333221 Inability to get out of bed.
13	Quadriplegia	Person who is paralyzed from the neck downwards but can breathe independently; he/she is unable to move his/her arms or hands and is confined to a bed or special wheelchair.	Inability to wash your face, brush your teeth, bathe or dress yourself. Inability to perform daily activities. Having some degree of pain or discomfort. Have some degree of anxiety or depression. Not having any difficulty with cognition EQ-5D+C-3La: 111211
14	Mild chronic cadmium poisoning	Dizziness, fatigue, pain in the lower back and limbs, smell disorders, etc.	Can move around without any difficulty Can look after themselves without any difficulty Can carry out daily activities without any difficulty Feel moderate pain or discomfort Does not feel anxious or depressed Does not have any difficulty with cognition
15	Severe chronic cadmium poisoning	Chronic renal insufficiency (at the initial stage, there may be weakness, back pain, increased nocturia, loss of appetite; in severe cases, there may be high blood pressure, dyspnoea, inability to lie down, lack of concentration, memory loss, and even depression). May be accompanied by osteoporosis or osteochondrosis (bone pain, muscle weakness, easy to fracture)	EQ-5D+C-3L: 222222 Some difficulty moving around. Some difficulty in washing face, brushing teeth, bathing or dressing. Some difficulty in carrying out daily activities. Having some degree of pain or discomfort. Some degree of anxiety or depression. Some difficulty with cognition.

Note: The questionnaire consists of five dimensions (5D): mobility, self-care, activities of daily living, pain/discomfort, anxiety/depression, and an additional dimension: cognition (+C). Each dimension is assessed according to one of three levels of severity (3 L), i.e., "no problem," "problematic," and "severe problem."

Abbreviation: EQ-5D+C-3L=EuroQol 5-dimension plus cognition 3-level.

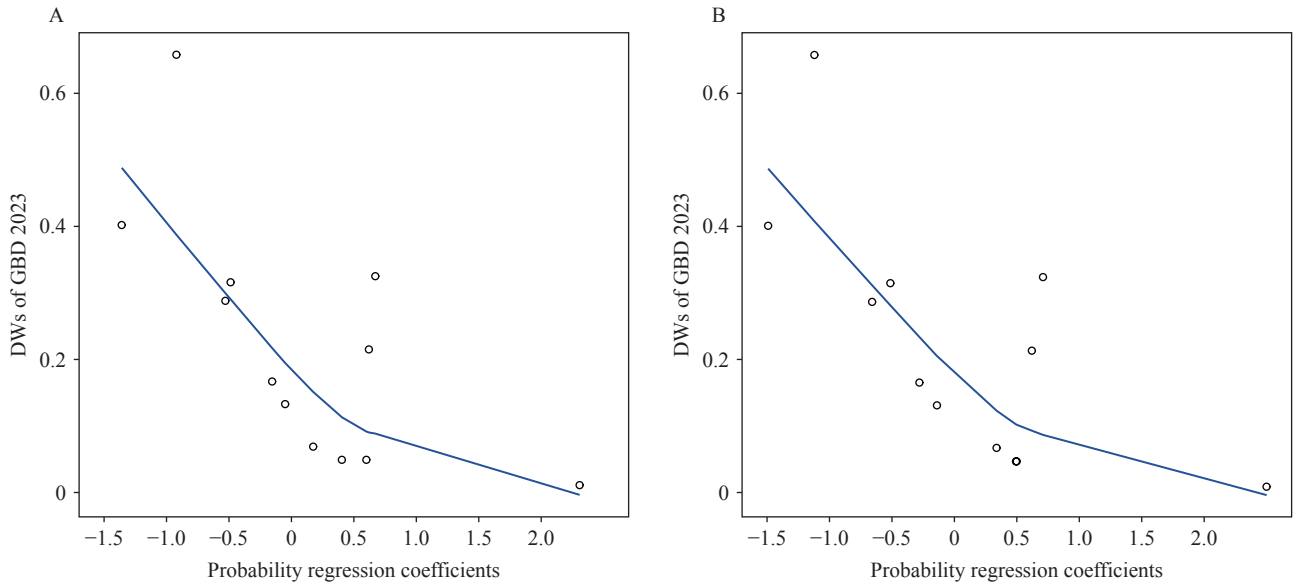
independent variables and the corresponding DWs in the GBD 2023 study were used as dependent variables. The Loess model was used to fit the regression curve between DWs and probability regression coefficients, based on which the DWs of 13 health states in the severity spectrum and two health states (mild and severe) for chronic cadmium poisoning were derived.

SUPPLEMENTARY TABLE S2. Consistency assessment of health state descriptions between the present study and GBD 2023 study using the Delphi method; Shenyang City, Liaoning Province, China, June–August 2022.

Serial number	Health states in the severity spectrum	GBD 2023 study		Cr [*]	
		Health state	Description	Mean	Coefficient
1	Mild vision disorder	Presbyopia	Has difficulty seeing things that are nearer than 3 feet but has no difficulty with seeing things at a distance.	3.70	0.26
2	Chronic low back pain	Back pain, severe, with leg pain	Has severe back and leg pain, which causes difficulty dressing, sitting, standing, walking, and lifting things. The person sleeps poorly and feels worried.	3.60	0.25
3	Breast cancer (disease-free stage without permanent sequelae)	Generic uncomplicated disease: worry and daily medication	Has a chronic disease that requires medication every day and causes some worry but minimal interference with daily activities.	3.85	0.21
4	Deafness	Hearing loss, complete	Cannot hear at all in any situation, including even the loudest sounds, and cannot communicate verbally or use a phone. Difficulties with communicating and relating to others often cause worry, depression or loneliness.	4.30	0.19
5	Diabetes mellitus	Generic uncomplicated disease: worry and daily medication	Has a chronic disease that requires medication every day and causes some worry but minimal interference with daily activities.	4.25	0.20
6	Mild dementia	Dementia: mild	Has some trouble remembering recent events and finds it hard to concentrate and make decisions and plans.	4.45	0.20
7	Severe asthma	Asthma, uncontrolled	Has wheezing, cough and shortness of breath more than twice a week, which causes difficulty with daily activities and sometimes wakes the person at night.	4.10	0.25
8	Coronary heart disease (stage at diagnosis and primary therapy)	Angina pectoris, severe	Has chest pain that occurs with minimal physical activity, such as walking only a short distance. After a brief rest, the pain goes away. The person avoids most physical activities because of the pain.	2.85	0.43
9	Stroke moderate impairments (acute incident plus rehabilitation phase)	Stroke: long term consequences, moderate plus cognition problems	Has some difficulty in moving around and some weakness in one hand but is able to walk without help.	3.40	0.26
10	Colorectal cancer	Cancer, diagnosis and primary therapy	Has pain, nausea, fatigue, weight loss and high anxiety.	3.25	0.28
11	HIV/AIDS (seropositive, asymptomatic)	Generic uncomplicated disease: anxiety about diagnosis	Has a disease diagnosis that causes some worry but minimal interference with daily activities.	4.00	0.29
12	Severe depression	Major depressive disorder: severe episode	Has overwhelming, constant sadness and cannot function in daily life. The person sometimes loses touch with reality and wants to harm or kill himself (or herself).	3.65	0.30
13	Quadriplegia	Motor impairment, severe	Unable to move around without help, and is not able to lift or hold objects, get dressed or sit upright.	4.50	0.13

Note: "*" The degree of authority of each expert is expressed as the coefficient of reliability (Cr), which is calculated as the mean score of the self-assessment questionnaire. A Cr value ≥ 0.7 was considered a reliable counselling result. Scores were assigned to the degree of consistency of the health state descriptions based on a 5-point Likert scale. The mean and the coefficient for each question were calculated after expert scoring. A mean value ≥ 3 and coefficient of variation ≤ 0.35 were considered a consensus.

Abbreviation: GBD=global burden of disease; Cr=coefficient of reliability.



SUPPLEMENTARY FIGURE S1. Loess model fit between DWs of the GBD 2023 study and probability regression coefficients. (A) General population; (B) Medical professionals. Abbreviation: DW=disability weight; GBD=global burden of disease.