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Preplanned Studies

Methods and Application

Notifiable Infectious Diseases Reports

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This week's issue were organized by Guest Editors Xin Sun and Meibian Zhang.

Preplanned Studies

Prevalence and Patterns of Multi-Site Musculoskeletal Disorders Among Occupational Populations in Key Industries — China, 2018–2023

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Summary

What is already known about this topic?

Work-related musculoskeletal disorders (WMSDs) represent a major global occupational health burden. Previous research has primarily focused on single-site WMSDs, with limited attention to multi-site WMSDs, which impose a substantially greater burden on health and the economy.

What is added by this report?

Multi-site WMSDs were more prevalent (26.4%) than single-site disorders (11.3%), accounting for 69.9% of all cases. The highest multi-site prevalence was seen in packaging and printing, healthcare, and nonferrous metal smelting. Female sex, higher education, prolonged standing, prolonged sitting, fixed postures, and insufficient rest were key risk factors, with risks rising with disorder severity.

What are the implications for public health practice?

Multi-site WMSDs impose a heavy burden on workers in China. Prevention and control strategies should prioritize high-risk industries and implement interventions targeting modifiable risk factors. WMSDs should be incorporated into the occupational disease surveillance system and promoted for inclusion in the statutory list of occupational diseases in China.

ABSTRACT

Introduction: This study investigated the prevalence, patterns, and risk factors of multi-site work-related musculoskeletal disorders (WMSDs) among workers in key industries across China.

Methods: A total of 88,609 workers from 441 enterprises across 29 industries were surveyed using stratified cluster sampling (2018–2023). The Chinese Musculoskeletal Disorders Questionnaire assessed symptoms. WMSDs were classified as single-site (1 body part), dual-site (2 body parts), triple-site (3 body parts), and over-3-site (>3 body parts). Cross-classified multilevel generalized linear mixed models identified associated factors.

Results: The prevalence of multi-site WMSDs was 26.4%, exceeding that of single-site disorders (11.3%), with multi-site cases comprising 69.9% of all WMSDs. Packaging and printing (28.0%), healthcare (20.5%), and nonferrous metal smelting (20.5%) exhibited the highest prevalence of multi-site WMSDs. Female sex was an independent risk factor for all WMSD types. Higher education levels correlated with increased risk, with a master's degree or above showing the strongest association with triple-site WMSDs. Prolonged standing, prolonged sitting, and fixed postures demonstrated dose–response relationships with WMSD severity. Insufficient rest was associated with the highest risk of multi-site WMSDs.

Conclusion: Multi-site WMSDs represented the predominant pattern among Chinese workers. Prevention strategies should prioritize high-risk industries and target modifiable factors, particularly insufficient rest and prolonged static postures.

Work-related musculoskeletal disorders (WMSDs) are conditions involving injuries or dysfunctions of muscles, bones, nerves, joints, tendons, ligaments, and cartilage that are induced or aggravated by occupational hazards such as adverse ergonomic factors during work activities, manifesting as pain, numbness, burning, tingling, limited movement, and related discomfort, thereby seriously threatening worker health (*1*). According to the Global Burden of Disease study, WMSDs account for 21.30% of disability-adjusted life years (DALYs), ranking third among all diseases (*2*). Compared with single-site involvement, patients with multi-site WMSDs are more prone to developing severe dysfunction, occupational absenteeism, increased medical burden, and reduced quality of life (*3*). Although low back pain and neck pain have been identified as major contributors to DALYs in the Global Burden of Disease Study (*4*), the prevalence pattern of multi-site WMSDs is often underestimated or overlooked in routine epidemiological surveillance. Previous studies have mostly focused on single-site WMSDs or specific high-risk industries, and epidemiological data on multi-site WMSDs based on nationally representative samples remain lacking. Using cross-sectional survey data from 88,609 workers at 441 enterprises across 29 industries provided in Supplementary Table S1 (available at https://weekly.chinacdc.cn/), this study systematically described the prevalence and distribution characteristics of multi-site WMSDs among occupational populations in China, providing a scientific basis for formulating precise hierarchical and classified intervention strategies.

A multistage stratified cluster random sampling approach was adopted. We selected 23 provincial-level administrative divisions (PLADs) across 7 regions, stratified industries by WMSD relevance, workforce size, and economic importance, and then sampled enterprises by size (large/medium/small/micro). Within each enterprise, all eligible frontline workers were cluster-sampled at the workshop level. From 2018 to 2023, 91,560 workers completed the questionnaire (Cronbach's α =0.86) via Quick Response (QR) code, yielding 88,609 valid responses (96.8% response rate). The survey employed a 1∶N format in which one investigator organized N respondents to scan the QR code of the electronic questionnaire and complete the survey online, with further elaboration provided in Supplementary Figure S1 (available at https://weekly.chinacdc.cn/).

The Chinese Version of the Musculoskeletal Disorders Questionnaire, embedded in the Ergonomic Assessment and Analysis System for WMSDs developed by the Department of Occupational Protection and Ergonomics at the National Institute of Occupational Health and Poison Control, was used. The electronic questionnaire included items on general information, musculoskeletal symptoms, and work conditions. The WMSD criteria followed the National Institute for Occupational Safety and Health (NIOSH) definition: the presence of discomfort such as pain, stiffness, burning, numbness, or tingling. Exclusion criteria included congenital spinal deformities and non-WMSD conditions due to trauma, infectious diseases, or malignant tumors, with further elaboration provided in Supplementary Material (available at https://weekly.chinacdc.cn/). WMSDs were categorized as single-site (1 body part) and multi-site, including dual-site (2 body parts), triple-site (3 body parts), and over-3-site (>3 body parts). All participants provided informed consent, and the study was approved by the Medical Ethics Review Committee of the National Institute of Occupational Health and Poison Control of the Chinese Centers for Disease Control and Prevention (NIOHP202122).

SPSS (version 29.0, SPSS Inc, Chicago, IL, USA) was used to characterize the basic demographic and occupational features of the surveyed population. Cross-classified multilevel generalized linear mixed models (CCMM) were employed to examine associations between potential risk factors and WMSDs, accounting for unobserved clustering at both regional and industrial levels. Statistical significance was set at a two-tailed α level of 0.05.

Among the 83,006 respondents, 31,314 had WMSDs (37.7%), including 9,418 with single-site (11.3%) and 21,896 with multi-site (26.4%) disorders. Among multi-site WMSDs, 6,574 were dual-site (20.99%), 4,779 were triple-site (15.26%), and 10,543 were over-3-site (33.67%). Patients with multi-site WMSDs accounted for 69.9% of all WMSD cases, indicating that multi-site involvement represents the predominant manifestation of WMSDs among occupational populations in China (Table 1).

Significant variations in multi-site WMSD prevalence were observed across industries. The top three industries for dual-site WMSDs were packaging and printing (20.00%), general aviation services (11.26%), and electricity, heat, gas, and water production and supply (9.30%). For triple-site WMSDs, the top three were packaging and printing (28.00%), healthcare (10.84%), and animal husbandry (10.20%). For over-3-site WMSDs, the leading four were toy manufacturing (26.77%), packaging and printing (26.00%), nonferrous metal smelting and pressing (20.54%), and healthcare (20.54%). Packaging and printing ranked among the high-prevalence industries across all multi-site categories, representing a key high-risk industry for multi-site WMSDs (Figure 1).

The prevalence of WMSDs by site number is presented in Supplementary Tables S2–S3 (available at https://weekly.chinacdc.cn/). Cross-classified multilevel generalized linear mixed model (CCMM) analysis revealed that the industry-level intraclass correlation coefficient (ICC) increased with the

TABLE 1. Distribution of musculoskeletal disorders by number of affected body parts among occupational populations in China (*N*=83,006).

Category	*n*	Proportion of total population (%)	Proportion of all WMSDs patients (%)
Single-site WMSDs (1 body part)	9,418	11.3	30.08
Multi-site WMSDs (≥2 body parts)			
Dual-site (2 body parts)	6,574	7.9	20.99
Triple-site (3 body parts)	4,779	5.8	15.26
Over-3-site (>3 body parts)	10,543	12.7	33.67
Total	31,314	37.7	100.00

Note: 5,603 non-frontline workers (logistics, office, and management) were excluded from the analysis.
Abbreviation: WMSDs=work-related musculoskeletal disorders.

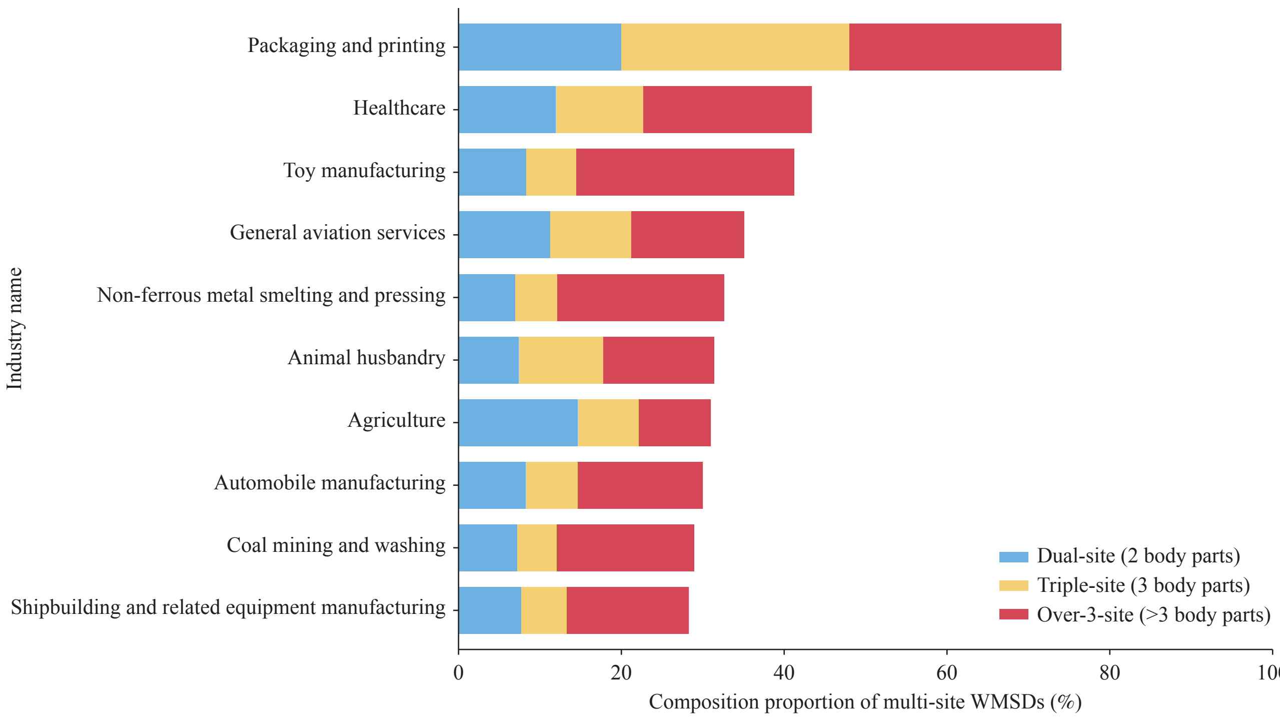

FIGURE 1. Top 10 industries with the highest prevalence of multi-site musculoskeletal disorders (*n*=83,006).
Abbreviation: WMSDs=work-related musculoskeletal disorders.

number of affected body sites, suggesting that the risk of multi-site WMSDs was more strongly influenced by industrial factors. The city-level ICC remained below 4% across all subgroups, reflecting a minor impact of regional disparities. The median odds ratio (MOR) results were consistent with the ICC trends. In addition, sex, age, education, physical exercise, ergonomic exposure, and work organizational factors were significantly associated with WMSD risk at different severity levels, with varying trends in effect strength as the number of affected sites increased (Table 2). Female sex was identified as an independent risk factor for all WMSD types. Using males as the reference group, females had a significantly higher risk for all WMSD types, and the protective effect of male sex increased gradually with disease severity. Age showed a non-linear association with WMSD risk. Using the <30-year group as the reference, the 30–39-year group showed a significantly elevated risk for all WMSDs. Education showed a significant positive correlation with WMSD risk. Using junior high school and below as the reference group, the risk progressively increased with education level. Physical exercise demonstrated protective effects.

For ergonomic risk factors, very frequent prolonged standing, prolonged sitting, fixed neck posture, trunk bending and twisting, wrist bending, and fixed back posture significantly increased risk for all WMSDs,

TABLE 2. Multilevel modeling analysis of WMSDs among frontline workers.

Variable	*aOR* (95% *CI*)			
	Single-site (1 body part)	Dual-site (2 body parts)	Triple-site (3 body parts)	Over-3-site (>3 body parts)
Fixed effects				
Gender				
Male	1	1	1	1
Female	1.19 (1.12, 1.27)	1.50 (1.40, 1.62)	1.66 (1.52, 1.82)	1.71 (1.60, 1.84)
Age (years)				
<30	1	1	1	1
30–34	1.06 (1.00, 1.13)	1.18 (1.10, 1.27)	1.17 (1.07, 1.28)	1.11 (1.04, 1.19)
35–39	1.12 (1.04, 1.21)	1.15 (1.05, 1.25)	1.21 (1.09, 1.34)	1.17 (1.08, 1.26)
40–44	1.07 (0.98, 1.17)	1.10 (0.99, 1.22)	1.12 (0.99, 1.27)	1.12 (1.02, 1.23)
45–49	1.10 (1.01, 1.21)	0.99 (0.88, 1.11)	0.99 (0.86, 1.14)	1.08 (0.97, 1.19)
50–54	1.02 (0.91, 1.15)	1.05 (0.91, 1.20)	1.11 (0.94, 1.31)	1.04 (0.92, 1.18)
55–59	1.20 (1.01, 1.41)	1.17 (0.95, 1.45)	1.01 (0.77, 1.33)	0.98 (0.80, 1.20)
≥60	0.97 (0.83, 1.13)	1.03 (0.86, 1.23)	1.12 (0.92, 1.37)	1.12 (0.96, 1.30)
Education				
Junior high and below	1	1	1	1
Senior high/technical	1.10 (1.04, 1.18)	1.10 (1.01, 1.19)	1.18 (1.07, 1.30)	1.12 (1.05, 1.20)
College and undergraduate	1.29 (1.20, 1.40)	1.29 (1.17, 1.41)	1.43 (1.28, 1.60)	1.23 (1.13, 1.33)
Master's and above	1.44 (1.16, 1.79)	1.49 (1.18, 1.88)	1.60 (1.23, 2.08)	1.08 (0.86, 1.37)
BMI (kg/m²)				
<18.5	1	1	1	1
18.5–23.9	1.00 (0.92, 1.09)	1.00 (0.90, 1.10)	1.09 (0.98, 1.23)	1.02 (0.94, 1.11)
24.0–27.9	1.04 (0.95, 1.14)	1.03 (0.93, 1.15)	1.16 (1.02, 1.31)	1.01 (0.92, 1.11)
≥28.0	1.06 (0.95, 1.19)	1.07 (0.94, 1.22)	1.16 (1.00, 1.35)	1.13 (1.01, 1.26)
Physical exercise				
No	1	1	1	1
Occasionally	0.89 (0.85, 0.94)	0.91 (0.85, 0.96)	0.90 (0.84, 0.96)	0.97 (0.92, 1.03)
2–3 times/month	0.88 (0.78, 0.99)	0.97 (0.85, 1.10)	0.92 (0.79, 1.08)	0.95 (0.84, 1.07)
2–3 times/week	0.82 (0.74, 0.90)	0.85 (0.76, 0.95)	0.86 (0.76, 0.98)	0.89 (0.80, 0.98)
>2 times/week	0.82 (0.73, 0.91)	0.84 (0.74, 0.96)	0.64 (0.54, 0.76)	0.84 (0.75, 0.95)
Workplace risk factors				
Standing often at work				
No	1	1	1	1
Occasionally	1.00 (0.92, 1.09)	1.00 (0.90, 1.10)	1.02 (0.91, 1.14)	0.98 (0.89, 1.07)
Frequent	1.10 (1.01, 1.18)	1.20 (1.09, 1.33)	1.13 (1.00, 1.28)	1.10 (1.01, 1.21)
Very frequent	1.19 (1.08, 1.30)	1.54 (1.39, 1.72)	1.48 (1.31, 1.68)	1.48 (1.34, 1.63)
Sitting often at work				
No	1	1	1	1
Occasionally	0.92 (0.87, 0.98)	0.92 (0.86, 1.00)	0.91 (0.83, 0.99)	0.88 (0.82, 0.94)
Frequent	1.09 (1.01, 1.18)	1.28 (1.17, 1.40)	1.36 (1.23, 1.51)	1.30 (1.20, 1.40)
Very frequent	1.19 (1.08, 1.30)	1.56 (1.40, 1.73)	1.80 (1.60, 2.02)	1.63 (1.49, 1.78)
Fixed neck posture				
No	1	1	1	1

Continued

Variable	a*OR* (95% *CI*)			
	Single-site (1 body part)	Dual-site (2 body parts)	Triple-site (3 body parts)	Over-3-site (>3 body parts)
Yes	1.21 (1.15, 1.33)	1.50 (1.37, 1.64)	1.55 (1.38, 1.73)	1.40 (1.30, 1.53)
Frequent repetitive lower limb/ankle movements				
No	1	1	1	1
Yes	0.99 (0.94, 1.05)	1.08 (1.02, 1.15)	1.15 (1.07, 1.24)	1.64 (1.56, 1.73)
Lifting heavy loads (more than 20 kg)				
No	1	1	1	1
Occasionally	1.01 (0.95, 1.06)	1.03 (0.96, 1.10)	1.07 (0.99, 1.16)	1.32 (1.25, 1.40)
Frequent	0.98 (0.90, 1.07)	1.13 (1.03, 1.25)	1.10 (0.98, 1.24)	1.49 (1.37, 1.61)
Very frequent	1.03 (0.92, 1.16)	1.16 (1.02, 1.32)	1.06 (0.91, 1.24)	1.58 (1.43, 1.75)
Trunk bending and twisting				
No	1	1	1	1
Yes	1.11 (1.05, 1.17)	1.09 (1.02, 1.16)	1.26 (1.17, 1.35)	1.49 (1.41, 1.57)
Wrist bending				
No	1	1	1	1
Yes	1.02 (0.97, 1.07)	1.14 (1.07, 1.21)	1.24 (1.16, 1.33)	1.68 (1.59, 1.77)
Prolonged fixed back posture				
No	1	1	1	1
Yes	1.14 (1.08, 1.21)	1.17 (1.09, 1.25)	1.21 (1.11, 1.32)	1.21 (1.14, 1.29)
Work organizational factors				
Frequent overtime				
No	1	1	1	1
Yes	1.11 (1.05, 1.16)	1.15 (1.08, 1.22)	1.14 (1.06, 1.22)	1.24 (1.18, 1.32)
Insufficient rest				
No	0.72 (0.69, 0.76)	0.63 (0.60, 0.67)	0.54 (0.50, 0.58)	0.44 (0.42, 0.47)
Yes	1	1	1	1
Staff shortages				
No	1	1	1	1
Yes	1.14 (1.08, 1.19)	1.17 (1.10, 1.24)	1.17 (1.09, 1.25)	1.40 (1.33, 1.47)
Do same working				
No	1	1	1	1
Yes	1.18 (1.10, 1.28)	1.12 (1.02, 1.23)	1.43 (1.28, 1.62)	1.36 (1.24, 1.49)
Job rotation				
No	1.00 (0.95, 1.06)	1.03 (0.97, 1.10)	1.06 (0.98, 1.15)	1.14 (1.07, 1.21)
Yes	1	1	1	1
Random effects				
City level				
ICC (%)	2.78	3.33	3.57	3.09
mOR	1.34	1.38	1.43	1.39
Industry level				
ICC (%)	1.09	2.15	11.52	10.34
mOR	1.20	1.30	1.89	1.82

Abbreviation: WMSD=work-related musculoskeletal disorders; a*OR*=adjusted odds ratio; BMI=body mass index; *CI*=confidence interval; ICC=intraclass correlation coefficient; mOR=median odds ratio.

with the greatest risk amplification observed for multi-site WMSDs.

Among work organizational factors, frequent overtime, insufficient rest, and staff shortage were associated with elevated WMSD risk. Compared with insufficient rest, adequate rest reduced the risk of multi-site WMSDs. Performing the same work repeatedly increased the risk of all WMSDs, whereas job rotation showed a protective effect against over-3-site WMSDs.

DISCUSSION

From 2018 to 2023, all annual surveys adopted a standardized research protocol and questionnaire. Therefore, all valid data were pooled for comprehensive analysis to enhance statistical power. The prevalence of multi-site WMSDs among occupational populations in China reached 26.4%, substantially exceeding the single-site prevalence (11.3%), with multi-site cases accounting for 69.9% of all WMSDs. This finding indicates that multi-site WMSDs are highly prevalent and cause functional impairment, medical burden, and productivity loss that exceed those of single-site disorders.

Regarding industry distribution, packaging and printing ranked among the high-prevalence industries for dual-site, triple-site, and over-3-site WMSDs, suggesting that high-intensity repetitive operations and prolonged fixed postures characterize this industry. The healthcare and nonferrous metal smelting and pressing industries displayed over-3-site WMSD prevalence exceeding 20.5%, likely related to occupational characteristics (*5*) that contribute to cumulative multi-site musculoskeletal damage. In toy manufacturing, the prevalence of over-3-site WMSDs reached 26.77%. Given the relatively small sample size of this industry, these results cannot be generalized.

Based on CCMM analysis, female sex was identified as an independent risk factor for all WMSD types, and the sex difference became increasingly pronounced with a greater number of affected body sites. Compared with males (reference group), the adjusted odds ratios (a*OR*) for females were 1.19, 1.50, 1.66, and 1.71 for single-site, dual-site, triple-site, and over-3-site WMSDs, respectively. This finding aligns with the Global Burden of Disease study and previous occupational health surveys (*2*,*6*) and may relate to lower spinal load-bearing capacity in females, hormonal differences, and the dual burden of domestic labor. Accordingly, strengthening gender-targeted protection strategies for female workers is critical, with focused attention on the prevention and intervention of multi-site musculoskeletal disorders in high-risk female populations. Education was positively correlated with WMSD risk, with the strongest dose–response relationship observed for triple-site WMSDs (master's degree and above: a*OR*=1.60), possibly because highly educated individuals more frequently engage in sedentary work, experience greater psychological stress, and hold higher occupational expectations (*7*). Highly educated employees predominantly engage in prolonged sedentary work with long-term static loading, causing sustained tension of the cervical, shoulder, lumbar, and wrist muscles, local microcirculation disturbance, metabolic by-product accumulation, and chronic fascial strain, thereby increasing physiological susceptibility to multi-site musculoskeletal injuries. They also face heavy work pressure; chronic stress alters somatic nerve excitability, induces muscle contraction, and reduces pain tolerance, while higher career expectations reduce recovery time, leading to cumulative adverse occupational exposure.

Ergonomic factors demonstrated significant dose–response relationships between adverse posture exposure and WMSD risk. Very frequent prolonged standing and sitting exhibited the strongest effects for multi-site WMSDs (≥2 body parts) (a*OR*>1.4), while prolonged fixed neck and back postures displayed the most prominent effects for over-3-site WMSDs (a*OR*=1.55 and 1.21, respectively). This confirms that multi-site WMSDs are not simple additions of single-site disorders but result from systemic ergonomic load accumulation, with cumulative adverse ergonomic exposure serving as the core driver of multi-site damage (*8*). Frequent repetitive lower limb/ankle movements shifted from protective for single-site WMSDs (a*OR*=0.99) to a risk factor for over-3-site WMSDs (a*OR*=1.64), further confirming the unique pathogenic pattern of multi-site WMSDs.

Among work organization factors, sufficient rest was the strongest protective factor for all WMSDs, with the most pronounced association identified for over-3-site WMSDs (a*OR*=0.44). Adequate rest can effectively relieve musculoskeletal strain and reduce cumulative occupational physical damage (*9*). Physical exercise also served as a protective factor against WMSDs. Therefore, increasing physical activity is recommended to reduce the incidence of WMSDs.

This study has two major strengths. The large sample size ensures good representativeness of the occupational population, and the use of validated standardized tools fills the domestic multi-site WMSD data gap with sound external validity.

In conclusion, future interventions should prioritize the following: first, industry-specific interventions for printing and toy manufacturing should reduce repetitive motions through automation while optimizing ergonomic design; for healthcare, mandatory implementation of rest break systems and proper patient-handling technique training are essential; and finally, multi-site WMSDs should be incorporated into China's occupational disease surveillance system to dynamically monitor high-risk industry trends and precisely target prevention priorities.

The findings in this report are subject to at least three limitations. First, the cross-sectional design cannot establish causal relationships between risk factors and WMSDs; it captures only associations at a single point in time, which may introduce temporal ambiguity regarding exposure and outcome sequences. Second, retrospective self-reporting of symptoms may involve recall bias, potentially leading to underestimation or overestimation of symptom severity and affecting the accuracy of associations between exposures and outcomes. Finally, the study focused on frontline operational personnel, which may limit generalizability to other occupational populations such as administrative staff or management personnel.

These findings highlight that multi-site WMSDs constitute the predominant pattern of WMSDs among occupational populations in China. Targeted prevention strategies should prioritize high-risk industries, including packaging and printing, toy manufacturing, and healthcare. This study suggests that implementing standardized rest break policies and reducing prolonged static postures can effectively prevent multi-site WMSDs. Workplace interventions should focus on modifiable ergonomic risk factors, with key protective measures tailored for female workers. In line with International Labour Organization occupational safety guidelines, China should integrate multi-site WMSDs into the national occupational disease surveillance system and strengthen legal safeguards for targeted preventive interventions.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY MATERIAL

Questionnaire Survey

The Chinese version of the Musculoskeletal Disorders Survey (*1*), embedded within the work-related musculoskeletal disorders (WMSDs) Ergonomic Assessment and Analysis System developed by the Department of Occupational Protection and Ergonomics, National Institute of Occupational Health and Poison Control, Chinese Center for Disease Control and Prevention, was used to investigate general characteristics, WMSD occurrence, and associated risk factors among key occupational populations across various regions of China. The questionnaire demonstrated good internal consistency, with a Cronbach's α coefficient of 0.86. Survey content encompassed three domains: general characteristics, musculoskeletal symptom occurrence, and occupational characteristics.

Quality Control

During the initial study design phase, research objectives and survey strategies were clearly defined, with core content and key indicators for investigation and analysis established to minimize information bias. The survey team comprised professional technical personnel from provincial-level administrative division (PLAD)-level centers for disease control and prevention and occupational disease prevention and treatment institutes, all of whom received systematic training on professional knowledge and research protocols to ensure consistency and accuracy in questionnaire administration. Prior to survey implementation, all investigators underwent standardized training to ensure full comprehension of research objectives, significance, and survey methods. During data collection, uniform survey content and completion standards were strictly enforced. Face-to-face centralized questionnaire completion was conducted, with on-site real-time review to ensure the authenticity and reliability of information. To address potential logical errors, the questionnaire incorporated built-in logic correction functions and completeness verification mechanisms, enabling timely verification, supplementation, and correction of omissions, missing data, and logical inconsistencies, thereby ensuring the data quality and scientific validity of the research findings.

Diagnostic Criteria for WMSDs

WMSDs were defined according to the National Institute for Occupational Safety and Health (NIOSH) criteria (*2*). A case was confirmed when all four of the following conditions were met simultaneously: 1) presence of symptoms including pain, stiffness, burning sensation, numbness, or tingling; 2) symptoms occurring during the preceding 12 months; 3) symptom onset after beginning current employment; and 4) no prior accidents or acute injuries affecting the symptomatic body region. Additionally, symptoms had to have occurred at least monthly or persisted for more than one week to qualify as WMSDs in the affected body region.

Study Design and Participants

This study employed a multistage stratified cluster sampling method. Industries were stratified based on their association with WMSDs, workforce size, and economic importance to the national economy. Within each stratum, cluster sampling was conducted by enterprise size (large, medium, small, and micro enterprises) to select representative enterprises, with on-duty workers selected as the study subjects to ensure sample representativeness and diversity. The study covered 9 major categories of national economic industries, including agriculture, forestry, animal husbandry, and fishery; mining; manufacturing; production and supply of electricity, heat, gas, and water; construction; wholesale and retail trade; transportation, warehousing, and postal services; resident services, repair, and other services; and health and social work, involving 29 specific industries or job types. A total of 441 enterprises were included, comprising 72 large enterprises (16.3%), 48 medium enterprises (10.9%), 182 small enterprises (41.3%), and 139 micro enterprises (31.5%). The number of surveyed workers by industry nationwide is shown in Supplementary Table S1; the national sampling flowchart is shown in Supplementary Figure S1. The prevalence of WMSDs by number of affected body sites is shown in Supplementary Tables S2–S3.

SUPPLEMENTARY TABLE S1. Number of surveyed participants by industry nationwide.

No.	Industry (Code)	Frequency
1	Packaging and Decoration, and Other Printing (C2319)	50
2	Animal Husbandry (A03)	245
3	Shipbuilding and Related Equipment Manufacturing (C373)	3,431
4	Road Transport (G54)	2,296
5	Production and Supply of Electric Power, Heat, Gas, and Water (D44)	86
6	Electrical Machinery and Equipment Manufacturing (C38)	3,434
7	Smelting and Rolling of Ferrous Metals (C31)	3,494
8	Manufacture of Chemical Raw Materials and Chemical Products (C26)	95
9	Manufacture of Computers, Communication, and Other Electronic Equipment (C39)	10,638
10	Furniture Manufacturing (C21)	9,004
11	Construction (E47)	1,434
12	Metal Products (C33)	3,195
13	Coal Mining and Washing (B06)	3,356
14	Agriculture (A01)	239
15	Automobile Repair and Maintenance (O8111)	777
16	Automobile Manufacturing (C36)	21,759
17	Petrochemical Industry (C251)	150
18	Food Manufacturing (C14)	828
19	Manufacture of Cement, Lime and Plaster (C301)	194
20	Manufacture of Railway Transport Equipment (C371)	1,674
21	General Aviation Services (G562)	1,341
22	Toy Manufacturing (C245)	325
23	Health Services (Q84)	7,011
24	Pharmaceutical Manufacturing (C27)	1,738
25	Non-ferrous Metal Ore Mining and Dressing (B09)	1,225
26	Smelting and Rolling of Non-ferrous Metals (C32)	2,312
27	Footwear Manufacturing (C195)	7,100
28	Handling, Loading and Unloading, and Warehousing (G59)	92
29	General Retail Trade (F521)	1,086
Total		88,609

SUPPLEMENTARY TABLE S2. Characteristics and proportions of populations with different numbers of affected sites of WMSDs.

Basic variables	*N*	Single-site (1 body part)		Dual-site (2 body parts)		Triple-site (3 body parts)		Over-3-site (>3 body parts)	
		n	Proportion (%)	*n*	Proportion (%)	*n*	Proportion (%)	*n*	Proportion (%)
Gender									
Male	56,149	6,176	11.0	3,982	7.1	2,753	4.9	6,692	11.9
Female	26,857	3,242	12.1	2,592	9.7	2,026	7.5	3,851	14.3
Age (years)									
<30	29,245	3,305	11.3	2,294	7.8	1,716	5.9	3,850	13.2
30–34	16,837	1,926	11.4	1,490	8.8	1,078	6.4	2,273	13.5
35–39	11,660	1,374	11.8	949	8.1	706	6.1	1,503	12.9
40–44	8,641	979	11.3	681	7.9	482	5.6	1,051	12.2
45–49	7,809	902	11.6	544	7.0	372	4.8	914	11.7
50–54	4,748	495	10.4	323	6.8	223	4.7	512	10.8
55–59	1,665	205	12.3	122	7.3	65	3.9	135	8.1
≥60	2,401	232	9.7	171	7.1	137	5.7	305	12.7
Education									
Junior high and below	27,285	2,942	10.8	1,885	6.9	1,197	4.4	2,789	10.2
Senior high/technical	30,861	3,395	11.0	2,330	7.5	1,696	5.5	4,073	13.2
College and undergraduate	23,814	2,942	12.4	2,225	9.3	1,779	7.5	3,533	14.8
Master’s and above	1,046	139	13.3	134	12.8	107	10.2	148	14.1
BMI (kg/m²)									
<18.5	6,896	795	11.5	585	8.5	412	6.0	924	13.4
18.5–23.9	47,311	5,341	11.3	3,756	7.9	2,763	5.8	6,013	12.7
24.0–27.9	21,433	2,447	11.4	1,653	7.7	1,199	5.6	2,579	12.0
≥28.0	7,366	835	11.3	580	7.9	405	5.5	1,027	13.9
Physical exercise									
No	25,892	3,233	12.5	2,236	8.6	1,622	6.3	3,481	13.4
Occasionally	43,229	4,716	10.9	3,289	7.6	2,429	5.6	5,475	12.7
2–3 times/month	3,675	403	11.0	306	8.3	218	5.9	440	12.0
2–3 times/week	5,952	614	10.3	434	7.3	332	5.6	684	11.5
>2 times/week	4,258	452	10.6	309	7.3	178	4.2	463	10.9

Abbreviation: WMSDs=work-related musculoskeletal disorders; BMI=body mass index.

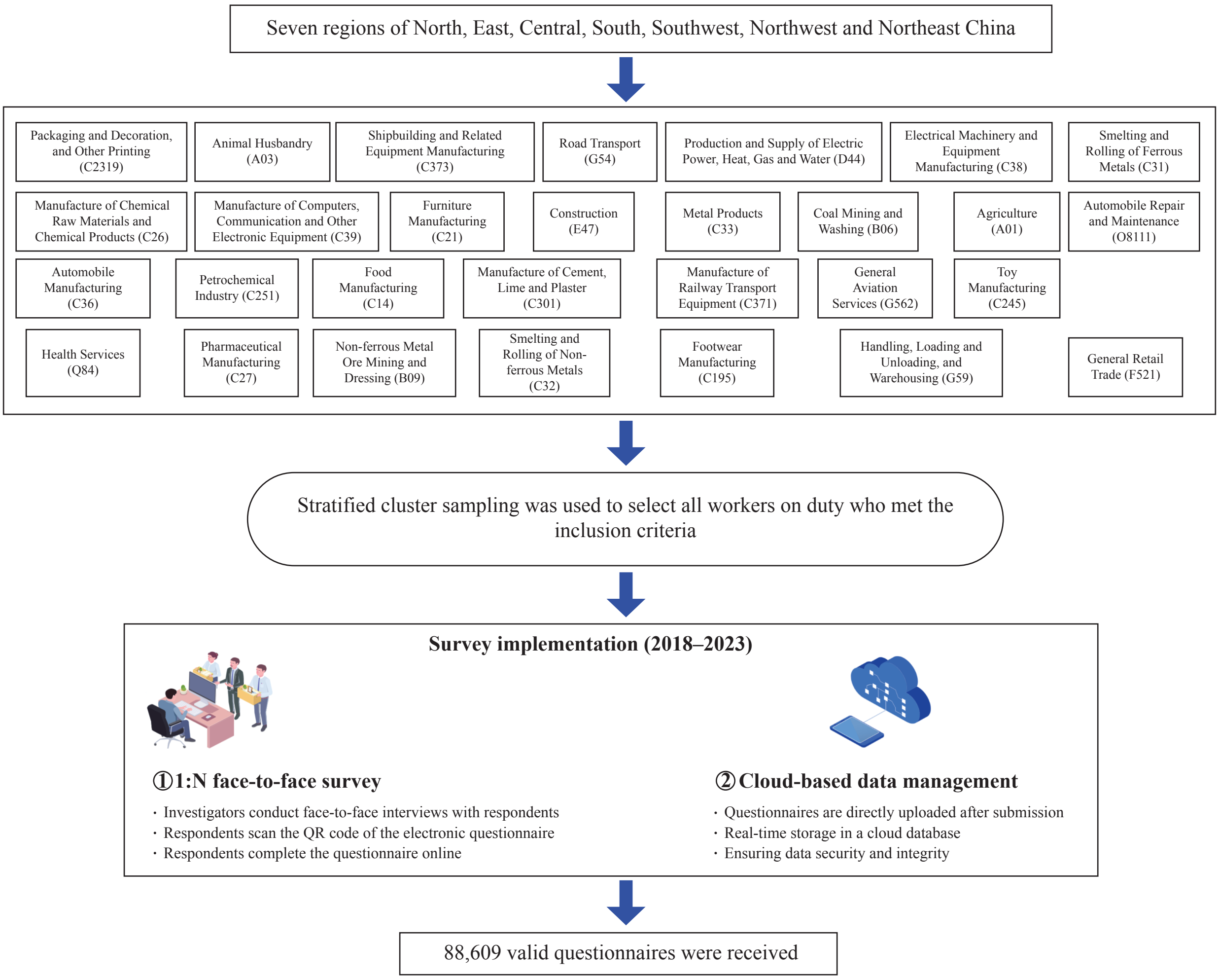
SUPPLEMENTARY TABLE S3. Characteristics and proportions of populations with different numbers of affected sites of WMSDs.

Work related variables	*N*	Single-site (1 body part)		Dual-site (2 body parts)		Triple-site (3 body parts)		Over-3-site (>3 body parts)	
		n	Proportion (%)	*n*	Proportion (%)	*n*	Proportion (%)	*n*	Proportion (%)
Workplace risk factors									
Standing often at work									
No	12,701	1,294	10.2	987	7.8	745	5.9	1,358	10.7
Occasionally	18,427	1,859	10.1	1,266	6.9	944	5.1	1,761	9.6
Frequent	27,979	3,134	11.2	2,070	7.4	1,446	5.2	3,295	11.8
Very frequent	23,899	3,131	13.1	2,251	9.4	1,644	6.9	4,129	17.3
Sitting often at work									
No	37,069	4,465	12.0	2,900	7.8	1,979	5.3	4,826	13.0
Occasionally	23,919	2,548	10.7	1,656	6.9	1,160	4.8	2,434	10.2
Frequent	13,754	1,510	11.0	1,195	8.7	919	6.7	1,866	13.6
Very frequent	8,264	895	10.8	823	10.0	721	8.7	1,417	17.1
Fixed neck posture									
No	34,212	3,741	10.9	2,112	6.2	1,370	4.0	2,550	7.5
Yes	48,794	5,677	11.6	4,462	9.1	3,409	7.0	7,993	16.4
Frequent repetitive lower limb/ankle movements									
No	49,758	5,885	11.8	3,833	7.7	2,584	5.2	4,167	8.4
Yes	33,248	3,533	10.6	2,741	8.2	2,195	6.6	6,376	19.2
Lifting heavy loads (>20 kg)									
No	45,236	5,296	11.7	3,664	8.1	2,638	5.8	4,602	10.2
Occasionally	24,911	2,720	10.9	1,848	7.4	1,408	5.7	3,510	14.1
Frequent	8,840	929	10.5	691	7.8	479	5.4	1,488	16.8
Very frequent	4,019	473	11.8	371	9.2	254	6.3	943	23.5
Trunk bending and twisting									
No	47,513	5,305	11.2	3,597	7.6	2,393	5.0	3,918	8.2
Yes	35,493	4,113	11.6	2,977	8.4	2,386	6.7	6,625	18.7
Wrist bending									
No	47,700	5,500	11.5	3,497	7.3	2,300	4.8	3,650	7.7
Yes	35,306	3,918	11.1	3,077	8.7	2,479	7.0	6,893	19.5
Prolonged fixed back posture									
No	34,620	3,902	11.3	2,310	6.7	1,458	4.2	2,523	7.3
Yes	48,386	5,516	11.4	4,264	8.8	3,321	6.9	8,020	16.6
Work organizational factors									
Frequent overtime									
No	41,660	4,527	10.9	3,027	7.3	2,152	5.2	4,119	9.9
Yes	41,346	4,891	11.8	3,547	8.6	2,627	6.4	6,424	15.5
Insufficient rest									
No	41,799	4,383	10.5	2,649	6.3	1,635	3.9	2,721	6.5
Yes	41,207	5,035	12.2	3,925	9.5	3,144	7.6	7,822	19.0
Staff shortages									
No	47,181	5,179	11.0	3,368	7.1	2,273	4.8	4,098	8.7

Continued

Work related variables	N	Single-site (1 body part)		Dual-site (2 body parts)		Triple-site (3 body parts)		Over-3-site (>3 body parts)	
		n	Proportion (%)	n	Proportion (%)	n	Proportion (%)	n	Proportion (%)
Yes	35,825	4,239	11.8	3,206	8.9	2,506	7.0	6,445	18.0
Do same working									
No	9,271	920	9.9	617	6.7	338	3.6	662	7.1
Yes	73,735	8,498	11.5	5,957	8.1	4,441	6.0	9,881	13.4
Job rotation									
No	38,913	4,471	11.5	3,250	8.4	2,396	6.2	5,316	13.7
Yes	44,093	4,947	11.2	3,324	7.5	2,383	5.4	5,227	11.9

Abbreviation: WMSDs=work-related musculoskeletal disorders.



SUPPLEMENTARY FIGURE S1. Implementation Process of the Study.

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Preplanned Studies

Associations of Occupational Noise Exposure with Hearing-Related Functional Difficulty and Menstrual Abnormalities Among Female Workers — Selected Regions, China, 2024–2025

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Summary

What is already known about this topic?

Occupational noise exposure is a well-established risk factor for adverse auditory outcomes. Emerging evidence suggests it may also affect women's reproductive health.

What is added by this report?

Among 1,538 female workers, high occupational noise exposure was associated with hearing-related functional difficulty [adjusted odds ratio a*OR*=1.79, 95% confiden ceinterval (*CI*): 1.30–2.46] and menstrual abnormalities (a*OR*=2.70, 95% *CI*: 1.96–3.73). These findings remained consistent in sensitivity analyses for menstrual abnormalities, and mean noise annoyance was higher in the high-noise group (2.61 *vs.* 2.22). Indirect effects through noise annoyance were modest for hearing-related outcomes and not statistically significant for menstrual abnormalities.

What are the implications for public health practice?

Occupational noise management for female workers should consider hearing and menstrual health effects, with greater attention to female reproductive health in risk assessments and surveillance.

ABSTRACT

Introduction: This study examined the associations among occupational noise exposure, hearing-related functional difficulty, and menstrual abnormalities in female workers, and explored the potential role of noise annoyance.

Methods: In this cross-sectional survey, 3,283 female workers were screened, and 1,538 were included in the final analysis. Multivariate logistic regression and exploratory mediation analyses were conducted with bootstrap resampling.

Results: The prevalence rates of menstrual abnormalities and hearing-related functional difficulties were 22.82% and 17.88%, respectively. High occupational noise exposure was associated with higher odds of hearing-related functional difficulty [adjusted odds ratio (a*OR*)=1.79, 95% confidence interval (*CI*): 1.30–2.46] and menstrual abnormalities (a*OR*=2.70, 95% *CI*: 1.96–3.73). Sensitivity analyses for menstrual abnormalities yielded consistent results. In the exploratory mediation analyses, the indirect effect estimates were modest for hearing-related outcomes and not statistically significant for menstrual abnormalities.

Conclusion: High occupational noise exposure is associated with higher odds of hearing-related functional difficulties and menstrual abnormalities in female workers. Noise annoyance may represent a potential explanatory pathway for hearing-related outcomes; however, the mediation findings should be interpreted cautiously.

Occupational noise is a pervasive hazard in modern industries, and its adverse effects extend beyond the auditory system (*1*). As an environmental stressor, noise can disrupt endocrine equilibrium. Emerging evidence suggests that chronic noise exposure is associated with menstrual abnormalities. However, the mechanisms linking physical exposure to reproductive outcomes remain unclear.

Noise annoyance has been proposed as a psychophysiological stress-related response that may explain how noise exposure affects health. This rationale is supported by a systematic review and meta-analysis showing that high noise annoyance is associated with poorer mental health outcomes. A recent systematic review suggests that noise annoyance is among the most plausible mediating pathways linking noise exposure to adverse health effects (*2–3*). Recent reviews have indicated that noise-related stress may affect mental and physiological health through broader stress and neuroendocrine pathways (*4*). This cross-sectional study examined occupational noise exposure, hearing-related functional difficulties, and menstrual abnormalities in female workers. By evaluating whether noise-related disturbances represent a potential explanatory pathway for these associations, this study aims to provide evidence for more comprehensive occupational health interventions that address both physical hazards and work-related stress responses.

This cross-sectional survey was conducted in 2024-2025 across enterprises in the food, machinery, and mining sectors in four provincial-level administrative divisions (PLADs) of China (Gansu, Beijing, Hebei, and Chongqing). Study sites and industries were selected to capture regional variations, reflect industry-specific noise exposure patterns, and ensure feasibility in field implementation. Participants were recruited from representative enterprises in each study region. A total of 3,283 female workers were screened, and 1,538 were included in the final analysis after applying the prespecified exclusion criteria and removing records with incomplete information; the recruitment and exclusion process is shown in Supplementary Figure S1 (available at https://weekly.chinacdc.cn/). The study protocol was approved by the Ethics Committee of the National Institute of Occupational Health and Poison Control, Chinese Center for Disease Control and Prevention (NIOHP202324). All the participants provided written informed consent. The inclusion criteria were: 1) age between 20 and 50 years, and 2) at least one year of employment at the factory, with at least six months in the current position. The exclusion criteria were as follows: 1) pregnant or breastfeeding women; 2) use of hormone medications or ototoxic drugs in the past 3–6 months; and 3) diagnosis of organic reproductive system diseases, ear disorders, or a history of surgery.

Individual occupational noise exposure was quantified as the 8-h normalized A-weighted equivalent continuous sound level [$L_{EX,8h}$, dB(A)] for each participant. Noise was measured using a personal noise dosimeter (ASV5910-R, Hangzhou Aihua Instruments Co., Ltd.) according to GBZ/T 189.8–2007 (Measurement of Physical Agents in Workplace — Part 8: noise). Each participant was measured thrice during routine shifts, and the dosimeter was calibrated before and after each measurement using a sound-level calibrator.

A structured questionnaire was used to collect data on: 1) General information, including age, education, marital status, smoking, alcohol consumption, work duration, shift work, hearing protection use, age at menarche, and parity history. Shift work was classified according to the self-reported work schedule into normal shift, day-shift rotation, and night-shift rotation. When both day- and night-shift rotations were reported, the participants were classified as having night-shift rotations. Parity history refers to whether the participant had a previous childbirth history (yes/no). 2) Hearing-related functional difficulty was assessed using the Hearing Handicap Inventory for Adults (HHIA) (*5*). Each participant rated the frequency of hearing difficulties, and responses were summed to yield a total score, with higher scores indicating greater functional impairment. An HHIA >8 indicated hearing-related functional difficulty. 3) Menstrual abnormalities were evaluated using self-reporting based on clinical criteria (*6*), including cycle irregularities (<21 or >35 days), abnormal flow (excessive or <5 mL), and duration (<2 or >8 days). Any abnormality was classified as a menstrual abnormality. 4) Noise annoyance was assessed using a five-point scale specified in the Chinese national standard GB/Z 21233–2007 (Acoustics — Assessment of noise annoyance in social and socio-acoustic surveys). The response options ranged from "not at all" to "very severe" (*7*).

Data were double-entered into Microsoft Excel and analyzed using Python (version 3.13.5, Python Software Foundation, Fredericksburg, VA, US) with pandas, numpy, and statsmodels. Baseline characteristics across noise exposure groups were compared using Welch's *t*-test or the Mann–Whitney U test for continuous variables and the chi-squared test or Fisher's exact test for categorical variables, as appropriate. Multivariable logistic regression was used to estimate the odds ratios (*OR*s) and 95% confidence intervals (*CI*s). The hearing-related model was adjusted for age, education, marital status, work duration, shift work, body mass index, smoking, alcohol consumption, hearing protection use, hypertension, diabetes, hyperlipidemia, and study site. The menstrual abnormality model adjusted for age, education, marital status, work duration, shift work, body mass index, smoking, alcohol consumption, hypertension, diabetes, hyperlipidemia, age at menarche, parity history, perimenopausal status, and study site. Mediation analysis was conducted using a regression-based approach with 5,000 bootstrap re-samples. In this framework, the total effect represents the overall association between occupational noise exposure and the outcome, the direct effect reflects the association after accounting for noise annoyance, and the indirect effect represents the portion operating through noise annoyance. The proportion of mediation was calculated as the indirect effect divided by the total effect.

Among the 1,538 female workers in the final analysis, the mean age was 39.35 (6.34) years. The prevalence rates of menstrual abnormalities and hearing-related functional difficulties were 22.82% and 17.88%, respectively. The baseline characteristics stratified by noise exposure group are shown in Table 1; both outcomes were more common in the high-noise group (Figure 1). After adjustment for potential confounders, high occupational noise exposure was significantly associated with hearing-related functional difficulty (a*OR*=1.79, 95% *CI*: 1.30–2.46) and menstrual abnormalities (a*OR*=2.70, 95% *CI*: 1.96–3.73) (Figure 2). Sensitivity analyses redefining perimenopausal status using a cutoff of ≥40 years, as well as subgroup analyses restricted to women aged <45 years, yielded generally consistent results for menstrual abnormalities (perim40: *OR*=2.70, 95% *CI*: 1.96–3.72; age <45 years: *OR*=3.32, 95% *CI*: 2.25–4.91). In the mediation analyses, the indirect effect estimates were modest for hearing-related outcomes and were not statistically significant for menstrual abnormalities (Supplementary Figure S2, available at https://weekly.chinacdc.cn/).

DISCUSSION

This study found that high occupational noise exposure is associated with increased odds of hearing-related functional difficulties and menstrual abnormalities among female workers. This association with hearing-related outcomes is consistent with previous evidence suggesting adverse auditory effects of occupational noise exposure (*8*). The indirect effect estimates for noise annoyance in the hearing-related model were modest, suggesting that psychophysiological stress responses may represent a potential explanatory pathway, in addition to direct auditory injury. The first mechanism is the well-established direct mechanical injury to cochlear hair cells. The second mechanism may be an indirect psychophysiological pathway in which chronic annoyance activates the HPA axis (*9*). Triggering the stress response (e.g., altered blood flow and oxidative stress) can amplify cochlear damage. Because this was a cross-sectional study, the findings should not be interpreted as evidence of a confirmed causal mediation pathway. We also observed a significant association between high noise exposure and menstrual abnormalities. Menstrual function depends on coordinated neuroendocrine regulation, and chronic stress related to noise exposure may contribute to menstrual disturbance (*10*). However, no statistically significant indirect effect of noise annoyance on menstrual abnormalities was observed, suggesting that other mechanisms may be involved.

This study had several limitations. First, due to its cross-sectional design, the temporal sequence and causal pathways could not be established, and the mediation findings should be interpreted cautiously. Second, the HHIA reflects self-reported hearing-related difficulty rather than objective audiometric hearing loss. Therefore, the findings should not be interpreted as evidence of clinically confirmed or noise-induced hearing loss. Third, menstrual abnormalities were defined using broad self-reported composite outcomes. Additionally, the observed prevalence may have been influenced by study sites, industries, and sampling proportions. Because only participants meeting the eligibility criteria with complete information were included in the final analysis, selection bias could not be excluded. Residual confounding factors and reporting biases were not excluded.

Overall, occupational noise exposure is associated with hearing-related functional difficulties and menstrual abnormalities. Noise annoyance may represent a potential explanatory pathway for hearing-related outcomes; however, the mediation findings should be interpreted cautiously. Longitudinal studies are required to elucidate these underlying mechanisms.

Conflicts of interest: No conflict of interest.

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TABLE 1. Baseline characteristics of participants stratified by noise exposure group.

Variable	<85 dB(A) (*n*=921) *n* (%)	≥85 dB(A) (*n*=617) *n* (%)	*P*
Age (years)	39.27 (6.50)	39.47 (6.10)	0.537
BMI (kg/m^2)	23.03 (3.11)	22.89 (3.06)	0.389
Menarche age (year)	14.17 (1.56)	14.06 (1.63)	0.219
Exposure duration (year)	4 (2,9)	7 (3,12)	<0.001
$L_{EX,8h}$ [dB(A)]	78.16 (5.61)	86.59 (2.24)	<0.001
Study site			
Beijing	66 (7.17)	15 (2.43)	<0.001
Hebei	487 (52.88)	196 (31.77)	
Chongqing	249 (27.04)	59 (9.56)	
Gansu	119 (12.92)	347 (56.24)	
Smoking status			
Non-smoking	917 (99.57)	614 (99.51)	1.000
Smoking	4 (0.43)	3 (0.49)	
Alcohol consumption			
Occasional/none	895 (97.18)	603 (97.73)	0.613
Regular drinking	26 (2.82)	14 (2.27)	
Annoyance			
Not at all	214 (23.24)	67 (10.86)	<0.001
Slight	337 (36.59)	225 (36.47)	
Moderate	336 (36.48)	228 (36.95)	
Severe	22 (2.39)	74 (11.99)	
Very severe	12 (1.30)	23 (3.73)	
Shift work			
Normal shift	481 (52.23)	259 (41.98)	<0.001
Day-shift rotation	82 (8.90)	80 (12.97)	
Night-shift rotation	358 (38.87)	278 (45.06)	
Parity history			
Yes	794 (86.21)	550 (89.14)	0.106
No	127 (13.79)	67 (10.86)	
Menstrual abnormality			
Normal	774 (84.04)	413 (66.94)	<0.001
Abnormal	147 (15.96)	204 (33.06)	
Hearing-related functional difficulty			
Normal	809 (87.84)	454 (73.58)	<0.001
Abnormal	112 (12.16)	163 (26.42)	

Note: Continuous variables are presented as mean (SD) or median (interquartile range), as appropriate. Categorical variables are presented as *n* (%). *P* values were calculated using Welch's t-test, Mann–Whitney U test, chi-squared test, or Fisher's exact test, as appropriate. The noise exposure groups were defined according to the individual 8-hour equivalent continuous A-weighted sound pressure level [$L_{EX,8h}$], with <85 dB(A) as the low-noise group and ≥85 dB(A) as the high-noise group. Shift work was classified as normal shift, day-shift rotation, and night-shift rotation according to the self-reported work schedule. Parity history refers to whether the participant had a childbirth history (yes/no).

Abbreviation: BMI=body mass index; $L_{EX,8h}$=8-hour normalized A-weighted equivalent continuous sound level; SD=standard deviation.

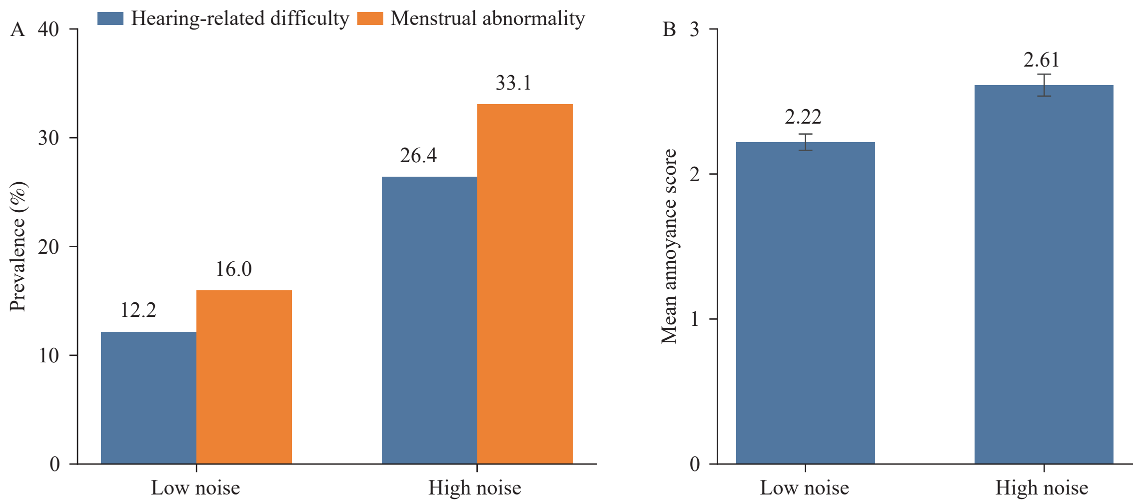

FIGURE 1. Crude prevalence of hearing-related functional difficulty and menstrual abnormalities and mean annoyance score by the low-noise [$L_{EX,8h}$<85 dB(A)] and high-noise [$L_{EX,8h}$≥85 dB(A)] groups. (A) unadjusted prevalence of hearing-related functional difficulty and menstrual abnormalities. (B) mean annoyance score with 95% confidence intervals.
Note: $L_{EX,8h}$=8-hour normalized A-weighted equivalent continuous sound level.

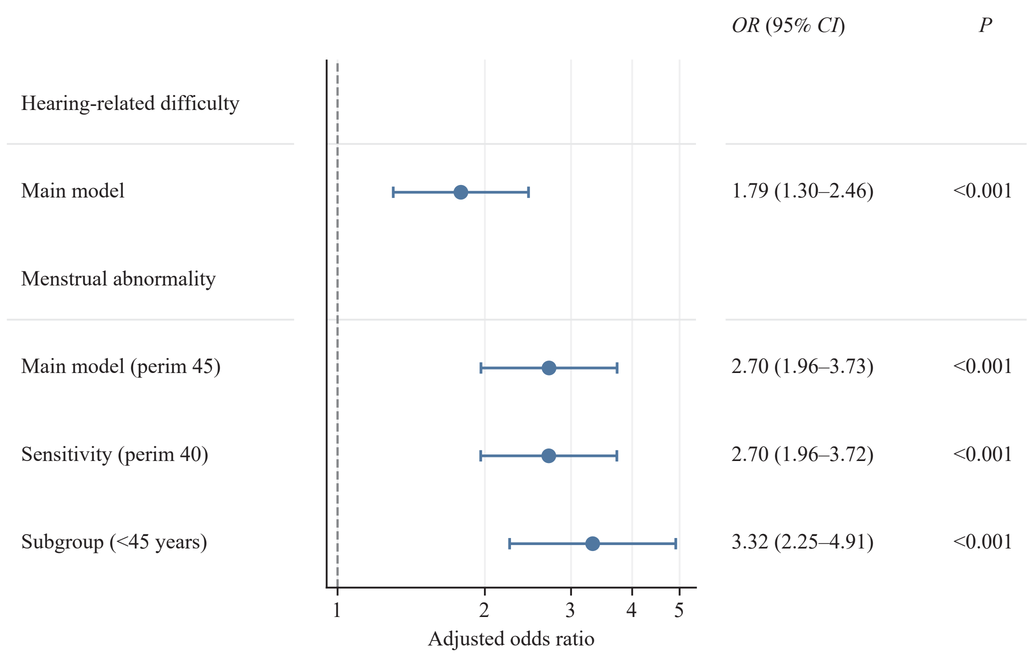

FIGURE 2. Adjusted associations of high occupational noise exposure with hearing-related functional difficulty and menstrual abnormalities.
Note: Points indicate odds ratios and horizontal lines indicate 95% *CI*s. Results are shown for the main adjusted models and menstrual sensitivity/subgroup analyses.
Abbreviation: *OR*=odds ratio; *CI*=confidence interval.

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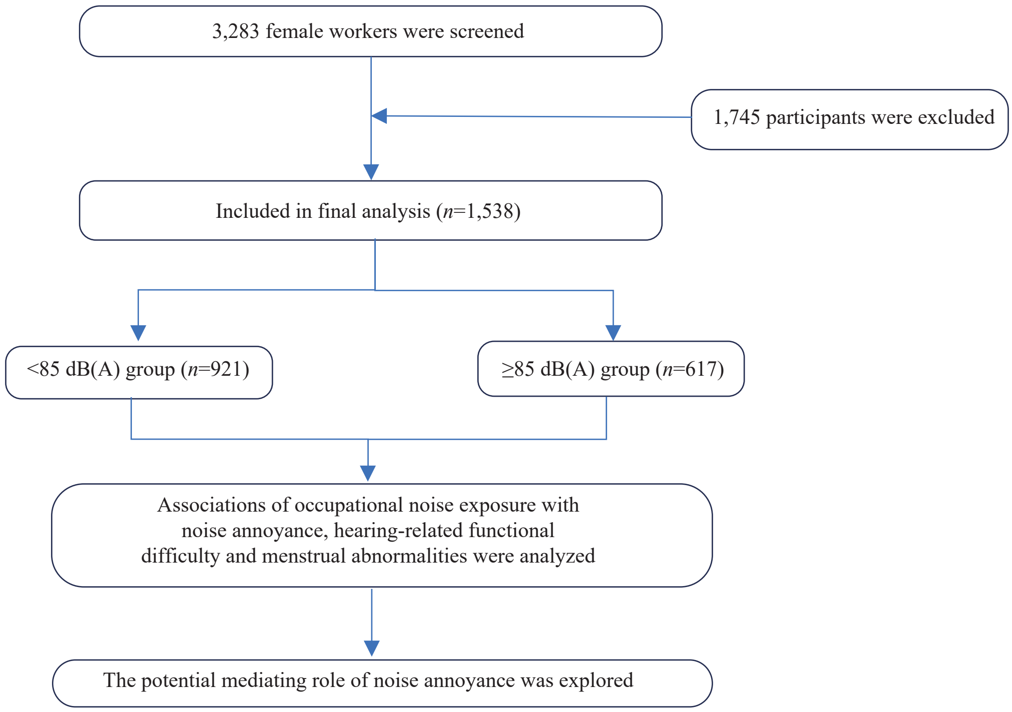
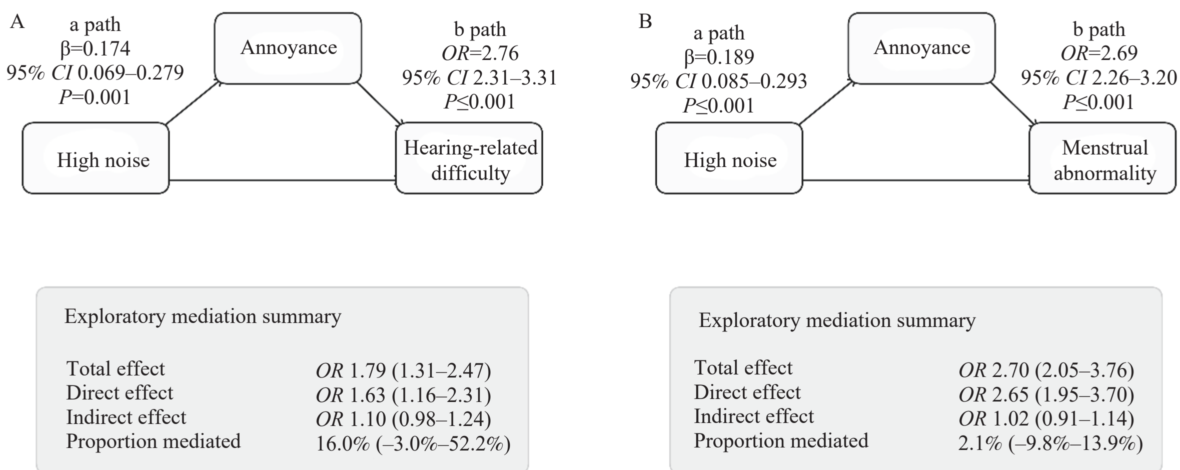
SUPPLEMENTARY MATERIALS



SUPPLEMENTARY FIGURE S1. Flowchart of participant selection and analysis.
Note: Participants were excluded if they were pregnant (*n*=235), reported a history of relevant medication use and/or medical conditions (*n*=366), or had incomplete information (*n*=1,144).



SUPPLEMENTARY FIGURE S2. Mediation analysis of noise annoyance in the associations of occupational noise exposure with hearing-related functional difficulty and menstrual abnormalities. (A) Mediation model: Hearing-related functional difficulty; (B) Mediation model: Menstrual abnormality.
Note: The *a* path denotes the association between high noise exposure and annoyance, and the *b* path denotes the association between annoyance and the outcome conditional on high noise exposure. Total, direct, and indirect effects, as well as proportion mediated, were estimated using bootstrap mediation analysis (5,000 iterations). For panel A, the *a* path model was adjusted for age, education, marital status, work duration, shift work, body mass index, smoking, alcohol consumption, hearing protection use, hypertension, diabetes, hyperlipidemia, and study site; the *b* path model additionally included high noise exposure. For panel B, the *a* path model was adjusted for age, education, marital status, work duration, shift work, body mass index, smoking, alcohol consumption, hypertension, diabetes, hyperlipidemia, age at menarche, parity history, perimenopausal status, and study site; the *b* path model additionally included high noise exposure.

Preplanned Studies

Propensity Score Matching Analysis on Interaction Between Noise Exposure and Gestational Hypertension for Preterm Birth Among Female Workers — 4 PLADs, China, 2024–2025

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Summary

What is already known about this topic?

Preterm birth (PTB) is a major public health concern. While noise exposure and gestational hypertension (GH) are recognized risk factors for PTB, evidence on their independent and combined effects among female workers remains limited.

What is added by this report?

Using PSM and logistic regression in 7,886 female manufacturing and mining workers, this study confirmed an overall PTB prevalence of 9.3%. Occupational noise and GH independently elevated PTB risk, with a significant positive additive interaction and the highest risk in the co-exposed group [adjusted odds ratio (a*OR*)=4.06, 95% (*CI*): 2.14, 7.70; relative excess risk due to interaction (RERI)=1.11, attributable proportion (AP)=27.34%, synergy index (S)=1.57].

What are the implications for public health practice?

Targeted, integrated public health interventions are needed to reduce PTB risk among female workers, including occupational noise control in manufacturing and mining settings, routine GH screening and management during pregnancy, and enhanced surveillance for workers exposed to both risk factors.

ABSTRACT

Introduction: Preterm birth (PTB) is a major public health concern. Noise exposure and gestational hypertension (GH) are recognized risk factors for PTB; however, few studies have examined their independent and combined effects on PTB among female workers.

Methods: A cross-sectional survey was conducted among female manufacturing and mining workers in Gansu, Chongqing, Hebei, and Beijing. Propensity score matching (PSM) at a 1∶1 ratio balanced baseline characteristics between noise-exposed and non-exposed groups, yielding 7,886 matched participants (3,943 per group). Univariate logistic regression estimated the independent associations of noise exposure and GH with PTB, while multivariate logistic regression assessed their additive interaction, quantified by relative excess risk due to interaction (RERI), attributable proportion (AP), and synergy index (S).

Results: After PSM, the overall PTB prevalence was 9.3%, with higher rates in manufacturing (10.9%) than in mining (7.7%). Occupational noise [odds ratio (*OR*)=2.26, 95% confidence interval (*CI*): 1.93, 2.66] and GH (*OR*=1.83, 95% *CI*: 1.24, 2.68) independently elevated PTB risk. A significant positive additive interaction was detected, with the highest risk in the co-exposed group (a*OR*=4.06, 95% *CI*: 2.14, 7.70; RERI=1.11, AP=27.34%, S=1.57).

Conclusion: Occupational noise exposure and GH are independent risk factors for PTB among female workers, with a synergistic additive effect when co-present. Integrated interventions targeting both exposures may help reduce the PTB burden in this population.

Preterm birth (PTB), defined as delivery before 37 weeks of gestation, represents a major global public health challenge, contributing substantially to neonatal morbidity, mortality, and long-term developmental impairment (*1*). Global estimates indicate that 13.4 million preterm births occurred in 2020 (9.9% of live births), with notable regional disparities (*2*), while in China, PTB rates rose from 5.13% in 2017 to 6.56% in 2022 (*3*). The burden may be disproportionately heavy among female workers — who account for 45% of China's workforce — owing to cumulative reproductive risks from occupational stressors. PTB is multifactorial, with modifiable risk factors including occupational environmental exposures and pregnancy-related complications (*4*). Excessive occupational noise, prevalent in industrial settings (31.2% of Chinese manufacturing workers were exposed to >85 dB(A) in 2020) (*5*), and gestational hypertension (GH, affecting 5.6%–9.4% of pregnancies in China) (*6*) have each been independently linked to PTB through mechanisms such as hypothalamic-pituitary-adrenal (HPA) axis activation, placental dysfunction, and endothelial injury (*7*–*8*).

To date, most studies have focused on the independent effects of noise or GH, overlooking potential interactive effects that may amplify PTB risk. In addition, confounding factors (e.g., age, lifestyle) are often inadequately controlled in observational studies, leading to biased effect estimates. Moreover, large-scale evidence specifically targeting female workers — a high-risk occupational population — remains scarce, hindering the development of context-specific occupational health policies. To address these gaps, this cross-sectional survey aimed to investigate the independent associations of occupational noise exposure and GH with PTB among female workers and to evaluate their additive interaction on PTB risk.

A cross-sectional survey was conducted from 2024 to 2025 across four provincial-level administrative divisions (PLADs) — Gansu, Chongqing, Hebei, and Beijing — targeting female workers aged 20–50 years with ≥1 year of work experience and a pregnancy history in the mining and manufacturing industries (selected for their high proportion of female employees). Exclusion criteria included confirmed organic diseases affecting reproductive health, a personal or family history of reproductive system tumors, other malignant tumors, and severe mental or cognitive impairment precluding independent questionnaire completion. Of 9,345 initially recruited workers, 20 with incomplete basic information were excluded, leaving 9,325 participants for analysis. Propensity score matching (PSM) was performed using a 1∶1 nearest-neighbor algorithm with a caliper width of 0.2 standard deviations of the propensity score — a widely recommended threshold to balance baseline comparability and reduce matching bias. The matching model included the following covariates: age, marital status, smoking, alcohol consumption, and industry type, selected based on published evidence and data accessibility. Characteristics of unmatched participants were summarized (Supplementary Table S1, available at https://weekly.chinacdc.cn/), and covariate balance was rigorously evaluated before and after matching using standardized mean differences (SMD). Robust standard errors were employed in subsequent regression models to improve estimation accuracy. Sensitivity analyses using alternative caliper values (0.1 and 0.3) were conducted to verify the robustness of the main findings. After PSM, the final matched sample comprised 7,886 participants (3,943 in the noise-exposed group and 3,943 in the non-exposed group) (Supplementary Figure S1, available at https://weekly.chinacdc.cn/).

A standardized questionnaire developed by the research team was used for data collection (*9*), capturing the following variables: demographic and lifestyle characteristics (industry type, gestational age, marital status, smoking, and alcohol consumption) (*10*); occupational noise exposure, based on self-report during pregnancy and verified against enterprise occupational hazard detection reports [8-hour equivalent continuous A-weighted sound pressure level ($L_{EX,8h}$)] to reduce recall bias (*11*); gestational hypertension (GH), defined per international guidelines as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg after 20 weeks of gestation with no pre-pregnancy history of hypertension, validated through self-reported medical records and prenatal examination data; and PTB, defined as delivery at <37 completed weeks of gestation, determined by self-reported gestational age at delivery (*1*).

All statistical analyses were performed using R (version 4.5.1, R Foundation for Statistical Computing, Vienna, Austria). Standardized mean differences (SMD) assessed covariate balance after PSM, with SMD<0.1 indicating adequate balance. Univariate logistic regression estimated odds ratios (*OR*) and 95% confidence intervals (*CI*) for the independent associations of noise exposure and GH with PTB. Multivariate logistic regression evaluated the additive interaction between noise exposure and GH on PTB risk, quantified by relative excess risk due to interaction (RERI), attributable proportion (AP), and synergy index (S). The 95% *CI*s for additive interaction indices were calculated using the delta method. Pairwise association analyses informed the study's conceptual framework. Statistical significance was set at a two-sided α =0.05.

Table 1 presents the baseline characteristics of the 7,886 matched participants (3,943 per group). After PSM, SMD values for all covariates — age, marital status, smoking, alcohol consumption, and industry type — were below 0.1, confirming adequate balance

TABLE 1. Epidemiological characteristics of participants in noise and non-noise groups after propensity score matching (n=7,886).

Variables	Total (n=7,886) n (%)	Noise group (n=3,943) n (%)	Non-noise group (n=3,943) n (%)	SMD	$L_{EX,8h}$ ≥85 [dB(A), %]	Prevalence of GH (%)	Prevalence of PTB (%)
Age (years)				0.002*			
<25	1,658 (21.0)	828 (21.0)	830 (21.0)		21.8	1.3	9.3
25–29	3,388 (43.0)	1,695 (43.0)	1,693 (42.9)		20.0	2.0	9.0
≥30	2,840 (36.0)	1,420 (36.0)	1,420 (36.0)		22.4	4.2	9.6
Marital status				0.006*			
Unmarried	38 (0.5)	19 (0.5)	19 (0.5)		10.5	5.3	15.8
Married	7,635 (96.8)	3,816 (96.8)	3,819 (96.9)		21.4	2.6	9.2
Divorced/widowed	213 (2.7)	108 (2.7)	105 (2.7)		17.8	1.4	12.2
Smoking status				0.012*			
Yes	59 (0.7)	28 (0.7)	31 (0.8)		18.6	5.1	8.5
No	7,827 (99.3)	3,915 (99.3)	3,912 (99.2)		21.3	2.6	9.3
Alcohol consumption				0.007*			
Yes	171 (2.2)	87 (2.2)	84 (2.1)		24.0	4.1	14.6
No	7,715 (97.8)	3,856 (97.8)	3,859 (97.9)		21.2	2.6	9.2
Industry				0.016*			
Manufacturing	3,961 (50.2)	1,965 (49.8)	1,996 (50.6)		25.2	2.4	10.9
Mining	3,925 (49.8)	1,978 (50.2)	1,947 (49.4)		17.3	2.8	7.7
Total	7,886 (100.0)	3,943 (100.0)	3,943 (100.0)		21.3	2.6	9.3

Abbreviation: SMD=standardized mean difference; $L_{EX,8h}$=8-hour equivalent continuous A-weighted sound pressure level; GH=gestational hypertension; PTB=preterm birth; dB(A)=A-weighted decibel.
* SMD<0.1, indicating good balance of confounding factors between the two groups.

between groups. The overall GH prevalence was 2.6%, and PTB prevalence was 9.3%. Among all participants, 21.3% had noise exposure levels ($L_{EX,8h}$) exceeding 85 dB(A), with a higher proportion observed in the noise-exposed group than in the non-exposed group.

Univariate logistic regression (Figure 1) examined the pairwise associations among noise exposure, GH, and PTB to establish the basis for subsequent interaction analyses. In Model 1, noise exposure was significantly associated with increased PTB risk (OR=2.26, 95% CI: 1.93, 2.66; P<0.01). In Model 2, no significant association was observed between noise exposure and GH (OR=1.23, 95% CI: 0.89, 1.69; P>0.05). In Model 3, GH was significantly associated with elevated PTB risk (OR=1.83, 95% CI: 1.24, 2.68; P<0.01). These results, summarized as a conceptual framework (Figure 1), indicate that both noise exposure and GH may independently contribute to PTB risk, whereas noise exposure itself was not associated with GH development.

Table 2 presents the results of multivariate logistic regression, adjusted for maternal age, marital status, smoking, alcohol consumption, and industry type, with the "no noise exposure + no GH" group as the reference (OR=1.00). PTB risk was significantly elevated in both the GH-only group [adjusted odds ratio (aOR)=1.77, 95% CI: 1.09, 2.91; P=0.02] and the noise-only group (aOR=2.18, 95% CI: 1.85, 2.56; P<0.01), with the highest risk observed in the co-exposed group (aOR=4.06, 95% CI: 2.14, 7.70; P<0.01).

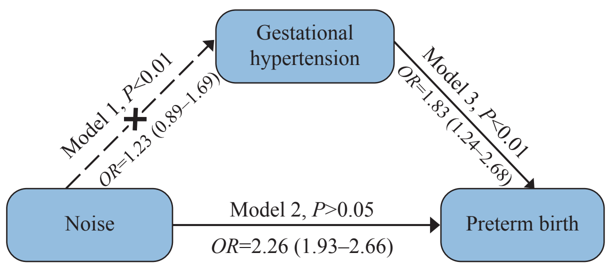

FIGURE 1. A conceptual framework illustrating relationships among noise exposure, GH, and PTB using univariate logistic regression.
Abbreviation: GH=gestational hypertension; PTB=preterm birth; OR=odds ratio; CI=confidence interval.

Additive interaction analysis revealed a significant positive interaction between noise exposure and GH on PTB risk, with a RERI of 1.11 (95% CI: 0.02, 2.20), an AP of 27.34% (95% CI: 1.20%, 53.48%),

TABLE 2. Interaction of noise exposure and GH on PTB using multivariate logistic regression.

Group	*N* (PTB cases)	a*OR* (95% *CI*)	*P*	RERI (95% *CI*)	AP (95% *CI*)	S (95% *CI*)
No noise + No gestational hypertension	6,055 (453)	1.00				
Gestational hypertension	155 (19)	1.77 (1.09, 2.91)	0.02			
Noise	1,625 (250)	2.18 (1.85, 2.56)	<0.01			
Noise + Gestational hypertension	51 (13)	4.06 (2.14, 7.70)	<0.01	1.11 (0.02, 2.20)	27.34% (1.20%, 53.48%)	1.57 (1.03, 2.11)

Note: Multivariate logistic regression adjusted for maternal age, marital status, smoking status, alcohol consumption, and industry type as independent variables.

Abbreviation: a*OR*=adjusted odds ratio; *CI*=confidence interval; RERI=relative excess risk due to interaction; AP=attributable proportion; S=synergy index; GH=gestational hypertension; PTB=preterm birth.

and an S of 1.57 (95% *CI*: 1.03, 2.11), indicating that the combined effect of both exposures exceeded the sum of their individual effects (Table 2).

DISCUSSION

In this study, the independent association between occupational noise exposure and PTB (*OR*=2.26, 95% *CI*: 1.93, 2.66) was consistent with prior epidemiological evidence. Wing et al. demonstrated that combined stressors of noise and air pollution elevated PTB risk (*OR*=1.15, 95% *CI*: 1.03, 1.28) in Los Angeles (*12*). Our large sample size strengthens the reliability of these findings within the study population, providing a preliminary reference for occupational health protection among female workers in manufacturing and mining in similar settings (*13*). The underlying mechanisms may involve chronic noise-induced psychological stress that disrupts the hypothalamic-pituitary-adrenal axis, elevates cortisol levels, impairs placental blood flow, and triggers oxidative stress and inflammation (*14–15*).

Gestational hypertension was independently associated with a 1.83-fold increased risk of PTB (95% *CI*: 1.24, 2.68), consistent with global epidemiological data and recent studies. A systematic review and meta-analysis by Jin et al. confirmed a significant association between GH and elevated PTB risk (*OR*=1.58, 95% *CI*: 1.35, 1.85) (*16*). Similarly, Hu et al. evaluated the 2017 American College of Cardiology/American Heart Association (ACC/AHA) hypertension guideline and found that standardized GH diagnosis was associated with a 1.72-fold higher risk of preterm delivery (95% *CI*: 1.28, 2.31), underscoring the consistency of this association and the clinical importance of rigorous diagnosis. GH contributes to PTB through mechanisms including placental dysfunction, endothelial injury, and reduced uterine-placental perfusion, and may also necessitate iatrogenic preterm delivery to safeguard maternal and fetal health.

A key novel finding of this study is the significant positive additive interaction between noise exposure and GH on PTB risk, with a RERI of 1.11, an AP of 27.34%, and an S of 1.57. These results indicate that 27.34% of PTB cases in the co-exposed group were attributable to the interaction effect, and the combined exposure exceeded the sum of individual effects. To our knowledge, this is among the first studies to quantify this additive interaction using PSM, thereby addressing confounding bias that has limited previous observational research. The interaction mechanism may involve synergistic amplification of oxidative stress and inflammation: noise exposure induces systemic inflammation and placental vascular damage, while GH further impairs endothelial function and uterine-placental perfusion. Together, these pathways create a "double burden" on fetal development, increasing the likelihood of preterm delivery.

This study has several limitations. First, as a cross-sectional design, it cannot establish definitive causal relationships among noise exposure, GH, and PTB, although PSM reduces confounding bias. Second, occupational noise exposure was primarily based on self-report, with only partial validation through enterprise-level data rather than individual objective monitoring, potentially resulting in exposure misclassification bias. Similarly, data on GH and PTB (including gestational age at delivery) partially relied on self-reported information, which may introduce recall bias. These biases could affect the accuracy of effect estimates and should be considered when interpreting the findings. Third, important potential confounders — including pre-pregnancy body mass index (BMI), gravidity and parity, history of preterm birth, frequency of prenatal care, psychological stress, physical workload, and co-exposure to other occupational hazards — were not adjusted for, which may lead to residual confounding. Fourth, the study population was restricted to female workers in manufacturing and mining industries from four

PLADs in China, which may limit the external validity and generalizability of the findings. Therefore, the results should be interpreted with caution and should not be extrapolated to other populations.

In conclusion, occupational noise exposure and GH are independent risk factors for PTB among female workers in manufacturing and mining industries, and their co-occurrence exerts a synergistic additive effect on PTB risk. These findings underscore the need for integrated interventions, including workplace noise control, enhanced GH screening, and targeted care for high-risk subgroups. Future studies employing prospective cohort designs, objective noise measurements, and biological markers are needed to confirm causal relationships and elucidate the underlying mechanisms.

Conflicts of interest: No conflict of interest.

Ethical statement: Approval by National Institute of Occupational Health and Poison Control, Chinese Center for Disease Control and Prevention (IRB-NIOHP202013).

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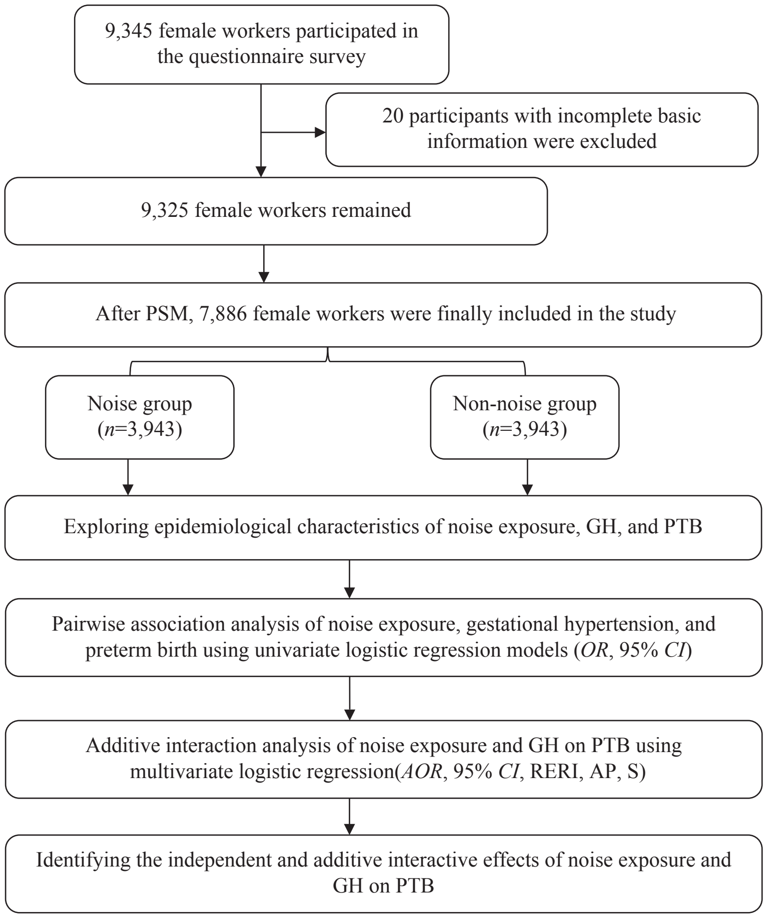
SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Basic characteristics of study subjects before matching.

Variables	Total (*n*=9,325) *n* (%)	Noise (*n*=4,091) *n* (%)	Non-noise (*n*=5,234) *n* (%)	SMD
Age (years)				0.129
<25	1,946 (20.87)	876 (21.41)	1,070 (20.44)	
25–29	3,870 (41.50)	1,748 (42.73)	2,122 (40.54)	
≥30	3,509 (37.63)	1,467 (35.86)	2,042 (39.01)	
Marital status				0.083
Unmarried	83 (0.89)	21 (0.51)	62 (1.18)	
Married	8,978 (96.28)	3,923 (95.89)	5,055 (96.58)	
Divorced / Widowed	264 (2.83)	147 (3.59)	117 (2.24)	
Smoking status				0.044
Yes	99 (1.06)	54 (1.32)	45 (0.86)	
No	9,226 (98.94)	4,037 (98.68)	5,189 (99.14)	
Alcohol consumption				0.006
Yes	224 (2.40)	110 (2.69)	114 (2.18)	
No	9,101 (97.60)	3,981 (97.31)	5,120 (97.82)	
Industry				0.041
Manufacturing	4,209 (45.14)	2,015 (49.25)	2,194 (41.92)	
Mining	5,116 (54.86)	2,076 (50.75)	3,040 (58.08)	
Total	9,325 (100.00)	4,091 (100.00)	5,234 (100.0)	

Note: SMD<0.1, indicating good balance of confounding factors between the two groups.
Abbreviation: SMD=standardized mean difference.



SUPPLEMENTARY FIGURE S1. Flow chart of the study.
Abbreviation: PSM=Using propensity score matching; GH=gestational hypertension; PTB=Preterm birth; *OR*=odds ratio; a*OR*=adjusted odds ratio; *CI*=confidence interval; RERI=relative excess risk due to interaction; AP=attributable proportion; S=synergy index.

Methods and Application

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

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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.

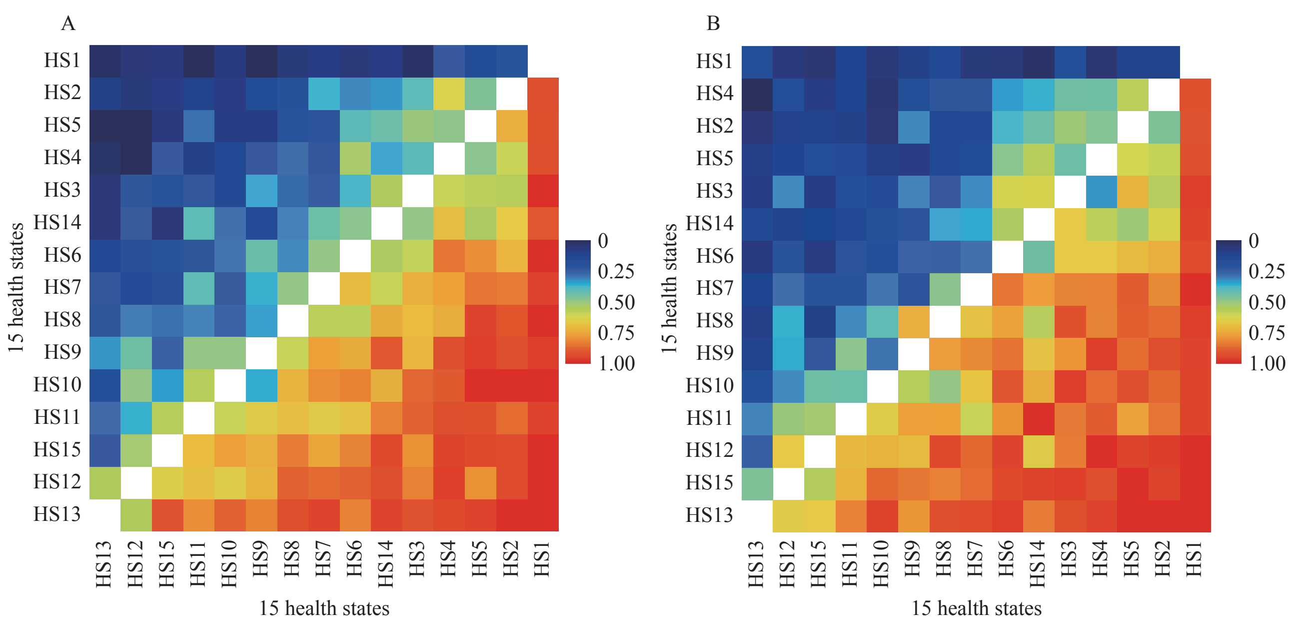

FIGURE 1. Response probabilities for pairwise comparisons of health states. (A) General population; (B) Medical professionals.

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% *UI*s of the GBD 2023 study. DWs of chronic low back pain, deafness, and severe depression were below the lower limit of the corresponding 95% *UI*s 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% *UI*s 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% *UI*s 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).

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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 × 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.
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.	EQ-5D+C-3L: 212221 Some mobility problems. Can take care of himself/herself. 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.
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.	EQ-5D+C-3L: 111221 Can walk around. 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.
4	Deafness	Person with severe congenital or early acquired hearing disorder.	EQ-5D+C-3L: 112122 Can walk around. 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.
5	Diabetes mellitus	Person with poor glycemic control despite careful adherence to insulin and diet, resulting in unexpected hypoglycemic attacks.	EQ-5D+C-3L: 111221 Can walk around. 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.
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.	EQ-5D+C-3L: 112122 Can walk around. 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.
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.	EQ-5D+C-3L: 112221 Can walk around. 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.
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.	EQ-5D+C-3L: 212321 Some mobility problems. Can take care of himself. 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
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.	EQ-5D+C-3L: 222222 Some mobility problems. 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.
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.	EQ-5D+C-3L: 222221 Some mobility problems. 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.
11	HIV/AIDS (seropositive, asymptomatic)	Healthy person who knows that an incurable disease is acquired.	EQ-5D+C-3L: 111131 Can walk around 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.
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.	EQ-5D+C-3L: 113233 Can walk around. 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.
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.	EQ-5D+C-3L: 333221 Inability to get out of bed. 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
14	Mild chronic cadmium poisoning	Dizziness, fatigue, pain in the lower back and limbs, smell disorders, etc.	EQ-5D+C-3La: 111211 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.”

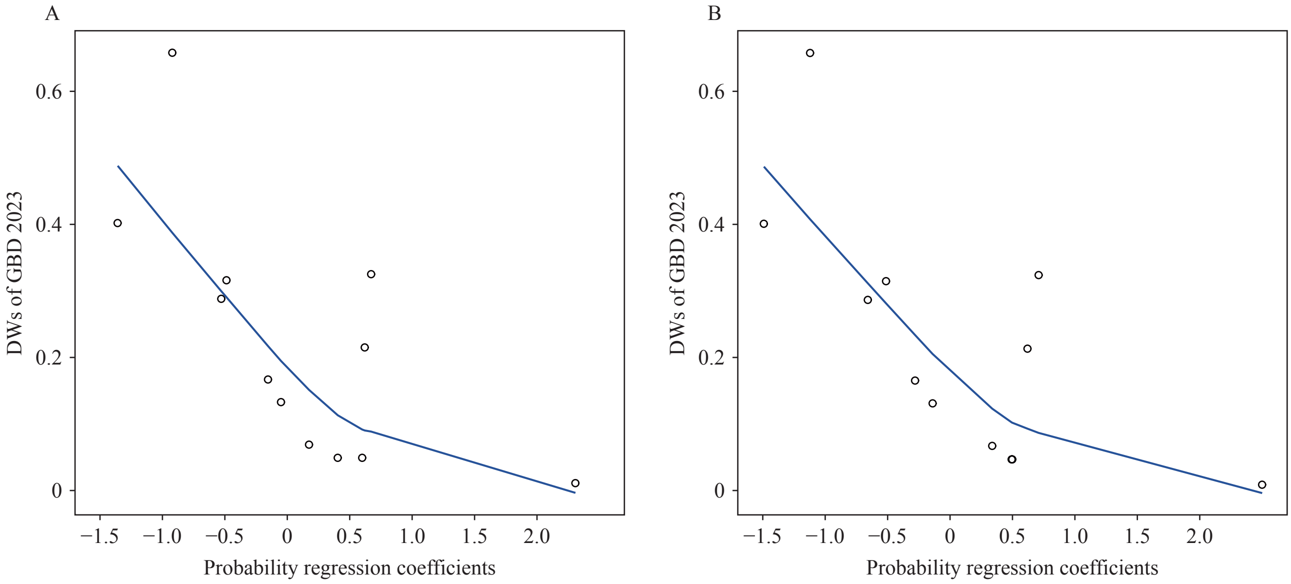
Abbreviation: EQ-5D+C-3L=EuroQol 5-dimension plus cognition 3-level.

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.

Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, March 2026*

Diseases	Cases	Deaths
Plague	0	0
Cholera	0	0
COVID-19	26,306	2
SARS-CoV	0	0
Acquired immune deficiency syndrome†	4,821	1,644
Hepatitis	145,066	136
Hepatitis A	1,382	0
Hepatitis B	123,191	29
Hepatitis C	16,305	107
Hepatitis D	28	0
Hepatitis E	3,534	0
Other hepatitis	626	0
Poliomyelitis	0	0
Human infection with noval influenza virus	3	0
Measles	117	0
Epidemic hemorrhagic fever	183	0
Rabies	26	21
Japanese encephalitis	0	0
Dengue	92	0
Monkey pox§	28	0
Anthrax	21	0
Dysentery	1,682	0
Tuberculosis	63,201	188
Typhoid fever and paratyphoid fever	247	0
Meningococcal meningitis	19	1
Pertussis	636	0
Diphtheria	0	0
Neonatal tetanus	2	0
Scarlet fever	1,471	0
Brucellosis	5,448	0
Gonorrhea	10,197	0
Syphilis	62,781	3
Leptospirosis	8	0
Schistosomiasis	1	0
Malaria	221	1
Influenza	479,991	2
Mumps	6,125	0

Continued

Diseases	Cases	Deaths
Rubella	36	0
Acute hemorrhagic conjunctivitis	1,883	0
Leprosy	35	0
Typhus	59	0
Kala azar	28	0
Echinococcosis	411	2
Filariasis	0	0
Hand, foot and mouth disease	22,484	0
Infectious diarrhea¶	229,629	0
Total	1,063,258	2,000

* According to the National Bureau of Disease Control and Prevention.

† The number of deaths of Acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients..

§ Since September 20, 2023, Monkey pox was included in the management of Class B infectious diseases.

¶ Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the Chinese mainland are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan, China are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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