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ARTICLE

# Prediction Model and Assessment of Work-Related Musculoskeletal Disorders Among Nurses in Tertiary Hospitals in China: A Cross-Sectional Study

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## Abstract

**Aims/Background** Work-related musculoskeletal disorders (WMSDs) significantly impact the health and work efficiency of nurses. This study aimed to investigate factors influencing WMSD risk among nurses, including protective measures, physical activity, and biomechanical factors.

**Methods** This cross-sectional study surveyed 3500 nurses from tertiary hospitals to assess musculoskeletal disorder risk factors, yielding 3380 valid responses. The dataset was randomly split into a training set (n = 2350) and a validation set (n = 1030). Univariate analysis and binary logistic regression were applied to develop a predictive model, which was evaluated based on its area under the curve (AUC), sensitivity, and specificity.

**Results** Binary logistic regression analysis identified significant risk factors for WMSDs, including a higher movement and assistance of hospital patients (MAPO) Index (odds ratio (OR) = 1.579, 95% confidence interval (CI): 1.431–1.742, $p < 0.001$), quick exposure check (QEC) score (OR = 1.028, 95% CI: 1.021–1.034, $p < 0.001$), work-family interference (OR = 1.016, 95% CI: 1.008–1.023, $p < 0.001$), lack of protective measures (OR = 1.571, 95% CI: 1.075–2.296, $p = 0.020$), severe pelvic rotation (OR = 1.746, 95% CI: 1.229–2.480, $p = 0.002$), and older age ($\geq$50 years, OR = 1.885, 95% CI: 1.171–3.036, $p = 0.009$). Conversely, higher job satisfaction was associated with a lower risk of WMSDs (OR = 0.807, 95% CI: 0.786–0.828, $p < 0.001$). Nurses who never exercised (OR = 1.608, 95% CI: 1.127–2.295, $p = 0.009$) or engaged in $\geq$16 hours of household labour per week (OR = 1.878, 95% CI: 1.305–2.703, $p = 0.001$) had an elevated WMSD risk. The nomogram model demonstrated excellent predictive performance, with an AUC of 0.822 (95% CI: 0.803–0.840, $p < 0.001$) in the training set and 0.810 (95% CI: 0.775–0.845, $p < 0.001$) in the validation set. Calibration plots and decision curve analyses confirmed its reliability and clinical applicability.

**Conclusion** Implementing comprehensive protective measures, promoting regular physical activity, and ensuring even foot pressure distribution can significantly mitigate WMSD risk. In contrast, a higher MAPO Index, elevated QEC scores, extended household labour, and work-family interference contribute to increased susceptibility. The developed predictive model provides a valuable tool for nurse health risk screening and personalized intervention planning, supporting early identification and prevention of WMSDs among nurses in clinical settings.

**Key words: musculoskeletal disorders; nurses; risk factors; work**

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## Introduction

Nurses are an integral part of the healthcare system, playing a critical role in direct patient care, which frequently involves physically demanding tasks. However, they are exposed to numerous occupational hazards, with work-related musculoskeletal disorders (WMSDs) being the most prevalent. WMSDs significantly impair nurses' physical health, work efficiency, and overall quality of life, contributing to an increased burden on global healthcare systems. Their prevalence among nurses has been well-documented across different countries. For instance, studies reported a prevalence rate of 69% in the USA (Lee et al, 2015) and 75.9% in Japan (Fujii et al, 2019). In China, prevalence rates range from 56% to 92% (Yan et al, 2018; Yang et al, 2019). These disorders frequently manifest as neck and shoulder pain, lower back pain, and carpal tunnel syndrome, which not only compromise nurses' physical health but also lead to increased sick leave and reduced income.

Despite the growing body of research on WMSDs among nurses, notable differences exist between international studies and those conducted in China. International research primarily emphasizes occupational factors such as repetitive tasks, patient handling, and ergonomic conditions (Abdul Halim et al, 2023; Durak and Mutlu, 2023; Fitria et al, 2023). However, studies in China must also account for unique healthcare system challenges, including high patient-to-nurse ratios, long working hours, and additional family responsibilities. Zeng et al (2024) demonstrated that Chinese nurses not only endure high levels of occupational stress but also face significant family-related pressures due to extended working hours and domestic responsibilities, which exacerbate fatigue and increase WMSD risk. While an international study recognizes organizational challenges such as night shifts and staffing shortages (Chang and Peng, 2021), these challenges are particularly pronounced in China, where traditional familial roles and societal expectations impose additional burdens on female nurses, who comprise the majority of the workforce.

A comprehensive understanding of occupational and family-related risk factors is essential for effectively preventing and managing WMSDs among nurses. Although previous studies have explored interventions such as health education and ergonomic improvements (Abdollahi et al, 2020; Weiner et al, 2015), significant gaps remain in the ability to quantitatively assess and predict these risk factors.

This study aimed to identify key occupational risk factors for nurses through a literature review, field surveys, and objective measurements. Furthermore, it aimed to construct and validate a WMSD risk prediction model using a cross-sectional study design. This model will serve as a quantitative and predictive occupational risk assessment tool for healthcare administrators in China, enhancing awareness of risk prevention, optimizing the nursing work environment, and offering a scientific basis for developing targeted intervention strategies.

# Methods

## Study Design

This study employed a cross-sectional design to develop and evaluate a predictive model for WMSDs among nurses in tertiary hospitals in China.

## Study Population

A multi-stage random sampling method was used to select six tertiary Grade A general hospitals in Chongqing, China. Nurses were then stratified into three age groups (20–29, 30–39, and 40–49 years), yielding a total sample of 3500 participants. Ethical approval was obtained from the Ethics Committee of Chongqing Traditional Chinese Medicine Hospital (approval number: 2021-ky-46), and all participants provided informed consent. This study followed the principles of the Declaration of Helsinki.

Inclusion criteria were as follows: (1) Nurses holding a valid nursing license and having at least one year of clinical nursing experience; (2) nurses with voluntary participation in the study; and (3) nurses with the ability to complete the survey online.

Exclusion criteria included: (1) Nurses enrolled in advanced training programs; (2) pregnant nurses or those with a pregnancy history within the past year; (3) those with congenital spinal disorders or spinal deformities; and (4) those using analgesics within the past three months.

## Sample Size Calculation

To meet the study requirements, we planned to include 120 predictor variables and determined the sample size to ensure a minimum of 10 events per predictor variable (EPV) (Peduzzi et al, 1996). A minimum of 1200 WMSD cases was required to ensure model stability and validity. Given a reported WMSD prevalence of 40% (Tavakkol et al, 2020; Yang et al, 2019), a sample size of 3000 nurses was needed. Accounting for a 15% attrition rate, the final required sample size was 3450 nurses. Consequently, 3500 nurses were targeted to ensure sufficient sample coverage and to compensate for potential attrition.

## Risk Factors

Based on a comprehensive review of domestic and international literature and the International Labour Organization–International Occupational Safety and Health Information Centre (ILO-CIS) (https://www.ilo.org/publications/nurse-occupational-health-international-hazard-datasheets-occupation) International Occupational Hazard Database classification of nursing occupational risk factors, this study utilized the 40-item Chinese Nursing Occupational Risk Assessment Tool, developed by Li et al (2009) through expert consensus meetings. See Fig. 1 for further details.

## Diagnostic Criteria for WMSDs

WMSDs were defined according to the Nordic Musculoskeletal Questionnaire (Crawford, 2007). When the presence of at least one of the following symptoms, ache, numbness, pain, or restricted movement, in any of nine body regions (e.g., neck, shoulders, back, elbows, etc.) for more than over 24 hours within the past year that persisted after rest, the condition was considered as WMSD-positive.

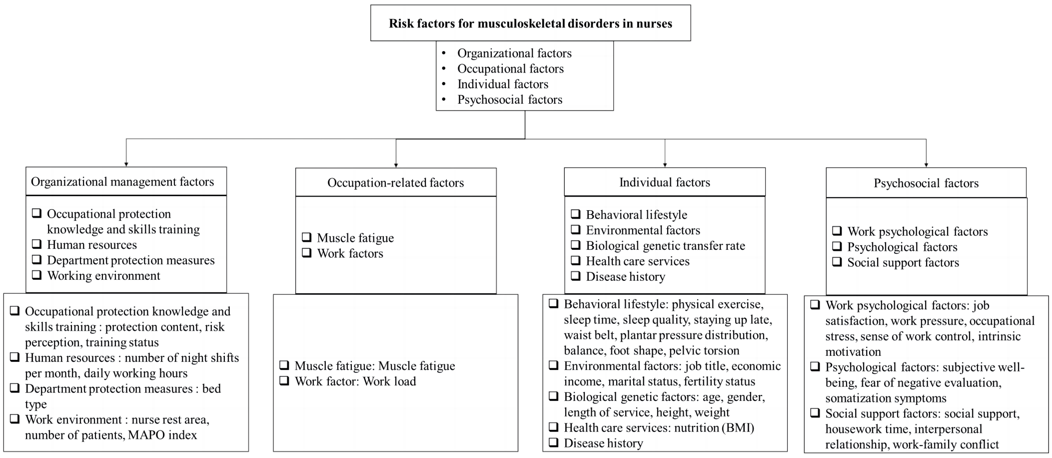


**Fig. 1. Identified risk factors for work-related musculoskeletal disorders among nurses.** The figure was created with Microsoft PowerPoint 2016 (Microsoft Corporation, Redmond, WA, USA). MAPO, movement and assistance of hospital patients. BMI, body mass index.

## Research Instruments

### *General Information Questionnaire*

This questionnaire collected demographic and background information, including age, gender, years of experience, medical history, marital status, childbearing status, education level, professional title, and income level. These indicators were categorized as ordinal variables and assigned scores ranging from 0 to 3 (Appendix Table 3).

### *The Movement and Assistance of Hospital Patients Method*

The movement and assistance of hospital patients (MAPO) Index (Zhang et al, 2020) assesses nurses' risk of WMSD from multiple perspectives, including nurse-to-patient ratio (workload), wheelchair use, restroom accessibility, patient room layout, and training. Data were collected through paper-based questionnaires by researchers, and on-site evaluations were conducted in nursing units. Head nurses were interviewed for staff counts, while bed spacing and other environmental measurements were recorded using a measuring tape. In this study, the Cronbach's $\alpha$ coefficient for the MAPO Index was 0.87, indicating high reliability.

### *Quick Exposure Check*

The quick exposure check (QEC) (Chen et al, 2018) includes observer and self-report sections. Observers rated ergonomic load based on changes in body position and movement of body parts during work tasks, while nurses self-reported their perceived workload. The combined observer ratings and self-assessment scores determined the overall QEC score and corresponding load level. Evaluation areas include the back, shoulders, wrists, and neck, considering factors like posture load, task frequency, duration, weight lifted, vibration, and job strain. The Cronbach's $\alpha$ value for QEC in this study was 0.84, indicating good internal consistency.

### *Foot Pressure Measurement Device*

The portable Gaitview AFA-50 system (20202073008, Jianai Scientific Instrument Co., Ltd., Shanghai, China), equipped with a 48HV matrix sensor, was used to assess foot pressure distribution, balance, foot shape, and pelvic rotation while participants stood in a natural posture. This compact and portable device allowed for convenient in-hospital measurements. Test-retest reliability analysis showed an intraclass correlation coefficient of 0.91, which suggests high measurement consistency across different operators over time.

### *Psychosocial and Work-Related Scales*

#### Muscle Fatigue

Muscle fatigue was measured using the Borg Fatigue Scale (Borg, 1982), with scores ranging from 0 (no fatigue) to 10 (extreme fatigue). The scale demonstrated strong reliability in this study (Cronbach's $\alpha = 0.86$).

#### Job Satisfaction

Job satisfaction was assessed using the Overall Job Satisfaction Scale (Lu et al, 2019), a 6-item tool with a total score range of 6–30, where higher scores indicate greater satisfaction. The scale demonstrated high internal consistency with a Cronbach's $\alpha$ of 0.89.

#### Job Stress

The Perceived Stress Scale (PSS) (Simon, 2021) was used to assess job stress levels. This 10-item scale assigned scores ranging from 0 to 40, with higher scores indicating greater perceived stress. The PSS demonstrated good internal consistency with a Cronbach's $\alpha$ of 0.83.

#### Occupational Strain

Occupational strain was measured using the Occupational Strain Scale (House et al, 1979), a 15-item scale with scores ranging from 0 to 60, where higher scores indicate greater strain. The Cronbach's $\alpha$ was 0.85.

#### Job Control

Job control was measured using the job control dimension of the Job Demand-Control model (Karasek, 1979). The 6-item scale had a total score range of 0–24, with higher scores indicating greater control over work tasks. The Cronbach's $\alpha$ was 0.79.

#### Intrinsic Motivation

Intrinsic motivation was assessed using the Intrinsic Motivation dimension of the Motivation at Work Scale (Gagné et al, 2010). This 3-item scale had a score range of 3 to 21, where higher scores represented greater intrinsic motivation. The Cronbach's $\alpha$ was 0.83.

### Subjective Well-Being

The Subjective Well-Being Scale (SWB) (Lyubomirsky and Lepper, 1999) was used to assess subjective well-being. This 20-item scale had a score range of 20–120, with higher scores indicating greater well-being. The Cronbach's $\alpha$ was 0.91.

### Fear of Negative Evaluation

Fear of negative evaluation was measured using the Fear of Negative Evaluation Scale (FNE) (Watson and Friend, 1969). This 12-item scale had a total score range of 12–60, with higher scores indicating greater fear of negative evaluation. The Cronbach's $\alpha$ was 0.85.

### Somatic Symptoms

Somatic symptoms were measured using the Somatic Symptom Scale-China (Wu et al, 2024), which focuses on somatization. This 9-item scale had a score range of 9–36, where higher scores indicated more severe somatic symptoms. The Cronbach's $\alpha$ was 0.88.

### Work-Family Conflict

Work-family conflict was evaluated using the Work-Family Behavioral Role Conflict Scale (Netemeyer et al, 1996). This 30-item scale had a score range of 30–150, with higher scores indicating higher levels of work-family conflict. The Cronbach's $\alpha$ was 0.85.

### Social Support

The Social Support Rating Scale (Zimet et al, 1988) was used to assess perceived social support. This 10-item scale had a score range of 12–66, where higher scores indicated greater levels of social support. The Cronbach's $\alpha$ was 0.90.

### Interpersonal Relationships

Interpersonal relationships were measured using the Interpersonal Support Evaluation List (ISEL) (Cohen and Hoberman, 1983). This 12-item scale had a score range of 0–36, with lower scores indicating poorer interpersonal relationships. The Cronbach's $\alpha$ was 0.86.

## Statistical Analysis

All sample data were randomly divided into training (approximately 70% of the data) and validation (approximately 30% of the data) sets. This 70:30 split is a commonly used ratio in statistical modeling and machine learning, as it ensures a sufficient number of samples for training the model while preserving an adequate portion for validation. According to Gholamy et al (2018), this ratio strikes an optimal balance between model training and validation. The model was developed based on the training set, with nurses diagnosed with work-related musculoskeletal disorders (WMSDs) as the case group and those without as the control group. Univariate and multivariate analyses were conducted using SPSS 19.0 (IBM Corporation, Armonk, NY, USA). Univariate analysis was performed for preliminary screening of all risk factors. Normality was tested using the Shapiro-Wilk test.

Continuous variables that followed a normal distribution were expressed as mean $\pm$ standard deviation (SD) and analysed using independent sample *t*-tests. Non-normally distributed continuous variables were expressed as median (interquartile range, IQR) and analysed using the rank-sum test. Categorical variables were presented as frequencies and percentages and analysed using the chi-square test. A two-sided *p*-value $< 0.05$ was considered statistically significant.

Variable selection was performed using Least Absolute Shrinkage and Selection Operator (LASSO) regression, implemented with the rms package in R software 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). Variables with statistical significance in the univariate analysis were included as independent variables in a binary logistic regression analysis. Based on the regression analysis results, a nomogram was constructed to visually represent the contribution of each variable to the risk of developing WMSDs. The rms package in R software 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) was used to develop the nomogram. Each variable's assigned scores were summed to calculate a total score, with higher scores indicating a greater risk of developing WMSDs. A risk probability curve was plotted based on the total score.

The receiver operating characteristic (ROC) curve of the predictive model was plotted, and the area under the curve (AUC) was calculated to assess the discriminative ability. A calibration curve was plotted to evaluate the consistency between predicted and observed incidence rates. Close alignment of the calibration curve with the 45° diagonal indicated robust agreement between predicted and actual outcomes. A decision curve analysis (DCA) was performed to assess the net benefits at different threshold probabilities, further validating the clinical effectiveness of the predictive model.

Figs. 2,3,4 in this study were generated using SPSS 19.0 (IBM Corporation, Armonk, NY, USA) and R software 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

# Results

## Analysis of Risk Factors for Musculoskeletal Disorders in Nurses in Tertiary Hospitals

A total of 3500 nurses were selected for the survey, and an equal number of electronic questionnaires were distributed. A total of 3481 responses were collected, of which 101 were deemed invalid, resulting in 3380 valid responses and an effective response rate of 96.57%. The data were randomly divided into a training set (n = 2350; 70%) and a validation set (n = 1030; 30%). Univariate analysis revealed that nurses in the case group (n = 1739) had significantly higher MAPO Index and QEC scores ($p < 0.001$), lower job satisfaction ($p < 0.001$), and greater work-family interference ($p < 0.001$) compared to the control group. The use of protective measures also differed significantly between the groups ($p < 0.05$). Additionally, physical exercise, plantar pressure distribution, and pelvic rotation exhibited statistically significant differences between the groups ($p < 0.001$). Nurses in the case group were older, had more childbearing responsibilities, and reported longer weekly household labour time ($p < 0.001$, Table 1).

## LASSO Regression

LASSO regression was applied to 11 candidate variables with statistical significance in univariate analysis. The optimal $\lambda$ value ($\lambda$ = –5.9861) was determined using 10-fold cross-validation. Ultimately, 10 key variables were selected, including MAPO Index, QEC score, job satisfaction, work-family interference, protective measures, physical exercise, foot pressure distribution, pelvic rotation, age, and weekly household labour time (Fig. 2A,B). LASSO regression effectively compressed and selected feature weights, effectively preventing model overfitting.

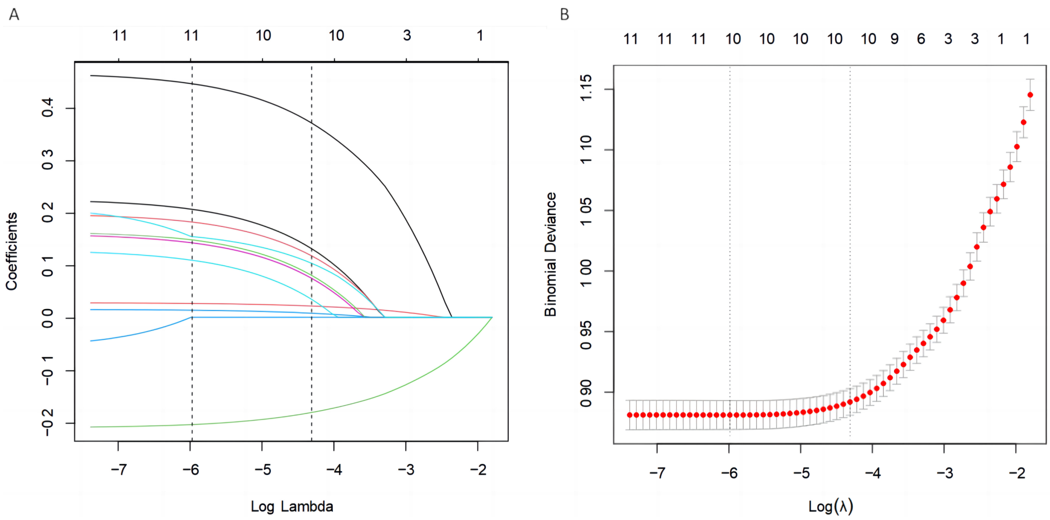


**Fig. 2. Feature selection using LASSO regression model for WMSD prediction.** (A) Dynamic plot of variable selection using LASSO regression. (B) 10-fold cross-validation for the LASSO model. LASSO, Least Absolute Shrinkage and Selection Operator; WMSD, work-related musculoskeletal disorder.

## Multivariate Logistic Regression

Binary logistic regression analysis identified several significant predictors associated with the incidence of WMSDs among nurses (Table 2). The MAPO Index (odds ratio (OR) = 1.579, 95% confidence interval (CI): 1.431–1.742, $p < 0.001$) and QEC score (OR = 1.028, 95% CI: 1.021–1.034, $p < 0.001$) were positively associated with WMSD incidence, while higher job satisfaction reduced the likelihood of developing WMSDs (OR = 0.807, 95% CI: 0.786–0.828, $p < 0.001$). Work-family interference (OR = 1.016, 95% CI: 1.008–1.023, $p < 0.001$) and lack of protective measures (OR = 1.571, 95% CI: 1.075–2.296, $p = 0.020$) were also significant risk factors.

Nurses who never exercised had an increased risk of WMSDs (OR = 1.608, 95% CI: 1.127–2.295, $p = 0.009$), while moderate and severe plantar pressure imbalance was also associated with higher odds of developing WMSDs (OR = 1.703–1.757, $p < 0.005$). Severe pelvic rotation was identified as a significant predictor

**Table 1. Univariate analysis of risk factors for work-related musculoskeletal disorders among nurses in tertiary hospitals.**

| Variable | Control group (n = 611) | Case group (n = 1739) | Statistic | *p*-value |
|---|---|---|---|---|
| MAPO Index, [M (P25, P75)] | 2.00 (1.00, 3.00) | 3.00 (2.00, 4.00) | 11.368 | <0.001 |
| QEC score, (mean ± SD) | 97.59 ± 16.87 | 106.06 ± 17.94 | 10.181 | <0.001 |
| Muscle fatigue, (mean ± SD) | 5.21 ± 1.77 | 5.22 ± 1.80 | 0.105 | 0.917 |
| Job satisfaction, (mean ± SD) | 22.40 ± 4.20 | 18.24 ± 4.60 | 19.724 | <0.001 |
| Subjective well-being, (mean ± SD) | 72.63 ± 10.15 | 72.31 ± 12.18 | 0.597 | 0.551 |
| Work-family interference (mean ± SD) | 82.26 ± 13.43 | 85.14 ± 14.72 | 4.256 | <0.001 |
| Job stress, (mean ± SD) | 31.68 ± 7.14 | 31.78 ± 8.50 | 0.258 | 0.796 |
| Job control, (mean ± SD) | 15.23 ± 3.65 | 15.51 ± 3.99 | 1.549 | 0.122 |
| Intrinsic motivation, (mean ± SD) | 13.79 ± 3.00 | 13.68 ± 3.22 | 0.798 | 0.425 |
| Subjective well-being, (mean ± SD) | 72.62 ± 10.28 | 72.46 ± 12.13 | 0.320 | 0.747 |
| Fear-avoidance beliefs, (mean ± SD) | 32.64 ± 8.41 | 32.84 ± 9.83 | 0.448 | 0.654 |
| Somatization symptoms, (mean ± SD) | 18.83 ± 4.59 | 19.14 ± 5.57 | 1.238 | 0.216 |
| Social support, (mean ± SD) | 42.31 ± 7.84 | 41.67 ± 8.61 | 1.620 | 0.105 |
| Interpersonal relationships, (mean ± SD) | 19.85 ± 5.36 | 20.03 ± 6.14 | 0.645 | 0.519 |
| Protective measures, n (%) | | | 8.038 | 0.045 |
| Comprehensive | 193 (31.59%) | 521 (29.96%) | | |
| Partial | 235 (38.46%) | 594 (34.16%) | | |
| Limited | 120 (19.64%) | 388 (22.31%) | | |
| None | 63 (10.31%) | 236 (13.57%) | | |
| Risk perception, n (%) | | | 7.600 | 0.055 |
| High | 304 (49.75%) | 813 (46.75%) | | |
| Moderate | 186 (30.45%) | 524 (30.13%) | | |
| Low | 94 (15.38%) | 270 (15.53%) | | |
| None | 27 (4.42%) | 132 (7.59%) | | |
| Training, n (%) | | | 6.785 | 0.079 |
| Regular training | 254 (41.57%) | 630 (36.23%) | | |
| Occasional training | 206 (33.72%) | 660 (37.95%) | | |
| One-time training | 95 (15.55%) | 302 (17.37%) | | |
| No training | 56 (9.17%) | 147 (8.45%) | | |
| Night shifts per month, n (%) | | | 7.074 | 0.069 |
| 0–5 times | 380 (62.19%) | 1008 (57.97%) | | |
| 6–10 times | 144 (23.57%) | 484 (27.83%) | | |
| 11–15 times | 55 (9.00%) | 179 (10.29%) | | |
| >15 times | 32 (5.24%) | 68 (3.91%) | | |
| Working hours per day, n (%) | | | 7.298 | 0.063 |
| <6 hours | 140 (22.912%) | 397 (22.83%) | | |
| 6–8 hours | 339 (55.48%) | 879 (50.55%) | | |
| 8–10 hours | 94 (15.38%) | 347 (19.95%) | | |
| >10 hours | 38 (6.22%) | 116 (6.67%) | | |
| Type of bed, n (%) | | | 3.926 | 0.1270 |
| Electric bed | 275 (45.01%) | 707 (40.65%) | | |
| Semi-electric bed | 125 (20.46%) | 388 (22.31%) | | |
| Others | 60 (9.82%) | 198 (11.39%) | | |
| Manual bed | 151 (24.71%) | 446 (25.65%) | | |

**Table 1. Continued.**

| Variable | Control group (n = 611) | Case group (n = 1739) | Statistic | *p*-value |
|---|---|---|---|---|
| Nurse rest area, n (%) | | | 4.151 | 0.246 |
| Well-equipped, comfortable, suitable for rest | 215 (35.19%) | 566 (32.55%) | | |
| Basic facilities available, moderate comfort | 249 (40.75%) | 683 (39.28%) | | |
| Insufficient facilities, poor comfort | 96 (15.71%) | 328 (18.86%) | | |
| No designated rest area | 51 (8.35%) | 162 (9.31%) | | |
| Number of patients, n (%) | | | 7.227 | 0.065 |
| Moderate, able to manage workload | 209 (34.20%) | 562 (32.32%) | | |
| Slightly high, occasionally required overtime | 187 (30.61%) | 618 (35.54%) | | |
| Relatively high, heavy workload | 149 (24.39%) | 356 (20.47%) | | |
| Extremely high, often required overtime and handling emergencies | 66 (10.80%) | 203 (11.67%) | | |
| Physical exercise, n (%) | | | 21.587 | <0.001 |
| At least 3 times per week | 101 (16.53%) | 252 (14.49%) | | |
| 1–2 times per week | 218 (35.68%) | 526 (30.25%) | | |
| 1–2 times per month | 166 (27.17%) | 434 (24.96%) | | |
| Never | 126 (20.62%) | 527 (30.30%) | | |
| Back belt, n (%) | | | 6.877 | 0.076 |
| Frequently used | 149 (24.39%) | 347 (19.95%) | | |
| Occasionally used | 172 (28.15%) | 534 (30.71%) | | |
| Rarely used | 192 (31.42%) | 535 (30.76%) | | |
| Never used | 98 (16.04%) | 323 (18.58%) | | |
| Plantar pressure distribution, n (%) | | | 21.662 | <0.001 |
| Normal, pressure evenly distributed | 153 (25.04%) | 349 (20.07%) | | |
| Slightly uneven, local pressure relatively high | 222 (36.34%) | 529 (30.42%) | | |
| Moderately uneven, significant pressure in some areas | 142 (23.24%) | 520 (29.90%) | | |
| Severely uneven, pressure concentrated in specific areas | 94 (15.38%) | 341 (19.61%) | | |
| Balance, n (%) | | | 1.024 | 0.795 |
| Good, able to maintain balance easily | 115 (18.82%) | 341 (19.61%) | | |
| Average, occasionally needs balance adjustment | 180 (29.46%) | 522 (30.02%) | | |
| Poor, frequent balance issues | 184 (30.12%) | 533 (30.65%) | | |
| Very poor, often requires external help to maintain balance | 132 (21.60%) | 343 (19.72%) | | |
| Foot morphology, n (%) | | | 0.381 | 0.944 |
| Normal, no significant issues | 112 (18.33%) | 331 (19.03%) | | |
| Minor issues (e.g., low or high arches) | 183 (29.95%) | 523 (30.08%) | | |
| Moderate issues (e.g., flat or high arches) | 184 (30.12%) | 528 (30.36%) | | |
| Severe issues (e.g., deformities) | 132 (21.60%) | 357 (20.53%) | | |
| Pelvic rotation, n (%) | | | 27.168 | <0.001 |
| Normal, no significant rotation | 186 (30.44%) | 421 (24.21%) | | |
| Mild rotation, feels uncomfortable | 215 (35.19%) | 526 (30.25%) | | |
| Moderate rotation, affects daily activities | 134 (21.93%) | 443 (25.47%) | | |
| Severe rotation, requires medical intervention | 76 (12.44%) | 349 (20.07%) | | |

**Table 1. Continued.**

| Variable | Control group (n = 611) | Case group (n = 1739) | Statistic | *p*-value |
|---|---|---|---|---|
| Professional title, n (%) | | | 4.615 | 0.202 |
| Junior nurse | 248 (40.59%) | 767 (44.11%) | | |
| Intermediate nurse | 233 (38.13%) | 580 (33.35%) | | |
| Senior nurse | 93 (15.22%) | 279 (16.04%) | | |
| Nursing management personnel | 37 (6.06%) | 113 (6.50%) | | |
| Economic income monthly, n (%) | | | 0.837 | 0.475 |
| <5000 Chinese yuan | 201 (32.90%) | 540 (31.05%) | | |
| 5000–8000 Chinese yuan | 236 (38.63%) | 687 (39.50%) | | |
| 8000–10,000 Chinese yuan | 115 (18.82%) | 346 (19.90%) | | |
| ≥10,000 Chinese yuan | 59 (9.65%) | 166 (9.55%) | | |
| Marital status, n (%) | | | 0.432 | 0.933 |
| Single | 124 (22.29%) | 358 (20.54%) | | |
| Married | 371 (59.08%) | 1050 (60.42%) | | |
| Divorced | 91 (14.49%) | 250 (14.38%) | | |
| Widowed or other | 25 (4.14%) | 81 (4.66%) | | |
| Age, n (%) | | | 22.275 | <0.001 |
| 20–29 years | 184 (30.11%) | 436 (25.07%) | | |
| 30–39 years | 274 (44.84%) | 694 (39.91%) | | |
| 40–49 years | 120 (19.64%) | 447 (25.70%) | | |
| 50 years and above | 33 (5.41%) | 162 (9.32%) | | |
| Gender, n (%) | | | 3.177 | 0.075 |
| Male | 136 (22.26%) | 329 (18.92%) | | |
| Female | 475 (77.74%) | 1410 (81.08%) | | |
| Sleep duration, n (%) | | | 1.459 | 0.692 |
| 7–8 hours | 146 (23.90%) | 445 (25.59%) | | |
| 6–7 hours | 237 (38.79%) | 690 (39.68%) | | |
| 5–6 hours | 164 (26.84%) | 434 (24.96%) | | |
| <5 hours | 64 (10.47%) | 170 (9.77%) | | |
| Staying up late, n (%) | | | 0.663 | 0.882 |
| <once a week | 252 (41.24%) | 686 (39.45%) | | |
| 1–2 times a week | 210 (34.37%) | 609 (35.02%) | | |
| 3–4 times a week | 89 (14.57%) | 267 (15.35%) | | |
| 5 times a week or more | 60 (9.82%) | 177 (10.18%) | | |
| Sleep quality, n (%) | | | 1.406 | 0.704 |
| Excellent | 129 (21.11%) | 349 (20.07%) | | |
| Good | 240 (39.28%) | 702 (40.37%) | | |
| Fair | 187 (30.61%) | 509 (29.27%) | | |
| Poor | 55 (9.00%) | 179 (10.29%) | | |
| Years of work experience, n (%) | | | 7.741 | 0.052 |
| <5 years | 81 (13.26%) | 285 (16.39%) | | |
| 5–10 years | 227 (37.15%) | 552 (31.74%) | | |
| 11–20 years | 168 (27.50%) | 480 (27.60%) | | |
| >20 years | 135 (22.09%) | 422 (24.27%) | | |

**Table 1. Continued.**

| Variable | Control group (n = 611) | Case group (n = 1739) | Statistic | $p$-value |
|---|---|---|---|---|
| Medical history, n (%) | | | 2.949 | 0.088 |
| No | 450 (73.65%) | 1217 (69.98%) | | |
| Yes | 161 (26.35%) | 522 (30.02%) | | |
| Childbearing status, n (%) | | | 32.271 | $<$0.001 |
| No children | 194 (31.75%) | 489 (28.12%) | | |
| Not applicable (e.g., unmarried) | 56 (9.16%) | 75 (4.31%) | | |
| 1–2 children | 305 (49.92%) | 902 (51.87%) | | |
| 3 or more children | 56 (9.17%) | 273 (15.70%) | | |
| Weekly household labour time, n (%) | | | 44.468 | $<$0.001 |
| $<$5 hours/week | 130 (21.28%) | 199 (11.44%) | | |
| 5–10 hours/week | 188 (30.77%) | 513 (29.50%) | | |
| 11–15 hours/week | 186 (30.44%) | 590 (33.93%) | | |
| $\geq$16 hours/week | 107 (17.51%) | 437 (25.13%) | | |

The exchange rate is 1 USD = 6.37 Chinese yuan (December 2021). SD, standard deviation; MAPO, movement and assistance of hospital patients; QEC, quick exposure check.

(OR = 1.746, 95% CI: 1.229–2.480, $p = 0.002$), as was older age ($\geq$50 years, OR = 1.885, 95% CI: 1.171–3.036, $p = 0.009$). Additionally, household labour time $\geq$16 hours/week was linked to an increased risk of WMSDs (OR = 1.878, 95% CI: 1.305–2.703, $p = 0.001$).

## Nomogram

A nomogram was developed to predict the risk of musculoskeletal disorders (MSDs) in nurses by integrating multiple variables to estimate an individual's probability of developing the condition. The included variables were the MAPO Index, QEC score, job satisfaction, work-family interference, protective measures, physical exercise, foot pressure distribution, pelvic rotation, age, and weekly household labour time. A total score was derived by assigning a corresponding score to each variable on the scale and summing them. Based on this total score, the corresponding linear prediction value was identified on the nomogram, which was then used to estimate the risk ratio for MSDs (Fig. 3A). For instance, if a nurse had a MAPO Index of 3, QEC score of 100, job satisfaction score of 30, work-family interference score of 70, protective measures score of 1, physical exercise score of 2, foot pressure distribution score of 2, pelvic rotation score of 2, age score of 2, and weekly household labour time core of 3, the corresponding scores would be MAPO Index = 13, QEC score = 26.5, job satisfaction = 14.5, work-family interference = 8, protective measures = 2, physical exercise = 4, foot pressure distribution = 6, pelvic rotation = 5, age = 4.8, and weekly household labour time = 7.8, yielding a total score of 91.6. This total score corresponded to a risk probability of approximately 0.43.

To validate the predictive performance of the model, the ROC curve was plotted, yielding an AUC of 0.822 (95% CI: 0.803–0.840, $p < 0.001$), with specificity and sensitivity values of 0.812 and 0.680, respectively (Fig. 3B). The model ef-

**Table 2. Multivariate logistic regression analysis of factors associated with musculoskeletal disorders among nurses.**

| Variable | $\beta$ | S.E. | Wald | $p$-value | OR | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower limit | Upper limit |
| MAPO Index | 0.457 | 0.050 | 82.613 | <0.001 | 1.579 | 1.431 | 1.742 |
| QEC score | 0.027 | 0.003 | 73.478 | <0.001 | 1.028 | 1.021 | 1.034 |
| Job satisfaction | –0.215 | 0.014 | 251.550 | <0.001 | 0.807 | 0.786 | 0.828 |
| Work-family interference | 0.015 | 0.004 | 15.481 | <0.001 | 1.016 | 1.008 | 1.023 |
| Protective measures | | | | | | | |
| Comprehensive | | | | | | | Reference |
| Partial | –0.104 | 0.136 | 0.579 | 0.447 | 0.902 | 0.690 | 1.177 |
| Limited | 0.185 | 0.159 | 1.357 | 0.244 | 1.204 | 0.881 | 1.645 |
| None | 0.452 | 0.194 | 5.444 | 0.020 | 1.571 | 1.075 | 2.296 |
| Physical exercise | | | | | | | |
| ≥3 times per week | | | | | | | Reference |
| 1–2 times per week | –0.054 | 0.170 | 0.102 | 0.749 | 0.947 | 0.678 | 1.322 |
| 1–2 times per month | –0.063 | 0.176 | 0.127 | 0.722 | 0.939 | 0.665 | 1.327 |
| Never | 0.475 | 0.181 | 6.846 | 0.009 | 1.608 | 1.127 | 2.295 |
| Plantar pressure distribution | | | | | | | |
| Normal (even distribution) | | | | | | | Reference |
| Slightly uneven, local pressure relatively high | 0.026 | 0.149 | 0.031 | 0.860 | 1.027 | 0.767 | 1.374 |
| Moderately uneven, significant pressure in some areas | 0.532 | 0.160 | 11.069 | 0.001 | 1.703 | 1.244 | 2.330 |
| Severely uneven, pressure concentrated in specific areas | 0.563 | 0.178 | 9.975 | 0.002 | 1.757 | 1.238 | 2.492 |
| Pelvic rotation | | | | | | | |
| Normal, no significant rotation | | | | | | | Reference |
| Mild rotation, feels uncomfortable | 0.130 | 0.142 | 0.836 | 0.361 | 1.139 | 0.862 | 1.505 |
| Moderate rotation, affects daily activities | 0.423 | 0.156 | 7.350 | 0.007 | 1.526 | 1.124 | 2.071 |
| Severe rotation, requires medical intervention | 0.557 | 0.179 | 9.681 | 0.002 | 1.746 | 1.229 | 2.480 |
| Age | | | | | | | |
| 20–29 years | | | | | | | Reference |
| 30–39 years | –0.025 | 0.135 | 0.035 | 0.853 | 0.975 | 0.749 | 1.270 |
| 40–49 years | 0.250 | 0.158 | 2.511 | 0.113 | 1.284 | 0.942 | 1.750 |
| ≥50 years | 0.634 | 0.243 | 6.806 | 0.009 | 1.885 | 1.171 | 3.036 |
| Weekly household labour time | | | | | | | |
| <5 hours/week | | | | | | | Reference |
| 5–10 hours/week | 0.376 | 0.172 | 4.768 | 0.029 | 1.457 | 1.039 | 2.043 |
| 11–15 hours/week | 0.369 | 0.171 | 4.679 | 0.031 | 1.446 | 1.035 | 2.021 |
| ≥16 hours/week | 0.630 | 0.186 | 11.510 | 0.001 | 1.878 | 1.305 | 2.703 |

OR, odds ratio; CI, confidence interval; MAPO, movement and assistance of hospital patients; QEC, quick exposure check; S.E., standard error.

fectively differentiates between nurses who develop work-related musculoskeletal disorders (WMSDs) and those who do not. The calibration plot demonstrates that the predicted probability (black line) closely aligns with the ideal calibration line (red line), indicating high calibration accuracy (Fig. 3C). Decision curve analysis results show that across various risk thresholds (e.g., 20%–75%), the net benefit of the model (blue curve) is significantly greater than the "treat all" (red curve) and "treat none" (green curve) strategies (Fig. 3D). These findings suggest that the model's predictions may serve as a valuable clinical decision-support tool for early intervention in work-related musculoskeletal disorders among nurses.

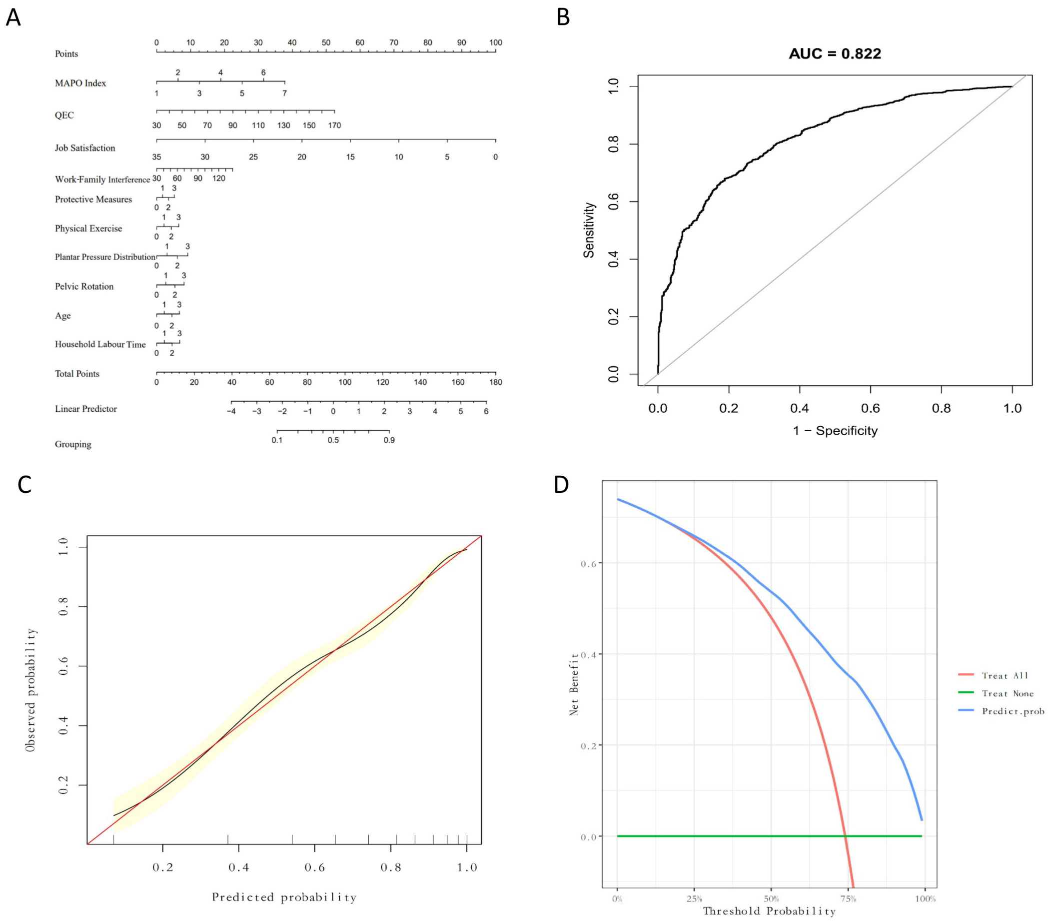


**Fig. 3. Development and performance evaluation of the WMSD prediction nomogram.** (A) Nomogram for estimating the risk of musculoskeletal disorders in nurses. (B) Discrimination curve for the training set. (C) Calibration curve assessing agreement between predicted and observed risk in the training set. (D) Decision curve analysis (DCA) evaluating the net clinical benefits across threshold probabilities. AUC, area under the curve.

## External Validation of the Nomogram Model

In the validation set, the model achieved an AUC of 0.810 (95% CI: 0.775–0.845, $p < 0.001$), with specificity and sensitivity values of 0.747 and 0.748, respectively, confirming its strong discriminatory ability (Fig. 4A). The calibration curve further demonstrated that predicted probabilities closely matched observed outcomes, as indicated by the curve's close alignment with the diagonal reference line (Fig. 4B). Decision curve analysis revealed that within various risk threshold ranges (e.g., 20%–80%), the net benefit of the model (blue curve) remained significantly higher than the "treat all" (red curve) and "treat none" (green curve) strategies (Fig. 4C).

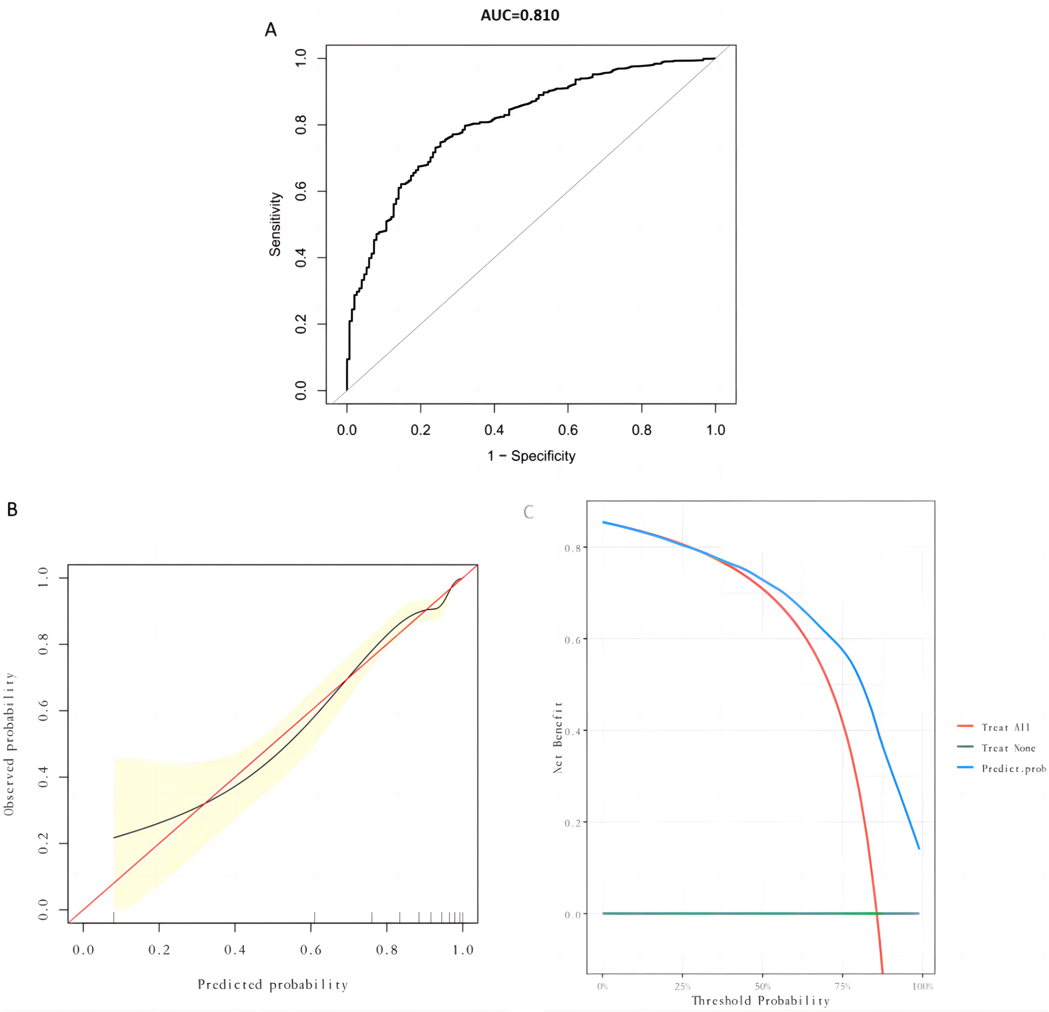


**Fig. 4. External validation of the WMSD prediction model.** (A) ROC curve of the validation set. (B) Calibration curve showing agreement between predicted and observed probabilities in the validation set. (C) Decision curve analysis (DCA) demonstrating the clinical utility of the model in the validation set. ROC, receiver operating characteristic.

# Discussion

This study aimed to develop and evaluate a predictive model for work-related musculoskeletal disorders (WMSDs) among nurses in tertiary hospitals in China. Using data collected from 3500 nurses, various risk assessment tools were employed, including the MAPO method, QEC, and foot pressure detectors, alongside several personal and work-related factors. By constructing a nomogram model and performing extensive data analysis, multiple significant risk factors associated with WMSDs in the nursing profession were identified.

The predictive model developed in this study demonstrated strong accuracy, with an AUC of 0.822 in the training set and 0.810 in the validation set, demonstrating its reliability across different subsets of the dataset. The model incorporates various risk factors, such as ergonomic indices (MAPO and QEC) and personal characteristics, highlighting its potential applicability to other healthcare environments with similar occupational hazards. However, further validation at regional and hospital levels is required to confirm the model's generalizability and ensure its effectiveness across diverse nursing settings. The nomogram provides a practical decision-making tool for identifying high-risk nurses and implementing targeted interventions. For example, hospitals could leverage this model to prioritize ergonomic adjustments, implement protective measures, and design tailored training programs. Additionally, integrating the model into electronic health records (EHR) systems could enhance its clinical utility by enabling real-time risk assessment and intervention planning.

Our findings align with national and international studies on WMSD risk factors among nurses. Notably, MAPO indices and QEC scores were significantly higher in nurses with musculoskeletal disorders compared to those without, suggesting a strong association between high work demands and WMSD incidence. This observation is consistent with the study by Almhdawi et al (2020), which identified manual handling tasks, prolonged standing, and high-intensity work as primary contributors to WMSDs among nurses. Furthermore, our study revealed a negative correlation between job satisfaction and WMSD incidence, consistent with findings by Mansour et al (2022). Low job satisfaction may heighten physical and psychological stress, exacerbating musculoskeletal strain among nurses.

However, our study also identified certain findings that differ from existing literature. For example, factors such as subjective well-being, work stress, social support, and interpersonal relationships did not show significant differences between the two groups, contrasting with studies that emphasize the role of psychological factors in WMSD development (Salmani Nodooshan et al, 2020; Silva et al, 2022). A possible explanation is that in the tertiary hospital settings, physical workload predominates, potentially overshadowing the impact of psychological factors. Nurses in these hospitals frequently engage in physically demanding tasks, such as patient handling and prolonged standing, which are directly associated with musculoskeletal strain. Additionally, structured institutional policies and peer support in tertiary hospitals may help mitigate the influence of psychological factors. Future research should examine the complex interactions between psychological and physiological factors across different nursing environments and roles.

Another key finding of this study is the significant influence of work-family conflict on WMSDs among nurses. Notably, nurses experiencing high work-family role conflict were more likely to develop WMSDs. Long work hours and heavy workloads are common in the nursing profession, not only directly increasing nurses' physical burden but also indirectly contributing to the musculoskeletal system over time through fatigue and stress. This finding suggests that reducing excess work hours, adjusting shift schedules, and promoting work-life balance may help lower the incidence of WMSDs among nurses.

Additionally, the use of protective measures showed a significant impact in this study. The proportion of nurses with WMSDs who used comprehensive protective measures was significantly lower than those without WMSDs, underscoring the critical role of such measures in preventing musculoskeletal disorders. Implementing appropriate protective interventions, such as mechanical assistive devices and proper patient-handling training, can effectively reduce the risk of injury among nurses. However, many hospitals have yet to fully adopt these protective measures, especially for frontline nursing staff, who often lack systematic training and equipment support. Hospital management should address this gap by introducing and promoting appropriate protective measures and training programs to safeguard the occupational health of nursing personnel.

One key strength of this study lies in its large sample size and diverse data sources. In addition to traditional questionnaires, we incorporated various objective assessment tools, such as the MAPO method, QEC, and foot pressure detectors, allowing for a comprehensive evaluation of WMSD risks among nurses. This multifaceted approach enhances the accuracy of assessing potential factors affecting nurses' health, offering a more objective and reliable risk evaluation compared to relying solely on self-reported surveys. Furthermore, the nomogram model developed in this study serves as a practical decision-making tool for nursing managers and offers theoretical support for implementing targeted interventions. By allowing for personalized risk assessment for each nurse, the nomogram enhances the precision and efficacy of intervention strategies.

Despite the study's strengths, including its large sample size and diverse assessment tools, several limitations must be acknowledged. First, as a cross-sectional study, it cannot establish causal relationships. While multiple risk factors associated with WMSDs were identified, their causal mechanisms require further validation through prospective studies. Second, the data in this study were primarily obtained from tertiary hospitals in Chongqing, which may introduce regional and institutional bias. As a result, the generalizability of these findings requires further verification in different regions and across hospitals of different levels. Additionally, certain data in this study were collected through self-reported questionnaires, and despite multiple quality control measures, the subjectivity and potential recall bias associated with self-reported data remain unavoidable. For example, nurses' responses to scales assessing job satisfaction or subjective well-being may be influenced by personal emotions or the environment in which the survey was completed, potentially introducing bias into the results. Future research should consider incorporating more objective physiological or behavioral indicators, such as biofeedback data collected during work, to validate these subjective assessments.

Regarding the strengths and limitations of this study, future research should focus on several key areas. Longitudinal studies are needed to establish causal relationships and track the evolution of WMSD risk factors over time. The development of real-time monitoring tools, such as wearable devices or biofeedback systems, could facilitate continuous assessment of occupational risks while providing objective data on physical and psychological stressors. Additionally, intervention studies should be conducted to evaluate the effectiveness of tailored protective measures, work-life balance programs, and systematic training in reducing WMSD risk. Further regional and institutional validation is required to test the model across diverse healthcare settings and improve its generalizability and effectiveness. Lastly, more research is needed on psychological factors, particularly their interaction with physiological stressors in different work environments and nursing roles to better understand their contribution to the development of WMSDs.

In conclusion, this study constructed a predictive model for WMSDs based on cross-sectional data from nurses in tertiary hospitals in China, providing valuable insights for future interventions and policy development. Further validation of the model's predictive accuracy and the implementation of effective intervention strategies are essential to reducing the occupational musculoskeletal disorder risk among nurses and improving their overall occupational health.

## Conclusion

This study constructed a predictive model for work-related musculoskeletal disorders (WMSDs), revealing that multiple factors significantly influence the risk of WMSDs among nurses. The findings suggest that comprehensive protective measures, regular physical activity, even foot pressure distribution, and normal pelvic alignment play a crucial role in reducing WMSD incidence. Conversely, older age, extended time spent on household tasks, elevated MAPO Index scores, and work-family interference are associated with an increased risk.

### Key Points

- Comprehensive protective measures and regular physical activity significantly reduce the risk of WMSDs among nurses.
- Even foot pressure distribution (OR = 0.63) and normal pelvic alignment (OR = 0.49) are effective protective factors against WMSDs.
- Advancing age and prolonged household work hours significantly increase the risk of WMSDs.
- High job satisfaction significantly reduces the risk of WMSDs, underscoring the importance of psychological factors.

## Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

## Author Contributions

LY and JM designed the study; all authors conducted the study; LF and JL collected and analysed the data. JT, LH and YY participated in drafting the manuscript, and all authors contributed to the critical revision of the manuscript for important intellectual content. All authors gave final approval of the version to be published. All authors participated fully in the work, took public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or completeness of any part of the work were appropriately investigated and resolved.

## Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Chongqing Traditional Chinese Medicine Hospital (approval number: 2021-ky-46). This study was performed in accordance with the principles of the Declaration of Helsinki. Informed consent has been obtained from all participants involved in the study.

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## Conflict of Interest

The authors declare no conflict of interest.

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# Appendix

See Table 3.

**Table 3. Risk factors for musculoskeletal disorders related to nursing work.**

| Variables | Scores |
|---|---|
| Protective measures | |
| Comprehensive | 0 |
| Partial | 1 |
| Limited | 2 |
| None | 3 |
| Risk perception | |
| High | 0 |
| Moderate | 1 |
| Low | 2 |
| None | 3 |
| Training | |
| Regular training | 0 |
| Occasional training | 1 |
| One-time training | 2 |
| No training | 3 |
| Night shifts per month | |
| 0–5 times | 0 |
| 6–10 times | 1 |
| 11–15 times | 2 |
| >15 times | 3 |
| Working hours per day | |
| Less than 6 hours | 0 |
| 6–8 hours | 1 |
| 8–10 hours | 2 |
| More than 10 hours | 3 |
| Type of bed | |
| Electric bed | 0 |
| Semi-electric bed | 1 |
| Others | 2 |
| Manual bed | 3 |
| Nurse rest area | |
| Well-equipped, comfortable, suitable for rest | 0 |
| Basic facilities available, moderate comfort | 1 |
| Insufficient facilities, poor comfort | 2 |
| No designated rest area | 3 |

**Table 3. Continued.**

| Variables | Scores |
|---|---|
| Number of patients | |
| Moderate, able to manage workload | 0 |
| Slightly high, occasionally required overtime | 1 |
| Relatively high, heavy workload | 2 |
| Extremely high, often required overtime and handling emergencies | 3 |
| Physical exercise | |
| At least 3 times per week | 0 |
| 1–2 times per week | 1 |
| 1–2 times per month | 2 |
| Never | 3 |
| Back belt | |
| Frequently used | 0 |
| Occasionally used | 1 |
| Rarely used | 2 |
| Never used | 3 |
| Plantar pressure distribution | |
| Normal, pressure evenly distributed | 0 |
| Slightly uneven, local pressure relatively high | 1 |
| Moderately uneven, significant pressure in some areas | 2 |
| Severely uneven, pressure concentrated in specific areas | 3 |
| Balance | |
| Good, able to maintain balance easily | 0 |
| Average, occasionally needs balance adjustment | 1 |
| Poor, frequent balance issues | 2 |
| Very poor, often requires external help to maintain balance | 3 |
| Foot morphology | |
| Normal, no significant issues | 0 |
| Minor issues, such as low or excessively high arches | 1 |
| Moderate issues, such as flat feet or high arches | 2 |
| Severe issues, such as foot deformities | 3 |
| Pelvic rotation | |
| Normal, no significant rotation | 0 |
| Mild rotation, feels uncomfortable | 1 |
| Moderate rotation, affects daily activities | 2 |
| Severe rotation, requires medical intervention | 3 |
| Economic income, n (%) | |
| Less than 5000 Chinese yuan | 0 |
| 5000–8000 Chinese yuan | 1 |
| 8000–10,000 Chinese yuan | 2 |
| ≥10,000 Chinese yuan | 3 |
| Age, n (%) | |
| 20–29 years | 0 |
| 30–39 years | 1 |
| 40–49 years | 2 |
| 50 years and above | 3 |

**Table 3. Continued.**

| Variables | Scores |
|---|---|
| Sleep duration, n (%) | |
| 7–8 hours | 0 |
| 6–7 hours | 1 |
| 5–6 hours | 2 |
| Less than 5 hours | 3 |
| Staying up late | |
| Less than once a week | 0 |
| 1–2 times a week | 1 |
| 3–4 times a week | 2 |
| 5 times a week or more | 3 |
| Sleep quality | |
| Excellent | 0 |
| Good | 1 |
| Fair | 2 |
| Poor | 3 |
| Years of work experience | |
| Less than 5 years | 0 |
| 5–10 years | 1 |
| 11–20 years | 2 |
| More than 20 years | 3 |
| Medical history | |
| No | 0 |
| Yes | 1 |
| Childbearing status | |
| No children | 0 |
| Not applicable (e.g., unmarried) | 1 |
| 1–2 children | 2 |
| 3 or more children | 3 |
| Household labour time | |
| Less than 5 hours/week | 0 |
| 5–10 hours/week | 1 |
| 11–15 hours/week | 2 |
| ≥16 hours/week | 3 |

The exchange rate is 1 USD = 6.37 Chinese yuan (December 2021).