Shoulder work-related musculoskeletal disorders and related factors of workers in 15 industries of China: a cross-sectional study

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Abstract

Background: Changes in modern industrial production practices can easily lead to shoulder work-related musculoskeletal disorders (WMSD). The current reports on shoulder WMSD are limited to some industries are less well studied, and the sample size is usually small. This study aimed to describe the prevalence and severity of shoulder WMSD in a large sample of Chinese workers from 15 industries, analyze the possible correlations with sociodemographic and work-related variables, and compare the differences between industries.

Methods: A cross-sectional study was conducted among a sample of 55,749 participants from 252 enterprises in 15 industries throughout China. A Chinese version of the musculoskeletal disease questionnaire was used to collect the demographic factors, shoulder symptoms in past 12 months, and work-related factors including posture-related factors, repetition, vibration, work organization, job control, and environmental factors as independent variables. Descriptive statistics were used, and the binary logistic regression analysis was performed to explore the association between shoulder WMSD and potential demographic and work-related factors.

Results: Nearly 35.5% of participants reported shoulder pain and discomfort in the previous 12 months. Biopharmaceutical manufacturing (56.2%), medical services (54.4%), and aviation services (50.1%) were the three industries with the highest prevalence of shoulder WMSD. The pain score of aviation services workers was the highest. The related factors for shoulder WMSD varied among the different industries.

Conclusion: Our study found a relatively high prevalence of shoulder WMSD in China. There were large differences in the prevalence of shoulder WMSD among industries, and the related factors were particular to each industry. Such information is useful to help occupational health practitioners and policymakers conduct preventive programs to reduce shoulder disorders in these working populations.

Keywords: Work-related musculoskeletal disorders (WMSD), Shoulder pain, Related factor
in the workplace [1], are the second most common work-related problem worldwide [2].

With the development of industrial science and technology and changes in production practices, forced posture movements of low-load, rapid rhythms and high repetition for long duration have become a primary feature of modern industry. These work practices can easily lead to local muscle fatigue, and in severe cases, local musculoskeletal disease. An epidemiological study found that one of the most common sites of WMSD among workers was the shoulder [3]. Previous research on shoulder WMSD has focused on medical staff [4], such as nurses [5], dentists [6], and surgeons [7]. Although there are some studies on shoulder WMSD in other industries, such as aviation services [8] and vegetable greenhouses [9], more information is needed. In addition, there are no reports of the prevalence of shoulder WMSD in automobile 4S workplaces (4S indicates Sales, Spare parts, Service, and Survey).

According to several previous studies [10–12], demographic factors (e.g., age, gender, body mass index, and education level) are associated with WMSD, and occupational factors such as posture-related factors, work organization, and environmental factors can significantly contribute to pain. Wang et al. [1] reported that years of work and perceived health status increased the prevalence of shoulder symptoms. Seidler et al. [13] identified a dose–response relationship between specific shoulder diseases and hands at/above shoulder level, repetitive movements, forceful work, and hand/arm vibrations.

The current study aimed to determine the prevalence and severity of shoulder WMSD in Chinese workers from various industries and investigated the possible correlations with sociodemographic and work-related variables. These findings could help occupational health practitioners and policymakers conduct specific interventions to reduce shoulder disorders in these working populations.

**Methods**

**Survey participants**

The survey was carried out in the north, the east, the central, the south, the southwest, the northwest, and the northeast 7 regions of China, and the participants were from 15 industries, including automobile manufacturing, shoemaking, shipbuilding, medical services, construction, electronic equipment manufacturing, animal husbandry, vegetable greenhouses, and automobile 4S workplaces. In each industry, 1 ~ 2 large enterprises, 2 ~ 4 medium-sized enterprises, and 5 ~ 7 small enterprises were selected, according to national classification standard for small and medium-sized enterprises [14]. A total of 252 enterprises were included in the study.

All employees of the selected enterprises participated in the survey. Full-time workers with more than 1 year of employment at the time of investigation were recruited as study participants. Workers who had musculoskeletal disorders caused by non-work-related factors, such as trauma, infectious diseases, rheumatic diseases, malignant tumors, congenital diseases, were excluded.

**Survey methods**

To assess the prevalence of shoulder WMSD in China, a Chinese version of the musculoskeletal disease questionnaire was used, which was based on the Nordic Musculoskeletal Questionnaire (NMQ) [15, 16]. The validity and reliability of the Chinese version of NMQ have been previously validated in Chinese occupational groups [17, 18]. An electronic version of the questionnaire was revised by the Institute of Occupational Health and Poisoning, China Center for Disease Control and Prevention.

The survey adopted the 1: N face-to-face filling method, that is, a trained investigator instructed 2 ~ 4 participants to fill in the form themselves using the mobile client. The electronic version of the questionnaire included logic error correction processing. Finally, 55,749 valid questionnaires were received, and the effective recovery rate was 100%.

**Questionnaire**

The questionnaire consisted of three sections: demographic factors, musculoskeletal symptoms, and work-related factors.

The first section gathered information on gender, date of birth, years of work, marital status, highest education level, physical activity, monthly income, and perceived health status.

The second section of the questionnaire captured information on musculoskeletal symptoms. The participants were asked whether, in the past 12 months, they had experienced discomfort, numbness, pain, or limited activity in the shoulder lasting more than 24 hours or that did not resolve after their workday [19]. If they had any positive symptoms, they were asked to answer supplementary questions about their shoulder-related pain frequency (more than a week in every month/less than a week in every month/more than a week but not in every month/less than a week but not in every month), accumulated duration in the past year (1 ~ 7 days/8 ~ 30 days/more than 30 days but not every day/almost every day), and self-feeling pain level (score 1 ~ 10, with score 1 for mild and score 10 for unbearable).

The third section of the questionnaire focused on work-related factors. There were 21 items and all the detailed descriptions of independent variables in Table 1.
Data analysis

The data obtained from the questionnaire were analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to determine the normality of the data. Continuous data accorded with normal distribution were expressed as the mean ± standard deviation; otherwise, they were presented as median (Q10, Q90). Categorical variables are presented as numbers and percentages. Chi-square tests were used to determine differences among multiple groups. Binary logistic regression models were then developed to estimate associations between variables and shoulder WMSD. The variables considered in the analysis included 8 demographic factors and 21 work-related factors. Independent models were constructed for each industry. For those industries with small sample size, such as animal husbandry, automobile 4S workplaces, biopharmaceutical manufacturing, petrochemical industry, vegetable greenhouses and toy manufacturing, chi-squared tests were conducted first to select variables (P < 0.1). The fit of the models was assessed by the Hosmer-Lemeshow test. The odds ratios (ORs) and respective 95% confidence intervals (95% CI) were calculated as measures of association between the dependent variable and independent variables. The significance level was set as 0.05.

Results

Demographics characteristics of the participants

In total, 36,155 (64.9%) participants were male. The mean age of the participants was 32 (23, 47) years, and a majority were 20 ~ 40 years old (n = 42,293, 75.9%). The average length of employment was 6 (2, 11) years, and a majority had been employed for 1 ~ 15 years (n = 45,881, 82.3%).

Prevalence of shoulder WMSD

A total of 19,779 participants reported work-related musculoskeletal pain or discomfort in the shoulder in the previous 12 months; the prevalence of shoulder WMSD was 35.5%. Biopharmaceutical manufacturing, medical services, and aviation services had the highest prevalence of shoulder WMSD, all of which were higher than 50%. By contrast, the prevalence of shoulder WMSD in the petrochemical industry and construction industry was less than 20%.

The number and proportion of participants in each industry were presented in Table 2. The Chi-square test showed significant differences in the prevalence of shoulder WMSD among the industries (p < 0.05).

Severity of shoulder WMSD

Shoulder WMSD was graded from mild (score of 1) to unbearable (score of 10). The pain score of flight

Table 1 Checklist of work-related factors

| Standing for a long time | Seldom or never/sometimes/ often/frequent |
|--------------------------|------------------------------------------|
| Sitting for a long time   | Seldom or never/sometimes/ often/frequent |
| Squatting for a long time | Seldom or never/sometimes/ often/frequent |
| Uncomfortable posture    | Seldom or never/sometimes/ often/frequent |
| Heavy physical labor with the upper limbs or hands | Seldom or never/sometimes/ often/frequent |
| Use vibration tools when working | Seldom or never/sometimes/ often/frequent |
| Lifting objects weighing more than 5 kg | Seldom or never/sometimes/ often/frequent |
| Driving cars             | Seldom or never/sometimes/ often/frequent |
| Hand position during operation | Yes/no |
| Do the same work almost every day | Yes/no |
| Repeated operation numerous times per minute | Yes/no |
| Take turns with coworkers | Yes/no |
| Outdoors                 | Yes/no |
| Deal with customers, patients and the public | Yes/no |
| Feeling cold, wind or temperature change at work | Yes/no |
| Often work overtime      | Yes/no |
| Enough rest time         | Yes/no |
| Self-decision when to start and finish work | Yes/no |
| Self-decision when to take a break | Yes/no |
| Shortage of staff in the work department | Yes/no |
| Substitute for colleagues | Yes/no |
attendants was the highest. Detailed data on the frequency of occurrence and cumulative duration of shoulder symptoms were presented in Table 3.

The gender and age characteristics of shoulder WMSD
Generally speaking, the prevalence of shoulder WMSD in women was higher than that in men according to Chi-square test results. There were significant differences in gender in most industries except animal husbandry, coal mining and washing industry, biopharmaceutical manufacturing, and toy manufacturing. A significant difference in the prevalence of WMSDs was observed between different age groups. Detailed data were presented in Table 4.

Related factors associated with shoulder WMSD
The related factors with statistical significances in binary logistic regression models were presented in Table 5.

Repeated work as indicated by ‘do the same work almost every day’ and/or ‘repeated operation numerous times per minute’ was associated with the occurrence of shoulder symptoms in the animal husbandry, shipbuilding, electronic equipment manufacturing, furniture manufacturing, automobile manufacturing, shoemaking, and medical services workers. In electronic equipment workers, construction workers, and automobile manufacturers, “lifting objects weighing more than 5 kg” was a related factor of shoulder WMSD.

Regarding work organization, ‘overtime work’ in medical services workers and ‘staff shortages’ in furniture manufacturing, coal mining and washing, automobile 4S workplaces, automobile manufacturing, and toy manufacturing workers significantly increased the participants’ musculoskeletal symptoms in the shoulder. The employees who were able to have ‘enough rest time’ reported fewer shoulder symptoms in most industries. ‘Self-decision when to start and finish work’ for shipbuilders and ‘self-decision when to take a break’ for shoemakers decreased shoulder symptoms.

Two environmental factors were found to be associated with shoulder WMSD, ‘outdoors’ in furniture manufacturing and automobile manufacturing workers, and ‘feeling cold, wind or temperature changes at work’ in animal husbandry, shipbuilding, furniture manufacturing, coal mining and washing, automobile manufacturing, shoemaking, and medical services workers. In addition to work-related factors, some personal factors were found to have statistical significance.

Table 2  Prevalence rate and pain level of shoulder WMSDs of participants in 15 industries

| Industry                          | N.   | Proportion(%) | The shoulder musculoskeletal symptoms in the past 12 months | No. of cases | Prevalence, % |
|-----------------------------------|------|---------------|-------------------------------------------------------------|--------------|---------------|
| Animal husbandry                  | 247  | 0.44          | 55                                                          | 22.3         |
| Shipbuilding                      | 3353 | 6.01          | 1137                                                        | 33.9         |
| Electronic equipment manufacturing| 7780 | 13.96         | 2680                                                        | 34.4         |
| Furniture manufacturing           | 4409 | 7.91          | 1138                                                        | 25.8         |
| Construction                      | 1357 | 2.43          | 248                                                         | 18.3         |
| Coal mining and washing industry  | 1458 | 2.62          | 509                                                         | 34.9         |
| Aviation services                 | 1314 | 2.36          | 658                                                         | 50.1         |
| Automobile 4S workplaces          | 604  | 1.08          | 229                                                         | 37.9         |
| Automobile manufacturing          | 20,806| 37.32         | 6757                                                        | 32.5         |
| Biopharmaceutical manufacturing   | 242  | 0.43          | 136                                                         | 56.2         |
| Petrochemical industry            | 148  | 0.27          | 17                                                          | 11.5         |
| Vegetable greenhouses             | 243  | 0.44          | 64                                                          | 26.3         |
| Toy manufacturing                | 314  | 0.56          | 146                                                         | 46.5         |
| Medical services                  | 6564 | 11.77         | 3571                                                        | 54.4         |
| Shoemaking                        | 6910 | 12.39         | 2434                                                        | 35.2         |
| Total                             | 55,749| 100           | 19,779                                                      | 35.5         |
gender and age, poor perceived health status, high educational level, and the length of employment were associated with reported shoulder WMSD in some industries.

**Discussion**

According to our study, the prevalence of shoulder WMSD among participants in the key industries was 35.5%. This prevalence was lower than that found by Renée Govaerts et al. in a meta-analysis covering 7 secondary industries in 13 European countries in which the mean 12-month prevalence of shoulder WMSD was 50% [20]. However, our result was far higher than that reported by the US Bureau of Labor Statistics, which found that the incidence of shoulder WMSD was 11.8% in 2016 [21].

In different industries, the prevalence of shoulder WMSD ranged from 11.5 to 56.2%. The three industries with the highest prevalence of shoulder WMSD were biopharmaceutical manufacturing (56.2%), medical services (54.4%), and aviation services (50.1%). The prevalence and the related factors of shoulder WMSD were reported for the first time in shipbuilding, automobile 4S workplaces, and some other industries.

Medical personnel have been found to be vulnerable to WMSD in previous surveys. In China, the prevalence of shoulder WMSD has been reported for different types

| Industry                           | Pain level, (M,IQR, Q90) | Frequency of occurrence, N (%) | Cumulative duration of symptoms, N (%) |
|------------------------------------|---------------------------|-------------------------------|---------------------------------------|
|                                    |                           | More than a week in every month | Less than a week but not in every month | More than a week but not in every month | Less than a week but not in every month | 1~7 days | 8~30 days | >30 days, but not everyday | Almost every day |
| Animal husbandry                   | 4 (2, 6)                  | 6 (10.9)                      | 10 (18.2)                             | 24 (43.6)                              | 15 (27.3)                              | 14 (25.5) | 24 (43.6) | 14 (25.5)                              | 3 (5.5) |
| Shipbuilding                       | 4 (2, 7)                  | 271 (23.8)                    | 315 (27.7)                            | 129 (11.3)                             | 422 (37.1)                             | 453 (39.8) | 334 (29.4) | 279 (24.5)                             | 71 (6.2) |
| Electronic equipment manufacturing | 5 (3, 7)                  | 661 (24.7)                    | 878 (32.8)                            | 249 (9.3)                              | 892 (33.3)                             | 899 (33.5) | 704 (26.3) | 823 (30.7)                             | 254 (9.5) |
| Furniture manufacturing            | 5 (2, 7)                  | 275 (24.2)                    | 285 (25.0)                            | 134 (11.8)                             | 444 (39.0)                             | 562 (49.4) | 233 (20.5) | 249 (21.9)                             | 94 (8.3) |
| Construction                       | 5 (3, 7)                  | 36 (14.5)                     | 82 (33.1)                             | 33 (13.3)                              | 97 (39.1)                              | 77 (31.0) | 80 (32.3) | 82 (33.1)                              | 9 (3.6) |
| Coal mining and washing industry   | 5 (3, 8)                  | 180 (35.4)                    | 155 (30.5)                            | 66 (13.0)                              | 108 (21.2)                             | 170 (33.4) | 125 (24.6) | 160 (31.4)                             | 54 (10.6) |
| Aviation services                  | 6 (4, 8)                  | 120 (18.2)                    | 251 (38.1)                            | 62 (9.4)                               | 225 (34.2)                             | 200 (30.4) | 199 (30.2) | 219 (33.3)                             | 40 (6.1) |
| Automobile 4S workplaces            | 5 (2, 7)                  | 57 (24.9)                     | 60 (26.2)                             | 15 (6.6)                               | 97 (42.4)                              | 75 (32.8) | 57 (24.9) | 84 (36.7)                              | 13 (5.7) |
| Automobile manufacturing            | 5 (3, 7)                  | 1738 (25.7)                   | 2050 (30.3)                           | 652 (9.6)                              | 2317 (34.3)                            | 2461 (36.4) | 1649 (24.4) | 1895 (28.0)                             | 752 (1.1) |
| Biopharmaceutical manufacturing    | 5 (3, 7)                  | 27 (19.9)                     | 53 (39.0)                             | 13 (9.6)                               | 43 (31.6)                              | 26 (19.1) | 34 (25.0) | 67 (49.3)                              | 9 (6.6) |
| Petrochemical industry             | 4 (1, 6)                  | 4 (23.5)                      | 2 (11.8)                              | 1 (5.9)                                | 10 (58.8)                              | 8 (47.1) | 5 (29.4) | 3 (17.6)                               | 1 (5.9) |
| Vegetable greenhouses              | 4 (3, 7)                  | 11 (17.2)                     | 20 (31.3)                             | 15 (23.4)                              | 18 (28.1)                              | 7 (10.9) | 22 (34.4) | 30 (46.9)                              | 5 (7.8) |
| Toy manufacturing                  | 4 (4, 7)                  | 50 (34.2)                     | 45 (30.8)                             | 11 (7.5)                               | 40 (27.4)                              | 52 (35.6) | 34 (23.3) | 39 (26.7)                              | 21 (14.4) |
| Medical services                   | 5 (3, 7)                  | 951 (26.6)                    | 1157 (32.4)                           | 371 (10.4)                             | 1092 (30.6)                            | 1081 (30.3) | 974 (27.3) | 1161 (32.5)                            | 355 (9.9) |
| Shoemaking                          | 4 (2, 7)                  | 598 (24.6)                    | 671 (27.6)                            | 269 (11.1)                             | 896 (36.8)                             | 873 (35.9) | 623 (25.6) | 671 (27.6)                             | 267 (11.0) |
| Total                              | 5 (3, 7)                  | 4985 (25.2)                   | 6034 (30.5)                           | 2044 (10.3)                            | 6716 (34.0)                            | 6958 (35.2) | 5097 (25.8) | 5776 (29.2)                            | 1948 (9.8) |
of medical staff, including dentists (92.2%) [22], ultrasound department staff (87%) [23], obstetrics and gynecology staff (62%) [1], nurses (54.6%) [24], and midwives (42.7%) [25]. In our study, 54.4% of medical staff suffered from shoulder pain in the past 12 months. The following factors were found to be associated with shoulder musculoskeletal symptoms: female gender, years of work, perceived health status, sitting for a long time, heavy physical labor with the upper limbs or hands, uncomfortable posture, doing the same work almost every day, feeling cold, wind, or temperature changes at work, and often working overtime.

The previous research in aviation services was not sufficient. Only one study is available, by Rau PP et al., and included a small sample size of Chinese female flight attendants. The study conducted an online questionnaire (46 flight attendants) and semi-structured interviews (16 flight attendants) and identified the following risk factors: working with improperly designed overhead bins and providing food and drink service in an awkward posture [8]. According to our study, female gender, worse perceived health status, and uncomfortable postures were found to be associated with shoulder musculoskeletal problems among the aviation services participants.

The manufacturing industry includes electronic equipment manufacturing, furniture manufacturing, automobile manufacturing, and shoemaking, which are characterized by assembly line operations. The prevalence of shoulder WMSD ranged from 25.8 to 46.5% in these industries, with sitting/standing for a long time,
Table 5  The OR (95% CI) of related factors for shoulder WMSD among participants in 15 industries

| Industry                  | Factors                                      | Categories          | ORs     | 95% CI       |
|---------------------------|----------------------------------------------|---------------------|---------|--------------|
|                           |                                              |  | Lower | Upper |
| **Animal husbandry**      | Repeated operation numerous times per minute | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 2.01   | 1.03 3.91    |
|                           | Feeling cold, wind or temperature change at work | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 2.74   | 1.18 6.39    |
| **Shipbuilding**          | Gender                                       | Male                 | 1.00   | –             |
|                           |                                              | Female               | 1.79   | 1.36 2.35    |
|                           | Age                                          | No                   | 1.08   | 1.05 1.12    |
|                           |                                              | Yes                  | 1.79   | 1.36 2.35    |
|                           | Physical activity                            | No                   | 1.00   | –             |
|                           |                                              | occasional           | 1.71   | 1.10 2.66    |
|                           |                                              | 2-3 times/month      | 1.81   | 1.18 2.77    |
|                           |                                              | 1-2 times/week       | 2.22   | 1.22 4.02    |
|                           |                                              | > 2 times/week       | 1.95   | 1.15 3.30    |
|                           | Perceived health status                      | perfect              | 1.00   | –             |
|                           |                                              | fine                 | 1.91   | 1.59 2.31    |
|                           |                                              | poor                 | 3.30   | 2.23 4.90    |
|                           |                                              | very poor            | 2.02   | 0.76 5.37    |
|                           | Heavy physical labor with the upper limbs or hands | seldom/never       | 1.00   | –             |
|                           |                                              | sometimes            | 1.19   | 0.84 1.69    |
|                           |                                              | often                | 1.41   | 1.00 1.99    |
|                           |                                              | frequent             | 2.24   | 1.55 3.24    |
|                           | Uncomfortable posture                        | seldom/never         | 1.00   | –             |
|                           |                                              | sometimes            | 1.24   | 0.98 1.57    |
|                           |                                              | often                | 1.87   | 1.39 2.51    |
|                           |                                              | frequent             | 2.37   | 1.60 3.51    |
|                           | Do the same work almost every day            | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 1.55   | 1.15 2.08    |
|                           | Feeling cold, wind or temperature change at work | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 1.33   | 1.07 1.65    |
|                           | Enough rest time                             | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 0.72   | 0.59 0.87    |
|                           | Self-decision when to start and finish work  | No                   | 1.00   | –             |
|                           |                                              | Yes                  | 0.78   | 0.61 0.99    |
| **Electronic equipment manufacturing** | Gender                                       | Male                 | 1.00   | –             |
|                           |                                              | Female               | 2.22   | 1.91 2.58    |
|                           | Age                                          | No                   | 1.11   | 1.09 1.14    |
|                           |                                              | < 2                  | 1.00   | –             |
|                           |                                              | 2 ~ 6                | 1.13   | 0.94 1.36    |
|                           |                                              | 7 ~ 11               | 1.56   | 1.16 2.10    |
|                           |                                              | ≥ 12                 | 1.76   | 1.09 2.85    |
|                           | Perceived health status                      | perfect              | 1.00   | –             |
|                           |                                              | fine                 | 1.92   | 1.68 2.20    |
|                           |                                              | poor                 | 2.74   | 2.11 3.57    |
|                           |                                              | very poor            | 3.82   | 1.98 7.36    |
|                           | Sitting for a long time                      | seldom/never         | 1.00   | –             |
|                           |                                              | sometimes            | 1.43   | 1.18 1.73    |
|                           |                                              | often                | 2.80   | 2.28 3.44    |
|                           |                                              | frequent             | 3.73   | 2.91 4.77    |
Table 5 (continued)

| Industry                   | Factors                                      | Categories     | ORs  | 95% CI     |
|-----------------------------|----------------------------------------------|----------------|------|------------|
|                             |                                              |                | Lower| Upper      |
|                             | Lifting object weighing more than 5 kg       | seldom/never   | 1.00 | –          |
|                             |                                              | sometimes      | 1.18 | 1.01  1.38 |
|                             |                                              | often          | 1.70 | 1.37  2.11 |
|                             |                                              | frequent       | 1.34 | 0.97  1.84 |
|                             | Heavy physical labor with the upper limbs or hands | seldom/never | 1.00 | –          |
|                             |                                              | sometimes      | 1.19 | 1.00  1.43 |
|                             |                                              | often          | 1.35 | 1.12  1.63 |
|                             |                                              | frequent       | 1.82 | 1.46  2.28 |
|                             | Uncomfortable posture                        | seldom/never   | 1.00 | –          |
|                             |                                              | sometimes      | 1.47 | 1.27  1.70 |
|                             |                                              | often          | 2.26 | 1.75  2.93 |
|                             |                                              | frequent       | 2.65 | 1.78  3.94 |
|                             | Repeated operation numerous times per minute | No             | 1.00 | –          |
|                             |                                              | Yes            | 1.70 | 1.48  1.94 |
|                             | Take turns with coworkers                    | No             | 1.00 | –          |
|                             |                                              | Yes            | 0.80 | 0.70  0.90 |
|                             | Enough rest time                            | No             | 1.00 | –          |
|                             |                                              | Yes            | 0.63 | 0.56  0.72 |
| Furniture manufacturing    | Gender                                       | Male           | 1.00 | –          |
|                             |                                              | Female         | 1.32 | 1.09  1.59 |
|                             | Age                                          |                | 0.97 | 0.94  0.99 |
|                             | Education                                    | junior high school | 1.00 | –          |
|                             |                                              | senior high school | 1.23 | 1.04  1.47 |
|                             |                                              | Junior College  | 1.62 | 1.21  2.18 |
|                             |                                              | bachelor degree or above | 1.84 | 1.15  2.93 |
|                             | Perceived health status                      | perfect        | 1.00 | –          |
|                             |                                              | fine           | 2.02 | 1.73  2.37 |
|                             |                                              | poor           | 3.01 | 2.15  4.22 |
|                             |                                              | very poor      | 1.44 | 0.70  2.94 |
|                             | Heavy physical labor with the upper limbs or hands | seldom/never | 1.00 | –          |
|                             |                                              | sometimes      | 1.10 | 0.78  1.56 |
|                             |                                              | often          | 1.17 | 0.83  1.63 |
|                             |                                              | frequent       | 1.57 | 1.09  2.25 |
|                             | Uncomfortable posture                        | seldom/never   | 1.00 | –          |
|                             |                                              | sometimes      | 1.55 | 1.30  1.85 |
|                             |                                              | often          | 2.60 | 1.98  3.43 |
|                             |                                              | frequent       | 2.14 | 1.43  3.19 |
|                             | Repeated operation numerous times per minute | No             | 1.00 | –          |
|                             |                                              | Yes            | 1.34 | 1.12  1.60 |
|                             | Do the same work almost every day            | No             | 1.00 | –          |
|                             |                                              | Yes            | 1.87 | 1.35  2.59 |
|                             | Outdoors                                     | No             | 1.00 | –          |
|                             |                                              | Yes            | 0.58 | 0.37  0.92 |
|                             | Deal with customers, patients and the public | No             | 1.00 | –          |
|                             |                                              | Yes            | 1.48 | 1.06  2.06 |
|                             | Feeling cold, wind or temperature change at work | No             | 1.00 | –          |
|                             |                                              | Yes            | 1.21 | 1.00  1.45 |
### Table 5 (continued)

| Industry                        | Factors                              | Categories     | ORs  | 95% CI   |
|---------------------------------|--------------------------------------|----------------|------|----------|
|                                 |                                      |                | Lower| Upper    |
|                                 | Enough rest time                     | No             | 1.00 | –        |
|                                 |                                      | Yes            | 0.69 | 0.58 0.81|
| Construction                    | Shortage of staff in the work department | No             | 1.00 | –        |
|                                 |                                      | Yes            | 1.25 | 1.05 1.48|
|                                 | Gender                               | Male           | 1.00 | –        |
|                                 |                                      | Female         | 2.43 | 1.34 4.40|
| Coal mining and washing industry | Age                                  | 1.09 | 1.02 1.16|
|                                 | Lifting object weighing more than 5 kg | seldom/never   | 1.00 | –        |
|                                 |                                      | sometimes      | 1.24 | 0.66 2.32|
|                                 |                                      | often          | 4.05 | 2.03 8.08|
|                                 |                                      | frequent       | 3.50 | 1.52 8.06|
|                                 | Heavy physical labor with the upper limbs or hands | seldom/never | 1.00 | –        |
|                                 |                                      | sometimes      | 2.41 | 1.07 5.43|
|                                 |                                      | often          | 2.92 | 1.27 6.73|
|                                 |                                      | frequent       | 2.96 | 1.17 7.47|
|                                 | Uncomfortable posture                | seldom/never   | 1.00 | –        |
|                                 |                                      | sometimes      | 2.47 | 1.53 4.00|
|                                 |                                      | often          | 2.66 | 1.39 5.09|
|                                 |                                      | frequent       | 3.67 | 0.99 13.56|
|                                 | Enough rest time                     | No             | 1.00 | –        |
|                                 |                                      | Yes            | 0.66 | 0.44 0.97|
|                                 | Substitute for colleagues            | No             | 1.00 | –        |
|                                 |                                      | Yes            | 2.03 | 1.27 3.26|
| Aviation services               | Gender                               | Male           | 1.00 | –        |
|                                 |                                      | Female         | 2.37 | 1.25 4.51|
|                                 | Perceived health status              | perfect        | 1.00 | –        |
|                                 |                                      | fine           | 1.84 | 1.38 2.45|
|                                 |                                      | poor           | 2.90 | 1.87 4.50|
|                                 |                                      | very poor      | 4.71 | 1.94 11.40|
|                                 | Feeling cold, wind or temperature change at work | No             | 1.00 | –        |
|                                 |                                      | Yes            | 1.76 | 1.29 2.40|
|                                 | Often work overtime                  | No             | 1.00 | –        |
|                                 |                                      | Yes            | 1.38 | 1.03 1.85|
|                                 | Shortage of staff in the work department | No             | 1.00 | –        |
|                                 |                                      | Yes            | 1.42 | 1.07 1.87|
| Automobile 4S workplaces        | Gender                               | Male           | 1.00 | –        |
|                                 |                                      | Female         | 3.10 | 1.97 4.88|
|                                 | Perceived health status              | perfect        | 1.00 | –        |
|                                 |                                      | fine           | 2.44 | 1.59 3.74|
|                                 |                                      | poor           | 3.25 | 1.93 5.49|
|                                 |                                      | very poor      | 3.55 | 1.41 8.95|
|                                 | Uncomfortable posture                | seldom/never   | 1.00 | –        |
|                                 |                                      | sometimes      | 2.11 | 1.43 3.11|
|                                 |                                      | often          | 2.16 | 1.36 3.43|
|                                 |                                      | frequent       | 4.55 | 2.50 8.26|
|                                 | Age                                  | 1.04 | 1.01 1.08|
Table 5 (continued)

| Industry                      | Factors                                         | Categories       | ORs   | 95% CI   |
|-------------------------------|-------------------------------------------------|------------------|-------|----------|
|                               |                                                 |                  | Lower | Upper    |
| Uncomfortable posture         | seldom/never                                    | 1.00             | –     |          |
|                               | sometimes                                       | 1.94             | 1.00  | 3.76     |
|                               | often                                            | 3.27             | 1.46  | 7.33     |
|                               | frequent                                         | 3.69             | 1.27  | 10.69    |
| Enough rest time              | No                                               | 1.00             | –     |          |
|                               | Yes                                              | 0.44             | 0.26  | 0.75     |
| Shortage of staff in the work department | No                                               | 1.00             | –     |          |
|                               | Yes                                              | 1.87             | 1.13  | 3.08     |
| Automobile manufacturing      | Gender                                           | Male             | 1.00  |          |
|                               | Female                                           | 2.11             | 1.86  | 2.41     |
|                               | Age                                              | 1.03             | 1.02  | 1.05     |
|                               | Length of employment (years)                      | < 2              | 1.00  |          |
|                               |                                                  | 2 ~ 6            | 1.39  | 1.26 1.54|
|                               |                                                  | 7 ~ 11           | 1.54  | 1.33 1.78|
|                               |                                                  | ≥ 12             | 1.61  | 1.30 1.98|
|                               | Education                                        | junior high school | 1.00  |          |
|                               |                                                  | senior high school | 0.98  | 0.85 1.12|
|                               |                                                  | Junior College   | 1.06  | 0.92 1.23|
|                               |                                                  | bachelor degree  | 1.38  | 1.13 1.67|
|                               |                                                  | master degree or above | 1.67  | 1.10 2.53|
|                               | Perceived health status                          | perfect          | 1.00  |          |
|                               |                                                  | fine             | 1.67  | 1.56 1.80|
|                               |                                                  | poor             | 2.33  | 2.06 2.64|
|                               |                                                  | very poor        | 2.35  | 1.74 3.16|
|                               | Lifting object weighing more than 5 kg           | seldom/never     | 1.00  |          |
|                               |                                                  | sometimes        | 1.05  | 0.97 1.14|
|                               |                                                  | often            | 1.25  | 1.12 1.39|
|                               |                                                  | frequent         | 1.19  | 1.05 1.34|
|                               | Sitting for a long time                          | seldom/never     | 1.00  |          |
|                               |                                                  | sometimes        | 1.02  | 0.93 1.12|
|                               |                                                  | often            | 1.59  | 1.40 1.80|
|                               |                                                  | frequent         | 1.50  | 1.30 1.74|
|                               | Heavy physical labor with the upper limbs or hands | seldom/never   | 1.00  |          |
|                               |                                                  | sometimes        | 1.03  | 0.90 1.16|
|                               |                                                  | often            | 1.23  | 1.08 1.40|
|                               |                                                  | frequent         | 1.46  | 1.28 1.66|
|                               | Uncomfortable posture                            | seldom/never     | 1.00  |          |
|                               |                                                  | sometimes        | 1.51  | 1.40 1.64|
|                               |                                                  | often            | 2.04  | 1.82 2.29|
|                               |                                                  | frequent         | 2.62  | 2.28 3.01|
|                               | Repeated operation numerous times per minute     | No               | 1.00  |          |
|                               |                                                  | Yes              | 1.34  | 1.25 1.43|
|                               | Do the same work almost every day                | No               | 1.00  |          |
|                               |                                                  | Yes              | 1.13  | 1.02 1.26|
|                               | Take turns with coworkers                        | No               | 1.00  |          |
|                               |                                                  | Yes              | 0.91  | 0.85 0.98|
|                               | Outdoors                                        | No               | 1.00  |          |
|                               |                                                  | Yes              | 0.80  | 0.69 0.92|
| Industry                          | Factors                                      | Categories | ORs   | 95% CI     |
|----------------------------------|----------------------------------------------|------------|-------|------------|
|                                  |                                              |            | Lower | Upper      |
| Biopharmaceutical manufacturing  | Age                                          |            | 0.93  | 0.89 0.97  |
| Petrochemical industry           | Monthly income (RMB)                         | ≤1000      | 1.00  | –          |
|                                  |                                              | 1001 ~ 3000| 0.02  | 0.00 0.29  |
|                                  |                                              | 3001 ~ 5000| 0.04  | 0.00 0.72  |
| Vegetable greenhouses            | Gender                                       | Male       | 1.00  | –          |
|                                  |                                              | Female     | 2.10  | 1.13 3.91  |
| Toy manufacturing                | Gender                                       | Male       | 1.00  | –          |
|                                  |                                              | Female     | 1.98  | 1.02 3.83  |
|                                  | Age                                          |            | 0.95  | 0.92 0.98  |
|                                  | Take turns with coworkers                     | No         | 1.00  | –          |
|                                  |                                              | Yes        | 0.58  | 0.34 0.99  |
|                                  | Perceived health status                      | perfect    | 1.00  | –          |
|                                  |                                              | fine       | 2.86  | 1.67 4.89  |
|                                  |                                              | poor       | 2.61  | 0.59 11.60 |
|                                  | Shortage of staff in the work department     | No         | 1.00  | –          |
|                                  |                                              | Yes        | 2.34  | 1.26 4.37  |
| Medical services                 | Gender                                       | Male       | 1.00  | –          |
|                                  |                                              | Female     | 1.66  | 1.38 1.99  |
|                                  | Age                                          |            | 0.98  | 0.96 1.00  |
|                                  | Length of employment (years)                 | < 2        | 1.00  | –          |
|                                  |                                              | 2 ~ 6      | 1.25  | 1.01 1.56  |
|                                  |                                              | 7 ~ 11     | 1.50  | 1.15 1.97  |
|                                  |                                              | ≥12        | 1.54  | 1.07 2.21  |
|                                  | Perceived health status                      | perfect    | 1.00  | –          |
|                                  |                                              | fine       | 1.65  | 1.44 1.90  |
|                                  |                                              | poor       | 2.50  | 2.04 3.06  |
|                                  |                                              | very poor  | 2.07  | 1.32 3.24  |
|                                  | Sitting for a long time                      | seldom/never| 1.00  | –          |
|                                  |                                              | sometimes  | 1.04  | 0.89 1.20  |
|                                  |                                              | often      | 1.57  | 1.31 1.89  |
|                                  |                                              | frequent   | 2.18  | 1.75 2.72  |
|                                  | Heavy physical labor with the upper limbs or hands | seldom/never | 1.00  | –          |
|                                  |                                              | sometimes  | 1.11  | 0.92 1.34  |
|                                  |                                              | often      | 1.29  | 1.07 1.56  |
|                                  |                                              | frequent   | 1.36  | 1.11 1.66  |
### Table 5 (continued)

| Industry | Factors                        | Categories          | ORs  | 95% CI    |
|----------|--------------------------------|---------------------|------|-----------|
|          |                                |                     | Lower| Upper     |
|          | Uncomfortable posture          | seldom/never        | 1.00 | –         |
|          |                                | sometimes           | 1.75 | 1.52 2.02 |
|          |                                | often               | 2.76 | 2.30 3.32 |
|          |                                | frequent            | 3.01 | 2.33 3.90 |
|          | Do the same work almost every day | No              | 1.00 | –         |
|          |                                | Yes                | 1.33 | 1.07 1.66 |
|          | Take turns with coworkers      | No                  | 1.00 | –         |
|          |                                | Yes                | 0.83 | 0.73 0.94 |
|          | Feeling cold, wind or temperature change at work | No | 1.00 | –         |
|          |                                | Yes                | 1.17 | 1.02 1.34 |
|          | Often work overtime            | No                  | 1.00 | –         |
|          |                                | Yes                | 1.22 | 1.08 1.37 |
|          | Enough rest time               | No                  | 1.00 | –         |
|          |                                | Yes                | 0.77 | 0.68 0.87 |
| Shoemaking | Gender                       | Male               | 1.00 | –         |
|          |                                | Female             | 1.73 | 1.48 2.03 |
|          | Length of employment (years)   | < 2                | 1.00 | –         |
|          |                                | 2 ~ 6              | 1.24 | 1.02 1.53 |
|          |                                | 7 ~ 11             | 1.51 | 1.14 2.00 |
|          |                                | ≥ 12               | 1.15 | 0.75 1.76 |
|          | Education                      | junior high school | 1.00 | –         |
|          |                                | senior high school | 1.22 | 1.05 1.41 |
|          |                                | Junior College     | 2.80 | 2.01 3.91 |
|          |                                | bachelor degree    | 3.34 | 1.77 6.32 |
|          | Physical activity              | seldom/never       | 1.00 | –         |
|          |                                | sometimes          | 1.18 | 1.04 1.34 |
|          |                                | often              | 1.25 | 0.90 1.73 |
|          |                                | frequent           | 1.38 | 1.07 1.77 |
|          | Perceived health status        | perfect            | 1.00 | –         |
|          |                                | fine               | 1.88 | 1.67 2.12 |
|          |                                | poor               | 3.52 | 2.56 4.85 |
|          |                                | very poor          | 2.24 | 1.20 4.19 |
|          | Standing for a long time       | seldom/never       | 1.00 | –         |
|          |                                | sometimes          | 1.26 | 1.08 1.46 |
|          |                                | often              | 1.52 | 1.25 1.84 |
|          |                                | frequent           | 1.31 | 1.03 1.66 |
|          | Sitting for a long time        | seldom/never       | 1.00 | –         |
|          |                                | sometimes          | 0.88 | 0.74 1.05 |
|          |                                | often              | 1.34 | 1.11 1.62 |
|          |                                | frequent           | 1.63 | 1.31 2.04 |
|          | Heavy physical labor with the upper limbs or hands | seldom/never | 1.00 | –         |
|          |                                | sometimes          | 1.20 | 1.01 1.42 |
|          |                                | often              | 1.17 | 0.99 1.38 |
|          |                                | frequent           | 1.53 | 1.26 1.88 |
|          | Uncomfortable posture          | seldom/never       | 1.00 | –         |
|          |                                | sometimes          | 1.43 | 1.23 1.67 |
|          |                                | often              | 1.93 | 1.47 2.54 |
|          |                                | frequent           | 2.21 | 1.49 3.28 |
repeated operations, and high hand forces being recognized as important contributing factors. Heavy lifting was a related factor only in electronics manufacturing and automobile manufacturing. Similar prevalence was found in a case-control study conducted in the Spanish automotive manufacturing sector [26], in a cross-sectional study among Iranian hand-woven shoe workers [27], in a cross-sectional study among 931 workers from an electronics factory in Taiwan, China [28], and from self-reported data of shoulder WMSD-injured manufacturing workers in Washington state, USA [29]. Overtime work and staff shortages in the work department significantly increased the participants’ musculoskeletal symptoms in the shoulder. Participants were more likely to be protected from shoulder WMSD if they had sufficient rest and autonomy over their rest.

The prevalence of shoulder WMSD in animal husbandry and vegetable greenhouse workers was 22.3 and 26.3%, respectively. Our results were much lower than that found in 249 vegetable greenhouse farmers in a rural area of Shandong, China (31.7%) [9] and lower than that of the 2-week prevalence of neck/shoulder pain in 518 farmers in the US Midwest (30.8%) [30]. Fethke et al. observed a significant association between milking animals and neck/shoulder pain [30]. Caiheiro et al. reported that egg classification, candling, and in vivo vaccination required repetitive shoulder abduction and elbow flexion [31]. Kang et al. found that the main activities in growing greenhouse vegetables (planting seeding, pruning stems and leaves, picking, carrying, shoveling, spraying pesticides, weeding, and fertilizing) resulted in different levels of disorder in the farmers’ musculoskeletal structure [9]. We found that ‘feeling cold, wind or temperature changes at work” was also a related factor for shoulder WMSD in the animal husbandry participants.

The prevalence of shoulder WMSD in construction and petrochemical industry workers was 18.3 and 11.5%, respectively. These data were consistent with studies of construction workers in Hong Kong (19.8%) [32] and India (11.7%) [33]. In our study, ‘female gender’, ‘lifting object weighing more than 5 kg’, ‘heavy physical labor with the upper limbs or hands’, ‘uncomfortable posture’, ‘not enough rest time’, and ‘filling in for colleagues’ were independent related factors for shoulder WMSD in the construction industry workers.

In addition to work-related factors, some demographic and socioeconomic factors, including female gender and age, were significantly associated with the prevalence of shoulder WMSD in most industries. Ning Jia et al. found that female workers had a 1.5 times increased risk of WMSD compared with males, and the highest prevalence was among those aged 35 ~ 45 years [3]. Similarly, the perceived health status was found to be a related factor for shoulder WMSD. In some industries, monthly income (e.g., petrochemical industry), length of employment (e.g., medical services), the highest education level (e.g., automobile manufacturing, furniture manufacturing, and shoemaking), and physical activity (e.g., shoemaking) were also factors that influenced shoulder WMSD. Notably, the demographic characteristics of people differed by position (e.g., age, gender, and education level in frontline workers and administrative staff). It would be necessary to conduct a stratified analysis by gender and age to clarify the risk factors for shoulder WMSD in certain industries.

In addition, the composition of different types of work in various industries may also affect the prevalence of shoulder WMSD in this industry. In the NMQ survey of the 154 production personnel and 24 management personnel of a poultry breeding company, the prevalence of pain in the shoulder was higher among the production employees (47%) compared with administrative employees (38%) [31]. However, in a cross-sectional study using NMQ of 1415 employees (830 frontline workers and 585 other employees) in six industrial companies in Beijing, China, it was found that the prevalence of shoulder pain

### Table 5 (continued)

| Industry                  | Factors                                                                 | Categories | ORs  | 95% CI      |
|---------------------------|-------------------------------------------------------------------------|------------|------|-------------|
|                           | Repeated operation numerous times per minute                           | No         | 1.00 | –           |
|                           |                                                                         | Yes        | 1.26 | 1.10 1.44   |
|                           | Feeling cold, wind or temperature change at work                        | No         | 1.00 | –           |
|                           |                                                                         | Yes        | 1.58 | 1.36 1.83   |
|                           | Enough rest time                                                        | No         | 1.00 | –           |
|                           |                                                                         | Yes        | 0.67 | 0.59 0.76   |
|                           | Self-decision when to take a break                                      | No         | 1.00 | –           |
|                           |                                                                         | Yes        | 0.73 | 0.60 0.89   |
among frontline employees (15.42%) was significantly lower than that of other employees (19.66%), including office clerks, support staff and technicians [34].

This study has some limitations that should be considered when interpreting the results. First, there could be selection bias in the cross-sectional study because older and less healthy individuals may have left the workforce; reporting bias could also have influenced the results. Second, some participants may have suffered from shoulder musculoskeletal diseases caused by non-work-related factors such as rheumatism and tumors that had not yet been diagnosed, which could have altered the validity of the results. Additionally, some industries related to shoulder WMSD but that are characterized by individual workers rather than organizations (such as hairdressers [35]) were not investigated. Work stress and occupational psychological factors, as well as their interconnections, were also not considered in our study, although earlier studies have linked them to the development of WMSD [25, 36].

Conclusions
In summary, the prevalence of shoulder WMSD was relatively high in China, with large differences between industries. The three industries with the highest prevalence of shoulder WMSD were biopharmaceutical manufacturing, medical services, and aviation services. This was the first report of such data in some industries. We found that the related factors for shoulder WMSD were different in each industry. Based on the data of this study, further analysis according to different posts (different operations) can give a better explanation to the risk of shoulder WMSD in a certain industry. As a result, it is necessary to take interventional actions based on the specific factors in each industry to reduce the impact of shoulder WMSD. These actions could include improving the work environment, optimizing work organization, and strengthening ergonomics awareness.

Abbreviations
WMSD: Work-related musculoskeletal disorders; 4S: Sales, Spare parts, Service, and Survey; NMQ: Nordic Musculoskeletal Questionnaire; OR: Odds ratios; CI: confidence intervals.

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Authors’ contributions
JL performed the questionnaire survey, analyzed the data and wrote the manuscript. NJ and FZ designed the study and collected the data. HT, HL, HZ, RL, YL, GL, DL, YY, HS, HZ, BQ, XF, DW, QZ, JC, DZ, LM, YL, JL, CZ, TL, performed the questionnaire survey. RW and ZW got financial support for the project of this study and assume supervision responsibility. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available due to ethical considerations as they were gathered in the context of an ongoing study and further analysis according to different posts (different operations) can give a better explanation to the risk of shoulder WMSD in a certain industry. As a result, it is necessary to take interventional actions based on the specific factors in each industry to reduce the impact of shoulder WMSD. These actions could include improving the work environment, optimizing work organization, and strengthening ergonomics awareness.

Competing interests
The authors declare that they have no competing interests.

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