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Review Article

The Prevalence of Musculoskeletal Disorders among Miners around the World: A Systematic Review and Meta-Analysis

Hadiseh Rabiei [1], ***Mahdi Malakoutikhah*** [2], ***Mohammad Hossein Vaziri*** [3], ****Ali Salehi Sahlabadi*** [4]

1. *Department of Occupational Health Engineering, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
2. *Department of Occupational Health, School of Public Health, Kashan University of Medical Sciences, Kashan, Iran*
3. *Department of Health, Safety and Environmental Management, School of Public Health and Safety, Workplace Health Promotion Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
4. *Department of Occupational Health and Safety, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

***Corresponding Author:** Email: asalehi529@sbmu.ac.ir

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Abstract

Background: Musculoskeletal disorders are responsible for significant problem for workers' health. The present study aimed to investigate the prevalence of musculoskeletal disorders among mining workers.

Methods: This systematic review and meta-analysis study were designed in 2020 (from Jan to Mar). The researchers searched five international databases Medline/PubMed, ProQuest, Scopus, Embase and Web of Science. All analyzes were performed using STATA statistical software.

Results: The search results were 447 articles and after screening stage finally 50 studies were included in review. The highest number of studies (26 studies) reported the prevalence of musculoskeletal disorders of upper back and 4 studies reported the prevalence of musculoskeletal disorders of the arms and ankles & feet. The results of meta-analysis based on prevalence in different organs showed that the highest prevalence of musculoskeletal disorders was in the upper back and the lowest in the knees with a prevalence of 50.39% (CI 95%: 31.23-54.73%) and 16.03% (CI 95%: 11.78-20.28%), respectively.

Conclusion: The prevalence of musculoskeletal disorders among miners is relatively high. Therefore, supervisors and mine managers should pay more attention to reducing musculoskeletal disorders and increasing the ergonomic level of mines in order to increase workers' health.

Keywords: Musculoskeletal disorders; Miners; Systematic review; Meta-analysis

Introduction

Musculoskeletal disorders (MSDs) are commonly described as soft tissue disorders and surrounding structures that are not just related to an acute or immediate event (such as a slip or fall) and are more likely to occur in the neck, shoulders, elbows, wrists, and lower back (1). According to the International Labor Organization (ILO), among the approximately 160 million work-

related illnesses that occur worldwide each year, work related musculoskeletal disorders (WMSDs) are known to be the second most common occupational disease (2). If the cause of this type of disorder is in the work environment and leads to disorder of body structures such as muscles, joints, tendons, ligaments, nerves or local circulatory system, it is defined as WMSDs (3). WMSDs are associated with a number of occupational hazards, including physical workloads such as awkward posture, manual material handling (MMH), vibration, psychosocial factors, and individual factor (4).

According to statistics, MSDs are responsible for significant costs in various industries and have detrimental effects on workers' health, quality of life, job satisfaction, and loss of working days (5). In the United States, MSDs account for 56% to 65% of all occupational injuries (6). In Europe, about 40 million workers (more than 30% of workers) suffer from these disorders, accounting for 0.2% of the EU's gross domestic product (GDP) (7). In general, the prevalence of MSDs is reported to be 75% in men and 74%-77% in women. However, MSDs alone are the largest group of occupational-related diseases, accounting for one-third or more of all occupational diseases registered in the United States, Nordic countries, and Japan (8).

MSDs risk factors can be classified into two categories: personal and occupational. Repetitive tasks, awkward postures, and psychological factors are known as occupational risk factors, and age, gender, body mass index are as personal risk factors (9, 10). These and other factors affecting MSDs are seen in a variety of occupations, including mining. These include recurrent kneeling, associated with an increased risk of knee disorders, including inflammation of the knee joints, bursitis, and osteoarthritis (11, 12). Awkward posture is similarly associated with an increased risk of low back pain (13) and has also been associated with degenerative changes in the lumbar spine of underground miners (14). A study among workers in South African in steel industry showed reports of work-related pain or discomfort that reported the most damage to the lumbar region, with respondents also consistently twisting. And bending the trunk is considered to be the main cause of pain or discomfort (15, 16).

Due to the importance and difficulty of miners' work, various studies have been conducted to investigate the prevalence of MSDs in miners around the world, but the results of these studies have been reported scattered. Due to the criteria for entering the study and the goals of each study, the results are still controversial and sometimes vague. In order to integrate the results of previous studies, systematic reviews are performed on the prevalence of MSDs and the factors affecting it (17). Since, according to our knowledge, no comprehensive study has been conducted on the prevalence of MSDs among miners. Therefore, the present study aimed to investigate the prevalence of MSDs among mining workers by a systematic review and meta-analysis.

Methods

This systematic review and meta-analysis study were designed in 2020 (from Jan to Mar). Based on the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), the researchers searched five international databases Medline/PubMed, ProQuest, Scopus, Embase and Web of Science, as well as Google Scholar for grey literature. There was no time limit for searching studies.

Keywords include three categories a) related to mine workers (such as Mine Workers, Mineworker, Miners, Miner, Mine, Mining), b) related to MSDs (such as Musculoskeletal disorders, Musculoskeletal Pain, Musculoskeletal problems, Musculoskeletal symptoms, Musculoskeletal disease), and c) related to prevalence (such as prevalence, frequency, incidence, epidemiology). After searching the databases, EndNote X8 software was used to manage the studies, and duplicate articles were deleted. It is worth noting that two researchers examined the articles separately.

Inclusion and exclusion criteria

Different studies use different methods to investigate the prevalence of MSDs, in which only questionnaires and medical diagnoses were included. Studies have also been included that report disorders in general or at least one organ. Otherwise, the study is excluded. In addition, studies that only assessed the risk of MSDs, based on risk assessment methods such as REBA or OWAS, or reported occupational accidents, were excluded. Due to linguistic limitations, just English-language studies were examined.

Evaluating the quality of articles

The Joanna Briggs Institute checklist was used to check and control the quality of articles. This checklist consists of 9 questions with Yes, No, Uncertain and Unused answers. The number of positive responses shows that the articles were categorized into three categories, which is low, average, and high quality. The purpose of this tool is to evaluate the methodological quality of the studies, and ways to access and understand the errors in the studies, design, implementation and analysis of data.

Screening studies

Two researchers (H.R and M.M) conducted an initial search, and other stages of the study, such as screening studies and extracting the results separately, were performed by two researchers (M.V and H.R). Finally, the team leader (A.S) reviewed the studies and gave a final opinion on the results.

Statistics analysis

The discrepancy between the studies was investigated by Cochran's test (with a significance level of less than 0.1) and its combination using the I^2 statistic (with a significance level greater than 50%). In case of heterogeneity, random effects model was used with reverse variance method and in case of non-heterogeneity, fixed effects model was used. Meta-regression was used to investigate the relationship between quantitative variables and the prevalence of MSDs. All analyzes were performed using STATA statistical software ver. 12.

Results

Description of the search for studies

Fig. 1 shows the steps from the initial search of the studies to the number of studies included to the final analysis. The search results of all international databases were 447 articles, and after removing duplicate articles, 334 articles included the stage of title and abstract review. After this step, the full text of the articles was reviewed and 46 articles included the final analysis. Moreover, the reference checking added 4 more studies to the final analysis and finally 50 studies were reviewed.

Description of the included studies

Table S1, S2, and Figs. S1-9 are supplementary files (Not published but in case of requesting will be presented). The number of studies conducted in different countries showed in Table 1. The lowest number of participants in the study was 14 and the highest was 15,987. The study tools showed that 24 studies used a Nordic questionnaire, 15 studies used a researcher-made questionnaire, 4 studies used a body map questionnaire, and one study used an x-ray medical test, and five studies did not mention the used tool. The mean age (SD) of age, work experience and body mass index of the results of 34, 30 and 38 studies, respectively, were 37.33 yr (5.75), 11.41 yr (6.01), and 24.91 (4.11), respectively. Eleven studies were performed on men only, one study was conducted on women and 20 studies were conducted on both genders, and 18 studies did not mention the gender. Twenty studies conducted in coal mines, 10 studies in gold mines, 4 studies in underground mines, 2 studies in open pit mines and lead mines, platinum, sandstone, each with 11 studies and 11 studies did not mention the mine. In addition, most studies (45 studies) were cross-sectional. Included studies were from 2002 to 2018 (Table S1).

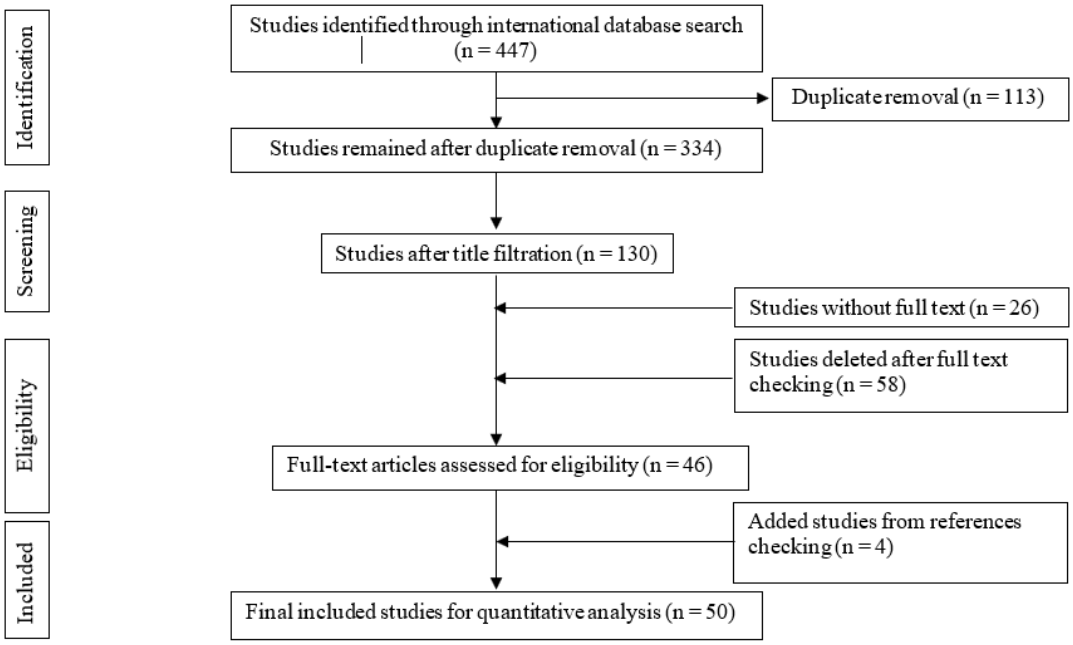

Fig. 1: Flowchart of the included studies in systematic review

Table 1: Frequency of the included studies by country and number of studies

Country	*Number of studies*	*References*
India	11	(22-32)
Indonesia	6	(20, 33-36)
South African	4	(16, 37-39)
United States	4	(40-43)
Australia	3	(43-45)
China	3	(19, 46, 47)
Ghana	3	(8, 48, 49)
Philippines	3	(50-52)
Iran	2	(13, 53)
Pakistan	2	(54, 55)
Brazil	1	(56)
Cameroon	1	(57)
Nigeria	1	(58)
Poland	1	(59)
Russia	1	(60)
Turkey	1	(61)
United Kingdom	1	(62)
Zambia	1	(63)
Scandinavian region	1	(64)

Results of heterogeneity

Due to the high heterogeneity observed in the study results, the *P*-value, df, Q, and I^2 indices for MSDs of all organs are expressed separately and generally in Table 2. The highest number of studies (26 studies) reported the prevalence of MSDs of upper back and the lowest number of studies (4 studies) reported the prevalence of MSDs of the arms and ankles & feet.

Table 2: Description of heterogeneous for included studies in systematic review and meta-analysis

Variables	*Number of studies*	*I²*	*Df*	*Q*	*P value*
Neck	24	99.6	23	5142.33	< 0.001
Shoulders	26	95.3	25	528.51	< 0.001
Arms	4	94.7	3	56.23	< 0.001
Elbows	16	90.2	15	152.42	< 0.001
Wrists & hands	22	94.8	21	402.51	< 0.001
Fingers	21	97.5	20	814.49	< 0.001
Upper back	38	99.6	37	9320.98	< 0.001
Lower back	18	98.5	17	1144.36	< 0.001
Hip	20	92.4	19	249.36	< 0.001
Knees	17	95.9	16	394.79	< 0.001
Ankles & feet	4	88.7	3	26.47	< 0.001
Total	20	99.7	19	6362.24	< 0.001

Results of meta-analysis

Due to the high heterogeneity in the results, the random effects model was used. The results of meta-analysis based on prevalence in different organs are as follows. The highest prevalence of MSDs was in the upper back and the lowest in the knees with a prevalence of 50.39% and 16.03%, respectively.

Total prevalence of MSDs

Fig. 2 shows that of the 20 studies that reported the total prevalence of MSDs, the prevalence of MSDs was 55.81% (confidence interval (CI) 95%: 41.01%-70.61%). The classification of studies based on the Human Development Index (HDI) shows that the highest and lowest prevalence of these disorders are related to countries with medium HDI with a prevalence of 59.30% (CI 95%: 41.16%-77.44%) and countries with very high HDI with a prevalence of 49.69% (CI 95%: 23.56%-75.82%), respectively.

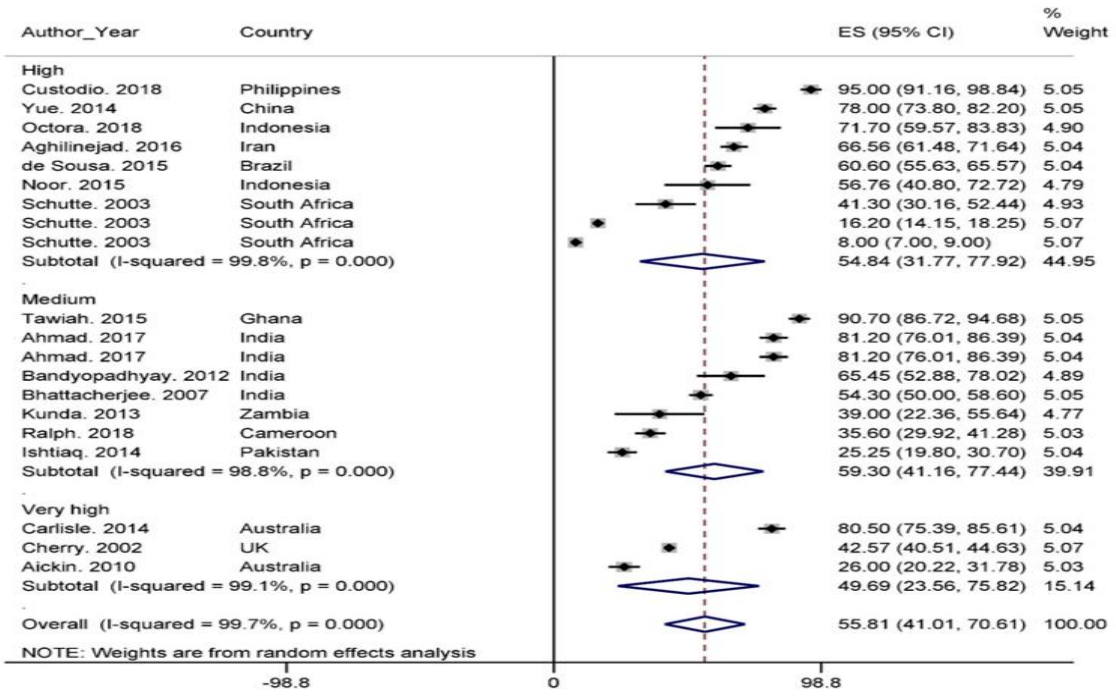

Fig. 2: Prevalence of total musculoskeletal disorders in amongst studies included

Neck

Figure 3 shows that of the 24 studies that reported the prevalence of MSDs of the neck, and the prevalence of this organ 29.75% (CI 95%: 20.36%-39.14%). The classification of studies based on the HDI showed that the highest and lowest prevalence was for high HDI with prevalence of 41.60% (CI 95%: 21.52%-61.67%), and very high HDI with prevalence of 22.38% (CI 95%: 7.42%-37.35%), respectively.

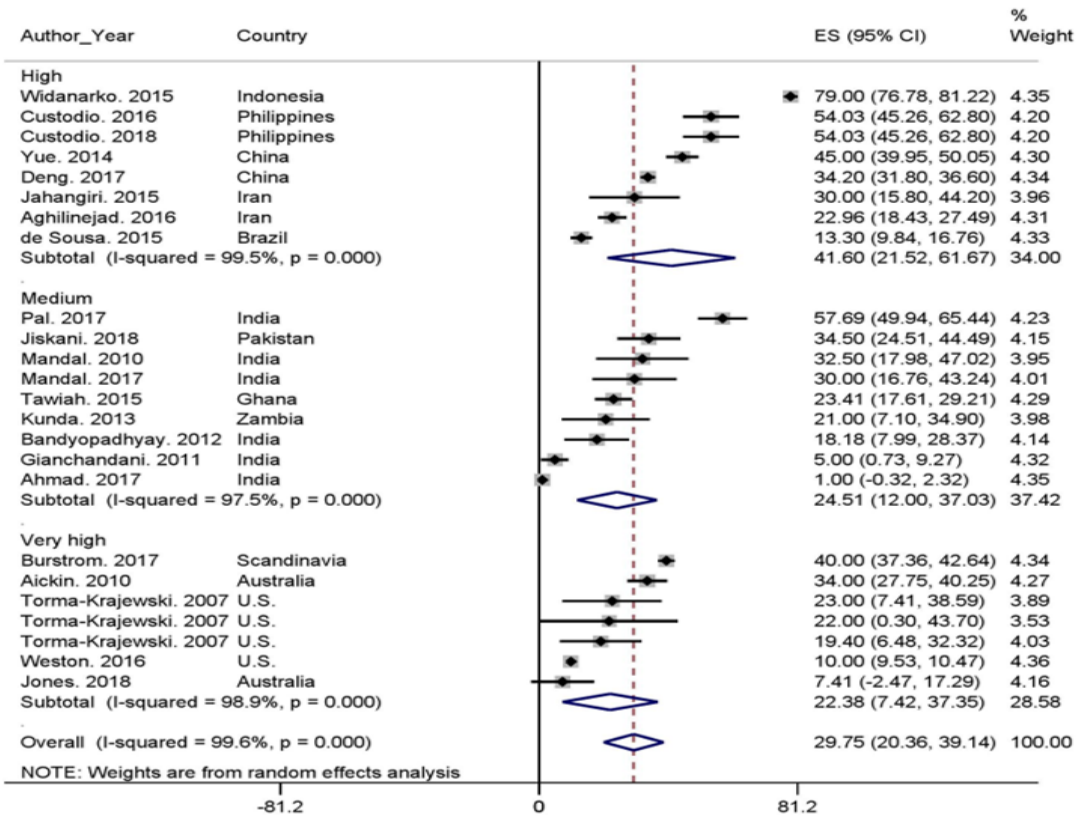

Fig. 3: Prevalence of neck musculoskeletal disorders in amongst studies included

Shoulders

Of the 26 studies that reported the prevalence of shoulder MSDs, the prevalence was 29.72% (CI 95%: 25.88%-33.56%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with 34.75% (CI 95%: 25.77%-43.73%) and the lowest prevalence among countries with very high HDI with 26.84% (CI 95%: 20.19-33.49%) (Fig. S1).

Arms

Of 4 studies that reported the prevalence of MSDs in the arms, the prevalence was 18.31% (CI 95%: 7.60%-29.02%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with 29.34% prevalence (CI 95%: 11.81%-46.88%) and the lowest prevalence among countries with medium HDI with prevalence 8.16% (CI 95%: 5.09%-11.24%) (Fig. S2).

Elbows

Of the 16 studies that reported the prevalence of MSDs in the elbows, the prevalence was 17.65% (CI 95%: 13.18%-22.13%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with medium HDI with 21.92%

prevalence (CI 95%: 11.70%-32.14%) and the lowest prevalence among countries with very high HDI with 14.42% (CI 95%: 8.37% to 20.47%) (Fig. S3).

Wrists & Hands

Twenty-two studies that reported the prevalence of MSDs of the wrists & hands are shown in Fig. S4. The prevalence of this disorder was 23.52% (CI 95%: 18.84%-28.21%). The classification of studies based on the HDI shows that the prevalence of this disorder is highest among countries with low HDI with only one study with a prevalence of 59.60% (CI 95%: 50.59%-68.61%) and the lowest prevalence among countries with a very high HDI with a prevalence of 19.51% (CI 95%: 14.64%-24.38%).

Fingers

Of the 21 studies that reported the prevalence of MSDs in the fingers, the prevalence was 24.43% (CI 95%: 17.23%-31.62%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with prevalence of 36.38% (CI 95%: 30.44%-42.31%) and the lowest prevalence among countries with low HDI and very high HDI with a prevalence of 8.80% (CI 95%: 3.60%-14.00%) and 18.84% (CI 95%: 2.85%-34.82%), respectively (Fig. S5).

Upper back

The 38 studies that reported the prevalence of MSDs above the upper back are shown in Fig. 4. The prevalence of this disorder was 50.39% (CI 95%: 42.05%-58.73%). The classification of studies based on the HDI shows that the prevalence of this disorder is highest among countries with low HDI with only one study with a prevalence of 78.90% (CI 95%: 71.41%-86.39%) and the lowest prevalence among countries with very high HDI with a prevalence of 42.98% (CI 95%: 31.23%-54.73%).

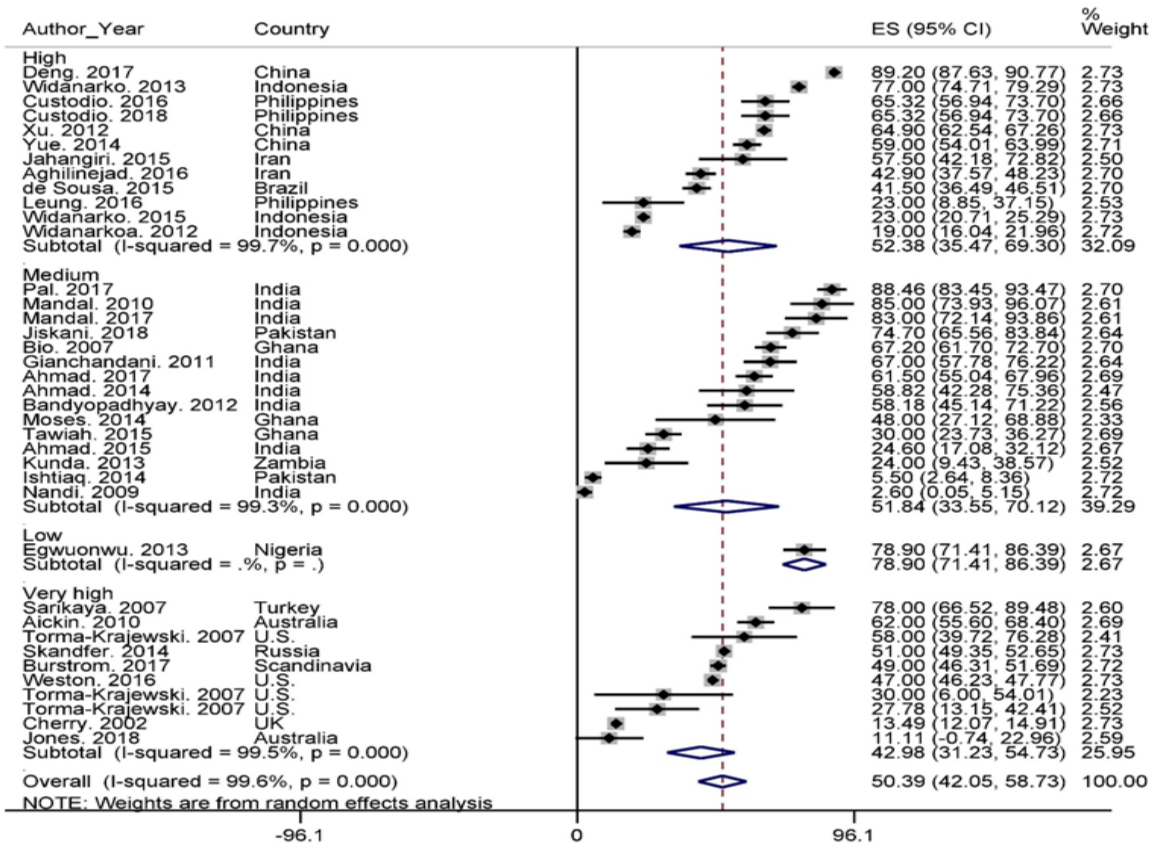

Fig. 4: Prevalence of upper back musculoskeletal disorders amongst studies included

Lower back

The 18 studies that reported the prevalence of MSDs in the lower back were shown in Fig. S6. The prevalence of this disorder was 24.25% (CI 95%: 16.21-32.29%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with a prevalence of 32.08% (CI 95%: 25.92%-38.23%) and the lowest prevalence among countries with low HDI and very high HDI with a prevalence of 8.80% (CI 95%: 3.60%-14.00%) and 18.59% (CI 95%: 5.81%-31.37%), respectively.

Hip

Of the 20 studies that reported the prevalence of hip MSDs, the prevalence was 26.03% (CI 95%: 22.30%-29.76%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with a prevalence of 34.66% (CI 95%: 26.97%-42.34%) and the lowest prevalence among countries with very high HDI with the prevalence of 23.33% (CI 95%: 19.13%-27.54%) (Fig. S7).

Knees

Of the 17 studies that reported the prevalence of MSDs in the knees, the prevalence was 16.03% (CI 95%: 11.78%-20.28%). The classification of studies based on the HDI shows that the prevalence of this disorder has the highest prevalence among countries with high HDI with a prevalence of 22.21% (CI 95%: 14.45%-29.97%) and the lowest prevalence among countries with medium HDI with a prevalence of 12.19% (CI 95%: 5.47%-18.92%) (Fig. S8).

Ankles & Feet

Of the 4 studies that reported the prevalence of MSDs in the ankles & feet, the prevalence was 18.25% (CI 95%: 8.19%-28.30%). The classification of studies based on the HDI shows that the prevalence of this disorder among countries with high HDI with only one study with a prevalence of 26.61% (CI 95%: 18.83%-34.39%) has the highest prevalence and the lowest prevalence among countries with medium HDI with a prevalence of 14.99% (CI 95%: 5.44%-24.54%) (Fig. S9).

Results of meta-regression

In order to investigate the various factors on the prevalence of MSDs in all organs, the meta-regression test was used. The results of the study of the relationship between year of study, mean of age, mean of work experience, and body mass index and prevalence of MSDs showed that neck disorders with mean of age and mean of work experience had a significant and reverse relationship, finger disorders and year of study had a significant and direct relationship, knee and mean of age disorders had a significant and inverse relationship and total prevalence had a significant and direct relationship with the year of study (Table S2). Of course, in the meta-regression calculations of some variables, because of insufficient data, calculations were not performed and no results were reported.

Discussion

The present study investigated the prevalence of MSDs among miners with a systematic review and meta-analysis. After searching the international databases, 447 studies were extracted, and finally, after screening the studies, 50 studies were included that reported the prevalence of MSDs among these workers. Overall, 26 studies were reported the upper back MSDs and 4 studies were reported the arms and legs MSDs. The results of meta-analysis also showed that the highest prevalence of MSDs was in the upper back and the lowest in the knees with a prevalence of 50.39% and 16.03%, respectively.

The most common MSDs among miners is about the upper back. This can be due to issues such as MMH, bending and turning of the waist, awkward postures and prolonged standing at work, which is common in almost all mines, especially coal mines (13). Moreover, the specific nature of

mining and low safety, lack of compliance with guidelines, limited ergonomic training, lack of proper health and safety management systems, and lack of appropriate control strategies may be responsible for this high rate. The prevalence of this type of disorder was higher among countries with low, medium and high HDI such as China, Iran, Philippines, Ghana and Nigeria than the United States, Australia and the Scandinavian region. The reason for this result may be a difference in the working conditions of the mines in different countries. Coal mines in countries with a very high HDI use more automatic machines and advanced technologies than other countries, so miners do less MMH. The results of meta-regression also show that with increasing age of workers, the prevalence of high back disorder increases, although this relationship was not significant. However, this can be attributed to the heavy workload and age, affected the physiological health of the miners and led to their MSD. Other studies also show that the physiological performance of older miners has decreased (18). For example, the physiological condition of coal miners, especially those of older age, was poor and that with age, the psychological distress of coal miners intensified (19). The prevalence of low back pain was also higher than other organs (24.25%). Doing all three awkward postures (bending, squatting, and kneeling) increases the load on the spine, and low back pain, usually results in decreased muscle strength, disability. Studies conducted in miners showed that the hip angle is much larger than other joints angles. The worker must work forward while bending. Prolonged static standing may also have a negative effect on intervertebral disc (19).

Other parts of the body that had high MSDs include the neck, shoulders, hands, and fingers. Workers exposed to both psychosocial and physical risk factors were more likely to have neck disorders compared to the control group (20). A cohort study in UK workers also found that exposure to various factors increased the risk of neck disorders (21). The high prevalence of these disorders may be due to the lack of safety of the mines, the lack of attention of the miners to the instructions, and the lack of effective national programs for prevention. The results of meta-regression showed that the prevalence of neck MSDs was significantly related to the mean of workers experience, and the occurrence of symptoms is function of time of exposure to risk factors for MSDs during work. Other causes of neck disorders include bending of the head and neck. Studies included in the analysis of the present study showed that the major parts of the upper limbs, such as the shoulders, wrists & hand, and elbows are affected. Miners kept their hands above shoulder height for a long time that resulting in a static load on the shoulder. Moreover, raising the tool while working is associated with a large deviation of the shoulder angle, the time that miners are in this posture, according to a study, about 85% of the working time was about 11 hours (22). In addition, a significant number of studies reported wrists & hands disorders (22 studies). Heavy hand tools, along with vibration, repetitive activities, and awkward posture, have also been a risk factor for MSDs of the wrists & hands.

In the total prevalence and some body parts such as neck, shoulders, elbows, wrists, fingers, lower back, the lowest prevalence among countries with a high HDI. These include factors such as identifying ergonomic risk factors and preventing them from being encountered, using advanced tools and methods, and having national prevention guidelines and programs in these countries. Such cases are very rare in countries with low or medium HDI, and this has led to workers facing more inappropriate working conditions and risk factors for MSDs during their working hours.

Conclusion

The prevalence of MSDs among miners is relatively high. Among the most common disorders are upper back, lower back and neck disorders, the most important causes of which are poor working conditions, poor posters, old tools and equipment, and lack of ergonomic training. Therefore, supervisors and mine managers

should pay more attention to reducing MSDs and increasing the ergonomic level of mines in order to increase workers' health.
The most common disorders are upper back and lower back disorders, also the most important causes of which are poor working conditions, poor posters and old tools and equipment. Therefore, future researches can make several interventions on these causes to reduce prevalence of upper of lower back disorders in miners.

Limitations

Our work clearly has some limitations. The most important one lies in the fact that the risk factors of MSDs are more than what is stated in this study such as psychosocial and physical risk factors. The present study initially intended to investigate and integrate the prevalence of MSDs and it is recommended that future studies examine the risk factors for these disorders.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

Authors declare that there is no competing of interest.

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