



## Musculoskeletal Disorders and Sick Leave among Peruvian Construction Workers: Implications for Safety Management

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### ABSTRACT

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Work-related musculoskeletal disorders (WMSDs) are a major occupational health concern in construction. In Peru, limited ergonomic awareness and informal labour conditions may contribute to their under-recognition. This study estimated the prevalence, severity and sick leave associated with WMSDs among construction workers in Lima and explored workers' perceptions of pain and symptom reporting in relation to job demands. A cross-sectional survey of 120 workers on a building project was conducted using a modified Nordic Musculoskeletal Questionnaire (NMQ). Descriptive statistics and Kendall's tau-b correlations were applied, and brief field comments were analysed qualitatively. Overall, 70.0% of participants reported pain in at least one body region in the previous 12 months, most frequently in the lower back, shoulders and knees. Pain was generally mild to moderate. Sick leave was reported by 32.0% of workers with lower-back pain and 36.0% of those with shoulder pain. Qualitative comments showed that pain was often normalized, underreported because of stigma, and self-managed to continue working under demanding conditions. These findings support the integration of ergonomic measures, early symptom recognition and supportive reporting cultures into construction safety management.

## 1. INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are a major cause of work-related morbidity in the construction sector, as shown by extensive literature describing their magnitude and trends over several decades [1, 2]. High prevalence and recurring patterns, particularly low back and shoulder pain, have been reported in different regions, from China and India to the Gulf countries and East Asia [3-5]. These complaints are associated with occupational stress and reduced quality of life [6] and may be influenced by circadian rhythm and work schedules [7]. From a biomechanical perspective, task height and manual materials handling generate different loads on the lumbar spine and upper limbs [8], while sustained awkward postures of the lower extremities increase the risk of WMSDs in the thighs, legs, and feet [9]. Fatigue acts as a transversal determinant [10], which supports the need for integrated ergonomic risk management approaches, such as bow-tie models and hazard mapping, to guide preventive strategies [11]. Although ergonomic interventions have demonstrated effectiveness in reducing pain, particularly in the lumbar region [12], these problems persist in complex construction environments worldwide [13].

Psychosocial and sociocultural factors also shape both the occurrence of WMSDs and the likelihood that symptoms are

reported. The high proportion of migrant labour in construction introduces specific vulnerabilities that require culturally sensitive approaches [14], and differences in injury rates between migrant and local workers have been documented [15]. Underreporting of occupational injuries and diseases has been estimated between 20% and 91%, driven by fear of job loss, bureaucratic barriers, and the psychosocial climate at work [16]. Perceptions of risk may include elements of fatalism and social behaviour [17], influenced by group dynamics, family responsibilities, and the prevailing preventive culture [18].

In Latin America, spatio-temporal clustering of occupational injuries highlights the need for region-specific surveillance and intervention [19]. In Peru, persistent gaps in occupational health services coexist with emerging opportunities for telehealth-based delivery [20]. National evidence has underscored the burden of WMSDs in industrial settings [21] and their association with absenteeism among construction workers in Lima [22], while regional analyses have revealed spatial gradients that can inform prevention policies [23].

Against this background, the present study builds on the research conducted by Al-Khiami et al. [24], which estimated WMSD prevalence and examined sociocultural reporting behaviours among construction workers using a modified

Nordic Musculoskeletal Questionnaire (NMQ) combined with qualitative field notes. In the Peruvian context, although previous studies have documented musculoskeletal symptoms in occupational settings [21] and absenteeism among construction workers in Lima [22], there is still limited site-based evidence integrating symptom prevalence, pain severity, sick leave and workers' perceptions of pain reporting in relation to job demands. The NMQ has shown robust psychometric performance in recent regional validations [25, 26] and remains a useful tool for mapping pain distribution and functional impact [27]. Therefore, this study aimed to estimate the prevalence, severity and sick leave associated with WMSDs among construction workers in Lima, and to explore workers' perceptions of pain and symptom reporting in relation to job demands.

## 2. METHODOLOGY

This study used a quantitative cross-sectional design to obtain a comprehensive understanding of WMSDs in the Peruvian construction sector. The methodological framework was adapted from the protocol described by Al-Khiami et al. [24] to fit the local occupational context. The process comprised two main stages: first, administration of a modified version of the NMQ, previously validated for construction workers [24], to collect quantitative data on musculoskeletal symptoms in nine body regions; and second, statistical analysis using IBM SPSS Statistics to describe prevalence rates and explore associations between pain reports and selected demographic and work-related variables. The overall methodological workflow is summarised in Figure 1.



Figure 1. Overview of the study process

### 2.1 Instrument selection, translation and contextual review

For data collection, this study used the questionnaire reported by Al-Khiami et al. [24], which is based on a modified version of the NMQ for construction workers. Rather than developing a new instrument, the study adopted this previously published questionnaire because it was aligned with the research objectives and occupational context. The questionnaire covers nine body regions and records symptoms during the previous 12 months, work impairment, and symptom severity using a five-point Likert scale from 1 (very mild) to 5 (very severe). This structure follows the base study [24] and is consistent with recent evidence supporting the semantic, cultural, and functional applicability of the NMQ in Portuguese- and Spanish-speaking settings [25-27]. For application in Peru, the questionnaire was translated into Spanish and underwent a contextual review by the co-authors to improve clarity, wording, and appropriateness for local construction workers. Minor wording adjustments were introduced to improve comprehension while preserving the meaning and structure of the source instrument.

### 2.2 Sample size determination and recruitment strategy

The sample size was calculated using Cochran's formula for a finite population, considering an accessible population of approximately 300 workers employed on a building foundation project in Lima, Peru. With a 95% confidence level ( $Z = 1.96$ ), a conservative proportion of 0.5, and a 7% margin of error, the initial sample size for an infinite population  $n_0$  was estimated as:

$$n_0 = \frac{Z^2 \times p(1 - p)}{e^2} \quad (1)$$

where,  $n_0$  is the required sample size for an infinite population,  $Z$  is the standard normal deviate for the chosen confidence

level,  $p$  is the assumed proportion of workers with the outcome of interest and  $e$  is the margin of error. For a finite population of  $N \approx 300$ , the corrected sample size ( $n$ ) was then obtained using:

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}} \quad (2)$$

which yielded a minimum required sample of 119 participants. Recruitment was carried out through consecutive sampling between September and October 2025, during the foundation stage of the project. Eligible workers were approached during the routine pre-shift meeting at the study site, where the study was explained and workers present at that time were invited sequentially to participate until the target sample was reached. Participation was voluntary and limited to active workers aged 18 years or older, with at least one month of continuous employment at the site. Workers with non-work-related injuries in the previous three months were excluded. The sample included workers from trades typically present in early-stage construction, such as steel fixers, concrete workers, bricklayers, helpers and general labourers. Although the data were collected from a single site, the work processes and environmental conditions are representative of urban building projects in Peru.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human participants. No identifying personal data was collected. Participation was strictly voluntary, and all workers were informed about the aims and procedures of the study and provided informed consent before completing the questionnaire. Seventeen invited workers declined to participate. Because recruitment was limited to workers present at the time of field administration, and the presence or absence of other workers was not systematically recorded, a healthy-worker effect or selection bias cannot be ruled out. In addition, the use of a 12-month recall period may have

introduced recall bias. Symptom reporting may also have been affected by underreporting, since workers may normalise pain or hesitate to disclose discomfort in a work environment where complaining can be perceived negatively.

### 2.3 Questionnaire structure and administration

Quantitative data were collected using the questionnaire described in Section 2.1. The instrument began with basic demographic and occupational variables, specifically age, sex, and years of experience in construction. Participants then reported musculoskeletal symptoms across nine body regions: neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet. For each region, respondents indicated whether they had experienced pain during the previous 12 months and whether the discomfort had limited their ability to perform work during the same period. When pain was reported, symptom intensity was rated using a five-point Likert scale ranging from 1 (very mild) to 5 (very severe). The questionnaire was administered directly to workers at the study site under researcher's supervision to ensure comprehension and completeness of responses. All completed questionnaires were subsequently reviewed and coded for statistical processing.

### 2.4 Qualitative data collection

During the survey process, several participants spontaneously shared brief reflections on their experiences of work-related discomfort. In total, 17 reflective comments were collected and analysed using thematic analysis, following the six-phase framework proposed by Braun and Clarke [28]. The researcher independently reviewed and coded all responses, identified recurring ideas and grouped them into broader categories to capture shared perceptions. This process emphasised conceptual clarity and internal consistency rather than inter-rater comparison. The thematic analysis was conducted inductively, allowing patterns to emerge from the data without applying predefined categories. The resulting themes were then contrasted with the quantitative findings to contextualise symptom reporting within broader sociocultural attitudes towards pain in construction work.

### 2.5 Data analysis

All quantitative data were manually entered into Microsoft Excel, checked for completeness and exported as a CSV file for statistical analysis. The analytical process was conducted using IBM SPSS Statistics version 27, following procedures consistent with those described by Al-Khiami et al. [24]. The analysis involved three main stages. First, normality testing was performed. Data distributions were visually assessed using quantile–quantile (Q–Q) plots to determine whether the use of parametric or non-parametric tests was appropriate.

Second, a descriptive analysis was conducted. Measures of central tendency (mean and median) and dispersion (standard deviation, minimum and maximum) were computed for quantitative variables such as age and years of experience, while frequency distributions were generated for categorical variables representing the presence or absence of WMSD symptoms across the nine body regions. Overall 12-month prevalence (“any body region”) was calculated as the proportion of participants with at least one positive response across the nine NMQ regions. In addition, 95% confidence

intervals for overall and regional prevalence estimates were calculated using the Wald (normal approximation) method as implemented in SPSS. This approach was retained as a simple and consistent method for reporting descriptive prevalence estimates across body regions.

Third, an inferential analysis was carried out. Given the binary nature of the pain variables, Kendall's tau-b ( $\tau$ ) coefficients were computed to explore pairwise associations between body regions. This method is robust to ties and is suitable for non-parametric, ordinal and dichotomous data. To check robustness, phi ( $\phi$ ) coefficients were also calculated. Correlations between pain occurrence and demographic factors (age and years of experience) were likewise tested using non-parametric methods. Given the exploratory nature of this study and the limited sample size, no multivariable models were fitted, and results are interpreted as bivariate associations rather than causal relationships. No formal adjustment for multiple comparisons was applied; therefore, the correlation findings were interpreted as exploratory and with caution.

### 2.6 Data quality and reproducibility

To ensure data accuracy, a random 10% of the survey entries were double-checked against the original paper questionnaires to verify correct transcription into the electronic database. No inconsistencies were detected. Data validation procedures included internal range checks and verification of missing values prior to statistical analysis. All analyses were conducted using standardised syntax files in IBM SPSS Statistics version 27 to ensure replicability, and analytical decisions and coding steps were documented to maintain traceability throughout the process. An anonymised dataset and analysis scripts are available from the corresponding author upon reasonable request.

## 3. RESULTS AND DISCUSSION

This section presents the study's findings, beginning with an overview of the respondents' demographic characteristics. It then describes the prevalence of WMSDs, the severity of reported conditions, and absenteeism attributable to WMSDs. The section concludes with the analysis of correlations and statistical significance.

### 3.1 Demographic profile

Participants' ages ranged from 20 to 55 years (mean = 34.1, SD = 10.2), while their work experience varied between 1 and 28 years (mean = 7.7, SD = 7.2). Visual inspection of histograms and Q–Q plots showed a right-skewed distribution for both variables, reflecting a predominance of younger workers with limited experience in the construction sector. The Shapiro–Wilk test confirmed non-normality for age and experience ( $p < 0.001$ ), and therefore non-parametric analyses were used in the subsequent statistical procedures. Descriptive statistics for age and work experience are presented in Table 1.

### 3.2 Exploring the prevalence of work-related musculoskeletal disorders

As shown in Table 2, 70.0% of the 120 construction workers reported experiencing musculoskeletal discomfort in at least

one body region during the past 12 months. This overall prevalence corresponds to 84 participants, as reflected in the distribution across affected regions presented in Table 3. Among specific anatomical sites, the lower back was the most frequently affected area (41.7%, n = 50), followed by the shoulders (20.8%) and knees (15.0%). These patterns are consistent with the mechanical demands of manual construction work, where repetitive lifting and awkward postures contribute to localised strain.

**Table 1.** Descriptive statistics for age and work experience

Statistics	Age (Years)	Experience (Years)
Mean	34.08	7.72
Std	10.24	7.19
Min	20.00	1.00
Lower quartile (Q1)	25.00	2.00
Middle quartile (Q2)	33.50	5.00
Upper quartile (Q3)	43.00	12.00
Max	55.00	28.00

**Table 2.** Frequency of work-related musculoskeletal disorders (WMSDs) by body region in the previous 12 months

Body Region	Total Count	Percentage	95% CI
Lower back	50	41.67	32.9–50.5
Shoulders	25	20.83	13.6–28.1
Knees	18	15.00	8.5–21.4
Upper back	10	8.33	3.4–13.2
Hips/thighs	10	8.33	3.4–13.2
Neck	9	7.50	2.8–12.2
Wrists/hands	8	6.67	2.3–11.0
Ankles/feet	8	6.67	2.3–11.0
Elbows	5	4.17	0.6–7.7

Notes: Counts refer to body-region complaints. Participants may report more than one region; therefore, totals exceed the sample size.

**Table 3.** Number of affected body regions in the total sample (12-month recall)

Number of Body Regions	Percentage of Total Sample (N = 120)
1	34.17
2	25.83
3	6.67
4	3.33
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00

Notes: Percentages were calculated using the full sample (N = 120) as the denominator. Therefore, the values sum to the overall 12-month prevalence of musculoskeletal symptoms (70.0%) rather than 100%.

### 3.3 Pain severity

As summarised in Table 4, the overall intensity of musculoskeletal discomfort reported across all body regions was generally low. Mean severity values remained below three points on the five-level scale, indicating that pain was mostly perceived as mild to moderate. The highest mean severity was observed in the lower back, followed by the upper back and ankles/feet, reflecting the mechanical demands of manual construction work. Severity analysis was performed on all reported complaints (n = 143). Levels 2 and 3 together accounted for 71.4% of cases, while levels 4–5 represented 16.8%. This pattern suggests that severe pain was relatively

uncommon within the sample, possibly due to task habituation or the normalisation of discomfort as an expected aspect of construction work.

**Table 4.** Distribution of pain severity levels (percentage of total complaints, n = 143)

Severity Level	Count	Percentage of Total Complaints
1 (very mild)	17	11.9
2 (mild)	65	45.5
3 (moderate)	37	25.9
4 (severe)	19	13.3
5 (very severe)	5	3.5
Total	143	100

Note: Percentages are calculated using the total number of reported complaints (n = 143) as the denominator; participants could report multiple body regions.

### 3.4 Absenteeism

Absences related to musculoskeletal complaints are summarised in Table 5. Among participants reporting lower-back pain (n = 50), 32.0% indicated having taken time off work, while 36.0% of those with shoulder discomfort (n = 25) did so. Percentages for other regions ranged from 5.6% for knee pain to 40.0% for upper-back and elbow pain. Table 5 presents the distribution of pain severity among workers who reported sick leave. Table 6 presents the proportion of workers reporting sick leave among those with pain in each body region.

Notably, no absences occurred at severity level 5, even though five cases of “very severe” pain were recorded overall (see Table 4). This suggests that workers experiencing extreme discomfort may continue working despite their symptoms, reflecting both economic pressure and normalisation of pain within the construction context.

**Table 5.** Reported absences by severity level

Body Region	Severity Level 1	Severity Level 2	Severity Level 3	Severity Level 4
Neck	0	1	0	0
Shoulders	1	2	0	5
Upper back	0	1	1	1
Lower back	1	5	4	4
Elbows	1	1	0	0
Wrists/hands	0	1	0	1
Hips/thighs	0	0	3	0
Knees	0	0	1	0
Ankles/feet	1	1	0	0

Note: This table includes only participants who reported work absences due to work-related musculoskeletal disorders (WMSDs).

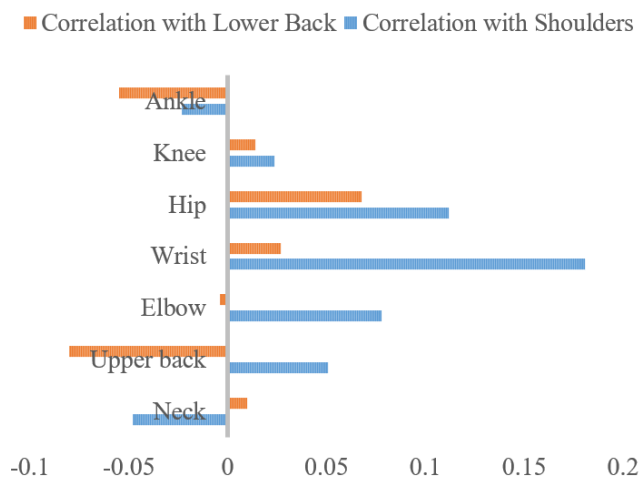
**Table 6.** Proportion of workers reporting sick leave among those with pain, by body region

Body Region	n with Pain	n with Sick Leave	% among Those with Pain
Lower back	50	16	32.0
Shoulders	25	9	36.0
Upper back	10	4	40.0
Elbows	5	2	40.0
Wrists/hands	8	3	37.5
Hips/thighs	10	3	30.0
Ankles/feet	8	2	25.0
Neck	9	1	11.1
Knees	18	1	5.6

Note: Percentages are calculated among participants reporting pain in the respective body region.

### 3.5 Correlation analysis

Figure 2 presents non-parametric correlations among reported pain regions. All Kendall's tau-b and phi coefficients were weak ( $|\tau| < 0.20$ ) and non-significant (all  $p > 0.05$ ), indicating limited co-occurrence of symptoms across body areas. The strongest observed associations were between lower-back and wrist/hand pain ( $\tau = 0.18$ ,  $p = 0.07$ ) and between lower-back and hips/thighs pain ( $\tau = 0.11$ ,  $p = 0.12$ ), although neither reached statistical significance. No significant relationships were identified between pain variables and demographic factors such as age or work experience. These findings suggest a predominantly localised pattern of self-reported musculoskeletal symptoms in this sample, rather than a generalised pattern across multiple body regions. Because direct exposure measures were not collected, these results should not be interpreted as evidence of specific localised ergonomic exposures.



**Figure 2.** Kendall's tau-b correlations between body-region pain variables (autocorrelations excluded)  
Note: All coefficients were weak ( $|\tau| < 0.20$ ).

### 3.6 Qualitative findings

The thematic analysis of the 17 reflective comments revealed three recurrent themes related to how workers perceive and report musculoskeletal discomfort.

(1) Normalisation of pain. Many participants viewed discomfort as an inherent part of construction work, for example, "Back pain is part of the job; everyone has it here." This attitude often led to under-reporting of symptoms and limited use of preventive measures.

(2) Stigma of complaining. Several workers expressed hesitation to acknowledge pain for fear of being seen as weak or losing work opportunities, as illustrated by the statement, "If you say something, they think you can't handle the job." Such stigma reinforces silence around musculoskeletal issues.

(3) Self-management of symptoms. Some participants described coping strategies such as taking informal breaks or using self-medication, for instance, "I take a pill and keep working because there's no time to rest." These behaviours reflect adaptation to demanding conditions and a lack of ergonomic support.

Taken together, these themes illustrate a cultural normalisation of pain and reliance on individual coping, which aligns with the quantitative finding of moderate symptom severity but relatively low absenteeism. As a reflexive note,

the researcher acknowledges that participants' statements were collected within the work environment, which may have influenced their openness and tone. Nevertheless, recurring patterns across responses suggest genuine perceptions that are consistent with prior studies on pain reporting among manual labourers.

These findings are broadly consistent with previous evidence from Peru and Latin America. In construction workers in Lima, Peru, musculoskeletal symptoms were reported by 76.47% of workers and work absenteeism by 44.12%, with the lumbar region being the most frequently affected anatomical area [22]. Although the present study found a slightly lower overall prevalence (70.0%), it similarly identified the lower back and shoulders as key problem areas, which supports the relevance of trunk and upper-limb strain in Peruvian construction work. National evidence from another physically demanding occupational setting in Peru has also shown a high burden of musculoskeletal disorders, particularly in the shoulder and lumbar regions, reinforcing that these problems are not restricted to a single sector [21]. At the regional level, Brazilian surveillance data further indicate that WMSDs represent a substantial occupational health burden in Latin America and frequently involve pain, functional limitation, and time off work for treatment [23]. In the present study, the coexistence of frequent symptoms with only partial sick leave may plausibly reflect cultural and organisational factors such as pain normalisation, stigma around complaining, economic pressure to remain at work, or under-recognition of symptoms. However, these mechanisms were not directly measured and should therefore be interpreted as contextual explanations rather than empirical findings of this study.

## 4. CONCLUSIONS

This study examined the prevalence and reporting patterns of WMSDs among construction workers in Peru. The findings showed that 70.0% of participants experienced musculoskeletal discomfort in at least one body region during the previous 12 months, with the lower back (41.7%), shoulders (20.8%), and knees (15.0%) identified as the most affected areas. These results are consistent with the predominance of lumbar and upper-limb strain as key ergonomic concerns in construction work. Pain intensity was predominantly mild to moderate, with severity levels 2 and 3 representing the majority of reports and only isolated cases of severe discomfort. Absenteeism analysis indicated that lower-back pain was the main factor associated with work leave, followed by shoulder-related problems, underscoring the occupational relevance of trunk and upper-limb disorders. Kendall's tau-b correlation analysis demonstrated weak and localised associations ( $|\tau| < 0.20$ ) between body regions, suggesting a predominantly localised pattern of self-reported discomfort rather than a generalised multi-region pattern in this sample. Although these patterns may be compatible with task-specific loading, objective task or exposure metrics were not collected, and causal inferences cannot be drawn. Age and work experience showed negligible correlations with WMSD occurrence, indicating that demographic characteristics exert limited influence on symptom distribution.

Overall, these findings support the importance of strengthening ergonomic prevention and early symptom recognition in the Peruvian construction sector. However, given the cross-sectional, single-site design and the reliance on

self-reported symptoms, the results should be interpreted as descriptive and exploratory rather than causal. Within these limits, practical next steps for occupational safety management include posture-oriented ergonomic training, early reporting and symptom-recognition mechanisms, and awareness programmes that help reduce the normalisation and stigma of pain in construction work.

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## REFERENCES

- [1] Antwi-Afari, M.F., Li, H., Chan, A.H.S., Seo, J., Anwer, S., Mi, H.Y., Wu, Z.Z., Wong, A.Y.L. (2023). A science mapping-based review of work-related musculoskeletal disorders among construction workers. *Journal of Safety Research*, 85: 114-128. <https://doi.org/10.1016/j.jsr.2023.01.011>
- [2] Santos, W., Lorente, A., Rojas, C., Isidoro, R., Dias, A., Mariscal, G., Zabady, A.H., Lorente, R. (2025). A systematic review and meta-analysis on the prevalence and demographic risk factors of work-related musculoskeletal disorders in construction workers. *Frontiers in Public Health*, 13: 1651921. <https://doi.org/10.3389/fpubh.2025.1651921>
- [3] Lee, Y.C., Hong, X., Man, S.S. (2023). Prevalence and associated factors of work-related musculoskeletal disorders symptoms among construction workers: A cross-sectional study in South China. *International Journal of Environmental Research and Public Health*, 20(5): 4653. <https://doi.org/10.3390/ijerph20054653>
- [4] Akhtar, S.M.F., Mumtaz, N., Khan, A.R. (2025). Prevalence and nature of ergonomic hazards among construction workers in India: A cross-sectional study. *Safety*, 11(3): 62. <https://doi.org/10.3390/safety11030062>
- [5] Anwar, W., Rashid, F.A., Hazari, A., Kandakurti, P.K. (2025). Work-related Musculoskeletal Disorders (WMSDs) and Quality of Life (QoL) among the construction workers in the United Arab Emirates. *F1000Research*, 14: 80. <https://doi.org/10.12688/f1000research.160557.1>
- [6] Jeong, S., Lee, B.H. (2024). The moderating effect of work-related musculoskeletal disorders in relation to occupational stress and health-related quality of life of construction workers: A cross-sectional research. *BMC Musculoskeletal Disorders*, 25(1): 147. <https://doi.org/10.1186/s12891-024-07216-4>
- [7] Kumar Singh, A., Aljohani, A., Shakor, P., Awuzie, B.O., Uddin, S.J., Shivendra, B.T. (2024). Study on safety health of construction workers at workplace: A sustainable perspective approach. *Frontiers in Built Environment*, 10: 1451727. <https://doi.org/10.3389/fbuil.2024.1451727>
- [8] Rahman, M.S., Yazaki, T., Chihara, T., Sakamoto, J. (2025). Evaluating lumbar biomechanics for work-related musculoskeletal disorders at varying working heights during wall construction tasks. *Biomechanics*, 5(3): 58. <https://doi.org/10.3390/biomechanics5030058>
- [9] Bispo, L.G.M., da Silva, J.M.N. (2024). Risk factors for work-related musculoskeletal disorders among workers in Brazil: A structural equation model approach. *International Journal of Industrial Ergonomics*, 99: 103551. <https://doi.org/10.1016/j.ergon.2024.103551>
- [10] Zong, H., Yi, W., Antwi-Afari, M.F., Yu, Y. (2024). Fatigue in construction workers: A systematic review of causes, evaluation methods, and interventions. *Safety Science*, 176: 106529. <https://doi.org/10.1016/j.ssci.2024.106529>
- [11] Bazaluk, O., Tsopa, V., Cheberichko, S., Deryugin, O., Radchuk, D., Borovytskyi, O., Lozynskyi, V. (2023). Ergonomic risk management process for safety and health at work. *Frontiers in Public Health*, 11: 1253141. <https://doi.org/10.3389/fpubh.2023.1253141>
- [12] Santos, W., Rojas, C., Isidoro, R., Lorente, A., Dias, A., Mariscal, G., Benlloch, M., Lorente, R. (2025). Efficacy of ergonomic interventions on work-related musculoskeletal pain: A systematic review and meta-analysis. *Journal of Clinical Medicine*, 14(9): 3034. <https://doi.org/10.3390/jcm14093034>
- [13] Maluleke, D., Deacon, C., Smallwood, J. (2023). Musculoskeletal disorders among construction workers. In the 33rd European Safety and Reliability Conference (ESREL 2023), Southampton, UK, pp. 1624-1630. [https://doi.org/10.3850/978-981-18-8071-1\\_P650-cd](https://doi.org/10.3850/978-981-18-8071-1_P650-cd)
- [14] Lyu, S., Zhu, Q., Hu, X., Hon, C.K., Zhang, R.P., Skitmore, M. (2025). A science mapping-based review of safety and health research on migrant and ethnic minority construction workers. *Journal of Safety Research*, 95: 569-585. <https://doi.org/10.1016/j.jsr.2025.10.023>
- [15] Alruwaili, M., Carrillo, P., Soetanto, R., Munir, F. (2024). Occupational accidents, injuries, and associated factors among migrant and domestic construction workers in Saudi Arabia. *Buildings*, 14(9): 2714. <https://doi.org/10.3390/buildings14092714>
- [16] Kyung, M., Lee, S.J., Dancu, C., Hong, O. (2023). Underreporting of workers' injuries or illnesses and contributing factors: A systematic review. *BMC Public Health*, 23(1): 558. <https://doi.org/10.1186/s12889-023-15487-0>
- [17] Mastrantonio, R., Cofini, V., Mastrangeli, G., Pettinaro, M., Mastrodomenico, M., Fabiani, L. (2024). Occupational risk perception of construction workers: A cross sectional study. *Frontiers in Public Health*, 12: 1338604. <https://doi.org/10.3389/fpubh.2024.1338604>
- [18] García-Mainar, I., Montuenga, V.M. (2024). Risk self-perception and occupational accidents. *Journal of Safety Research*, 88: 135-144. <https://doi.org/10.1016/j.jsr.2023.11.001>
- [19] Moreira, F.G., de Oliveira, C.P., Farias, C.A. (2024). Workplace accidents and the probabilities of injuries occurring in the civil construction industry in Brazilian Amazon: A descriptive and inferential analysis. *Safety Science*, 173: 106449. <https://doi.org/10.1016/j.ssci.2024.106449>
- [20] Astete-Cornejo, J., Burgos-Flores, M.A., Cruz-Ausejo, L., Cainamarks-Alejandro, J.A., Ambrosio-Melgarejo, J.I., Rosales-Rimache, J. (2025). Implementation of occupational safety and health services and telehealth in Peru: A narrative review. *Revista Brasileira de Medicina do Trabalho*, 23(2): e20251405. <https://doi.org/10.47626/1679-4435-2025-1405>

- [21] Rodríguez-Pulido, A.G., Arrieta-Córdova, A.F., Arce-Huamani, M.A. (2025). Prevalence and correlation of workload and musculoskeletal disorders in industrial workers: A cross-sectional study. *Frontiers in Rehabilitation Sciences*, 6: 1677621. <https://doi.org/10.3389/fresc.2025.1677621>
- [22] Zorrilla, J.P.Q., Gonzales, S.P. (2023). Síntomas músculo-esqueléticos y ausentismo laboral en trabajadores de construcción civil, Lima-Perú. *CASUS: Revista de Investigación y Casos en Salud*, 7(1): 10-19. <https://doi.org/10.35626/casus.1.2023.497>
- [23] Lima, A.G.C.F., Ribeiro, C.J.N., Lima, S.V.M.A., Barbosa, Y.M., Oliveira, I.M.D., Araújo, K.C.G.M.D. (2024). Space-time analysis of work-related musculoskeletal disorders in Brazil: An ecological study. *Cadernos de Saude Publica*, 40: e00141823. <https://doi.org/10.1590/0102-311XEN141823>
- [24] Al-Khiami, M.I., Lindhard, S.M., Wandahl, S. (2025). Prevalence of work-related musculoskeletal disorders and associated sociocultural reporting behaviors in Kuwait's construction industry. *WORK: A Journal of Prevention, Assessment & Rehabilitation*, 81(3): 2937-2951. <https://doi.org/10.1177/10519815251325780>
- [25] Mattos, C.N.B.D., Pattussi, M.P. (2025). Nordic musculoskeletal questionnaire: Assessment of the factor structure in a population of Brazilian adults. *BrJP*, 8: e20250019. <https://doi.org/10.63231/2595-0118.20250001-en>
- [26] Mateos-González, L., Rodríguez-Suárez, J., Llosa, J.A., Agulló-Tomás, E. (2024). Spanish version of the Nordic Musculoskeletal Questionnaire: Cross-cultural adaptation and validation in nursing aides. *Anales del Sistema Sanitario de Navarra*, 47(1): e1066. <https://doi.org/10.23938/ASSN.1066>
- [27] Horn, C.G., Jensen, K., Hartvigsen, J., Wekre, L.L., Skou, S.T., Folkestad, L. (2024). Evaluation of the Nordic Musculoskeletal Questionnaire for measuring prevalence and the consequence of pain in a Danish adult OI population: A pilot study. *Calcified Tissue International*, 115(4): 405-412. <https://doi.org/10.1007/s00223-024-01262-9>
- [28] Braun, V., Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2): 77-101. <https://doi.org/10.1191/1478088706qp063oa>

## NOMENCLATURE

$n$	corrected sample size for a finite population (dimensionless)
$n_0$	initial sample size for an infinite population (dimensionless)
$N$	accessible population size (number of workers) (dimensionless)
$Z$	standard normal deviate for the chosen confidence level (dimensionless)
$p$	assumed proportion of workers with the outcome of interest (dimensionless)
$e$	margin of error in the sample size calculation (dimensionless)

## Greek symbols

$\tau$	Kendall's tau-b correlation coefficient (dimensionless)
$\phi$	phi correlation coefficient (dimensionless)