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RESEARCH ARTICLE

# Integration of Occupational Risk Factors and Ergonomic Assessment for Musculoskeletal Disorder Prevention

**M. Ramadhandie Odiesta[1]\*, Agita Diora Fitri[2], Indri Seta Septadina[3], Mariana[4]**
[1,3] Department of Anatomy Faculty of Medicine Sriwijaya University, Indonesia
[2,4] Department of Public Health sciences and community medicine Faculty of Medicine Sriwijaya University, Indonesia
\*Corresponding Author: ramadhandie@fk.unsri.ac.id

## ARTICLE INFO

## ABSTRACT

Background: Work-related musculoskeletal disorders (WRMSDs) are a major occupational health burden, impacting work ability, productivity, and quality of life. Despite extensive research, evidence on WRMSDs remains fragmented across sectors, hindering the development of comprehensive prevention strategies.

Objective: This review synthesizes recent evidence on WRMSDs across various occupational settings and proposes a public health-oriented framework linking occupational characteristics, risk factors, ergonomic assessments, and preventive strategies.

Methods: An integrative literature review was conducted, focusing on peer-reviewed studies from 2022 to 2026. Evidence was synthesized thematically, emphasizing occupational sectors, body regions, risk factors, assessment methods, and prevention.

Results: WRMSDs were commonly reported among workers in manufacturing, construction, healthcare, office work, transportation, and agriculture, with the neck, shoulders, and lower back most affected. Physical exposures were primary risk factors, while organizational and psychosocial factors acted as modifiers. Traditional ergonomic assessments predominated, with limited use of technology-assisted methods. An integrated conceptual framework was developed to link occupational exposure to prevention strategies.

Conclusion: WRMSDs are a multifactorial public health issue requiring integrated prevention strategies. The proposed framework offers a population-based approach to guide occupational health programs and policy development.

## INTRODUCTION

Work-related musculoskeletal disorders (WRMSDs) represent one of the most prevalent and burdensome occupational health problems worldwide and are increasingly recognized as a significant public health concern. WRMSDs encompass a wide range of inflammatory and degenerative conditions affecting muscles, tendons, ligaments, joints, and nerves that are attributable to occupational exposures. At the population level, these disorders contribute substantially to work absenteeism, reduced productivity, early retirement, and long-term disability, thereby imposing economic and social burdens on workers, employers, and health systems (Bonfiglioli et al., 2022).

From a public health and community medicine perspective, WRMSDs should not be viewed solely as individual clinical conditions, but rather as outcomes of complex interactions between occupational environments, work organization, psychosocial stressors, and individual susceptibility. High prevalence of WRMSDs has been consistently reported across a wide range of occupational sectors, including manufacturing, construction, healthcare, office-based work, transportation, and agriculture (Das, 2023; Kashif et al., 2022; Sun et al., 2023; Yang et al., 2023). This widespread distribution highlights that WRMSDs affect both physically demanding occupations and those characterized by prolonged static postures and repetitive tasks.

Epidemiological studies among manufacturing and industrial workers have demonstrated a high burden of neck, shoulder, and lower back disorders associated with repetitive movements, awkward postures, and forceful exertions (He et al., 2023; Yang et al., 2023). Similarly, construction workers exhibit elevated rates of lower back and lower limb disorders due to heavy manual handling and physically strenuous tasks (Lee et al., 2023; Rahman & Sakamoto, 2024). In the healthcare sector, nurses, physiotherapists, dentists, and other clinical professionals experience substantial WRMSD prevalence linked to patient handling, sustained postures, and high workload demands (Gorce & Jacquier-Bret, 2024; Jacquier-Bret & Gorce, 2023; Sun et al., 2023).

In addition to physical exposures, growing evidence indicates that organizational and psychosocial factors play a critical role in the development and progression of WRMSDs. Long working hours, insufficient rest breaks, high job demands, low decision latitude, and limited social support have been associated with increased musculoskeletal complaints across occupational groups (Afsharian et al., 2023; Bezzina et al., 2023). These findings support a biopsychosocial model of WRMSDs that aligns closely with public health approaches emphasizing upstream determinants of health.

Ergonomic assessment methods have been widely used to identify WRMSD risks and guide preventive efforts. Traditional tools such as the Nordic Musculoskeletal Questionnaire, Rapid Upper Limb Assessment, and Rapid Entire Body Assessment remain dominant due to their feasibility for large-scale occupational health surveillance (Kakaraparthi et al., 2023; Yazdanirad et al., 2022). However, recent advances in wearable sensors, motion capture, and artificial intelligence-based assessments suggest new opportunities for improving risk detection and intervention monitoring, although their application in occupational health practice remains limited (Lind et al., 2023).

Despite extensive research, the existing literature on WRMSDs remains fragmented, often focusing on single occupations, isolated risk factors, or specific assessment tools. There is a lack of integrative frameworks that systematically link occupational characteristics,

multidimensional risk factors, ergonomic assessment methods, and preventive strategies within a population health context. Therefore, this integrative review aims to synthesize recent evidence on WRMSDs across occupational sectors and to propose a public health–oriented conceptual framework to support comprehensive prevention strategies and inform occupational health policy and practice.

## METHODOLOGY

This study employed an integrative literature review design, appropriate for synthesizing heterogeneous evidence relevant to public health decision-making. Peer-reviewed articles published between 2022 and 2026 were included. Eligible studies addressed WRMSDs among working populations and reported on prevalence, risk factors, ergonomic assessment methods, or preventive strategies.

Evidence was synthesized thematically using a population health lens, emphasizing occupational determinants of health, prevention levels, and implications for workplace health promotion.

## RESULT AND DISCUSSION

Across the reviewed literature, a wide range of ergonomic assessment methods were applied to identify WRMSD risks. Subjective assessment tools such as the Nordic Musculoskeletal Questionnaire and Nordic Body Map were predominantly used for population-level surveillance (Adiyanto et al., 2022; Kakaraparthi et al., 2023). Observational tools, including RULA, REBA, OWAS, and their modified versions such as MOREBA, were commonly applied in manufacturing, healthcare, and agricultural settings (Bispo et al., 2022; Kolus et al., 2023; Yazdanirad et al., 2022). More recent studies have begun to explore technology-assisted ergonomic assessments using wearable sensors, motion capture systems, and artificial intelligence–based approaches, although their application remains limited (Hanumegowda & Gnanasekaran, 2022; Lind et al., 2023).

### Occupational Distribution of WRMSDs

Figure 1 demonstrates that WRMSDs affect workers across all major occupational sectors. Office workers, healthcare professionals, and drivers predominantly reported neck and shoulder disorders, reflecting prolonged static postures and repetitive tasks. In contrast, construction and agricultural workers exhibited higher prevalence of lower back disorders, associated with manual material handling and physically demanding tasks.
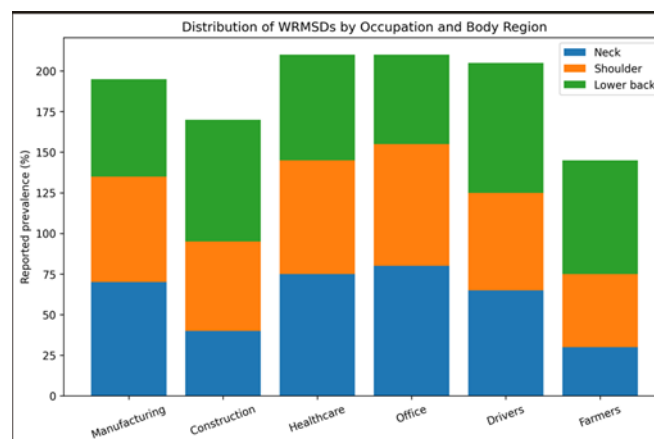


**Figure 1.** Distribution of WRMSD by Occupation and Body Region

**Ergonomic Assessment Approaches in WRMSD Research**

As shown in Figure 2, most studies relied on self-reported and observational assessment tools, particularly the Nordic Musculoskeletal Questionnaire, RULA, and REBA. These tools were primarily used for surveillance and risk identification. Technology-based assessment methods were infrequently applied, indicating limited integration of digital ergonomics within occupational health practice.
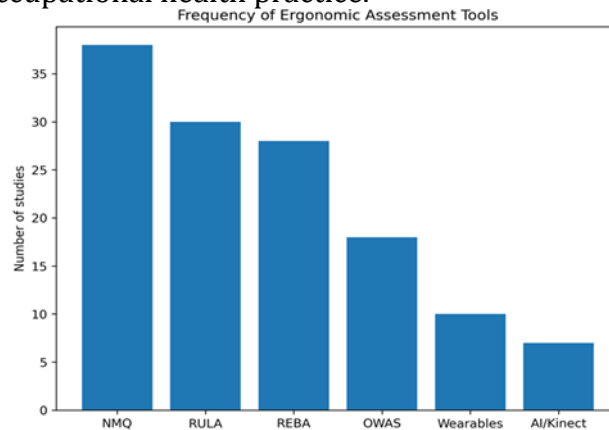


**Figure 2.** Frecuency of Ergonomic Assessment Tools

**Multidimensional Determinants of WRMSDs**

Figure 3 highlights the multifactorial nature of WRMSDs. Physical occupational exposures were dominant determinants; however, organizational factors such as long working hours and psychosocial stressors played a significant role in amplifying musculoskeletal complaints, underscoring the need for holistic prevention strategies.
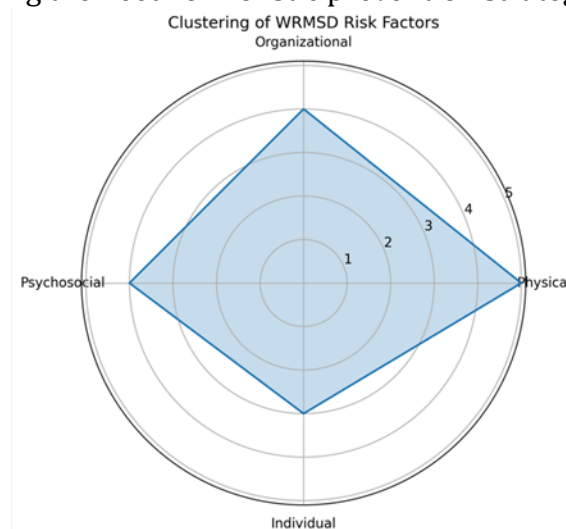


**Figure 3.** Clustering of WRMSD Risk Factors

**Conceptual Framework for WRMSD Prevention (Figure 1)**

Figure 4 presents an integrated occupational–ergonomic framework that conceptualizes WRMSDs as a public health outcome resulting from cumulative exposure to occupational risk factors. The framework emphasizes the role of ergonomic assessment in informing prevention strategies and improving worker health outcomes.
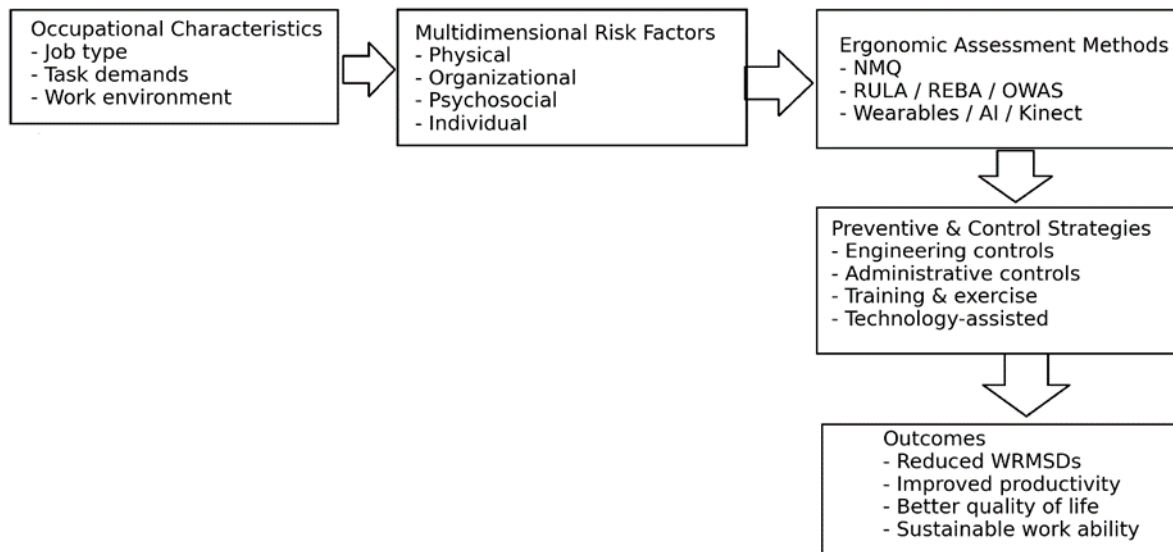
**Figure 4.** integratedOccupational Ergonomic Framework

## DISCUSSION

This integrative review confirms that work-related musculoskeletal disorders (WRMSDs) constitute a major occupational health problem across diverse employment sectors and should be addressed as a population-level public health issue. Consistent with previous epidemiological evidence, WRMSDs were widely reported among manufacturing, construction, healthcare, office-based, transportation, and agricultural workers, with variations in affected body regions reflecting sector-specific work demands (Das, 2023; Kashif et al., 2022; Sun et al., 2023; Yang et al., 2023). These findings support the view that WRMSDs are not confined to physically demanding occupations but also prevalent in sedentary and service-based work environments.

Analysis of Figure 1 highlights clear occupational patterns in WRMSD distribution. Neck and shoulder disorders were predominant among office workers, healthcare professionals, and drivers, likely attributable to prolonged static postures, repetitive upper limb movements, and constrained workstations (Ibrahim & Gaafar, 2024; Joseph et al., 2023; Putsa et al., 2022). In contrast, lower back disorders were more common among construction and agricultural workers, reflecting high physical loads, manual material handling, and awkward postures (Akbar et al., 2023; Rahman & Sakamoto, 2024). These findings align with previous cross-sectional and systematic reviews that emphasize the role of task characteristics in shaping musculoskeletal risk profiles (Kolus et al., 2023).

Figure 3 further demonstrates that WRMSDs arise from multidimensional and interacting risk factors. While physical exposures remain the primary determinants, organizational and psychosocial factors were consistently identified as important modifiers of musculoskeletal risk. Long working hours, high workload, limited rest breaks, and job stress were frequently associated with increased WRMSD prevalence across occupations (Afsharian et al., 2023; Bezzina et al., 2023). From a public health and community medicine perspective, these findings underscore the importance of addressing WRMSDs through upstream interventions that target work organization and psychosocial environments, rather than focusing solely on individual behavior or biomechanics.

Figure 2 reveals a notable reliance on traditional ergonomic assessment tools, particularly the Nordic Musculoskeletal Questionnaire, RULA, and REBA. These methods are well-established and suitable for population-level surveillance and risk screening;

however, their predominant use for descriptive assessment rather than intervention evaluation highlights a methodological gap (Kakaraparthi et al., 2023; Yazdanirad et al., 2022). Emerging digital approaches, including wearable sensors and AI-based posture analysis, remain underutilized despite their potential to provide real-time risk monitoring and feedback (Lind et al., 2023). This gap suggests an opportunity to strengthen occupational health surveillance systems by integrating conventional and technology-assisted ergonomic assessments.

The integrated occupational–ergonomic framework proposed in Figure 4 represents the principal contribution of this review. Unlike previous studies that examined WRMSDs within isolated occupational or disciplinary boundaries, the framework conceptualizes WRMSDs as the cumulative outcome of occupational characteristics, multidimensional risk factors, assessment practices, and preventive strategies. This integrative perspective is particularly relevant for public health practitioners and policymakers, as it supports the design of comprehensive, multi-level prevention programs that combine engineering controls, organizational measures, worker training, and health promotion initiatives (Gasibat et al., 2023).

Overall, the findings emphasize that effective WRMSD prevention requires coordinated action at individual, workplace, and policy levels. By framing WRMSDs within a public health–oriented conceptual model, this review provides a foundation for translating research evidence into sustainable occupational health interventions and policies.

## CONCLUSION

WRMSDs constitute a major occupational health burden with broad public health consequences. Addressing WRMSDs requires integrated prevention strategies that combine ergonomic risk assessment, organizational interventions, and worker health promotion. The proposed public health–oriented framework provides a practical foundation for guiding occupational health programs, workplace interventions, and policy development.

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