https://medpr.imp.lodz.pl/en
https://doi.org/10.13075/mp.5893.01724
REVIEW PAPER

OCCUPATIONAL BURNOUT AND ITS ASSOCIATION WITH PHYSICAL ACTIVITY AND CARDIORESPIRATORY FITNESS AMONG NURSES: A NARRATIVE REVIEW

Arnengsih Nazir[1,2,3], Yulia Sofiatin[1,4], Deni K. Sunjaya[1,5]

[1] Universitas Padjadjaran, Bandung, West Java, Indonesia
Faculty of Medicine

[2] Universitas Padjadjaran, Bandung, West Java, Indonesia
Department of Physical Medicine and Rehabilitation, Faculty of Medicine

[3] Dr. Hasan Sadikin General Hospital, Bandung, West Java, Indonesia
Department of Cardiovascular

[4] Universitas Padjadjaran, Bandung, West Java, Indonesia
Department of Epidemiology, Faculty of Medicine

[5] Universitas Padjadjaran, Bandung, West Java, Indonesia
Department of Public Health, Faculty of Medicine

Highlights

- Emotional exhaustion is the most prevalent burnout dimension in nurses.
- Physical activity may mitigate burnout through physiological resilience.
- Cardiorespiratory fitness remains underexplored in nursing research.
- Dimension-specific burnout analysis is critical for prevention strategies.

Abstract

Burnout is a multidimensional occupational syndrome characterized by emotional exhaustion (EE), depersonalization, and low personal accomplishment. Nurses are particularly vulnerable due to sustained physical, emotional, and organizational stressors. Physical activity (PA) and cardiorespiratory fitness (CRF) have been proposed as protective factors; however, evidence remains inconsistent, and burnout is often analyzed as a single global construct. This review aimed to synthesize evidence on the association between burnout and PA or CRF in nurses, with emphasis on burnout dimensions, underlying mechanisms, epidemiological findings, measurement considerations, and occupational health implications. A literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar for English-language studies published up to 2025. Observational and interventional studies, as well as systematic reviews, examining burnout in relation to PA or CRF were included. Evidence was synthesized narratively without quantitative meta-analysis. Burnout prevalence among nurses is high, particularly for EE. Most studies demonstrate an inverse association between PA and burnout, with some evidence of dose–response relationships. However, PA is predominantly self-reported, and objective CRF assessment in nurses is scarce. Burnout dimensions are inconsistently analyzed, with many studies relying on total scores rather than dimension-specific evaluation. Mechanistically, PA and CRF may reduce burnout risk through improved stress regulation, autonomic balance, recovery processes, and enhanced functional work capacity. To conclude, PA appears protective against burnout in nurses, whereas the role of objectively measured CRF remains underexplored. Future longitudinal research incorporating dimension-specific burnout analysis and objective CRF assessment is needed to inform targeted occupational health interventions. Med Pr Work Health Saf. 2026;77(3)

Key words: exercise, burnout, emotional exhaustion, occupational health, cardiorespiratory fitness, depersonalization

Corresponding author: Arnengsih Nazir, Dr. Hasan Sadikin General Hospital, Department of Cardiovascular, Jl. Pasteur No. 38, Bandung 40161, West Java, Indonesia, e-mail: arnengsih@unpad.ac.id
Received: March 16, 2026, accepted: May 28, 2026

Funding: this publication charge is funded by Unpad through the Indonesian Endowment Fund for Education (LPDP) on behalf of the Indonesian Ministry of Higher Education, Science and Technology and managed under the EQUITY Program (Contract No. 4303/B3/DT.03.08/2025 and 3927/UN6.RKT/HK.07.00/2025).

INTRODUCTION

Burnout is a syndrome resulting from chronic work-related stress and is characterized by 3 core dimensions, including emotional exhaustion (EE), depersonalization (DP), and decrease personal accomplishment (PAC) [1,2]. According to the World Health Organization (WHO), burnout is classified in the 11th edition of the International Classification of Diseases as a syndrome resulting from ineffectively managed work stress and specifically related to the work context, not other life domains [3]. This concept also emphasizes that burnout reflects a state of exhaustion accompanied by a cynicism towards work and a decrease in confidence in one's ability to carry out professional duties [2]. It has been recognized as a global occupational health problem that poses a substantial burden on individual well-being, quality of care, patient safety, and the sustainability of health systems [1,2]. From an occupational health perspective, burnout is particularly relevant in healthcare settings, where prolonged exposure to high job demands and emotional stressors is common [2].

Healthcare workers (HCWs), especially those working in intensive care units (ICUs) and emergency departments, are among the occupational groups most vulnerable to burnout. Intensive care unit work involves frequent exposure to life-threatening situations, complex and simultaneous clinical demands, time pressure, and ethically challenging decisions. Additional occupational stressors, such as night and weekend shifts, interpersonal conflicts within multidisciplinary teams, caring for terminally ill patients, and resistance to withdrawing life-sustaining treatments, further contribute to the high prevalence of burnout in this setting. In addition to work environment factors, individual characteristics such as age, gender, education level, short work experience, and smoking habits have also been reported to contribute to the risk of burnout [4,5]. A recent systematic review and meta-analysis involving 14 536 participants across multiple countries reported burnout prevalence rates of 48% in ICUs and 42% in emergency departments [4]. Similarly, a multinational survey conducted in Asian ICUs found that more than half of physicians and nurses experienced burnout [6]. When examined by dimension, the prevalence of EE, DP, and low PAC among ICU and emergency department staff was reported as 48%, 30%, and 47%, respectively, highlighting that EE is the most frequently affected dimension [4].

Burnout not only impacts the psychological well-being of HCWs, but is also associated with decreased work performance, increased absenteeism, and the emergence of intentions to leave work, which in turn can disrupt workforce stability and the quality of healthcare services [5]. In some contexts, differences between professions are also found, where nurses tend to experience higher levels of EE than other medical personnel, while other dimensions such as DP and decreased PAC can vary between professional groups [7].

Physical activity (PA) and cardiorespiratory fitness (CRF) have been proposed as potential protective factors against burnout. Evidence suggests that nurses who engage in regular PA report a lower prevalence of burnout compared with their inactive counterparts [8]. However, studies examining the association between burnout and PA or CRF have yielded heterogeneous findings [9–11]. Longitudinal data indicate that individuals with low levels of PA experience higher levels of stress-related fatigue and burnout symptoms than those with moderate or high PA levels [12]. Among nurses, physicians, and ICU support staff, PA has also been identified as one of the most frequently reported strategies for mitigating burnout, following rest and leave [13].

The association between burnout and PA or CRF is particularly relevant in nurses, as burnout not only affects the psychological well-being of HCWs but is also associated with an increased risk of medical errors, reduced job performance, and higher staff turnover, all of which threaten patient safety and healthcare system resilience [4,6,7]. Higher levels of CRF may act as a protective factor by enhancing stress tolerance, fatigue resistance, and recovery capacity, suggesting that PA-based interventions, such as submaximal exercise programs or promoting active lifestyles, could be integrated into occupational health policies to strengthen psychological resilience among HCWs [10,11].

Importantly, while prior studies have reported an inverse association between PA and burnout among nurses and other HCWs, burnout has predominantly been treated as a single global construct rather than a multidimensional syndrome comprising EE, DP, and PAC [9,14]. Even when multidimensional instruments were applied, analyses often emphasized total burnout scores or presented dimensions descriptively, without systematically examining whether PA relates differently to each component [6,15]. Although 1 study retained dimension-level assessment, CRF was not objectively measured, and PA was assessed solely through self-report [16].

Although accumulating evidence supports the role of PA in reducing burnout in the general population and among HCWs, studies specifically examining the associ-

ations between PA or CRF and burnout in nurses, particularly with attention to individual burnout dimensions, remain limited [6,9]. Therefore, this narrative review aimed to synthesize existing evidence on the association between burnout and PA or CRF in nurses with special attention to:

- the conceptualization, dimensions, and occupational health implications of burnout,
- the definitions, determinants, and measurement of PA and CRF in healthcare settings,
- the physiological and psychological mechanisms linking burnout with PA and CRF,
- epidemiological evidence on their associations,
- the importance of dimension-specific burnout analysis,
- the differential effects of PA and CRF on burnout dimensions,
- methodological limitations in burnout measurement,
- implications for prevention and occupational health interventions aimed at improving workforce sustainability and patient safety.

METHODS

A literature search was conducted using PubMed, Scopus, and Web of Science databases, complemented by searches in Google Scholar. The search included articles published in English up to 2025, using combinations of the following keywords: burnout, occupational stress, intensive care unit, emergency unit, nurses, healthcare workers, physical activity, exercise, cardiorespiratory fitness, fatigue, maximal oxygen uptake (VO_2max), peak oxygen uptake (VO_2peak), exercise capacity, exercise test, and cardiopulmonary exercise testing.

Eligible articles included observational studies (cross-sectional, cohort, and case–control), interventional studies, systematic reviews, and meta-analyses that examined burnout and/or fatigue in relation to PA or CRF in HCWs or working populations. Studies focusing on physiological mechanisms of stress were also considered. Articles were selected based on their relevance to the research question and scientific rigor. No formal quality scoring or meta-analysis was performed, in line with the narrative review methodology.

Data extraction focused on study design, population characteristics, assessment tools for burnout and PA/CRF, and key findings. The evidence was synthesized thematically, integrating epidemiological findings with physiological and behavioral mechanisms to provide a comprehensive conceptual framework linking burnout, PA, and CRF in nurses.

RESULTS

The factors influencing the prevalence of burnout in ICU nurses are summarized in Table 1, highlighting the contribution of individual characteristics, workload, organizational conditions, and high-intensity clinical environments [8]. Across the reviewed literature, burnout is consistently conceptualized as a multidimensional construct comprising EE, DP, and low PAC, with recognized implications for patient safety, work performance, and workforce sustainability.

Regarding exposure variables, definitions, determinants, and measurement approaches for PA and CRF in healthcare settings varied substantially across studies. Physical activity was predominantly assessed using self-report questionnaires, whereas objective measurement of CRF was largely absent in studies involving nurses. The epidemiological evidence linking PA, CRF, and burnout is presented in Table 2, demonstrating that most research has focused on PA in relation to burnout, while the association between objectively measured CRF and burnout in nurses has not been directly examined.

The extent to which burnout dimensions were analyzed in the reviewed studies is detailed in Table 3. Although burnout is theoretically multidimensional, many studies operationalized it using total scores or categorical classifications. When dimension-specific analyses were conducted, EE was the most frequently examined component, whereas DP and PAC received comparatively limited analytical attention. These patterns underscore the relevance of dimension-specific approaches in understanding differential occupational health risks.

The differential effects of PA and CRF on individual burnout dimensions and their occupational health implications are synthesized in Table 4. The literature suggests that PA and CRF may exert protective effects through enhanced physiological capacity, improved stress regulation, and better psychological recovery processes. The proposed physiological and psychological mechanisms linking burnout, PA, and CRF in HCWs are illustrated in Figure 1, depicting potential pathways underlying these associations.

Methodologically, most studies employed cross-sectional designs, relied on self-reported PA, and frequently used global burnout scores. Longitudinal designs and

Table 1. Summary of factors associated with burnout among intensive care unit nurses in 7 hospitals in Feira de Santana, Bahia, Brazil (N = 65): cross-sectional study, July–November 2016

Findings	Implications for burnout
Socio-demographics and lifestyle	
young nurses (<34 years) are more vulnerable due to a lack of coping experience	risk increases
smoking habits and alcohol consumption are significantly related to burnout	risk increases
regular physical activity reduces the prevalence of burnout	protective factor
Job characteristics	
working time >54 h/week, having >1 job	risk increases
intensive care unit specialists are prone to burnout due to high responsibility	risk increases
patient ratio >10/shift increases work pressure	risk increases
Demand-control model	
in high-demand and low-control (high-strain jobs), the prevalence of burnout is high	risk increases
high demands, even with control, still carry the risk of mental distress	risk increases

objective CRF assessments in nurses were not identified. Collectively, the reviewed evidence indicates that while the relationship between PA and burnout has been relatively explored, research examining CRF, dimension-specific burnout analysis, and their implications for occupational health remains limited.

Occupational burnout in nurses

Burnout in nurses is not only a highly prevalent phenomenon but also reflects a complex interaction between job demands, individual characteristics, and the dynamics of the work environment. Based on a synthesis of reviewed studies, EE consistently emerged as the most dominant dimension, particularly among nurses in high-stress units such as the ICU. This suggests that ongoing emotional burden is a key component in the development of burnout in this population [4,7].

Furthermore, interprofessional variations in burnout patterns suggest that nurses are more susceptible to EE, while other HCWs tend to exhibit varying degrees of DP and decreased PAC. These differences are likely due to the intensity of direct interactions with patients and the higher emotional involvement of nurses [7].

Risk factors for burnout are also multidimensional, encompassing individual factors such as age, work experience, and lifestyle, as well as organizational factors such as high workload, interpersonal conflict, and pressured clinical decision-making. In the context of the COVID-19 pandemic, increased workloads and resource constraints have further exacerbated these conditions, reinforcing the role of environmental factors in triggering burnout [4,8].

Interestingly, findings from studies during the pandemic indicate that high levels of burnout are not always uniform across HCW groups, with doctors and nurses exhibiting different patterns of burnout dimensions. This underscores the importance of a multidimensional approach to assessing burnout, rather than simply using a total score [9].

Physical activity and cardiorespiratory fitness in healthcare workers

Cardiorespiratory fitness, also referred to as aerobic fitness, describes the capacity of the cardiovascular and respiratory systems to deliver oxygen to working skeletal muscles and the muscles' ability to utilize oxygen efficiently during dynamic PA [17,18]. Cardiorespiratory fitness is a central indicator of physical health, as it is strongly associated with work capacity, productivity, cardiovascular disease risk, and all-cause mortality [17–19]. In occupational settings, particularly in healthcare, CRF represents not only cardiometabolic health but also the functional capacity to tolerate sustained physical and psychological job demands [20,21].

Physiologically, CRF reflects the integrated function of pulmonary ventilation, cardiovascular circulation, and skeletal muscle metabolism [18]. The gold standard for CRF assessment is VO_2max, typically measured via cardiopulmonary exercise testing, with VO_2peak as the primary outcome [17,20]. In clinical and occupational health settings, submaximal tests such as the 6-minute walk test are frequently used to estimate CRF because they are feasible and applicable to individuals unable to undergo maximal testing [22]. Variations in VO_2max across popula-

Table 2. Summary of studies investigating the association between burnout and physical activity (PA) or cardiorespiratory fitness (CRF) among nurses and healthcare workers across different healthcare settings and countries, 2018–2025

Study	Design	Subjects	Outcomes	Measurement instrument		Main results
				burnout	CRF/PA	
Li et al., 2025 [16]	cross-sectional (questionnaire survey) with mediation analysis	general hospital nurses in China (N = 912, 87% female)	work burnout, PA, recovery experience (psychological detachment, relaxation, mastery, control)	*Job Burnout Scale* for Chinese nurses (22 items: EE, DP, PAC)	CRF: not measured objectively PA: *Physical Activity Rating Scale* (intensity, duration, frequency; score 0–100)	– physical activity was significantly negatively associated with overall job burnout – this association was partially mediated by psychological detachment, relaxation, and mastery experience, but not by control experience
Kayan et al., 2025 [9]	cross-sectional	294 health workers at a university hospital (health workers, resident doctors, technicians; 47.3% nurses); mean age 29.4 years	the association between physical activity and burnout levels during the COVID-19 pandemic	MBI (MBS, 22 item)	PA: IPAQ, physical activity score	– burnout levels were higher among physicians and nurses and among those working in COVID-19-related units – most participants had low or inactive physical activity levels – physical activity levels were not significantly associated with total burnout or its subdimensions
Guerrero et al., 2024 [15]	cross-sectional survey	216 nurses completed the survey (data were analyzed for 210 respondents)	the association between physical activity and burnout, with additional analysis of COVID-19 exposure and medication errors	CBI	GLTEQ, PA score	– higher physical activity levels were associated with lower burnout scores – nurses with low PA were more likely to report high burnout – approx. 90% of nurses with high burnout had prior COVID-19 patient care exposure
See et al., 2018 [6]	cross-sectional multinational survey (SABA study)	4092 ICU staff (992 doctors, 3100 nurses) from 159 ICUs in 16 Asian countries	burnout prevalence, individual and organizational risk factors, stress, and depression	MBI-HSS, 22 items; high burnout classification	not measured	– >50% of ICU physicians and nurses experience burnout – prevalence varies across countries (34.6–61.5%) – protective factors include religiosity, work-life balance, shift work, and stay-at-home night calls – major risk factors include high workload and work-life imbalance – burnout is associated with high stress and depressive symptoms, as well as decreased adherence to clinical guidelines (in nurses)
Plaza-Ccuno et al., 2023 [14]	cross-sectional	300 health workers in a public hospital in Peru	the association between weekly PA frequency and burnout levels during the COVID-19 pandemic	a validated burnout questionnaire for the Peruvian population (no specific names mentioned)	PA: weekly frequency of PA (1-question item)	– a higher frequency of PA/week was significantly associated with lower levels of burnout – this effect demonstrated a dose-response (more frequent PA associated with lower burnout)

CBI – *Copenhagen Burnout Inventory*, DP – depersonalization, EE – emotional exhaustion, GLTEQ – *Godin–Leisure Time Exercise Questionnaire*, ICU – intensive care unit, IPAQ – *International Physical Activity Questionnaire*, MBI – *Maslach Burnout Inventory*, MBI-HSS – *Maslach Burnout Inventory–Human Services Survey*, MBS – *Maslach Burnout Scale*, PAC – personal accomplishment, SABA – *Survey of Asian Burnout in Asian Intensive Care Units.*

Table 3. Summary of burnout dimensions, measurement instruments, and occupational health implications reported in studies of nurses and healthcare workers worldwide examining the association between burnout and physical activity (PA) or cardiorespiratory fitness (CRF), 2018–2025

Study	Population	Instrument	Score reported	Dimension		Relevance to OHS
				analyzed	most reported	
Kayan et al., 2025 [9]	healthcare professionals	MBI	total burnout level	none	–	overall, burnout is not significantly linked to PA; dimension-specific risks remain unclear
Plaza-Ccuno et al., 2023 [14]	health professionals	*Validated Burnout Questionnaire*	overall category/level	none	–	global burnout may influence occupational health; no dimension-level insight is available
See et al., 2018 (SABA study) [6]	physicians and nurses, ICU	MBI-HSS	burnout present/ absent	EE, DP, PAC (descriptive only)	EE	burnout prevalence and organizational factors relevant to OHS; detailed dimension-level implications underexplored
Li et al., 2025 [16]	nurses	*Job Burnout Scale*	total and per-dimension	EE, DP, PAC	not specified	dimension-level burnout analysis retained, showing potential occupational health implications; CRF not objectively measured
Guerrero et al., 2024 [15]	nurses	CBI	personal, work-related, client-related burnout	all 3 subtypes	not specified	dimension-specific burnout retained; relevance to occupational health recognized, though practical implications per dimension not detailed

CBI – *Copenhagen Burnout Inventory*, DP – depersonalization, EE – emotional exhaustion, ICU – intensive care unit, MBI – *Maslach Burnout Inventory*, MBI-HSS – *Maslach Burnout Inventory – Human Services Survey*, OHS – occupational health and safety, PAC – personal accomplishment, SABA – *Survey of Asian Burnout in Asian Intensive Care Units*.

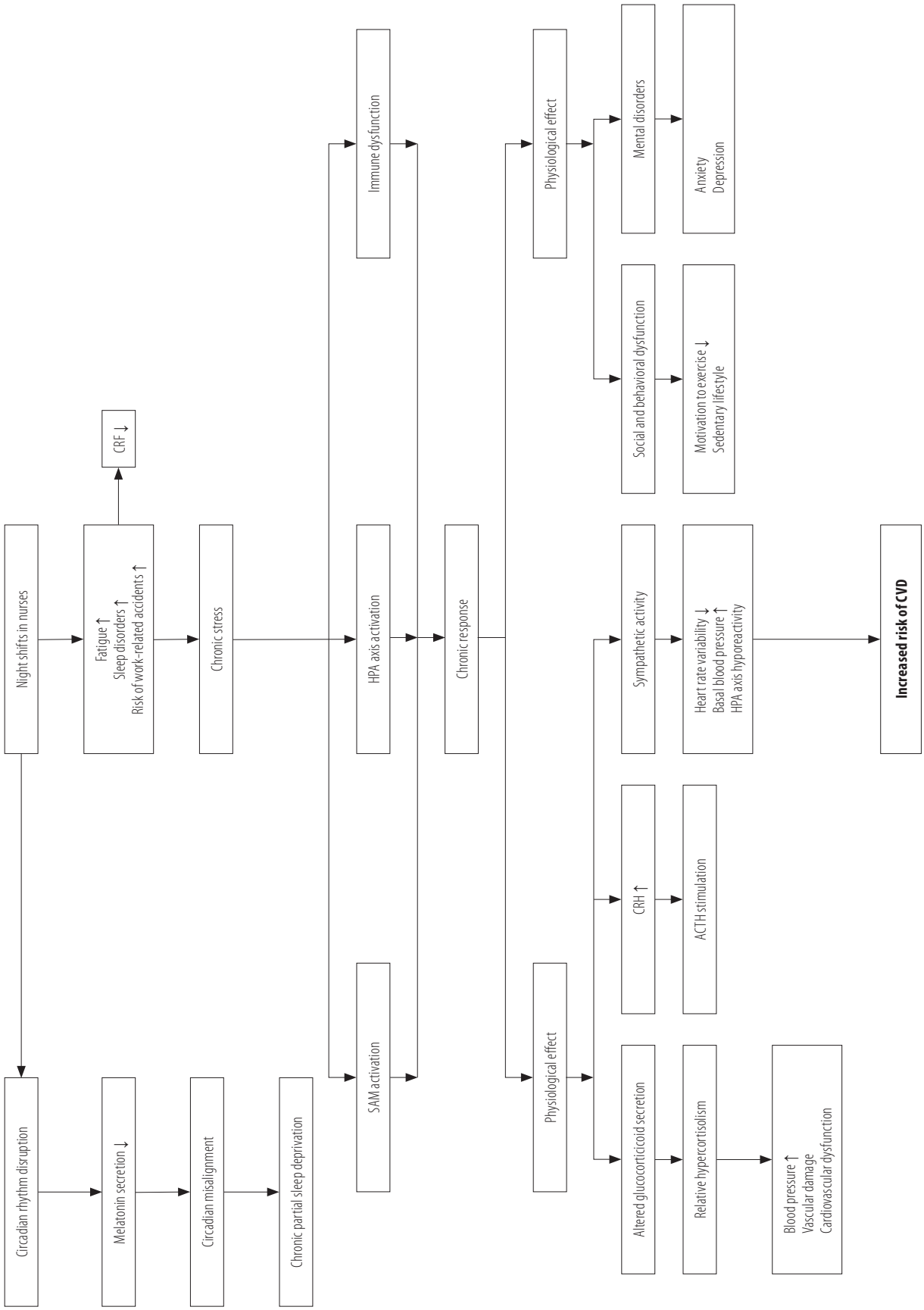
Table 4. Synthesis of evidence from international studies and reviews (2014–2024) on the associations of physical activity (PA) and cardiorespiratory fitness (CRF) with burnout dimensions and their occupational health impacts among nurses and healthcare workers

Dimension	Mechanism/Observed association	Occupational health impact
emotional exhaustion (EE)	depletion of physical and mental energy due to chronic work stress, particularly sensitive to low PA and poor CRF, inadequate physical conditioning reduces stress resilience and coping capacity in prolonged clinical demands [12,37]	high EE is linked to increased likelihood of medical errors, psychological strain, absenteeism, and reduced work capacity in nurses [52,53]
depersonalization (DP)	cynicism and detachment from patients or colleagues as maladaptive coping to sustained fatigue, higher CRF and regular moderate-to-vigorous PA improve stress adaptation and reduce risk of cynicism [49]	depersonalization contributes to impaired patient safety, poor communication, emotional distancing, and decreased professional engagement in nursing settings [52,53]
personal accomplishment (PAC)	feelings of inefficacy at work, mitigated by PA-mediated improvements in work capacity, energy, and cognitive function, allowing nurses to perform effectively and feel competent [15,24]	low PAC increases turnover intention, reduces overall workforce stability, and diminishes job satisfaction; improving PA and CRF supports retention and safer patient care [37]

tions are largely driven by differences in maximal cardiac output, particularly stroke volume and peak heart rate, reflecting both central and peripheral adaptations to aerobic training [18]. Physical activity is the primary modifiable determinant of CRF. The WHO recommends ≥150 min of moderate-intensity PA per week for adults, yet sedentary behavior remains prevalent among HCWs [23]. Insufficient PA is consistently associated with reduced CRF, increased cardiovascular risk, and chronic fatigue [19]. In hospital settings, nurses who engage in limited PA outside of work hours are particularly vulnerable to declining CRF due to shift work, long working hours, and insufficient recovery time [21,24].

Although non-modifiable factors such as age, sex, health status, and genetic predisposition influence CRF, habitual PA remains the most important modifiable determinant [17,25]. In occupational contexts, low CRF has been linked to reduced work performance, increased exhaustion, and mental health disorders, including burnout and depression [24,26].

From a mechanistic perspective, low CRF may heighten burnout risk by limiting physiological



ACTH – adreno-corticotropine hormone, CRH – corticotropine-releasing hormone, CVD – cardiovascular disease, HPA – hypothalamic-pituitary-adrenal, SAM – sympatho-adreno-medullary.

Figure 1. Proposed physiological and psychological mechanisms linking burnout, physical activity, and cardiorespiratory fitness (CRF) among healthcare workers: a synthesis of evidence from the reviewed literature [8,14,15,35–50]

resilience to prolonged occupational stress, impairing autonomic regulation, and delaying recovery after physically and emotionally demanding shifts [11,27]. Reduced CRF is associated with elevated resting heart rate, diminished vagal tone, systemic inflammation, and dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, biological pathways that have been implicated in EE and chronic fatigue [27].

Fatigue represents a subjective state of reduced physical and mental energy that interferes with optimal work performance [28]. Among HCWs, fatigue not only affects individual well-being but also compromises patient safety and quality of care, increasing the risk of medical errors, absenteeism, and staff turnover [4]. Although fatigue and burnout are distinct constructs, persistent occupational fatigue is widely recognized as a key precursor and reinforcing factor for burnout, particularly EE. Factors such as overweight and obesity, which are common among HCWs, further exacerbate fatigue and reduce CRF, compounding vulnerability to burnout [17,29].

Evidence consistently indicates that HCWs demonstrate insufficient PA levels and suboptimal CRF compared with the general population, despite adequate knowledge of PA benefits. A recent hospital-based study reported that <10% of employees met WHO PA recommendations, with nurses and administrative staff showing lower PA and CRF than medical or paramedical staff [30]. Female workers, older age groups, and individuals with overweight or obesity were particularly affected, underscoring the need for profession-specific occupational health interventions [31].

Importantly, although nursing work is often perceived as physically demanding, objective assessments reveal that most occupational PA performed by nurses consists of light-intensity activities, such as standing, slow walking, and documentation tasks. Even with high step counts per shift, the intensity of work-related PA rarely reaches levels sufficient to elicit meaningful CRF adaptations. This finding highlights a critical distinction between occupational PA and health-enhancing PA. It suggests that additional structured PA outside working hours is essential for maintaining CRF and long-term health in nurses [32].

Several studies using objective CRF assessments have demonstrated that a substantial proportion of nurses exhibit CRF levels below age- and sex-specific norms, corresponding to limited work capacity and increased cardiovascular risk [21]. Factors contributing to low CRF include high work stress, shift work, smoking, overweight and obesity, and insufficient leisure-time PA. Furthermore, longitudinal data indicate that acute health stressors, such as COVID-19 infection, may further reduce CRF, particularly among healthcare workers with higher body mass index (BMI), potentially exacerbating fatigue and burnout vulnerability [33].

Finally, a recent meta-analysis reported alarmingly high levels of both acute and chronic fatigue among nurses, accompanied by insufficient inter-shift recovery. Organizational factors such as high workload, staffing shortages, night shifts, and limited managerial support interact with individual factors, including health status and coping capacity, to perpetuate fatigue and burnout. Collectively, these findings support the notion that interventions aimed at improving CRF through structured PA may represent a promising strategy to enhance recovery, reduce fatigue, and mitigate burnout risk among nurses [34].

Mechanisms linking burnout and physical activity and cardiorespiratory fitness

Accumulating evidence indicates that PA is inversely associated with burnout among HCWs, with several studies demonstrating a dose–response relationship in which higher PA frequency or intensity corresponds to lower burnout scores [8,14,15]. Although most of this evidence is observational and relies on self-reported PA, the consistency of findings across settings suggests a biologically and psychologically plausible protective role of PA against occupational burnout (Figure 1) [14,35].

From a biological perspective, regular PA modulates the stress response through reductions in stress hormones such as cortisol and catecholamines, alongside increased release of neurotransmitters including endorphins, dopamine, and serotonin. These neuroendocrine adaptations are associated with improved mood regulation, enhanced stress tolerance, and greater psychological resilience, all of which are particularly relevant to the EE dimension of burnout [14]. In nurses exposed to sustained emotional and physical demands, these mechanisms may attenuate cumulative fatigue and delay the progression from transient stress to chronic exhaustion [36].

Beyond acute neurochemical effects, CRF represents a longer-term physiological buffer against occupational stress. Studies in working populations, including HCWs, show that higher CRF is associated with lower BMI, fewer sickness absences, reduced absenteeism costs, and better perceived work ability. Although associations with mental health–related quality of life are less consistent, high CRF appears to enhance overall functional

capacity, allowing workers to better tolerate prolonged physical and psychological demands. In the nursing context, this capacity may translate into sustained vigilance, preserved work performance, and reduced vulnerability to EE and disengagement during high workload periods [37].

Night shift work represents a critical occupational stressor that amplifies the interaction between burnout, PA, and CRF (Figure 1). Chronic exposure to night shifts leads to repeated activation of the HPA axis and the sympatho-adreno-medullary system, increasing long-term risk for anxiety, depression, and burnout [38]. Circadian disruption further induces sleep deprivation and fatigue, which have been linked to higher rates of medical errors and workplace accidents, underscoring the occupational safety implications of burnout in shift-working nurses [39].

Physiologically, prolonged occupational stress disrupts homeostasis and drives maladaptive stress responses involving the HPA axis, autonomic nervous system, and immune pathways [40]. While acute stress responses are adaptive, repeated or chronic stress, such as sustained high workload combined with circadian misalignment, results in hormonal dysregulation, altered glucocorticoid secretion, elevated blood pressure, endothelial dysfunction, and increased cardiovascular risk [41]. These changes are clinically relevant to burnout, as chronic psychosocial stress and EE have been associated with sympathetic dominance, reduced heart rate variability, and impaired cardiovascular recovery [42].

Within this framework, CRF may act as a key moderator of stress-related physiological burden. Adequate CRF improves autonomic balance, enhances parasympathetic tone, and facilitates more efficient cardiovascular and metabolic responses to stress. In contrast, low CRF may exacerbate the physiological consequences of chronic stress, accelerating the transition from EE to broader health deterioration. This interaction is particularly relevant for nurses, whose work involves sustained vigilance, rapid decision-making, and frequent exposure to emotionally demanding situations [43].

The impact of night shift work further extends to metabolic and behavioral pathways. Studies demonstrate that the number and duration of night shifts correlate with increased fatigue, sleep disturbances, and work-related errors, while also adversely affecting metabolic regulation and indirectly reducing CRF [44,45]. Circadian misalignment disrupts sleep architecture and reduces sleep duration and quality, impairing physical recovery and cognitive performance [46]. Over time, chronic partial sleep deprivation among nurses increases the risk of cardiovascular disease, metabolic syndrome, diabetes, and immune dysfunction, compounding both health and occupational safety risks [47,48].

Importantly, psychological stress also influences health behaviors that are central to CRF maintenance. High perceived stress is associated with reduced motivation to exercise, social withdrawal, and increased sedentary behavior, creating a negative feedback loop in which stress reduces PA, leading to declining CRF and further vulnerability to burnout [49]. Among nurses, this cycle may be particularly pronounced due to irregular schedules, limited recovery time, and competing family and social demands [50].

Taken together, these findings support a bidirectional and self-reinforcing model linking occupational stress, reduced PA, declining CRF, and burnout. Physical activity and CRF not only exert direct protective effects through neuroendocrine and cardiovascular mechanisms but also indirectly influence burnout by improving sleep quality, facilitating recovery, and sustaining functional work capacity. However, despite strong biological plausibility, most existing studies do not differentiate how PA or CRF relate to specific burnout dimensions (EE, DP, and low PAC), limiting the ability to identify dimension-specific preventive strategies. Addressing this gap is essential for advancing occupational health–oriented interventions tailored to the unique stress profile of nurses.

Epidemiological evidence

Most of the reviewed studies demonstrated an inverse relationship between PA and burnout, particularly in the EE and DP dimensions. Despite heterogeneity in measurement methods, the consistent direction of this relationship suggests biological and psychological mechanisms underlying the protective effects of PA against chronic work stress [10,11,15,35].

At the nursing population level, PA is not only associated with reduced burnout but also serves as an adaptive coping strategy by increasing psychological recovery, such as relaxation and detachment from work [4,13]. This suggests that the benefits of PA are not only physiological but also related to psychological stress regulation.

However, most studies still use PA as a proxy for CRF, without objective measures such as VO_2max. This is a significant limitation, as CRF reflects a more stable physiological capacity than behavioral PA. Studies objectively measuring CRF in HCWs are still very lim-

ited, although preliminary findings suggest that some nurses have CRF levels below the general population standard, potentially increasing vulnerability to chronic burnout [21].

Furthermore, the predominance of cross-sectional designs in the existing literature limits the ability to draw causal conclusions. Although longitudinal studies in non-HCW populations indicate that higher CRF levels are associated with improvements in stress-related burnout symptoms, the generalizability of these findings to nurses requires further confirmation [12].

Another significant limitation is the lack of dimension-based analyses of burnout in epidemiological studies. Most studies still use total burnout scores, thus failing to identify whether PA and CRF have differential effects on EE, DP, and PAC. In fact, the synthesis of results in this review suggests that EE is likely the dimension most responsive to PA-based interventions [9,15]. Furthermore, although the prevalence of burnout in ICU nurses has been reported to be high in various studies, including meta-analyses, there remains a research gap regarding the direct relationship between objective CRF and dimension-based burnout in this population [51].

Burnout dimensions considered in reviewed studies

Burnout is a multidimensional construct, and each dimension reflects a distinct psychological and occupational pathway through which chronic work stress affects health, safety, and work performance. Emotional exhaustion reflects sustained depletion of physical and emotional energy, DP represents maladaptive coping through emotional distancing and cynicism, and low PAC reflects disengagement and loss of professional meaning [2].

Across the reviewed studies, the assessment of burnout dimensions varied considerably and was closely related to the measurement instruments used. Several studies reported burnout primarily at the overall or categorical level without detailed dimension-specific analysis, reflecting the use of instruments or scoring approaches that emphasized global burnout rather than individual dimensions. Studies involving mixed populations of HCWs commonly reported total burnout levels, thereby limiting insights into specific burnout dimensions relevant to occupational health outcomes [9,14]. In particular, the use of the *Maslach Burnout Inventory* (MBI) with total score reporting or categorical classification constrained the interpretation of dimension-specific risks [9]. In the large multinational ICU study, burnout was classified as present or absent using the MBI–*Human Services Survey*, with EE, DP, and low PAC reported descriptively only, and EE emerging as the most frequently reported dimension [6].

In contrast, studies focusing exclusively on nurses were more likely to retain dimension-level analyses, supported by the selection of measurement instruments designed to capture burnout subdimensions (Table 3). One study employed the *Job Burnout Scale*, enabling assessment of burnout both overall and by individual dimensions, thereby allowing a more nuanced evaluation of EE, DP, and PAC in relation to occupational health implications, although CRF was not objectively measured [16]. Another study utilized the *Copenhagen Burnout Inventory* (CBI), which differentiates personal, work-related, and client-related burnout, preserving all subtypes and facilitating a broader conceptualization of burnout relevant to occupational health. However, despite this multidimensional approach, practical implications at the individual dimension level were not extensively discussed [15].

Differential effects of physical activity and cardiorespiratory fitness on burnout dimensions in nurses

Physical activity and CRF influence the 3 core dimensions of burnout (EE, DP, and low PAC) through distinct but overlapping mechanisms (Table 4). Emotional exhaustion, characterized by depletion of physical and mental energy, is particularly sensitive to both low PA and poor CRF, as inadequate physical conditioning diminishes the body's ability to regulate stress hormones and cope with prolonged occupational demands [14,37]. Depersonalization, involving cynicism and detachment from patients or colleagues, may arise as a maladaptive coping response to sustained fatigue and impaired physiological resilience. Higher CRF and regular moderate-to-vigorous PA enhance adaptive stress responses and improve the activity of mood-regulating neurotransmitters, reducing the risk of cynicism [49]. Low PAC, reflecting feelings of inefficacy at work, can be mitigated by PA-mediated improvements in work capacity, energy, and cognitive function, which allow nurses to engage more effectively in patient care and feel competent in their roles [15,24].

The relevance of burnout dimensions for occupational health

The differential effects of PA and CRF on burnout dimensions have direct implications for occupational health and safety (OHS). Nurses experiencing high EE or DP are more prone to making medical errors, compromising

patient safety, and contributing to adverse clinical outcomes, while persistent low PAC increases turnover intention and reduces overall workforce stability [52–54]. By enhancing PA levels and CRF, healthcare organizations can strengthen physiological resilience, improve nurses' capacity to cope with chronic stress, and reduce the incidence of burnout-related errors, ultimately promoting safer patient care, improving job satisfaction, and mitigating workforce attrition, key components of OHS strategies [24,37].

Methodological limitations in burnout measurement

Burnout research in HCWs and the general adult population has revealed several methodological limitations in the measurement of burnout. First, many commonly used instruments, such as the *Shirom–Melamed Burnout Questionnaire* and the MBI, are ordinal in nature, using Likert-scale items. However, several studies treat ordinal responses as interval scores, summing them to produce total burnout scores. This assumption may not fully reflect the latent structure of burnout and can reduce the accuracy of both total and subscale scores. Second, the use of arbitrary cut-offs to classify burnout severity or define "burnout present/absent" may obscure the real range of symptom severity [6,9,14]. This reduces sensitivity to detect meaningful differences between individuals or occupational groups.

Third, most studies ignore dimension-specific analysis, focusing instead on total scores. Only limited studies retained analyses for EE, DP, and PAC [6,15,16]. Neglecting dimensions limits the ability to determine which aspects of burnout are most sensitive to work stress, PA, or CRF, and reduces relevance for OHS interventions.

To address methodological limitations in burnout measurement, Rasch modeling and item response theory are recommended. These approaches allow ordinal questionnaire responses to be transformed into interval-level measures, enhancing precision and interpretability compared with simple summed scores [55].

The Rasch model estimates the probability of a specific response based on the respondent's latent trait and item difficulty, enabling assessment of item fit, unidimensionality, and measurement invariance. This ensures that items meaningfully contribute to the construct being measured [56]. Importantly, Rasch analysis can identify items that do not discriminate burnout severity effectively, allowing them to be revised or removed. This approach supports dimension-specific, interval-level measurement, which is crucial for accurately identifying high-risk burnout dimensions and informing targeted occupational health interventions [55,56].

Implications for prevention and intervention

Comprehensive preventive interventions and OHS programs are essential to reduce burnout and its negative impact on the physical and mental health of HCWs. Evidence from systematic and narrative reviews indicates that workplace health promotion programs integrating mental and physical health components can provide significant benefits, although individual-level effects are often moderate [57–60]. Interventions targeting PA and healthy lifestyle behaviors have been shown to improve BMI, cardiometabolic risk factors, and CRF, while psychological interventions, such as cognitive-behavioral techniques, mindfulness, and relaxation approaches, have shown small but meaningful reductions in burnout, particularly in EE and DP [14,57].

In HCWs, workplace mental health interventions, including mindfulness, yoga, music therapy, and reflective group programs such as Balint groups, effectively reduce burnout symptoms and work-related stress, emphasizing the importance of non-pharmacological strategies focused on emotional and psychological regulation [58]. Multilevel programs that combine individual strategies (exercise, mindfulness, stress management) with structural modifications (work organization, shift scheduling) demonstrate the most promise for sustainable well-being and burnout reduction [57].

Mindfulness-based interventions implemented in clinical settings, including the mindfulness in motion program, have consistently reduced EE and DP while increasing resilience and work engagement, even in ICU nurses [59]. Similarly, structured workplace PA interventions, such as scheduled aerobic or group exercise sessions, improve psychological well-being, reduce stress and burnout, strengthen social cohesion, and enhance functional capacity, CRF, cardiovascular health, and subjective vitality [38].

Practical implementation examples include employee wellness programs integrating scheduled PA, health check-ups, diet and sleep management, and short in-shift recovery breaks. These strategies reduce sedentary behavior, enhance acute recovery, and support long-term cardiometabolic and psychological health [24,57]. From an organizational perspective, optimizing shift schedules, limiting excessive working hours, and providing supporting facilities for exercise and relaxation are key components of a holistic occupational health

approach, with downstream benefits for patient safety, medical error reduction, and staff retention [59].

Strength and limitations

This narrative review provides an integrative synthesis of burnout, PA, and CRF in nurses by combining conceptual, physiological, and epidemiological perspectives within an occupational health framework. It emphasizes the multidimensional nature of burnout and the importance of dimension-specific analysis, while also introducing CRF as a physiologically relevant construct that has been underexplored in nursing populations. By aligning theoretical mechanisms with epidemiological findings, the review offers a structured framework to guide future research and occupational health strategies aimed at improving workforce sustainability and patient safety.

Several considerations should be noted. The scope of the review was focused specifically on nurses and selected occupational health outcomes, which may limit generalizability to other HCWs or settings. The proposed conceptual model is theoretically grounded but requires empirical validation. In addition, variability in terminology and measurement approaches across studies may influence the interpretation of synthesized findings. These considerations highlight areas for future investigation to further refine and strengthen the evidence base.

CONCLUSIONS

In summary, burnout in nurses is a multidimensional occupational syndrome with important implications for performance, patient safety, and workforce sustainability. Although PA and CRF represent key determinants of physiological resilience and stress regulation, most studies have primarily examined PA using self-reported measures, while objective CRF assessment remains largely unexplored. Existing evidence suggests an inverse association between PA and burnout, particularly EE, yet dimension-specific analyses are inconsistently applied, with many studies relying on global burnout scores. Differential effects across EE, DP, and PAC highlight the importance of analyzing burnout dimensions separately. Methodological limitations, including cross-sectional designs and simplified scoring approaches, further constrain interpretation. Overall, strengthening PA and CRF through targeted occupational health strategies may help reduce burnout risk and support long-term workforce sustainability.

AI USE

The authors confirm that ChatGPT (OpenAI, v. GPT-5.2) was used solely for Indonesian–English translation to improve language clarity in this manuscript.

AUTHOR CONTRIBUTIONS

Research concept: Arnengsih Nazir, Yulia Sofiatin, Deni K. Sunjaya
Research methodology: Arnengsih Nazir, Yulia Sofiatin, Deni K. Sunjaya
Collecting material: Arnengsih Nazir
Interpretation of results: Arnengsih Nazir, Yulia Sofiatin, Deni K. Sunjaya
References: Arnengsih Nazir

REFERENCES

1. Bianchi R, Schonfeld IS. Examining the evidence base for burnout. Bull World Health Organ. 2023;101(11):743–5. https://doi.org/10.2471/BLT.23.289996.
2. Maslach C, Leiter MP. Understanding the burnout experience: recent research and its implications for psychiatry. World Psychiatry. 2016;15(2):103–11. https://doi.org/10.1002/wps.20311.
3. World Health Organization. Burn-out an "occupational phenomenon": International Classification of Diseases [Internet]. Geneva: WHO; 2019 [cited 2025 Sep 12]. Available from: https://www.who.int/news/item/28-05-2019-burn-out-an-occupational-phenomenon-international-classification-of-diseases.
4. Lin KH, Selvanayagam N, Patnaik S, Kuo CY. Burnout among physicians and nurses working in intensive care units and emergency departments: a systematic review and meta-analysis. J Emerg Nurs. 2025;51(4):702–20. https://doi.org/10.1016/j.jen.2025.02.007.
5. Koutsimani P, Montgomery A, Georganta K. The relationship between burnout, depression, and anxiety: a systematic review and meta-analysis. Front Psychol. 2019;10:284. https://doi.org/10.3389/fpsyg.2019.00284.
6. See KC, Zhao MY, Nakataki E, Chittawatanarat K, Fang WF, Faruq MO, et al. Professional burnout among physicians and nurses in Asian intensive care units: a multinational survey. Intensive Care Med. 2018;44(12):2079–90. https://doi.org/10.1007/s00134-018-5432-1.
7. Teixeira C, Ribeiro O, Fonseca AM, Carvalho AS. Burnout in intensive care units – a consideration of the possible prevalence and frequency of new risk factors: a descriptive correlational multicentre study. BMC Anesthesiol. 2013;13(1):38. https://doi.org/10.1186/1471-2253-13-38.

8. Aragão NSC, Barbosa GB, Santos CLC, Nascimento D, Bôas L, Martins Júnior DF, et al. Burnout syndrome and associated factors in intensive care unit nurses. Rev Bras Enferm. 2021;74(suppl. 3):e20190535. https://doi.org/10.1590/0034-7167-2019-0535.
9. Kayan M, Elbi H, Özcan F. Assessment of the relationship between physical activity and burnout levels of healthcare professionals during the COVID-19 pandemic. Turk J Fam Pract. 2025;29(2):51–8. https://doi.org/10.54308/turkjfampract.2025.808.
10. De Moraes MG, Calais SL, Verardi CEL. The influence of physical fitness on the symptoms of burnout. J Phys Educ Sport. 2019;19:945–51. https://doi.org/10.7752/jpes.2019.s3136.
11. Gerber M, Cody R, Beck J, Brand S, Donath L, Eckert A, et al. Cardiorespiratory fitness and cardiovascular risk among in-patients with depression compared to healthy controls. Front Psychiatry. 2023;14:1193004. https://doi.org/10.3389/fpsyt.2023.1193004.
12. Lindegård A, Wastensson G, Hadzibajramovic E, Grimby-Ekman A. Longitudinal associations between cardiorespiratory fitness and stress-related exhaustion, depression, anxiety and sleep disturbances. BMC Public Health. 2019;19(1):1726. https://doi.org/10.1186/s12889-019-8081-6.
13. Shbeer A, Ageel M. Assessment of occupational burnout among intensive care unit staff in Jazan, Saudi Arabia, using the *Maslach Burnout Inventory*. Crit Care Res Pract. 2022;2022:1298887. https://doi.org/10.1155/2022/1298887.
14. Plaza-Ccuno JNR, Vasquez Puri C, Calizaya-Milla YE, Morales-García WC, Huancahuire-Vega S, Soriano-Moreno AN, et al. Physical inactivity is associated with job burnout in health professionals during the COVID-19 pandemic. Risk Manag Healthc Policy. 2023;16:725–33. https://doi.org/10.2147/rmhp.s393311.
15. Guerrero K, Fleming S, Calderon A, Fontenot N. Original research: addressing nurse burnout: the relationship between burnout and physical activity. Am J Nurs. 2024;124(6):20–6. https://doi.org/10.1097/01.naj.0001023020.53993.34.
16. Li X, Zhang T, Zhao G, Li J, Chen C. How does physical activity alleviate nurse job burnout? The important role of recovery experiences. Front Public Health. 2025;13:1658020. https://doi.org/10.3389/fpubh.2025.1658020.
17. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription Evidence, 11th ed. Philadelphia: Wolters Kluwer; 2021.
18. LaMonte MJ. Cardiorespiratory fitness in the prevention and management of cardiovascular disease. Rev Cardiovasc Med. 2022;23(11):382. https://doi.org/10.31083/j.rcm2311382.
19. Myers J, Cadenas-Sanchez C, Ross R, Kokkinos P. The critical role of cardiorespiratory fitness in disease prevention. J Sports Med Phys Fitness. 2024;64(12):1361–71. https://doi.org/10.23736/s0022-4707.24.16159-2.
20. Ross R, Blair SN, Arena R, Church TS, Després J-P, Franklin BA, et al. Importance of assessing cardiorespiratory fitness in clinical practice: a case for fitness as a clinical vital sign: a scientific statement from the American Heart Association. Circulation. 2016;134(24):e653–e699. https://doi.org/10.1161/cir.0000000000000461.
21. Sovová M, Sovová E, Nakládalová M, Pokorná T, Štégnerová L, Masný O, et al. Are our nurses healthy? Cardiorespiratory fitness in a very exhausting profession. Cent Eur J Public Health. 2020;28 Suppl.:S53–S56. https://doi.org/10.21101/cejph.a6210.
22. Enright PL. The six-minute walk test. Respir Care. 2003;48(8):783–5. https://doi.org/10.4187/respcare.03480783.
23. World Health Organization. WHO guidelines on physical activity and sedentary behaviour [Internet]. Geneva: WHO; 2020 [cited 2026 Jan 1]. Available from: https://www.who.int/publications/i/item/9789240015128.
24. Mänttäri S, Oksa J, Lusa S, Korkiakangas E, Punakallio A, Oksanen T, et al. Interventions to promote work ability by increasing physical activity among workers with physically strenuous jobs: a scoping review. Scand J Public Health. 2021;49(2):206–18. https://doi.org/10.1177/1403494820917532.
25. Franklin BA, Wedig IJ, Sallis RE, Lavie CJ, Elmer SJ. Physical activity and cardiorespiratory fitness as modulators of health outcomes: a compelling research-based case presented to the medical community. Mayo Clin Proc. 2023;98(2):316–21. https://doi.org/10.1016/j.mayocp.2022.09.011.
26. Usas H, Weilenmann S, Princip M, Fuchs WJ, van Nuffel M, von Känel R, et al. Physician-specific symptoms of burnout compared to a non-physicians group. Int J Environ Res Public Health. 2023;20(3):2693. https://doi.org/10.3390/ijerph20032693.
27. Salmio A, Rissanen AE, Kurkela JLO, Rottensteiner M, Seipäjärvi S, Juurakko J, et al. Cardiorespiratory fitness is linked with heart rate variability during stress in "at-risk" adults. J Sports Med Phys Fitness. 2024;64(4):334–47. https://doi.org/10.23736/s0022-4707.23.15373-4.
28. Behrens M, Gube M, Chaabene H, Prieske O, Zenon A, Broscheid KC, et al. Fatigue and human performance: an updated framework. Sports Med. 2023;53(1):7–31. https://doi.org/10.1007/s40279-022-01748-2.
29. Raghuveer G, Hartz J, Lubans DR, Takken T, Wiltz JL, Mietus-Snyder M, et al. Cardiorespiratory fitness in youth: an important marker of health: a scientific statement from

the American Heart Association. Circulation. 2020;142: e101–e118. https://doi.org/10.1161/cir.0000000000000866.
30. Gelisanga MAP, Ramos SFA, Ang CD, Ignacio SD. Physical activity and fitness level of healthcare workers in a tertiary teaching hospital. Acta Med Philipp. 2024;58(20):53–61. https://doi.org/10.47895/amp.v58i20.9538.
31. Miao L, Niu X, Huang M, Cao G, Fu C. Association between body mass index and burnout among nurses in China: a cross-sectional study. BMJ Open. 2024;14(3):e081203. https://doi.org/10.1136/bmjopen-2023-081203.
32. Chappel SE, Verswijveren S, Aisbett B, Considine J, Ridgers ND. Nurses' occupational physical activity levels: a systematic review. Int J Nurs Stud. 2017;73:52–62. https://doi.org/10.1016/j.ijnurstu.2017.05.006.
33. Štěpánek L, Nakládalová M, Sovová E, Štěpánek L, Boriková A, Sovová M, et al. COVID-19 reduces cardiorespiratory fitness even months after a mild to moderate acute phase: a retrospective cohort study. Infect Dis (Lond). 2023;55(10):684–93. https://doi.org/10.1080/23744235.2023.2228408.
34. Pi R, Liu Y, Yan R, De Z, Wan Y, Chen Y, et al. Nurses' occupational fatigue level and risk factors: a systematic review and meta-analysis. PLoS One. 2025;20(7):e0326519. https://doi.org/10.1371/journal.pone.0326519.
35. Mincarone P, Bodini A, Tumolo MR, Sabina S, Colella R, Mannini L, et al. Association between physical activity and the risk of burnout in health care workers: systematic review. JMIR Public Health Surveill. 2024;10:e49772. https://doi.org/10.2196/49772.
36. Martín-Rodríguez A, Gostian-Ropotin LA, Beltrán-Velasco AI, Belando-Pedreño N, Simón JA, López-Mora C, et al. Sporting mind: the interplay of physical activity and psychological health. Sports (Basel). 2024;12(1). https://doi.org/10.3390/sports12010037.
37. Kolu P, Raitanen J, Sievänen H, Tokola K, Vähä-Ypyä H, Nieminen E, et al. Cardiorespiratory fitness is associated with sickness absence and work ability. Occup Med (Lond). 2022; 72(7):478–85. https://doi.org/10.1093/occmed/kqac070.
38. Lei AA, Phang VWX, Lee YZ, Kow ASF, Tham CL, Ho YC, et al. Chronic stress-associated depressive disorders: the impact of HPA axis dysregulation and neuroinflammation on the hippocampus – a mini review. Int J Mol Sci. 2025;26(7):2940. https://doi.org/10.3390/ijms26072940.
39. Boivin DB, Boudreau P, Kosmadopoulos A. Disturbance of the circadian system in shift work and its health impact. J Biol Rhythms. 2022;37(1):3–28. https://doi.org/10.1177/07487304211064218.
40. Chu B, Marwaha K, Sanvictores T, Awosika AO, Ayers D. Physiology, stress reaction. StatPearls. Treasure Island (FL): StatPearls Publishing; 2025.
41. Burford NG, Webster NA, Cruz-Topete D. Hypothalamic-pituitary-adrenal axis modulation of glucocorticoids in the cardiovascular system. Int J Mol Sci. 2017;18(10): 2150. https://doi.org/10.3390/ijms18102150.
42. Vancheri F, Longo G, Vancheri E, Henein MY. Mental stress and cardiovascular health – part I. J Clin Med. 2022; 11(12):3353. https://doi.org/10.3390/jcm11123353.
43. Teisala T, Mutikainen S, Tolvanen A, Rottensteiner M, Leskinen T, Kaprio J, et al. Associations of physical activity, fitness, and body composition with heart rate variability-based indicators of stress and recovery on workdays: a cross-sectional study. J Occup Med Toxicol. 2014;9:16. https://doi.org/10.1186/1745-6673-9-16.
44. Leso V, Fontana L, Caturano A, Vetrani I, Fedele M, Iavicoli I. Impact of shift work and long working hours on worker cognitive functions: current evidence and future research needs. Int J Environ Res Public Health. 2021; 18(12). https://doi.org/10.3390/ijerph18126540.
45. Kecklund G, Axelsson J. Health consequences of shift work and insufficient sleep. BMJ. 2016;355:i5210. https://doi.org/10.1136/bmj.i5210.
46. Alfonsi V, Scarpelli S, Gorgoni M, Pazzaglia M, Giannini AM, De Gennaro L. Sleep-related problems in night shift nurses: towards an individualized interventional practice. Front Hum Neurosci. 2021;15:644570. https://doi.org/10.3389/fnhum.2021.644570.
47. Rahimpoor R. Physiological and physical effects of sleep disorder among shift work nurses. New research in nursing-education and practice. California: IntechOpen; 2023.
48. Touitou Y, Reinberg A, Touitou D. Association between light at night, melatonin secretion, sleep deprivation, and the internal clock: health impacts and mechanisms of circadian disruption. Life Sci. 2017;173:94–106. https://doi.org/10.1016/j.lfs.2017.02.008.
49. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. Sports Med. 2014;44(1): 81–121. https://doi.org/10.1007/s40279-013-0090-5.
50. Chiang SL, Tzeng WC, Chiang LC, Lee MS, Lin CH, Lin CH. Physical activity patterns, sleep quality, and stress levels among rotating-shift nurses during the COVID-19 pandemic. Int Nurs Rev. 2025;72(1):e12997. https://doi.org/10.1111/inr.12997.
51. Ramírez-Elvira S, Romero-Béjar JL, Suleiman-Martos N, Gómez-Urquiza JL, Monsalve-Reyes C, Cañadas-De la Fuente GA, et al. Prevalence, risk factors and burnout levels in intensive care unit nurses: a systematic review and meta-analysis. Int J Environ Res Public Health. 2021;18(21). https://doi.org/10.3390/ijerph182111432.
52. Lin RT, Lin YT, Hsia YF, Kuo CC. Long working hours and burnout in health care workers: non-linear dose-response

relationship and the effect mediated by sleeping hours – a cross-sectional study. J Occup Health. 2021;63(1):e12228. https://doi.org/10.1002/1348-9585.12228.
53. Özkan AH. The effect of burnout and its dimensions on turnover intention among nurses: a meta-analytic review. J Nurs Manag. 2022;30(3):660–9. https://doi.org/10.1111/jonm.13525.
54. Pickup L, Redfern N, Plunkett E, Broadbent S, Young MS. Healthcare staff fatigue: the unrecognised risk for patient safety. Future Healthc J. 2025;12(2):100250. https://doi.org/10.1016/j.fhj.2025.100250.
55. Medvedev ON, Krägeloh CU, Titkova EA, Siegert RJ. Rasch analysis and ordinal-to-interval conversion tables for the *Depression, Anxiety and Stress Scale*. J Health Psychol. 2020;25(10–11):1374–83. https://doi.org/10.1177/1359105318755261.
56. Massof RW. Understanding Rasch and item response theory models: applications to the estimation and validation of interval latent trait measures from responses to rating scale questionnaires. Ophthalmic Epidemiol. 2011;18(1):1–19. https://doi.org/10.3109/09286586.2010.545501.
57. Shiri R, Nikunlaakso R, Laitinen J. Effectiveness of workplace interventions to improve health and well-being of health and social service workers: a narrative review of randomised controlled trials. Healthcare (Basel). 2023;11(12):1792. https://doi.org/10.3390/healthcare11121792.
58. Araújo D, Bártolo A, Fernandes C, Pereira A, Monteiro S. Intervention programs targeting burnout in health professionals: a systematic review. Iran J Public Health. 2024;53(5):997–1008. https://doi.org/10.18502/ijph.v53i5.15580.
59. Alharbi BAA, McKenna N. A systematic review of mindfulness-based interventions to reduce ICU nurse burnout: global evidence and thematic synthesis. BMC Nursing. 2025;24(1):927. https://doi.org/10.1186/s12912-025-03507-w.
60. Wei N, Wang L, Tang B, Huang Y, Xuan L. A global analysis of the burden of ischemic heart disease attributable to diet low in fiber between 1990 and 2019. BMC Cardiovasc Disord. 2024;24(1):491. https://doi.org/10.1186/s12872-024-04156-8.

Publisher: Nofer Institute of Occupational Medicine, Łódź, Poland