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Sleep deprivation and its impact on the health of shift workers from low- and middle-income countries: A systematic literature review

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Abstract

Background: Shift work is a common occupational arrangement worldwide and is associated with significant sleep dysfunction and a wide range of adverse health outcomes. Despite growing recognition of these risks in high income settings, the evidence base for low- and middle-income countries (LMIC) remains comparatively limited. This review examines the health consequences of sleep deprivation among shift workers in LMICs and evaluates the potential of physical activity as an intervention.

Methodology: A systematic review was conducted in accordance with PRISMA guidelines, drawing on searches of PubMed, Swisscovery and Google Scholar. Following the screening of 92 studies by title and abstract, 30 studies were included in the final review, covering shift workers across healthcare, industrial, and service sectors in LMICs.

Results: The findings demonstrate a substantial and consistent burden of sleep dysfunction among shift workers in LMICs, with poor sleep prevalence ranging from 36.8% to 85% across the included studies. Sleep deprivation was linked to impaired physical and cognitive functioning, higher rates of anxiety, depression, burnout, and increased cardiovascular and metabolic health risks, alongside significant social disruption. These adverse outcomes were further intensified by structural challenges such as chronic understaffing, long working hours, economic insecurity, and inadequate occupational health infrastructure. Evidence supporting physical activity as an intervention in this context was limited, with fatigue identified as a primary barrier to participation and no LMIC based studies evaluating structured exercise programs as a primary intervention.

Conclusion: Sleep deprivation among shift workers in LMICs constitutes a serious public health challenge that cannot be fully understood or effectively addressed without tackling the underlying structural issues. While physical activity shows theoretical potential as one component of a multifactorial intervention, the current evidence base remains insufficient to support it as a standalone solution. Addressing understaffing and improving shift scheduling should therefore be prioritized when considering interventions. Closing the evidence gap requires significantly more LMIC focused research that meaningfully integrates local realities and cultural contexts, especially longitudinal studies and intervention trials adapted to resource limited settings.

Zusammenfassung

Hintergrund: Schichtarbeit ist weltweit eine gängige Arbeitsform und geht mit erheblichen Schlafstörungen sowie einer Vielzahl negativer gesundheitlicher Folgen einher. Trotz der zunehmenden Anerkennung dieser Risiken in Ländern mit hohem Einkommen ist die Evidenzbasis für Länder mit niedrigem und mittlerem Einkommen (LMIC) nach wie vor vergleichsweise begrenzt. Diese Übersichtsarbeit untersucht die gesundheitlichen Folgen von Schlafmangel bei Schichtarbeitern in LMICs und bewertet das Potenzial körperlicher Aktivität als Intervention.

Methodik: Es wurde eine systematische Übersichtsarbeit gemäss den PRISMA-Leitlinien durchgeführt, wobei auf Recherchen in PubMed, Swiscovery und Google Scholar zurückgegriffen wurde. Nach der Vorauswahl von 92 Studien anhand von Titel und Abstract wurden 30 Studien in die endgültige Übersichtsarbeit aufgenommen, die Schichtarbeiter im Gesundheits-, Industrie- und Dienstleistungssektor in LMICs abdeckten.

Ergebnisse: Die Ergebnisse zeigen eine erhebliche und konsistente Belastung durch Schlafstörungen bei Schichtarbeitern in LMICs, wobei die Prävalenz von Schlafstörungen in den einbezogenen Studien zwischen 36.8 % und 85 % lag. Schlafmangel stand im Zusammenhang mit beeinträchtigten körperlichen und kognitiven Funktionen, höheren Raten von Angstzuständen, Depressionen und Burnout sowie erhöhten kardiovaskulären und metabolischen Gesundheitsrisiken, einhergehend mit erheblichen sozialen Beeinträchtigungen. Diese negativen Folgen wurden durch strukturelle Herausforderungen wie chronischen Personalmangel, lange Arbeitszeiten, wirtschaftliche Unsicherheit und eine unzureichende Infrastruktur im Bereich der Arbeitsmedizin weiter verstärkt. Die Evidenz für körperliche Aktivität als Intervention in diesem Kontext war begrenzt, wobei Müdigkeit als primäres Hindernis für die Teilnahme identifiziert wurde und keine Studien aus LMICs vorlagen, die strukturierte Bewegungsprogramme als primäre Intervention evaluierten.

Schlussfolgerung: Schlafmangel bei Schichtarbeitern in Ländern mit niedrigem und mittlerem Einkommen stellt eine ernsthafte Herausforderung für die öffentliche Gesundheit dar, die ohne die Bewältigung der zugrunde liegenden strukturellen Probleme nicht vollständig verstanden oder wirksam angegangen werden kann. Während körperliche Aktivität theoretisches Potenzial als eine Komponente einer multifaktoriellen Intervention aufweist, reicht die derzeitige Evidenzbasis nicht aus, um sie als eigenständige Lösung zu unterstützen. Die Bekämpfung von Personalmangel und die Verbesserung der Schichtplanung sollten daher bei der Erwägung von Interventionen Priorität haben. Um die Evidenzlücke zu schliessen, bedarf es mehr auf LMICs ausgerichteter Forschung, die lokale Realitäten und kulturelle Kontexte sinnvoll einbezieht, insbesondere Längsschnittstudien und Interventionsstudien, die an ressourcen-beschränkte Umgebungen angepasst sind.

Résumé

Contexte: Le travail posté est un mode d'organisation du travail courant dans le monde entier et est associé à d'importants troubles du sommeil ainsi qu'à un large éventail de conséquences néfastes pour la santé. Bien que ces risques soient de plus en plus reconnus dans les pays à revenu élevé, les données disponibles pour les pays à revenu faible et intermédiaire (PRFI) restent relativement limitées. Cette revue examine les conséquences sur la santé du manque de sommeil chez les travailleurs postés dans les PRFI et évalue le potentiel de l'activité physique en tant qu'intervention.

Méthodologie: Une revue systématique a été menée conformément aux lignes directrices PRISMA, à partir de recherches effectuées dans PubMed, Swisscovery et Google Scholar. Après une présélection de 92 études sur la base de leur titre et de leur résumé, 30 études ont été incluses dans la revue finale, couvrant des travailleurs postés dans les secteurs de la santé, de l'industrie et des services dans les PRFI.

Résultats: Les résultats mettent en évidence un fardeau important et constant lié aux troubles du sommeil chez les travailleurs postés dans les pays à revenu faible ou intermédiaire, la prévalence des troubles du sommeil variant entre 36.8 % et 85 % dans les études incluses. Le manque de sommeil était associé à une altération des fonctions physiques et cognitives, à des taux plus élevés d'anxiété, de dépression et d'épuisement professionnel, ainsi qu'à une augmentation des risques pour la santé cardiovasculaire et métabolique, sans compter d'importantes perturbations sociales. Ces effets néfastes ont été encore aggravés par des défis structurels tels que le manque chronique de personnel, les longues heures de travail, la précarité économique et l'insuffisance des infrastructures de santé au travail. Les données étayant l'activité physique comme intervention dans ce contexte étaient limitées, la fatigue étant identifiée comme un obstacle majeur à la participation et aucune étude menée dans les PRFI n'évaluait les programmes d'exercice structurés en tant qu'intervention principale.

Conclusion: La privation de sommeil chez les travailleurs postés dans les pays à revenu faible ou intermédiaire constitue un grave problème de santé publique qui ne peut être pleinement compris ni traité efficacement sans s'attaquer aux problèmes structurels sous-jacents. Si l'activité physique présente un potentiel théorique en tant que composante d'une intervention multifactorielle, les données actuelles restent insuffisantes pour la soutenir en tant que solution autonome. La lutte contre le manque de personnel et l'amélioration de la planification des horaires de travail posté devraient donc être prioritaires lors de l'examen des interventions. Pour combler ce manque de données, il faut multiplier considérablement les recherches axées sur les pays à revenu faible ou intermédiaire, qui tiennent véritablement compte des réalités locales et des contextes culturels, en particulier les études longitudinales et les essais d'intervention adaptés aux contextes où les ressources sont limitées.

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Abbreviations

ACGME	Accreditation Council for Graduate Medical Education
AOR	Adjusted Odds Ratio
BIS	Bargen Insomnia Scale
BMI	Body Mass Index
CFS	Chronic Fatigue Syndrome
COM-B	Capability, Opportunity, Motivation — Behaviour model
DASS-21	Depression Anxiety Stress Scale 21
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, 5th Edition
EEG	Electroencephalogram
ESS	Epworth Sleepiness Scale
FIRST	Ford Insomnia Response to Stress Test
GNI	Gross National Income
ICU	Intensive Care Unit
ICSD-3	International Classification of Sleep Disorders, 3rd Edition
ILO	International Labour Organization
ISI	Insomnia Severity Index
KSS	Karolinska Sleepiness Scale
LMIC	LMIC
MET	Metabolic Equivalent of Task
MSPSS	Multidimensional Scale of Perceived Social Support
NSI	Needlestick Injury
PHQ-9	Patient Health Questionnaire 9
PSQI	Pittsburgh Sleep Quality Index
PVT	Psychomotor Vigilance Task
SF-12	Short Form Health Survey 12
SMD	Standardised Mean Difference
SWSD	Shift Work Sleep Disorder
TMT	Trail Making Test
WAI	Work Ability Index
WHO	World Health Organization
WHOQOL-BREF	World Health Organization Quality of Life Brief Version
WISE	Work Improvement in Small Enterprises

Figure 1: List of abbreviations

1. Introduction

The phenomenon of sleep has fascinated researchers for centuries, with the first scientific studies on sleep deprivation conducted over one hundred years ago (Abrams, 2015). Despite this long-standing interest, today's world continues to present new challenges to maintain healthy sleep patterns. In recent decades, the boundaries between work and leisure have become increasingly mixed, as technological advancements and global economic demands have extended working hours well beyond the traditional daytime schedule. Workdays that once ended in the late afternoon now frequently stretch into the evening and night (Costa, 2015).

Shift work is nothing new. Certain professions such as bakers, innkeepers and soldiers have always worked irregular hours. Since the industrial revolution, however, there has been a spread of longer and irregular hours, traditionally involving work periods of 6-12 hours, with two, three or four rotating shifts in a 24-hour period (Harrington, 2001). A societal shift has also contributed to the widespread adoption of shift work, which allows continuous productivity beyond the standard eight-hour workday and often operates on a 24-hour cycle (Costa, 2015). Shift work is particularly prevalent in technological and industrial sectors such as steel and chemical production, as well as in essential public services including healthcare, transportation, electricity, entertainment and communication. It has also become increasingly common in areas like food production and banking, along with growing expectations of constant service availability (Costa, 2015).

In Europe, only about 27% of employees now follow a traditional Monday-to-Friday work schedule, with men more frequently engaged in shift work than women (Costa, 2015). This change in working patterns has significant implications for public health: Shift work disrupts the body's natural circadian rhythm, which can lead to misalignments between biological sleep-wake cycles and external work demands. As a result, it can negatively influence sleep quality, cognitive and physical performance, social relationships and overall health (Costa, 2015; Harrington, 2001). It has been shown that shift workers have an almost 200% increase in poor sleep quality when compared to non-shift workers (Thach et al., 2020). A performance loss during the night and very early in the morning has also been determined, leading to higher accident rates and more frequent mistakes (Harrington, 2001).

While the health consequences of shift work have received considerable attention in countries with high income economies, workers in low- and middle-income countries remain comparatively understudied. Workers in LMICs show a higher prevalence of sleep disorders such as insomnia, sleep related breathing disorders and circadian rhythm sleep-wake disorders than their counterparts in higher income settings (Khoshakhlagh et al., 2023). This gap in the evidence base is particularly concerning given that LMIC workforces are often exposed to numerous structural disadvantages that are likely to intensify the health consequences of shift work and sleep deprivation. Despite growing recognition of these risks, the translation of research into policy and practice in LMICs remains limited and the question of what interventions are feasible and effective in these settings remains largely unanswered.

The present systematic review addresses this gap. Following PRISMA guidelines (Moher et al., 2009), it aims to systematically identify and evaluate current research on sleep deprivation and its health consequences among shift workers in low and lower middle-income countries, with particular attention to physical performance, occupational outcomes and the potential of physical activity as a potential intervention. Results are presented in an overview table and discussed in relation to the context that shapes the occupational health of shift workers in these settings.

2. Theoretical Background

2.1 Shift Work and Sleep Issues

Sleep deprivation refers to a reduction in the quantity or quality of sleep and is a significant factor influencing both physical and mental functioning (Abrams, 2015; Orzeł-Gryglewska, 2010). Adequate sleep is essential for regeneration, recovery and the processing of information, as humans spend roughly one third of their lives sleeping (Abrams, 2015). When sleep is insufficient or disturbed, individuals experience reduced physical performance, decreased alertness and impaired mental health, as well as altered pain perception (Abrams, 2015; Orzeł-Gryglewska, 2010; Rødsjø, 2020).

Sleep architecture follows a cyclic pattern consisting of two main stages: non rapid eye movement (NREM) and rapid eye movement (REM) sleep (Afsharkhas et al., 2021), typically alternating across five cycles per night (Abrams, 2015). NREM sleep can be subdivided into three phases: N1, a transitional and light stage; N2, the predominant stage accounting for approximately 50% of total sleep time; and N3, the deep sleep stage from which it is most difficult to be awoken. REM sleep, by contrast, is characterized by brain activity resembling wakefulness and is associated with dreaming, though its full functional role remains an area of ongoing scientific discussion (Abrams, 2015).

The physiological and psychological consequences of chronic sleep deprivation are wide ranging and well documented. Studies have associated inadequate sleep with increased risks of cardiovascular disease, stroke, obesity, diabetes, cancer, osteoporosis, cognitive decline and higher overall mortality (Abrams, 2015). Fatigue, which can be understood as a mental sense of weakness, energy deficit and burnout, disturbs both physical and cognitive ability, representing one of the most immediate manifestations of insufficient sleep (Rasoulzadeh et al., 2015). Additionally, cognitive and emotional disturbances such as aggression, slower reaction times, impaired memory and logical thinking, reduced concentration and altered hormonal secretion are well documented outcomes of sleep loss (Orzeł-Gryglewska, 2010). Among the less immediate but serious long-term consequences is the disruption of melatonin synthesis which has been associated with an increased risk of breast cancer, as nocturnal light exposure suppresses the hormonal regulation that melatonin usually provides (Kubatka et al., 2018). During pregnancy, sleep deprivation is additionally linked to gestational diabetes, intrauterine growth restriction and a greater likelihood of caesarean delivery (Abrams, 2015).

Occupational fatigue resulting from long or irregular working hours is a prominent cause of sleep deprivation across professional contexts. Medical residents working repeated 24-hour shifts have been reported to commit 36% more medical errors and experience double the risk of motor vehicle accidents when driving home compared to well rested colleagues (Abrams, 2015). Such professionals also tend to display lower empathy toward patients, greater family stress, more frequent diagnostic mistakes and a higher risk of physical injury. Cognitive domains such as language and mathematical reasoning appear particularly sensitive to sleep loss (Abrams, 2015). In certain professions, such as firefighting, sleep disorder prevalence has been documented at rates of up to 30% (Khoshakhlagh et al., 2023). Healthcare work represents

a particularly high-pressure context in this regard: long hours, intense patient interactions and the demands of continuous clinical decision-making mean that the job itself is followed by fatigue and stress, even before the additional burden of irregular shift scheduling is considered. In LMIC healthcare settings, these pressures are amplified by restricted resources including chronic staff shortages, limited physical infrastructure and inadequate access to mental health services. These conditions interact with the cognitive and psychological effects of sleep deprivation to produce outcomes of particular severity (S. Shahzad et al., 2025).

Sleep duration and quality both play critical roles in maintaining health and performance and both contribute independently to sleep deprivation. While optimal sleep duration depends on the individual, adults generally need seven to eight hours of sleep per night for effective functioning (Abrams, 2015). However, individuals who obtain sufficient sleep length but experience poor sleep quality, often defined by five or more nocturnal awakenings, may still suffer from daytime sleepiness and cognitive fatigue (Abrams, 2015).

The causes of sleep deprivation are multifactorial and include voluntary behaviors such as late-night screen use, personal obligations including childcare, irregular or late work schedules and medical conditions such as sleep apnea (Abrams, 2015). Despite widespread awareness of its consequences, approximately 20% of the adult population is estimated to be chronically sleep deprived (Abrams, 2015). The scale of the problem is particularly evident in LMIC urban settings: a study conducted among 422 randomly selected adults in Jimma town, Southwest Ethiopia found an alarmingly high prevalence of poor sleep quality of 65.4%, a rate which the authors attribute to the urban setting and elevated levels of life stress (Berhanu et al., 2018). On average, participants slept only 6.8 hours per night, with 47.4% sleeping fewer than five hours and 51.4% reporting low sleep efficiency. Independent predictors of poor sleep in this general population cohort included age, with adults aged 40 to 49 being twice as likely to experience poor sleep as those aged 19 to 29; income, with individuals earning 1,000 Ethiopian Birr or less per month facing 2.2 times higher odds of poor sleep; obesity; and khat use, with daily khat chewers facing a 3.4 times elevated risk. The link between poverty and poor sleep in this context is attributed to mental dissatisfaction and a lower quality living environment that impairs the body's ability to regulate temperature and achieve restful sleep (Berhanu et al., 2018). Importantly, this study was not conducted among shift workers but among the general urban population, indicating that sleep dysfunction in LMICs is not solely an occupational phenomenon but reflects broader structural and socioeconomic conditions.

Shift work, however, does represent one of the most critical occupational contributors to sleep loss. Disruptions in circadian rhythms due to rotating or night shifts interfere with the body's natural sleep and wake cycle, often resulting in shortened and fragmented sleep (Costa, 2015). Roughly 10% of shift workers are estimated to suffer from a sleep disorder directly related to their work schedules, with a more severe clinical manifestation known as Shift Work Sleep Disorder (SWSD) characterized by persistent difficulties sleeping during designated rest periods and chronic fatigue during working hours. This chronic misalignment between biological rhythms and occupational demands can increase fatigue, impair alertness and elevate accident risk (Costa, 2015; Orzeł-Gryglewska, 2010). Shift workers also tend to exhibit

elevated cortisol levels as a consequence of disrupted circadian regulation and are more likely to engage in unhealthy lifestyle behaviors including smoking and physical inactivity (S. Shahzad et al., 2025). Night shifts in particular have been linked to disturbed circadian rhythm, cognitive decline, mood disorders and increased risk of chronic illness, with insomnia emerging as a particularly common and clinically significant outcome (S. Shahzad et al., 2025). Female healthcare workers on night shifts appear especially vulnerable to depression, due to the interaction of hormonal factors and the social pressures associated with night work in many cultural contexts (S. Shahzad et al., 2025).

Burnout represents a distinct but closely related occupational health outcome, defined by emotional exhaustion, depersonalization and reduced personal accomplishment resulting from chronic workplace stress (S. Shahzad et al., 2025). In Pakistan, 68% of healthcare workers report moderate to severe occupational stress, yet very few seek help, deterred by stigma surrounding mental health, poor access to services and cultural values that encourage silence and endurance in the face of professional hardship (S. Shahzad et al., 2025).

Petrochemical and other heavy industries present a similar occupational context in which the risks of shift work and sleep deprivation are similarly severe. These industries require unavoidable around-the-clock operations, making shift work a structural necessity rather than a scheduling choice and the combination of sleep deprived workers and hazardous industrial environments creates conditions of high risk (Rasoulzadeh et al., 2015).

Historically, the dangers of sleep deprivation in professional settings have only recently gained full scientific and institutional recognition. Although sleep research began to expand in the early 1970s, significant policy changes followed only after a fatal incident in 1984 involving two sleep deprived medical residents in the United States (Abrams, 2015). This event led to the establishment of the Accreditation Council for Graduate Medical Education (ACGME), which introduced a maximum 80-hour workweek and limited single shifts to 24 hours for medical residents. This regulatory response, while significant, remains specific to high income country contexts and illustrates the broader pattern in which institutional change has been slower to translate into policy in LMIC settings (Abrams, 2015).

Overall, the evidence shows that sleep deprivation is a societal health hazard with wide ranging physiological, cognitive and social consequences. Its prevalence and impact are particularly concerning among shift workers, whose disrupted sleep patterns place them at elevated risk for chronic illness, occupational accidents and diminished quality of life. While there is a growing body of research on sleep quality in high income countries, significant questions remain about the state of the evidence for workers in low- and middle-income countries and about whether accessible, sustainable interventions, including physical activity based approaches, could meaningfully improve both sleep quality and quality of life for workers in these settings.

2.2 Potential Interventions and Recommendations

The preceding section established the physiological, psychological and occupational consequences of shift work and sleep deprivation as a global phenomenon. A further question revolves around how these consequences might be mitigated through targeted interventions. While the evidence base for such interventions is considerably more developed in high income country contexts than in LMICs, understanding what has been shown to work provides an essential framework for evaluating what has been attempted in resource constrained settings and what remains to be done. This chapter reviews the intervention literature relevant to shift work and sleep dysfunction, drawing on evidence from non-LMIC contexts before turning to the question of how far this research has progressed in low- and middle-income settings.

Napping as an Occupational Intervention

Among the most extensively studied and practically accessible interventions for shift work related fatigue is the strategic use of nighttime napping. Short naps lasting 15 to 20 minutes can partially counteract sleepiness when total sleep time cannot be increased, functioning as a practical mitigation strategy in settings where scheduling constraints limit rest opportunities (Abrams, 2015). A review by Takeyama et al. (2005) drawing on studies from diverse industries including pulp and paper manufacturing, iron and steel, chemical production and emergency services in Japan provides a comprehensive evaluation of napping strategies for night shift workers. The central finding of this review is that nighttime naps taken during the shift itself are a powerful tool for mitigating the dangers of night work across multiple dimensions of worker functioning.

A particularly noteworthy finding concerns the concept of "anchor sleep": Napping at a consistent time each night can stabilize circadian rhythms and prevent the internal desynchronization that accumulates with irregular sleep patterns (Takeyama et al., 2005). Nighttime naps also allow for deeper sleep compared to daytime sleep, providing higher rest per unit of time. An additional benefit identified by the review is that taking a nap during the night shift often leads to shorter subsequent daytime sleep, which the authors frame positively: workers regain time for social and family activities rather than spending additional daytime hours recovering sleep debt, an outcome with direct relevance to the social impacts documented in the results of this review.

The review also identifies important nuances in the implementation of napping strategies. Optimal nap duration was found to be between 90 and 120 minutes, corresponding to one full sleep cycle, though even ultra-short naps of 20 minutes demonstrated significant improvements in vigilance by the end of a shift (Takeyama et al., 2005). Individual differences in age and chronotype matter too: older workers tended to prefer napping earlier in the shift, at or before midnight, while younger workers preferred the latter half and workers classified as "morning types" showed better performance recovery following naps than "evening types." A significant practical concern identified is sleep inertia, the brief period of impaired performance and mood immediately following waking from a nap, which must be managed carefully in safety critical

environments where workers need to return to full alertness rapidly after resting (Takeyama et al., 2005).

Environmental conditions are a critical enabler of effective napping. Workers in the reviewed studies reported that the effectiveness of naps was frequently undermined by noise, uncomfortable temperatures and inadequate facilities, underscoring the need for dedicated, comfortable napping spaces for any formal napping policy (Takeyama et al., 2005). The review advocates for participatory methods in which workers and managers collaborate using structured action checklists to design and implement napping strategies suited to their specific workplace context. Notably, Takeyama et al. observe that while nighttime napping is widely accepted as a professional norm in Japanese industries, it is viewed in many other countries as evidence of a lack of professional commitment.

Physical Activity Interventions in LMICs

Physical activity represents a promising intervention avenue for addressing the health consequences of shift work, given its well established effects on sleep quality, fatigue, mental health and cardiometabolic risk. A meta-analysis provides a foundation for understanding the effectiveness of physical activity promotion interventions in LMIC contexts more broadly, while a feasibility study from Botswana offers more specific evidence regarding shift workers in an African setting.

The meta-analysis from Shrestha et al. (2026), involving 23 studies and 12'689 participants, finds that physical activity interventions in LMICs produce a small but statistically significant overall effect on increasing activity levels ($SMD = 0.29$). Interventions were significantly more effective at improving activity intensity, measured through MET minutes ($SMD = 0.42$) and physical activity scores ($SMD = 0.86$), than at increasing total activity duration or reducing sedentary time, where effects were minimal and non-significant ($SMD = 0.07$).

Several factors were found to significantly moderate intervention effectiveness. Digital delivery performed particularly well, with interventions using mobile applications or software ($SMD = 0.47$) and interactive calls ($SMD = 0.89$) outperforming traditional approaches, while simple voice call reminders produced a negative effect on activity levels ($SMD = 0.94$). This suggests that passive, non-interactive digital contact may be counterproductive (Shrestha et al., 2026). Multi-component interventions combining educational sessions with structured exercise were more effective ($SMD = 0.61$) than education alone, pointing to the value of pairing knowledge with structured behavioral support. Professional involvement also mattered substantially: Programs led by researchers ($SMD = 0.63$) or clinicians ($SMD = 0.38$) produced significant effects, whereas those led by community health workers yielded non-significant results, indicating that specialized training may be a prerequisite for effective delivery (Shrestha et al., 2026). Short term interventions of three months or fewer with similarly short follow up periods produced higher effect sizes than longer programs, which struggled with sustained participant engagement. Economically, interventions were significantly more effective in upper middle-income countries ($SMD = 0.45$) than in lower middle-income countries, where results were non-significant, suggesting that even within the LMIC category,

income level shapes the conditions under which physical activity promotion can succeed (Shrestha et al., 2026).

Shrestha et al. (2026) identified a set of structural and cultural barriers that are specific to LMIC contexts and that complicate the translation of intervention evidence into sustained behavior change. In some regions, larger body size carries positive social connotations associated with status and prosperity, reducing the perceived motivation to lose weight or increase physical fitness. Gender stereotypes in many settings restrict women's access to public spaces suitable for exercise, disproportionately limiting intervention reach among female workers (Shrestha et al., 2026). Many individuals in LMICs engage in physically demanding occupational or domestic labor, making additional leisure time physical activity less appealing and potentially less feasible after long or night shifts. Limited infrastructure, unsafe public environments and low health literacy further constrain the adoption of active lifestyles in these contexts (Shrestha et al., 2026). The overall certainty of the evidence from the review is rated as low to very low, primarily due to high heterogeneity across included studies, heavy reliance on self-reported rather than objectively measured activity data and insufficient long term follow up to assess whether behavior changes are maintained beyond the intervention period.

A Feasibility Study Among Mining Shift Workers in Botswana

Moving closer to the specific population of interest in this review, Monnaatsie et al. (2023) conducted a feasibility study of a physical activity promotion intervention among 51 shift workers at a diamond mining company in Botswana. This setting, while not classified as a low- or low-middle-income country, shares important structural characteristics with LMIC contexts and offers valuable practical insights for intervention design in shift work populations in Africa. Participants worked a demanding 24 day shift cycle consisting of six consecutive days each of morning, evening and night shifts followed by two non-workdays and were on average overweight with a mean BMI of 26.2.

The intervention combined several components grounded in the COM-B behavioral framework, which addresses capability, opportunity and motivation as the three determinants of behavior change (Monnaatsie et al., 2023). Each participant attended a 30 to 45 minute individual meeting in which they received personalized feedback on their activity levels and set specific behavioral goals using the 5As approach: assess, advise, agree, assist and arrange. Over the 24 day cycle, participants received 15 individually tailored text messages timed to align with their specific shift schedule to provide contextually relevant motivational prompts. Participants were also provided with a Mi fitness band to monitor steps, heart rate and sleep, alongside a mobile app for daily assessments of physical activity. The fitness band served a dual function: as a self-monitoring tool and as a recruitment incentive, with some workers approaching the researchers specifically in order to receive the device (Monnaatsie et al., 2023).

The study concluded that the intervention was feasible across multiple dimensions assessed. It successfully reached 66% of targeted shift workers across three departments, maintained a dropout rate of only 15% and was delivered fully as intended within the shift cycle. The

program met the expectations of 94% of participants, all of whom stated they would recommend it to colleagues. Workers particularly valued the tailored text messages and action planning sessions and many reported increased awareness of the health risks associated with prolonged sitting or inactivity as well as immediate behavioral shifts such as more regular gym attendance (Monnaatsie et al., 2023).

However, the study also surfaced the central tension that defines physical activity interventions in shift work populations: fatigue. Workers consistently reported being too tired to exercise after their shifts, with night shifts specifically identified as disrupting sleep patterns in ways that further reduced their capacity to be active (Monnaatsie et al., 2023). The researchers suggest that future interventions may need to integrate physical activity opportunities during work hours rather than relying on workers to exercise during already depleted off-shift time. They also emphasize the importance of visible management involvement in program promotion, which workers identified as a missed opportunity in this study. Previous wellness programs at the mine had been less effective because they focused narrowly on weight loss without providing behavioral feedback or guidance, reinforcing the broader evidence that multi-component, behaviorally grounded approaches outperform single focus programs (Monnaatsie et al., 2023).

Toward an LMIC Evidence Base

The intervention literature reviewed in this chapter demonstrates that meaningful tools exist for addressing the sleep and health consequences of shift work: structured napping programs can preserve alertness and stabilize circadian function; physical activity interventions can improve activity intensity and support broader health outcomes; and digitally delivered, multi-component, professionally led programs show the greatest promise for sustained behavior change. At the same time, the evidence base remains predominantly located in high income settings, with LMIC specific research characterized by low certainty, short follow up periods and significant structural and cultural barriers that limit generalizability. The question of how far this intervention agenda has progressed within LMIC contexts specifically and what has actually been implemented among the shift workers is more narrowly defined by the following research questions and the results chapter that aims to answer them.

3. Research Questions

The preceding theoretical background has established that sleep deprivation and shift work carry significant occupational health consequences, with an evidence base that is quite developed in high income settings. Structural conditions specific to LMICs are likely to shape both the severity of these outcomes and the feasibility of interventions such as physical activity. Against this background, the present systematic review aims to address the following research questions:

1. How does sleep deprivation affect the physical performance and work capacity of shift workers in low-middle-income countries (LMICs)?
2. What are the documented health consequences of sleep deprivation among shift workers in LMICs?
3. To what extent does physical activity mitigate the negative health outcomes of sleep deprivation (e.g., cardiovascular disease, stress, metabolic disorders) in shift workers?
4. Can structured exercise programs be considered a feasible intervention to improve health and well-being among shift workers in LMICs?

4. Methodology

For this master's thesis, the current state of research on sleep deprivation and its impact on shift workers in LMICs was presented in the form of a systematic review. To ensure a structured and transparent overview, the PRISMA guidelines for conducting systematic reviews were applied (Moher et al., 2009). In addition, a PRISMA flow diagram was created to illustrate the literature search process and the study exclusion procedure (see Figure 1). Chosen studies were then presented in an overview table and described in more detail in the results section of the paper.

The steps of the review process according to PRISMA, along with methods specific to this paper, are as follows:

- Identification: A broad search for relevant literature was conducted using Google Scholar, PubMed and Swisscovery, based on predefined search terms (see Figure 3 in the Appendix). These search terms were developed during the preparatory phase, which encompassed initial research and the writing of the thesis proposal.
- Screening: First, links to all studies screened by title were compiled in a Word document and stored in Zotero for later referencing. In a second step, abstracts were read and studies not specifically addressing shift workers in LMICs were excluded. Finally, detailed notes were taken on all full-text studies assessed for eligibility, organized around the following categories: population, statistics, intervention (where applicable), methodology and results.
- Included: The final set of studies was used for the analysis and discussion of the research findings. Studies excluded at the full-text stage had appeared potentially relevant based on their abstracts but were found upon full reading to not meet the inclusion criteria.

To ensure a systematic approach to the review, the PRISMA checklist was followed. It ensures a uniform research and selection process, as well as structure for the paper (Prisma Executive, 2020).

An important consideration in this paper is the categorization of countries by income level. Such classifications can be complex and are often influenced by biases or inconsistencies. To maintain clarity and comparability, this paper adopts the terminology of *low*-, *lower-middle*-, *upper-middle*- and *high-income countries*, based on annually updated Gross National Income (GNI) per capita (Khokhar & Serajuddin, 2015). This framework is used to minimize ambiguity and ensure a more objective basis for cross-country comparisons. However, as discovered in a broad search during the preparation of this paper, the term “developing” countries has still seen widespread use and was thus used in the search terms to find sources. For the purpose of study inclusion, relevant countries were identified using the World Bank Group income classifications for “Low Income” and “Lower-middle Income” for the fiscal year 2026 (Metreau et al., 2025).

The three databases differ meaningfully in their search functionality and the nature of their results, which shaped how each was used in practice. Swisscovery, as an academic library

catalogue, supports precise Boolean search queries and returns well defined sets of peer reviewed sources, making it particularly well suited to systematic literature searches with specific inclusion criteria. Google Scholar, by contrast, employs a broader and less transparent search algorithm that prioritizes relevance ranking and does not support Boolean operators as well.

This difference in search architecture had practical consequences for the review process. The initial broad search on Google Scholar returned over 10,000 results. After reviewing the first ten pages without identifying any relevant sources not already retrieved through Swisscovery, the general Google Scholar search was discontinued. A targeted intervention search on Google Scholar was similarly terminated after 300 results, from 5110 total, as no additional relevant sources were identified. Google Scholar therefore served a supplementary rather than primary role in the literature identification process, with Swisscovery providing the majority of included sources. Here, the filters “Available Online” and “Open Access” were used. PubMed gave few but very specific results, with 3 studies included in the final results, as well as partially relevant material suitable for the theoretical background.

Several methodological considerations and limitations of the review process must be acknowledged. As this review does not conduct a meta-analysis but instead synthesizes findings narratively, results are presented descriptively with attention to consistency of patterns across studies rather than through statistical representations. Studies excluded at full text assessment were removed on the basis of three criteria: no reference to shift work or sleep, low quality (in this specific case an abundance of language errors), or conduct outside of LMIC settings, as detailed in the PRISMA flow diagram. An important limitation concerns the subjectivity in single reviewer screening. The entire identification, screening and selection process was conducted by one researcher, without a second independent reviewer to verify inclusion decisions. Although a consistent guiding question was applied throughout — whether a given study addressed the research questions in the context of shift work and LMICs — the determination of relevance remains a subjective decision.

4.1 Prisma Flow Chart

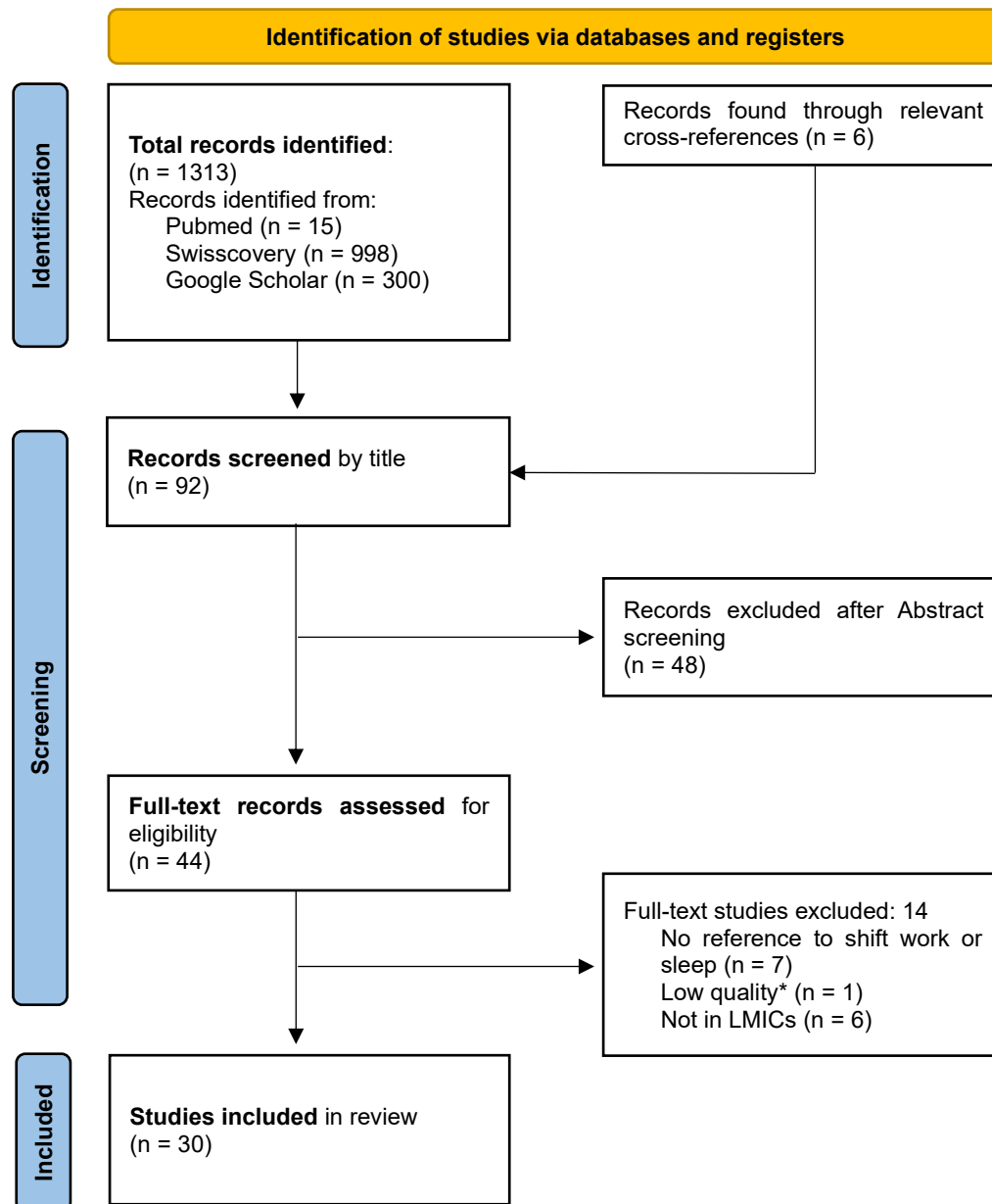


Figure 2: Prisma Flow Chart of included studies

*Language errors and inconsistencies

5. Results

5.1 Table of Results

Study	Population (number, demographics, location)	Intervention	Statistics	Methodology	Results
(Abate et al., 2023)	n=392 nurses (m=54.2%). Mean age 31.25 years. Eastern Ethiopia.		SPSS	Interviewer-guided, self-administered questionnaires. Various tools to assess sleep and mental health: - International Classification of Sleep Disorders (ICSD-3) - Bergen Insomnia Scale (BIS) - Epworth Sleepiness Scale (ESS) - DASS-21	Among the nurses surveyed, 30.4% met the criteria for Shift Work Sleep Disorder (SWSD). Additionally, 37.4% reported suffering from insomnia and 28.2% experienced significant daytime sleepiness. Night shifts were identified as a primary risk factor, increasing the likelihood of developing SWSD by 2.5 times. Notably, the recreational use of Khat increased the odds of developing the disorder by nearly fivefold. Mental health symptoms were also prevalent, with nurses reporting high rates of anxiety (29.5%), depression (27.1%) and stress (16.5%). Furthermore, female nurses were 2.4 times more likely to suffer from SWSD compared to their male colleagues.
(Abdelhamid et al., 2020)	n=50 anesthesia residents (f=27). Age 25–28 years. Cairo, Egypt.		SPSS	Four validated neuropsychological tests: - Psychomotor Vigilance Task (PVT) - Karolinska Sleepiness Scale (KSS) - Epworth Sleepiness Scale (ESS) - Trail Making Test (TMT Parts A and B)	Following a 24-hour shift, residents experienced a significant decline in nearly all measured cognitive functions. Average sleep dropped drastically from 7.12 hours at home to just 2.74 hours during the shift, causing subjective sleepiness scores to nearly double and indicating excessive daytime sleepiness post-shift. This sleep deprivation resulted in impaired reaction times (slowing from 302.1 ms to 371.9 ms) and reduced mental flexibility, as shown by significantly longer completion times for executive function tests. Notably, the study compared the impairment of 24-hour wakefulness to a blood alcohol concentration of 1 g/L, highlighting severe safety risks such as the link to hospital deaths and frequent pharmacological errors in anesthesia. These risks are further compounded in this setting by extreme work hours, where shifts can extend to 36 continuous hours.
(Adjibimey et al., 2022)	n=1883 cotton plant workers (m=90,8%). Mean age 38 years. Benin.		R software	Face-to-face interviews supported by a smartphone app. Further tools: - Karasek questionnaire - Siegrist model - WHO STEPS questionnaire	This study revealed an exceptionally high prevalence of occupational stress (77.7%) among workers, a figure significantly higher than that observed in other sectors, such as insurance (27.3%). A primary contributor is the disruption of the circadian cycle caused by industrial night work, which facilitates the development of insomnia. The authors noted that insomnia serves as a significant stressor, often driving night-shift workers toward maladaptive behaviors like alcohol or substance abuse. While high-intensity physical activity was associated with increased stress (aOR 1.33) due to physical overload, job insecurity was the strongest predictor: Occasional workers were over six times more likely to suffer from stress than permanent staff. Interestingly, being under the age of 38 acted as a protective factor, suggesting that younger workers may still be in an adjustment phase, whereas older employees perceive the cumulative physical and rhythmic demands as increasingly stressful over time.
(Ahasan et al., 1999)	n=60 (m) shoe factory workers. Rural backgrounds. Dhaka, Bangladesh.		Likert Score, Chi-Square	Subjective case study. - Job Attitude Questionnaire - Brayfield-Rothe Job Satisfaction Scale - Symptom and Feeling of Fatigue Scale.	The findings indicated that while workers generally liked their specific job tasks and wages, the rotating shift system had several adverse effects: 85% of subjects reported sleep disturbances, with statistically significant feelings of sleepiness. The researchers noted that the inability to stay awake or "tiredness cost" is a major global issue and in this specific sample, the rotating schedule was a primary driver of these sleep issues. Shift work was also highly disruptive to personal lives, with 75% reporting family life disturbances, 72% reporting marital problems and 65% reporting restricted social lives.

			Questionnaire for Specific Problems of Shift Work	Additionally, 80% struggled with restricted leisure time and difficulties meeting friends. 83% of the studied men suffered from general health problems and 78% experienced irregularities in their mealtimes. Although 73% of workers disliked the shift system, this dislike did not significantly lead to overall job dissatisfaction. The majority (57%) remained satisfied with other job components like wages and labor-management relations, which the authors suggest may be influenced by the scarcity of jobs and fear of unemployment in Bangladesh.
(Akhtar & Butt, 2022)	n=200 call center employees. Lahore, Pakistan.	SPSS	Structured questionnaires including: - Insomnia Assessment - Work-Life Balance Assessment - Job Performance Assessment	The study identified sleep deprivation and insomnia as the primary drivers of reduced job performance among night-shift workers. A significant sequential mediation was confirmed: night shifts disrupt work-life balance, creating pressure and stress that leads to insomnia, which in turn reduces performance. Notably, the direct impact of night shifts on performance was insignificant, suggesting that the shifts themselves do not inherently lower productivity, but rather the resulting sleep loss and work-life conflict do. In the context of Pakistan's cultural values, workers often compromise sleep to maintain daytime social and family obligations. To mitigate these effects, the study recommends that managers implement flexible shift systems and alternate working days to help employees balance personal responsibilities with necessary rest.
(Alinab & Diamante, 2025)	n=92 physicians in training (f=64%). Quezon City, Philippines.	SPSS	Self-administered online surveys using convenient sampling. Three tools used: - Pittsburgh Sleep Quality Index - Brief-Coping Orientation to Problems Experienced Inventory - FANTASTIC Lifestyle Questionnaire	The study revealed a high prevalence of sleep deprivation and significantly impaired sleep quality among physician trainees, with 85% of respondents reporting poor sleep. On average, trainees slept only 5.7 hours, well below the recommended threshold, with surgical residents experiencing the worst sleep quality (PSQI 9.14). Shorter sleep duration was significantly associated with longer working hours, while marital status appeared to be a protective factor linked to better rest. Poor sleep quality was also significantly connected to unhealthy lifestyle choices, including reduced physical activity and strained social relationships. To manage these pressures, trainees generally utilized proactive or emotional coping mechanisms, though the "surgical culture" appeared to discourage seeking support from supervisors. Given that long shifts cause severe circadian desynchronization, the study concluded that institutional changes, such as reducing consecutive work hours, are essential to protect both trainee well-being and patient safety.
(Aliyu et al., 2017)	n=100 nurses (f=77%). Mean age 31.4 years. Birnin Kebbi, Nigeria.	SPSS	Self-administered questionnaire using purposive sampling method. Tools: - Pittsburgh Sleep Quality Index - Epworth Sleepiness Scale	The study found that while 61% of nurses were classified as poor sleepers, this did not necessarily translate to extreme daytime sleepiness. The average sleep duration was 6.2 hours, with nurses sleeping less than 7 hours being significantly more likely to report poor sleep quality. Significant associations were found between shift-based schedules and poor sleep, particularly among nurses with five years or less of experience. Despite these findings, 53% of participants did not exhibit a tendency for daytime sleepiness, a result the researchers attribute to a hospital policy that grants seven days of rest following a seven-day night duty cycle, allowing staff to recover from "sleep debt." However, the authors emphasize that chronic understaffing in LMICs often forces nurses to work excessive shifts, increasing stress and the risk of medical errors.
(Amellah et al., 2025)	n=200 healthcare professionals (f=60%). 146 nurses, 54 physicians. Meknes prefecture, Morocco.	SPSS	Stratified random sampling strategy including the following tools: - Perceived Stress Scale - Maslach Burnout Inventory-Human Services Survey	This study highlighted significant psychological strain among healthcare professionals in Morocco, with 52% reporting high stress and 50.5% meeting burnout criteria. Sleep disturbances were prevalent, affecting 62.5% of participants and serving as a strong predictor of perceived stress. Conversely, the absence of sleep disorders reduced the odds of high stress by 76%. On-call schedules, including nights and weekends, were significantly associated with higher emotional exhaustion and depersonalization, whereas fixed administrative schedules acted as a protective factor. Nurses and those working in the Intensive Care Unit (ICU) were identified as particularly vulnerable groups. Collected in 2022, the

(Amoadu et al., 2023)	n=7315 commercial bus drivers (m=100%). Mean age 39 years (19-64). Ghana and West Africa.	SPSS	Survey interviews conducted at bus terminals using convenient sampling. Instruments used: • Job Content Questionnaire • Work-Family Conflict Scale • Psychosocial Safety Climate Scale • Self-Reported Incident Data	data captures the persistent psychological impact of the pandemic, leading the authors to call for urgent organizational reforms such as reduced on-call duties and staff rotation in high-pressure units. The study established that psychosocial work factors are direct predictors of traffic safety among bus drivers in Ghana and West Africa, with high job demands significantly contributing to driver impairment. A compromised work-life balance was found to cause fatigue and sleep disturbances, which reduce concentration and increase the likelihood of road traffic crashes (RTCs). Notably, minibus drivers reported significantly higher demands, longer hours and more frequent accidents compared to long-bus drivers, who generally benefit from higher autonomy and a safer environment. Conversely, supervisor support and job autonomy acted as protective resources by allowing drivers to manage workloads and take necessary rest breaks. Given that Ghana's road system is among the most dangerous in Africa, these findings highlight the critical need for systemic improvements in driver support and recovery time to reduce daily road fatalities.
(Chandra et al., 2023)	n=574 skilled and unskilled construction laborers (m=66%). Southern India.	SPSS	Standardized questionnaire with two data collection dates. Included tools: • Insomnia Scale (DSM-5) • Burnout Assessment Tool	The study emphasized that sleep quality exerts a more profound and sustained impact on worker behavior than the shift schedule itself. The data revealed that sleep disturbances measured in the early phase of the study were positively correlated with impaired rational abilities nine months later, suggesting a long-term deficit. Interestingly, lack of sleep had a long-lasting effect on a worker's ability to make logical, well-reasoned decisions. In contrast, its effect on general mental tasks (like quick thinking or memory) was only temporary. While shift work consistently negatively affected rational abilities across both phases, age also emerged as a factor: Older workers reported higher levels of disturbed rationality in the later phase of the study. Gender did not show a significant correlation with rational abilities at any point during the research.
(Debela et al., 2022)	n=1136 injured sugar manufacturing workers (m=97.9%). Ethiopia	STATA	Interview-administered semi-structured questionnaires, combined with secondary data from the Bureau of Labour and Social Affairs, industry insurance records and administrative claims.	The study calculated the total economic cost of workplace injuries at over 22.5 million Ethiopian Birr (\$537,800), finding that indirect costs, such as lost productivity, were nearly double the direct costs. Sleep disorders were a primary driver of these expenses, affecting 56% of injured workers and serving as a significant predictor of cost variation. The highest percentage of injuries (42.9%) occurred during the night shift, which researchers linked to fatigue-induced disorientation and slower cognitive processing. Other critical factors increasing financial loss included the severity of injuries, long-term absences and the inconsistent use of safety equipment. Ultimately, the findings suggest that the true burden of industrial accidents is often underestimated because the complex indirect costs associated with sleep-deprived or recovering workers are difficult to quantify.
(El-Khawaga et al., 2025)	n=273 oncology nurses (f=83-1%). Egypt.	SPSS	Two-part questionnaire	Here, a critical level of exhaustion among nursing staff in Egypt was observed, with 24.5% suffering from severe (Grade IV) fatigue and 68.1% reporting the highest category of work-related burden. Severe fatigue was most prevalent among nurses who were married, highly educated, or had less than ten years of experience. This was classified as an "education paradox" where higher degrees often lead to increased clinical and administrative responsibilities. Additionally, high work burden was strongly linked to being unmarried and experiencing financial insecurity, with insufficient income serving as a primary predictor of stress. These findings are framed against a national systemic shortage of nurses, forcing staff into extended shifts. Notably, female oncology nurses faced nearly double the risk of severe fatigue, likely due to the added pressure of balancing high-stress medical duties with traditional domestic roles.
(Ghammam et al., 2025)	n=205 healthcare professionals	SPSS	Pre-test questionnaire and biological testing:	This study found that 37.1% of healthcare professionals from the Farhat Hached University Hospital in Tunisia suffered from chronic fatigue, with 11.2% meeting the clinical criteria for Chronic Fatigue Syndrome, a rate significantly higher than the global general population average of 0.7%. Night shifts

	(f=89.3%). Mean age 43.5 years. Tunisia.		• Multidimensional Fatigue Inventory • CFS Severity Scale • PHQ-9 • SF-12 • Vitamin D3 measurements	and irregular scheduling were identified as primary occupational risk factors, while obesity was found to increase the risk by a factor of 2.5, likely due to breathing issues. Mental fatigue was even more prevalent (67.3%), which the authors characterize as a direct threat to patient safety and diagnostic accuracy. In contrast, maintaining a high health-related quality of life, including adequate rest, provided a 90% reduction of risk. Given the compounding effects of chronic understaffing in resource-limited settings, the researchers advocate for adopting aviation-style fatigue risk management protocols to minimize circadian disruption.
(Hailu Tesfaye et al., 2023)	n=370 garment and textile workers (f=70%). Mean age 30.5 years. Addis Ababa, Ethiopia.	Strata	Proportionate stratified sampling followed by random sampling. Interviewer-administered structured questionnaires. Tools used: • Pittsburgh Sleep Quality Index • FAO Individual Dietary Diversity Score • Caffeine Consumption Questionnaire	The study found an exceptionally high prevalence of poor sleep quality at 75.4% among industrial workers in Addis Ababa, a figure significantly higher than the global average for industrial employees of 36%. The authors attribute this to economic distress and high living costs in this region of Ethiopia. Night shift employees were 2.36 times more likely to experience poor sleep due to the disruption of circadian rhythms, on average obtaining only 6.1 hours of actual sleep and taking over 34 minutes to fall asleep. Dietary and lifestyle habits played a major role in this decline, as workers consuming more than 250 mg of caffeine daily faced a 2.57-fold higher risk because caffeine acts as a competitive antagonist to adenosine, the hormone responsible for regulating sleep cycles. Additionally, an undiversified diet increased the risk 1.63 times by interfering with the production of melatonin and serotonin, while nearly 86% of workers reported using electronic devices before bedtime. Beyond physical factors, 45.7% of workers reported high job stress and 39.5% were dissatisfied with their positions, contributing to a broader crisis of productivity. The researchers also emphasized that poor sleep is a massive economic burden.
(Jaradat et al., 2025)	n=166 nurses (m=58.4%). Hebron, West Bank.	SPSS	Self-administered questionnaires divided into three sections: • Socio-demographic characteristics • Occupational characteristics • Burnout assessment via Arabic version of Maslach Burnout Inventory-Human Services Survey	This study including four Palestinian hospitals identified significant burnout levels among nursing staff, with an overall mean score of 42.1. Those on rotating shifts reported higher depersonalization and greater overall psychological strain linked to circadian disruption. Demographic factors played a major role, as female nurses experienced significantly higher emotional exhaustion and lower personal accomplishment, while unmarried nurses and those without children also showed higher burnout levels, likely due to a lack of social support. Less than 7 years of work experiences also proved to be a factor for higher depersonalization and lower personal accomplishment. Additionally, institutional pressures were evident, with the highest burnout rates found in public hospitals facing heavy patient loads and resource constraints.
(Jawabreh et al., 2025)	n=214 nurses (f=53.7%). Mean age 30.8 years (21-55). West Bank and Gaza Strip.	STATA	Descriptive analytical design with questionnaires. Tools included: • Maslach Burnout Inventory-Health Services Survey	The study found that over half of the nursing staff (57.2%) experienced moderate burnout, with 69.4% suffering from emotional exhaustion. Shift work, specifically night and rotating shifts, was a significant driver of this distress, correlating with higher overall burnout and increased levels of depersonalization due to disrupted sleep and limited recovery time when compared to regular day shifts. Vulnerability was highest among younger nurses and those with less than five years of experience. Interestingly, male nurses reported significantly higher levels of emotional detachment (depersonalization) than their female colleagues, which the authors suggest may be a self-protective coping mechanism. Beyond occupational factors, the researchers highlight that burnout in this region is intensified by chronic staff and supply shortages, overcrowding and political instability.
(Kawakami et al., 2001)	n=21 factory workers. Mean age 35 years (22-56). Can Tho Province, Vietnam.		A participatory, action-oriented program based on the ILO's WISE training model. Included a scheduling overhaul, advisory meetings, Sunday	Collaborative framework between institutes in Japan and Vietnam. Included posture observation, fatigue monitoring, performance metrics and a follow up. This intervention study of Vietnamese factory workers revealed that the original night shift was plagued by extreme fatigue, with workers exhibiting involuntary body shaking and frequent "short sleeps" that peaked around 02:00, directly resulting in a high risk of accidents. This exhaustion made the night shift the least productive period, yielding only 2.8 cylinders per hour compared to 4.5 during the morning shift, particularly as workers were burdened by the heavy manual labor of carrying 54.8 kg oxygen cylinders. Following an intervention that replaced the night shift with a two-shift system

holiday and environmental upgrades.

between 06:00 and 22:00, the factory maintained strong production levels while successfully eliminating sleep-related safety hazards. The study also highlighted the success of low-cost local solutions, such as watering the roof to combat heat and debunked the preference for "docile" labor by showing that valuing worker input and participatory dialogue leads to significantly better safety and health outcomes.

(Lu Francesca & Lu Leilanie, 2021)	n=500 factory workers (f=89.8%). Mean age 23 years (18-33). Manila, Philippines.	Descriptive Statistics	Survey Questionnaire on work schedules, occupational hazards and mental health.	The study identified a strong link between night shift work and the prevalence of mental health symptoms, finding that night workers were 2.13 times more likely to experience frequent psychological distress compared to day workers. This risk was even more pronounced among women, who were 2.97 times more likely to suffer, a trend exacerbated by a "docility" factor where employers in the Philippines prefer female workers under the assumption they are easier to control and less likely to unionize. Insomnia affected 48.8% of respondents, with the resulting circadian disruption and sleep deprivation leading to cognitive impairments, such as a lack of concentration in 63.2% of workers. Beyond physiological disruption, mental health was significantly impacted by environmental hazards which increased the risk 5.78-fold. Job insecurity also emerged as a risk factor, with contractual workers facing higher levels of sadness and boredom. Furthermore, the pressure of forced overtime (reported by 97.2% of participants) and economic inequality in Philippine export zones create a cycle where workers accept high physical and mental strain to compensate for low income within unregulated labor environments.
(Merchaoui et al., 2017)	n=293 nurses and nursing assistants. Mean age 41.7 years. Tunisia.	SPSS	Standardized questionnaire and physical tests. • Work Ability Index • Perceived physical and mental workloads (PPL and MPL) • Physical Capacity Battery	The study emphasizes that while night work disrupts circadian rhythmicity and degrades sleep quality, napping can temporarily stabilize work performance. Rotating shift workers perceived their mental and physical workloads as significantly heavier than day workers, yet their overall Work Ability Index (WAI) remained comparable because they utilized on-shift naps and collaborative task-sharing to cope with the strain. However, this protective effect appears to be short term: Work ability significantly declined with job seniority, suggesting that cumulative shift work causes premature physical aging, particularly after ten years of service. To mitigate the associated risks to patient safety, the researchers recommend implementing planned 20-minute naps in dedicated, quiet areas and suggest that managers move older, more experienced nurses away from rotating schedules to protect their long-term health. Additionally, while the hospitals studied had not yet adopted them, the authors point to therapeutic interventions like bright and blue light therapies as effective tools for managing persistent circadian disturbances.
(Msaad et al., 2024)	n=3074 adults (f=63.1%). Mean age 36.25 years. 19% Engaged in night work. Tunisia	SPSS	Online Survey through Google Forms over 7 months. Tools: • Pittsburgh Sleep Quality Index • Insomnia Severity Index • Epworth Sleepiness Scale • Patient Health Questionnaire-9 • World Health Organization-Five Well-Being Index	This study revealed a general abundance of sleep disturbances among Tunisian adults, with 53.8% reporting poor sleep quality. Nocturnal shift workers specifically slept less than day workers, with an average of 6.85 hours compared to 7.1 hours. These workers also reported lower quality (60.9%), with 52.1% of day workers experiencing low sleep quality. Accordingly, a multivariable analysis determined night work to increase the likelihood of poor sleep by 30%. Other factors affecting sleep length and quality were the female gender, university-level education, internet use close to bedtime and severe depression.
(Mukherjee et al., 2022)	n=298 (198 health professionals, 100 office staff) of a medical college. Eastern India	SPSS	Online survey through Google Forms over 18 months. Tools used: • Perceived Stress Scale • Pittsburgh Sleep Quality Index • Insomnia Severity Scale	The study demonstrated that healthcare professionals suffer significantly more from sleep disturbances than other employee groups, reporting more severe insomnia and poorer overall sleep quality (PSQI 11.52 compared to 6.37). A strong positive correlation was found between perceived stress and sleep degradation in both groups, suggesting that sleep quality declines almost linearly as stress levels rise. Interestingly, a "job satisfaction paradox" emerged among doctors and nurses: while they reported higher job satisfaction, this satisfaction was positively correlated with stress, indicating

			• Job Satisfaction Scale	that the weight of high-level responsibilities contributes to a cycle of stress-induced insomnia. The researchers concluded that constant exposure to irregular shifts alters circadian rhythms, creating a "vicious cycle" of fatigue and burnout that persisted even as pandemic-related stress affected the general workforce.
(Ndongo et al., 2024)	n=331 hospital employees (f=74.9). Douala, Cameroon	StatView	Cross-sectional prospective and analytical design. Tools used: • Pittsburgh Sleep Quality Index • International Physical Activity Questionnaire • Clinical and physiological measurements	The study found an overall poor sleep prevalence of 68.3% among healthcare workers, with significantly higher rates in women (73.5%) and nurses (58.8%). Paramedical staff with more than five years of seniority faced a 67% higher risk of sleep disturbances. A notable distinction emerged between roles: while nurses had poorer overall sleep quality, medical-health technicians were at a significantly higher risk for short sleep duration, likely due to the high mental effort required for laboratory work. Although cardiometabolic risk factors such as obesity and hyperglycemia and low physical activity levels were common in the sample, the study found no statistically significant association between these factors and sleep quality.
(Ranawat & Srivastava, 2017)	n=400 textile mill workers (m=100%). Rajasthan, India	T-Tests, Chi-Square	Structured Interviews. Tools and Measurements: • Standard Shiftwork Index • Physical measurements • Clinical and biochemical tests • Dietary Survey	This study highlights that shift work creates a cascade of metabolic, cardiovascular and gastrointestinal issues, largely driven by extended waking hours and disrupted biological rhythms. Shift workers exhibited significantly higher BMI and waist-to-hip ratios, with nearly half suffering from Stage I hypertension and double the cardiovascular risk of daytime workers. These health declines are compounded by poor lifestyle choices, including higher rates of smoking and alcohol use, alongside a diet alarmingly deficient in fiber and essential nutrients. The irregular meal times common to shift work were found to interfere with the hormonal and enzymatic production necessary for digestion, leading to high rates of appetite disturbance and stomach upsets. Despite these risks and a significant desire among workers to leave shift schedules due to strain, 37% refused to give up their shifts because the schedule enabled them to hold second jobs to meet financial needs.
(S. Shahzad et al., 2025)	n=200 healthcare professionals. Attock, Pakistan	Python	In-person surveys and online forms. Tools and Instruments: • Perceived Stress Scale • Positive and Negative Affect Schedule • Ford Insomnia Response to Stress Test • Shift Work Disorder Index	In this study, age emerged as the primary predictor of stress, with healthcare professionals over 26 reporting significantly higher stress levels than their younger colleagues. While night and double shifts showed a trend toward higher strain, neither shift type nor total weekly hours were statistically significant predictors of stress in this specific group. Participants generally demonstrated resilience, maintaining higher positive emotional states than negative ones despite moderate levels of stress and sleep disturbances. However, the study identified a moderate susceptibility to insomnia under stress, with a clear correlation between perceived stress and sleep vulnerability. This susceptibility was strongly linked to negative emotional states and symptoms of shift work-related dysfunction, such as excessive sleepiness and poor sleep quality. The findings suggest that while these professionals maintain some emotional resilience, irregular work schedules continue to disrupt circadian rhythms and degrade long-term sleep health.
(M. N. Shahzad et al., 2019)	n=93 nurses. Gujrat City, Pakistan.	SPSS	Focus group discussions and questionnaire, split into qualitative and quantitative stages.	The study identified night shifts and the resulting exhaustion as critical drivers of burnout, with night-shift problems increasing the risk by nearly four times. This strain is deeply rooted in the "Theory of Role Strain," where the depletion of physical and emotional energy is worsened by a lack of family support, making night shifts a "nightmare" for parents. Vulnerability also varied by demographic: young, unmarried nurses felt more susceptible to social harassment during night duties, while nurses over the age of 30 saw their burnout risk increase by 23%. Beyond shift timing, the work environment proved to be the most significant factor, increasing burnout risk 5.4 times. Interestingly, the study found a "choice" factor: nurses who entered the profession voluntarily had a 61.6% lower risk of burnout than those who felt forced into the role.

(A. Sime & Worku, 2020)	n=443 steel factory workers (m=97.5%). Mean age 27.47 years. Bishoftu town, Ethiopia	SPSS	Structured face-to-face interviews using a stratified sampling technique, assessing socio economic factors, behavior and injury history.	This study revealed a high prevalence of occupational injuries, with 38.4% of workers reporting an incident annually, mostly as burns caused by hot metal or explosions. Sleep related factors emerged as critical predictors, as workers with sleep disorders were 1.83 times more likely to experience an injury. Night shift schedules specifically doubled the risk, with injuries peaking during the evening at 38.2% and midnight at 21.2%. Beyond physiological factors, the study found that low job satisfaction was associated with a 2.12-fold increase in injury risk, suggesting that psychological engagement plays a vital role in safety. These risks were further compounded by long hours, specifically working more than 48 hours per week and a severe lack of resources, as those without safety training or personal protective equipment faced a nearly fourfold increased injury risk. The study highlights a systemic neglected problem where a lack of national policy and equipment availability leaves over half of injured workers without medical treatment.
(Surani et al., 2015)	n=334 junior physicians (f=60%). Mean age 25.3 years. Karachi, Pakistan.	SPSS	Cross-sectional design using two self-administered questionnaires. Tools included: - Pittsburgh Sleep Quality Index - Epworth Sleepiness scale	The study found that 36.8% of junior physicians were classified as poor sleepers (achieving less than six hours of total sleep time and taking more than 30 minutes to fall asleep, with frequent middle of the night awakenings), with those in this group being twice as likely to experience excessive daytime sleepiness. Gender emerged as a major factor, as 42.2% of female physicians reported poor sleep compared to 28.9% of their male colleagues, a disparity the authors attribute to the added household and family responsibilities often placed on women in the region. Interestingly, age did not show a statistically significant correlation with sleep quality in this specific cohort. These findings highlight that nearly one fifth of the participants suffer from abnormal daytime hypersomnolence, directly impacting their alertness and performance.
(Ugwu et al., 2024)	n=387 healthcare professionals (f=67.7%). Mean age 34.67 years. Southeast Nigeria.	SmartPLS	Purposive sampling with multiple tools: - WHOQOL-BREF - DASS-21 - MSPSS	The findings of this study underscore that night shifts have significant negative health effects, primarily because they disrupt the natural sleep wake cycle and biological rhythms. This disruption was found to significantly deteriorate physical health scores and served as a robust link to mental health issues, with night shift workers reporting increased levels of anxiety, stress and depression. While average working hours between 7 and 10 hours had a slight negative impact on physical quality of life, the presence of social support acted as a crucial moderator that diminished the psychological distress caused by demanding schedules. Conversely, for those lacking such support, the negative connection between irregular work and physical health was even more pronounced. The study also highlighted that healthcare workers in lower income places like Nigeria face intensified challenges due to resource scarcity and overwhelming patient loads, prompting the researchers to advocate for systemic policy changes including revised shift lengths and the integration of self-care training.
(Verma et al., 2018)	n=550 nurses (half working rotating night shifts, half working only day shifts). Delhi, India.	SPSS	Standard Shift Work Index with stratified simple random sampling. Tools included: - Sleep Questionnaire - Chronic Fatigue Scale - Job Satisfaction Scale - General Health Questionnaire - Injury reporting	This study confirmed that rotating night shifts significantly degrade the health and safety of nursing personnel, with these workers reporting significantly lower sleep quantity and quality compared to those on day shifts. Fatigue was cited by half of the participants as the primary cause of recent needle stick injuries, the risk of which was 5.7 times higher for rotating shift workers and 4.9 times higher for those living off campus. Sleep disturbances were particularly prevalent among female nurses and those with a higher number of dependents, while psychological well-being and job satisfaction were notably lower in the rotating shift group, often worsened by the stress of commuting. These issues are especially critical in the Indian healthcare context, where a poor nurse to population ratio and limited resources create an environment of continuous pressure and minimal support. Furthermore, contractual nurses faced increased vulnerability due to higher stress and job insecurity, which nearly doubled their risk of accidental injuries. These findings suggest that the intersection of irregular schedules, living arrangements and employment status creates a combined threat to both worker health and patient safety.

(Yosef et al., 2022)	n=388 operating room clinicians (m=78.9%). Median age 29 years. Northwest Ethiopia.	STATA	Self-administered questionnaires using the United Kingdom Health and Safety Executive's (HSE) Management Standards Work-Related Stress Indicator Tool	This study found a high prevalence of occupational stress of 78.4% among operating room clinicians, with those on rotating shifts being 2.1 times more likely to experience strain than those on fixed schedules. Professional vulnerability was particularly high for anesthetists and nurses, who faced roughly 4 times the risk of stress compared to surgical staff, largely due to the need for continuous vigilance, the unpredictability of outcomes and the fear of litigation. This pressure was complemented by extreme work hours, as working more than 80 hours per week tripled the risk of stress, while recreational substance use was found to double its occurrence. Despite these intense conditions and the added workload of the pandemic, 59% of clinicians perceived good workplace relationships and support from management. The researchers highlighted a vicious cycle where high stress leads to early retirement and training dropouts, worsening staff shortages in lower income countries and further burdening the remaining workforce. The study also noted that being awake for over 24 hours during these long shifts causes performance impairments equivalent to legal alcohol intoxication, posing a severe threat to patient safety and clinician well-being.
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Figure 3: Table of included studies

5.2 Sleep Disturbances as an Occupational Hazard

The prevalence of sleep dysfunction among shift workers in LMICs is consistently high across studies and settings. Among male workers at a shoe factory in Dhaka, Bangladesh, 85% reported sleep disturbances, with rotating schedules identified as the primary driver (Ahasan et al., 1999). The “tiredness cost,” as the authors put it, or the inability to stay awake experienced by these workers, is not just a local occurrence, but rather a major global issue that must be addressed (Ahasan et al., 1999). A comparable pattern emerged in an industrial park in Ethiopia, where 75.4% of workers experienced poor sleep, a figure substantially above the global industrial average of 36%, which the authors attributed in part to economic pressures including elevated living costs in Addis Ababa (Hailu Tesfaye et al., 2023). These workers scored an average of 6.03 on the Pittsburgh Sleep Quality Index (PSQI), where scores above 5 (in a range from 0-21) indicate poor sleep and reported an average sleep onset latency of 34 minutes and only 6.1 hours of actual sleep per night (Hailu Tesfaye et al., 2023). Further evidence of this pattern comes from the Philippines, where approximately 48.8% of respondents suffered from insomnia (Lu Francesca & Lu Leilanie, 2021) and from Cameroon, where 68.3% of healthcare professionals reported poor sleep, with higher rates among women (73.5%) and nurses (58.8%) compared to medical-health technicians (Ndongo et al., 2024).

A central mechanism causing these disturbances is circadian disruption. Night shift work specifically interferes with the body's circadian rhythm, reducing both sleep quantity and quality and impairing alertness and performance (Merchaoui et al., 2017). In a Tunisian study, nocturnal workers slept significantly fewer hours (6.85) than day workers (7.10), with 60.9% experiencing poor sleep compared to 52.1% of their daytime counterparts (Msaad et al., 2024). Nocturnal work was identified as an independent predictor of poor sleep quality, increasing the likelihood by 30%. Notably, however, poor sleep was widespread even among non-shift workers in that sample, with 53.8% of adults reporting poor quality overall. This suggests that structural factors beyond scheduling, such as economic stress and living conditions, may independently impair sleep in LMIC contexts (Msaad et al., 2024). Among 400 male textile workers in Rajasthan, India, Ranawat & Srivastava (2017) similarly confirmed that shift workers suffered disproportionately from sleep-related problems, a finding echoed across the region by Verma et al. (2018), who documented lower sleep scores for both quality and quantity among nurses in India.

In a more severe form, circadian disruption can manifest as Shift Work Sleep Disorder (SWSD), characterized by difficulties sleeping during designated rest periods and excessive sleepiness during wake hours (S. Shahzad et al., 2025). Among Ethiopian nurses, Abate et al. (2023) found a SWSD prevalence of 30.4%, with nurses working more than 11 nights per month facing a 2.5-fold increased risk of developing the disorder.

Healthcare professionals and trainees represent a particularly affected subgroup and findings suggest that severity varies by role and specialty. A study comparing doctors and nurses with other hospital employees in Eastern India found that health professionals suffered significantly more from sleep disturbances: their mean PSQI score was 11.52 versus 6.37 for non-clinical

staff and their Insomnia Severity Index (ISI) scores were correspondingly higher (10.53 vs. 6.21), indicating more severe insomnia (Mukherjee et al., 2022). A strong positive correlation between perceived stress and sleep quality was observed in both groups, suggesting that as occupational stress rises, sleep quality degrades in near-linear fashion. The authors also described a "vicious cycle" in which irregular shift duties disrupt circadian rhythms, compounding fatigue and burnout. Paradoxically, higher job satisfaction among health professionals was itself associated with higher stress, reflecting the weight of clinical responsibility (Mukherjee et al., 2022).

Among junior physicians completing their internship year in Karachi, Pakistan, 36.8% were classified as poor sleepers (PSQI > 5), with 20% scoring abnormally on the Epworth Sleepiness Scale (ESS), indicating excessive daytime sleepiness. Poor sleepers were twice as likely to experience daytime sleepiness, with the most commonly reported disturbances being nocturnal awakenings and prolonged sleep onset (Surani et al., 2015). Anesthesia residents in Cairo showed similarly severe impairment post-shift: subjective sleepiness scores nearly doubled (KSS: 3.34 to 6.24) and ESS scores rose from 6.68 to 14.86, attributable in large part to averaging only 2.74 hours of sleep during night shifts (Abdelhamid et al., 2020). Among surgical residents in the Philippines, Alinab & Diamante (2025) recorded the highest average PSQI scores (9.14), followed by fellows (8.61) and non-surgical residents (8.47), with an overall poor sleep rate of 85% and an average sleep duration of just 5.7 hours.

Not all findings point in the same direction, however. In a Nigerian study of nurses at the Federal Medical Centre in Birnin Kebbi, 61% were classified as poor sleepers, yet 53% showed no tendency toward daytime sleepiness (mean ESS: 7.3), an outcome the authors linked to a hospital policy requiring 7 days off following a 7-day night duty cycle, allowing workers to recover sleep debt (Aliyu et al., 2017). Nonetheless, nurses sleeping fewer than 7 hours per night were significantly more likely to report lower overall sleep quality. Similarly, some studies noted that poor sleep quality does not always translate directly into excessive daytime sleepiness (Aliyu et al., 2017), pointing to the role of recovery time and scheduling design in moderating outcomes.

Across specialties, sleep-related dysfunction appears pervasive: poor sleep quality has been documented across medicine, surgery and pediatrics, attributed to the inherent stress of shift schedules, with surgery departments showing the most unfavorable sleepiness scores (Aliyu et al., 2017). Beyond shift schedules, a Tunisian study of nurses, health technicians and physicians found that 37.1% suffered from chronic fatigue, with 11.2% meeting formal criteria for Chronic Fatigue Syndrome, a rate much higher than the global population estimate of 0.7% (Ghammam et al., 2025). Night shifts and irregular scheduling were identified as the primary occupational risk factors driving this burden (Ghammam et al., 2025).

Finally, it is worth noting context that amplifies baseline occupational risk. The COVID-19 pandemic significantly worsened conditions: in Morocco, 62% of hospital staff reported sleep disturbances during the pandemic alongside elevated burnout risk, as extra workloads and institutional instability intensified pressure in an already demanding environment (Amellah et

al., 2025; Yosef et al., 2022). Structural health system deficiencies also play a role: In Palestine, chronic staff shortages and overcrowding have been linked to elevated burnout risk (Jawabreh et al., 2025), while in Egypt, severe fatigue has been attributed in part to a nurse-to-population ratio well below WHO recommendations (El-Khawaga et al., 2025).

5.3 Occupational Performance

The consequences of sleep dysfunction among shift workers extend well beyond individual health, affecting occupational performance, workplace safety and broader economic productivity. Across industries and professional contexts in LMICs, the evidence consistently links poor sleep and circadian disruption to degraded job performance, heightened accident risk and significant financial costs, forming a chain of harm that begins with a disrupted night's sleep and ends, in the most severe cases, in patient deaths, industrial disasters and national economic burden.

Cognitive Impairment and Reduced Job Performance

Sleep deprivation's most immediate occupational consequence is its effect on cognitive function. Among workers in the Philippines, 63.2% reported a lack of concentration directly attributable to sleep deprivation, which they identified as leading to poor job performance (Lu Francesca & Lu Leilanie, 2021). Irregular work schedules have been more broadly identified as negatively affecting both sleep and occupational performance (S. Shahzad et al., 2025) and rotating shift workers have been shown to perceive significantly higher mental and physical workloads compared to daytime workers because of the way atypical scheduling degrades both cognitive and physical capacity (Merchaoui et al., 2017).

A particularly insightful analysis of this relationship comes from a study of call center workers in Pakistan, where sleep deprivation was identified as the primary driver of reduced job performance for night shift workers (Akhtar & Butt, 2022). Crucially, the study found that the direct effect of night shift work on performance was statistically insignificant: Night shifts do not inherently reduce performance, rather, they do so indirectly, by causing sleep loss and work-life conflict. The authors confirmed a significant sequential mediation chain: night shifts disrupt work-life balance, which generates pressure and stress, which leads to insomnia, which in turn substantially reduces job performance (Akhtar & Butt, 2022). The researchers further highlight that night workers are, in a sense, biological "victims," working precisely when the circadian rhythm of alertness and performance reaches its lowest point (Akhtar & Butt, 2022). Given that Pakistan ranks among the ten largest labor forces in the world, the authors note that the health of its night-shift workforce may represent significant national economic consequences (Akhtar & Butt, 2022).

This biological conflict is compounded by the sheer physical toll of extended wakefulness. Research cited by Abdelhamid et al. (2020) and Yosef et al. (2022) notes that remaining awake for more than 24 consecutive hours produces performance impairments equivalent to a blood alcohol concentration of 1 g/L, the level associated with legal intoxication in many jurisdictions (Abdelhamid et al., 2020; Yosef et al., 2022). In the Egyptian hospital context studied by Abdelhamid et al. (2020), resident shifts can extend to 36 continuous hours, as emergency

duties are routinely followed by scheduled operations, making this level of impairment not an exceptional circumstance but a systemic one (Abdelhamid et al., 2020).

Safety Risks in Healthcare Settings

The implications for patient safety are severe and well-documented across the included studies. Fatigue has been estimated to contribute to between 44,000 and 98,000 hospital deaths annually and in anesthesia specifically, this strain frequently manifests in pharmacological errors such as syringe swaps or incorrect dosing (Abdelhamid et al., 2020). Decreased alertness resulting from sleep deprivation among nurses has been directly linked to increased risk of errors and accidents that can endanger patient lives (Merchaoui et al., 2017) and mental fatigue more broadly has been characterized as a direct threat to patient safety, reducing diagnostic accuracy and increasing susceptibility to clinical mistakes (Ghammam et al., 2025). The consequences of Shift Work Sleep Disorder in this context extend beyond the individual nurse. By increasing the likelihood of medical errors and accidents, SWSD becomes a systemic risk to the healthcare system as a whole (Abate et al., 2023).

One concrete illustration of these risks concerns needlestick injuries (NSIs) among nurses in India. Rotating shift nurses reported higher levels of fatigue and half of the participants in Verma et al.'s (2018) study identified fatigue as the primary cause of their most recent needlestick injury. The odds of experiencing an NSI were 5.7 times higher for rotating shift workers compared to fixed-schedule workers, 4.9 times higher for those living off-campus and nearly twice as high for contractual employees, a finding that underlines how unstable employment conditions interact with fatigue to amplify occupational risk (Verma et al., 2018). Healthcare systems in many lower income countries are already severely understaffed, forcing nurses to work more shifts than would otherwise be the norm, creating stress and further increasing the potential for medical errors (Aliyu et al., 2017).

Industrial and Manufacturing Contexts

Beyond healthcare, the safety consequences of sleep-impaired shift work are equally evident in industrial and manufacturing settings. A study of workers at a gas cylinder manufacturing plant in Vietnam documented the direct effects of nighttime fatigue: during night shifts, workers showed an increase in body shaking as a mechanism to fight sleepiness, yet still frequently fell into brief involuntary "short sleeps," with drowsiness and dullness peaking around 2:00 a.m. (Kawakami et al., 2001). The performance consequences were measurable and substantial: the night shift produced only 2.8 cylinders per hour compared to 4.5 during the morning shift, representing a dramatic loss of productivity. More alarmingly, the study identified a high risk of explosive accidents, as workers responsible for monitoring high-pressure control panels were falling asleep at their posts during night shifts (Kawakami et al., 2001).

In Ethiopia, the financial toll of this dynamic has been quantified directly. A study by Debela et al. (2022) calculated that the total economic cost of occupational injuries to employers amounted to 22,587,635.32 Ethiopian Birr (approximately \$537,800), with indirect costs, primarily presenteeism, the reduced productivity of workers who return to work before full

recovery, accounting for 65.86% of that total (Debela et al., 2022). Sleep disorders were implicated as a significant predictor of cost variation: for each one-unit increase in sleep disorder score, the odds of total cost variation increased by 10% (Debela et al., 2022). Over half of injured participants (55.99%) reported having a sleep disorder and the highest proportion of injuries occurred during night shifts (42.87%), compared to morning (36.44%) and afternoon (20.69%) shifts. The authors identify sleeping disorders as a major driver of fatigue, which in turn produces the slow thinking and disorientation that makes industrial accidents more likely (Debela et al., 2022).

A related study by Sime & Worku (2020), also conducted in Ethiopia, found that 38.4% of industrial workers reported an occupational injury in the previous year. Workers who worked between 3.25 and 3.75 night shifts per week were 2.14 times more likely to be injured than those who did not work nights and workers with sleep disorders were 1.83 times more likely to suffer an injury, as impaired concentration and reduced ability to maintain environmental awareness significantly increase exposure to harm (Sime & Worku, 2020). Working more than 48 hours per week was similarly associated with elevated injury rates. The injuries themselves were most common in the lower arms (25.8%), lower legs (16.8%) and fingers (15.2%), with burns, often caused by contact with hot metal or fire explosions, accounting for 43.5% of cases and injuries peaking in the evening (38.2%) and at midnight (21.2%) (Sime & Worku, 2020). These figures exist within an unpleasant reality: fatal injury rates in lower income countries are estimated to be three to four times higher than in richer nations, yet occupational health remains a neglected priority across much of the LMICs (Sime & Worku, 2020). The broader economic scale of this neglect is significant: Work-related injuries and diseases are estimated to cost approximately 5% of global gross national product (Sime & Worku, 2020).

Transport and Road Safety

The occupational consequences of fatigue and sleep disruption are not confined to healthcare or manufacturing. Among commercial drivers in Ghana, compromised work-life balance was found to produce fatigue and sleep disturbances that significantly impaired driving performance, with psychological demands and work-family conflict emerging as significant positive predictors of road traffic crashes (Amoadu et al., 2023). The study identified notable disparities between driver categories: minibus drivers reported significantly higher job demands, longer daily and weekly driving hours and more frequent near-miss incidents and crashes compared to long-bus drivers. Long-bus drivers, however, faced their own distinct risks, frequently driving alone without a co-driver for support, despite covering longer routes, leaving them without the safety net of driver rotation that minibus operators more commonly employed. Long-bus drivers also reported higher levels of decision autonomy and a better psychosocial safety climate, suggesting that structural working conditions, not just hours alone, shape fatigue-related risk in this sector (Amoadu et al., 2023).

Attitudes Toward Shift Work

It is worth noting that workers are not passive in their awareness of these conditions. In Bangladesh, 73% of factory workers reported disliking the shift system, yet this widespread

dissatisfaction did not translate into overall job dissatisfaction, with 57% remaining satisfied with other components of their employment such as wages and labor-management relations (Ahasan et al., 1999). The authors suggest this apparent paradox may reflect the economic reality of the labor market in Bangladesh, where job scarcity and fear of unemployment constrain workers' willingness to act on their dissatisfaction or advocate for schedule changes (Ahasan et al., 1999). This dynamic points to a structural dimension of the problem: in contexts where workers cannot afford to leave or complain, the occupational harms of shift work are likely to persist even when they are well understood by those experiencing them.

5.4 Physical Health

The physical health burden of shift work in LMICs extends far beyond sleep loss itself, manifesting across multiple bodily systems in ways that accumulate over a worker's career and interact with one another towards accumulative health issues. Sleep deprivation and circadian disruption are not simply nighttime inconveniences: They reshape eating behaviors, hormonal regulation, cardiovascular function and metabolic health in ways that are well-documented across the studies included in this review. Critically, many of these physical health consequences are bidirectional: Shift work produces behaviors and conditions that worsen sleep, which in turn deepens physical deterioration, creating self-reinforcing cycles that become increasingly difficult to interrupt the longer a worker remains in a shift system.

General Health and Gastrointestinal Consequences

A foundational indication of shift work's broad physical toll comes from Ahasan et al. (1999), who found that 83% of shift workers in their Bangladeshi cohort suffered from general health problems, with 78% experiencing irregularities in their mealtimes. These figures are striking in their scope, suggesting that physical health disruption is not a marginal consequence of shift work but a near-universal one in this population (Ahasan et al., 1999). Irregular mealtimes are not merely an inconvenience: Ranawat & Srivastava (2017) note that atypical eating schedules interfere with the production of hormones and enzymes necessary for proper digestion, creating a physiological basis for the gastrointestinal complaints that shift workers report (Ranawat & Srivastava, 2017). In their study of textile workers in Rajasthan, India, 43.5% of shift workers experienced regular disturbed appetite and 44.5% reported frequent stomach upsets, compared to substantially lower rates among daytime workers (Ranawat & Srivastava, 2017).

Extended waking hours further drive unhealthy eating behaviors. Shift workers consumed significantly more fried foods and tea during odd hours than their daytime counterparts and their diets were found to be alarmingly deficient in fiber, beta-carotene and folic acid — often receiving less than half of the recommended levels of these nutrients (Ranawat & Srivastava, 2017). This dietary picture, combining excess consumption of low-quality foods with deficiency in essential micronutrients, creates conditions that predispose workers to a cascade of downstream health problems (Ranawat & Srivastava, 2017). The hormonal dimension of diet is also significant: Hailu Tesfaye et al. (2023) note that both the timing and content of meals directly affect the production of melatonin and serotonin, hormones that are critical for regulating the circadian clock. Workers with an undiversified diet were 1.63 times more likely

to suffer from poor sleep quality, establishing a clear link between nutritional inadequacy and sleep dysfunction that runs in both directions. Poor sleep disrupts appetite regulation and poor diet disrupts the hormonal architecture of sleep (Hailu Tesfaye et al., 2023).

Substance Use and Lifestyle Factors

The lifestyle consequences of shift work extend into patterns of substance use that further negatively affect physical health. Alcoholism and smoking were significantly more prevalent among shift workers in the Indian textile cohort (Ranawat & Srivastava, 2017) and recreational substance use more broadly has been found to double the occurrence of occupational stress. It thus establishes itself as both a response to the pressures of shift work and an amplifier of its negative consequences (Yosef et al., 2022). Caffeine consumption represents a particularly common and physiologically meaningful coping behavior: workers consuming more than 250 mg of caffeine per day (roughly equivalent to two to three cups of coffee) faced a 2.57-fold higher risk of poor sleep quality (Hailu Tesfaye et al., 2023). The mechanism is well understood: caffeine and theobromine act as competitive antagonists to adenosine, the hormone responsible for regulating sleep-wake cycles, effectively suppressing the biological signal for sleep and disrupting its natural onset (Hailu Tesfaye et al., 2023). Workers who use caffeine to manage daytime fatigue thus inadvertently worsen the nighttime sleep that would otherwise help recover that fatigue, locking themselves into a cycle of stimulant dependence and deepening sleep debt (Hailu Tesfaye et al., 2023).

In the specific context of Eastern Ethiopia, khat use emerges as a particularly significant substance use concern. Khat is a widely consumed plant-based stimulant in the region containing cathinone, a compound with amphetamine-like activity that directly interferes with sleep regulation (Abate et al., 2023). Among Ethiopian nurses, khat use in the previous twelve months had the strongest association with Shift Work Sleep Disorder of any variable examined, increasing the odds of developing SWSD by nearly fivefold (Abate et al., 2023). This finding highlights how locally specific culture and substance use practices can dramatically affect the sleep and health consequences of shift work, emphasizing the importance of regional contextualization for any systematic review drawing on studies from diverse LMIC contexts.

Technology use before bedtime represents a further lifestyle factor with implications for sleep quality. In the Ethiopian industrial worker cohort, 85.9% of participants reported using electronic devices before sleep, a behavior well-established in the broader literature as disruptive to melatonin production and sleep onset through blue light exposure and cognitive stimulation (Hailu Tesfaye et al., 2023). While the included studies do not extensively elaborate on this finding, its near-universal prevalence in the sample suggests it deserves attention as a modifiable behavioral factor in future intervention research.

Obesity, Metabolic Health and Fatigue

The dietary and behavioral consequences of shift work translate directly into measurable anthropometric differences. Ranawat & Srivastava (2017) found that shift workers had significantly higher BMI and waist-to-hip ratios compared to non-shift workers, with more overweight (36.5%) and obese (7.0%) individuals in the shift-working group (Ranawat &

Srivastava, 2017). Poor sleep quality was more broadly linked to unhealthy lifestyles across medical professional populations in the Philippines, particularly affecting physical activity levels, nutrition and social relationships (Alinab & Diamante, 2025). This finding underlines how sleep dysfunction and poor health behaviors form a cycle rather than a simple one-directional relationship.

Obesity itself functions as an independent driver of further health deterioration. Ghammam et al. (2025) found that obesity increased the risk of chronic fatigue 2.5-fold, a relationship the authors attribute to several intersecting mechanisms: sleep-disordered breathing conditions such as obstructive sleep apnea, systemic inflammation, insulin resistance and reduced physical activity, all of which are both consequences of poor sleep and contributors to further sleep disruption (Ghammam et al., 2025). This bidirectionality is important. Shift work promotes weight gain through disrupted eating and reduced activity and the resulting obesity then worsens sleep quality and fatigue, creating a self-reinforcing cycle that becomes increasingly difficult to interrupt the longer a worker remains in a shift system.

The cardiometabolic picture is not uniform across studies, however. While Ndongo et al. (2024) found high prevalences of obesity (34%) and hyperglycemia (40.6%) among workers with poor sleep in their Cameroonian cohort, they did not find statistically significant associations between poor sleep quality and cardiometabolic risk factors or physical activity levels in that specific population (Ndongo et al., 2024). This null finding is worth noting, as it suggests that the relationship between shift work, sleep and metabolic outcomes is context dependent and can differ depending on factors such as diet, cultural practices, or the specific nature of the work. The creation of a clearer metabolic overview would warrant further investigation.

Cardiovascular Health

The cardiovascular consequences of shift work represent perhaps the most clinically serious dimension of its physical health burden. Among the textile workers studied by Ranawat & Srivastava (2017), nearly half of shift workers (49.0%) were classified as Stage I hypertensive, compared to 35.0% of non-shift workers (Ranawat & Srivastava, 2017). This substantial difference reflects the sustained physiological stress of circadian disruption and sleep deprivation on the cardiovascular system. More strikingly, shift workers were more than twice as likely to fall into the high-risk category for cardiovascular disease (20.5%) compared to their daytime counterparts (9.5%) (Ranawat & Srivastava, 2017). These findings connect naturally to the broader metabolic profile described above: elevated BMI, poor diet, higher rates of smoking and alcohol use and disrupted hormonal regulation all contribute independently and collectively to cardiovascular risk.

The cumulative and accelerating nature of this exposure is underlined by findings on career seniority. Symptoms such as dizziness and breathlessness appeared earlier in the careers of shift workers than daytime workers, with onset occurring within two to five years of employment in the shift system (Ranawat & Srivastava, 2017). This accelerated symptom onset suggests that the cardiovascular toll of shift work is not simply a product of long-term cumulative exposure but begins to manifest relatively early, with significant implications for how quickly

occupational health interventions need to be deployed to be effective. A workforce experiencing elevated rates of hypertension, cardiovascular risk, fatigue-driven obesity and gastrointestinal dysfunction is not only a population with poor health outcomes, it is a workforce with diminished capacity, higher absenteeism, greater presenteeism costs and increased vulnerability to the errors and accidents documented in the previous chapter. Physical health deterioration and lower occupational performance are not separated tracks but deeply interconnected ones, each affecting the other in ways that make the total burden of shift work substantially greater.

5.5 Mental Health

The mental health consequences of shift work represent one of the most pervasive and multidimensional burdens documented in this review. Across diverse LMIC contexts — from industrial workers in the Philippines to nurses in Palestine and Nigeria — the evidence consistently points to a workforce experiencing elevated rates of psychological distress, cognitive impairment, burnout and emotional exhaustion. These outcomes are not incidental byproducts of demanding jobs but are structurally produced by the specific mechanisms of shift work: circadian disruption, sleep deprivation, reduced recovery time and the chronic mismatch between biological rhythms and work.

Cognitive Impairment

The cognitive consequences of sleep deprivation among shift workers are measurable, clinically significant and in some cases long-lasting. Among anesthesia residents in Cairo, a single night shift produced marked deterioration across multiple cognitive domains. Mean reaction time on the Psychomotor Vigilance Task slowed significantly, from 302.1 milliseconds before the shift to 371.9 milliseconds afterward, a change that directly shows reduced alertness and slower problem-solving capacity (Abdelhamid et al., 2020). Mental flexibility, assessed through Trail Making Tests, similarly declined: Completion times increased for both Part A (38.8 to 44.8 seconds) and Part B (63.1 to 72.6 seconds), indicating impaired processing speed and executive function (Abdelhamid et al., 2020). Interestingly, the number of cases worked during the shift did not significantly correlate with the degree of cognitive impairment, with the exception of TMT-B results. This suggests that it is the duration and timing of the shift, rather than its busyness, that primarily drives cognitive fatigue (Abdelhamid et al., 2020).

In a separate study focusing on construction workers in southern India, Chandra et al. (2023) found that shift work negatively affected rational abilities, with the impact on sleep quality proving more significant than the effect of the shift schedule itself, an important distinction that suggests sleep loss, rather than shift work as a work format, is the primary driver of cognitive harm (Chandra et al., 2023). While impacts on cognitive behavior appeared relatively temporary, the correlation between sleep disturbances and impaired rational abilities was both stronger and more sustained over time: Sleep disturbances measured in an early phase were positively correlated with impaired rational abilities nine months later. This longitudinal finding is significant, as it suggests that the cognitive toll of chronic sleep disruption is not

simply recovered between shifts but accumulates in ways that may affect workers' reasoning capacities over the course of their careers (Chandra et al., 2023).

Occupational Stress and Its Drivers

Beyond the direct cognitive effects of sleep loss, shift work produces substantial occupational stress that itself becomes fuel for further psychological deterioration. The relationship between stress and sleep disruption is bidirectional and self-reinforcing: using the Ford Insomnia Response to Stress Test (FIRST), S. Shahzad et al. (2025) identified a clear stress-insomnia correlation among healthcare professionals in Pakistan, with a mean score of 19.15 on the 9–36 scale indicating moderate susceptibility to developing insomnia under stress (S. Shahzad et al., 2025). A significant positive correlation between perceived stress and insomnia vulnerability was confirmed, suggesting that as stress levels rise, sleep health declines. As a result, stress increases further, creating another co-dependent loop (S. Shahzad et al., 2025). A near-identical pattern was documented in a study at a Government Medical College in India, where participants' sleep health declined alongside rising perceived stress levels (Mukherjee et al., 2022). Notably, this study also uncovered a job satisfaction paradox: while health professionals reported significantly higher job satisfaction than other employees, their satisfaction scores were positively correlated with stress, suggesting that higher job responsibilities generate stress even in workers who find meaning in their work, which in turn contributes to insomnia (Mukherjee et al., 2022).

The prevalence of occupational stress in specific shift work contexts is strikingly high. Among Ethiopian operating room clinicians in a study by Yosef et al. (2022), 78.4% reported occupational stress. The authors link this figure to a clear set of structural and professional risk factors. Clinicians on rotating shifts were 2.1 times more likely to experience stress than those on fixed schedules, while those working more than 80 hours per week faced a 3.3-fold increased risk compared to those working fewer than 50 hours (Yosef et al., 2022). Professionally, anesthetists emerged as the most vulnerable group, with 87.0% reporting occupational stress and a 4.1-fold higher likelihood of stress compared to surgical staff. Nurses followed closely with a 4.0-fold elevated risk (Yosef et al., 2022). The authors attribute the particular vulnerability of anesthetists to the demands of constant vigilance, the unpredictability of surgical outcomes and the persistent fear of litigation. These pressures compound the physiological strain of shift work with a layer of high-stakes responsibility (Yosef et al., 2022). The COVID-19 pandemic further intensified these pressures by introducing additional workload and institutional instability into an already overburdened environment (Yosef et al., 2022).

A comparably high prevalence of occupational stress (77.7%) was identified among industrial workers from Benin in a study by Adjobimey et al. (2022), highlighting that this burden is not confined to healthcare. The authors describe a relationship between sleep disruption and workplace demands in which industrial night work directly influences the sleep-wake cycle, creating physiological conditions that favor the development of insomnia. Crucially, insomnia in this context is framed not merely as a symptom but as a stressor of its own, one that can push

workers toward negative coping behaviors including alcohol abuse and the use of psychotropic substances, connecting directly to the substance use patterns discussed in the physical health chapter (Adjobimey et al., 2022). While shift work was a significant factor in univariable analysis, it did not emerge as an independent predictor in the final multivariable model. Rather, the findings suggest that the critical issue is the combination of sleep loss and heavy workload, with high-intensity physical activity also significantly associated with increased stress (aOR 1.33). This in turn is reflected through a state of multidimensional physical overload (Adjobimey et al., 2022). The authors conclude that night shifts and irregular schedules represent the most harmful conditions for worker health, producing long-term reductions in both work efficiency and physical wellbeing (Adjobimey et al., 2022).

Psychological Distress: Anxiety, Depression and Stress

Night shift work is consistently associated with elevated rates of anxiety, depression and psychological distress across the included studies. Among workers in the Philippines, night shift workers were 2.13 times more likely to experience frequent mental health symptoms compared to day workers, with the most prevalent symptoms beyond concentration difficulties being sadness and depression (57.8%) and boredom (52.0%) (Lu Francesca & Lu Leilanie, 2021). Exposure to occupational hazards functioned as additional supplements to this risk: workers frequently exposed to physical risks such as heat or ergonomic hazards were 5.78 times more likely to experience frequent mental health symptoms. Thus, the psychological burden of shift work is compounded by the broader conditions of the work environment rather than operating in isolation (Lu Francesca & Lu Leilanie, 2021).

Among Nigerian nurses studied by Ugwu et al. (2024), night shifts were associated with significantly elevated levels of anxiety ($\beta = 3.78$), stress ($\beta = 3.9$) and depression ($\beta = 1.46$) compared to day shift workers, with overall psychological wellbeing substantially better among daytime workers. Night shifts produce distress, which in turn reduces quality of life, meaning that addressing mental health outcomes is not separable from addressing the broader wellbeing consequences of shift scheduling (Ugwu et al., 2024). Among healthcare workers studied by Abate et al. (2023) in Ethiopia, significant proportions of staff reported symptoms of anxiety (29.5%), depression (27.1%) and stress (16.5%) (Abate et al., 2023). These figures, while varying in magnitude across studies, point to a consistent pattern of psychological burden distributed across the nursing workforce in LMIC healthcare settings.

The relationship between chronic fatigue and depression deserves particular attention. Ghammam et al. (2025) found a clear and pronounced association between the two, with chronically fatigued workers facing up to a sixfold increased risk of depression. Chronic fatigue was also found to directly diminish quality of life independent of other variables, meaning it is serious clinical condition on its own rather than simply a symptom of overwork (Ghammam et al., 2025). These findings connect back to the physical health chapter, where chronic fatigue was identified as affecting 37.1% of the Tunisian healthcare cohort, with 11.2% meeting formal criteria for Chronic Fatigue Syndrome (Ghammam et al., 2025). The mental health dimension of the syndrome adds to what these health professionals consistently endure in their occupation.

Burnout and Emotional Exhaustion

Burnout represents a final point of sustained psychological strain and its prevalence among shift workers in LMICs is consistently high across the included studies. Among nurses in Palestine studied by Jawabreh et al. (2025), more than half of participants (57.2%) reported moderate levels of burnout, with nurses working rotating or night shifts demonstrating significantly higher overall burnout scores than those on day shifts ($p = .03$). Shift workers in this cohort also exhibited significantly higher levels of depersonalization, the emotional detachment and distancing from patients that is a hallmark of advanced burnout, likely attributable to disrupted sleep cycles and the limited recovery time of rotating schedules (Jawabreh et al., 2025). In a Jordanian nursing cohort studied by Jaradat et al. (2025), the overall mean burnout score of 42.1 indicated significant burnout levels across the staff, with rotating shift nurses scoring higher (43.4) than non-shift workers (39.5) and showing elevated depersonalization specifically (Jaradat et al., 2025). While the difference in total burnout scores between the two groups did not reach statistical significance ($p = 0.187$), the authors emphasize that shift rotations remain a major contributor to psychological strain and circadian disruption (Jaradat et al., 2025). This conclusion is supported by the broader pattern of evidence across the review.

The risk of burnout is also influenced by the specific experience of difficulty during night shifts. M. N. Shahzad et al. (2019) found that experiencing problems during night shifts was associated with a 3.9-fold increase in the risk of burnout, meaning that the subjective experience of struggling through night work, rather than simply working nights, is a key driver of psychological deterioration (M. N. Shahzad et al., 2019). This distinction is meaningful for intervention design: it suggests that reducing the difficulty of night shifts through better staffing, scheduling support, or adequate recovery time may be as important as reducing their frequency (M. N. Shahzad et al., 2019). The systemic consequences of burnout extend beyond individual workers: Yosef et al. (2022) note that high stress levels in LMIC healthcare settings lead to early retirement and training drop out, which worsens pre-existing staff shortages and further increases the burden on the remaining workforce (Yosef et al., 2022), a feedback loop that connects individual psychological harm to the structural fragility of health systems more broadly, a theme that will be developed further in the discussion.

Job Satisfaction, Psychological Wellbeing and Intention to Leave

Beyond clinical diagnoses of burnout and depression, shift work produces subtler but still relevant effects on workers' psychological wellbeing and their relationship to their work. Among rotating night shift nurses in India, psychological wellbeing scores were significantly lower than among day shift counterparts ($p = 0.047$) and job satisfaction was significantly reduced ($p = 0.04$), with dissatisfaction further compounded by the stress of commuting for those living outside the hospital (Verma et al., 2018). Among Indian textile workers, approximately 25.5% expressed a desire to leave shift work entirely for a regular daytime job, citing the cumulative strain of the schedule (Ranawat & Srivastava, 2017).

Employment insecurity also intersects with mental health vulnerability in important ways. Among workers in the Philippines, contractual employees were 2.33 times more likely to experience mental health issues compared to permanent staff (Lu Francesca & Lu Leilanie, 2021). Workers without job security face the psychological burden of shift work without the institutional protections such as sick leave, recovery days, or scheduling flexibility that might otherwise be of aid (Lu Francesca & Lu Leilanie, 2021).

5.6 Demographics and Predictors

The experienced difficulties of shift work are not uniform across populations. Age, gender, marital status, educational background, professional role and employment conditions all shape the degree to which individual workers are vulnerable to the sleep dysfunction, psychological distress and physical health consequences documented in previous chapters. Understanding these demographic and occupational predictors is essential not only for characterizing the populations most at risk but also for designing targeted interventions that account for the specific vulnerabilities of different worker groups.

Gender

Gender emerges as one of the most consistent predictors of shift work related health outcomes across the included studies. Female workers are disproportionately affected across multiple dimensions of sleep and psychological health. Among junior physicians in Pakistan, for example, female gender was significantly associated with poorer sleep quality, with 42.2% of female workers classified as poor sleepers compared to 28.9% of males (Surani et al., 2015). The authors attribute this in part to the additional burden of household and family responsibilities that women in the region disproportionately carry (Surani et al., 2015). Among nurses in India, sleep issues were similarly associated with female gender, living outside the hospital campus and having a higher number of dependents in the family, suggesting that domestic responsibilities add to the physiological burden of shift work in ways that affect women more (Verma et al., 2018). In Tunisia, female gender was identified as an independent risk factor for poor sleep alongside smoking, university level education, internet use close to bedtime and severe depression (Msaad et al., 2024), while in Cameroon, paramedical women were found to face an elevated risk of poor sleep compared to their male counterparts (Ndongo et al., 2024).

The gender difference is particularly prominent when it comes to Shift Work Sleep Disorder. Female nurses were 2.4 times more likely than male nurses to suffer from SWSD, a difference Abate et al. (2023) attribute to hormonal cycles that can independently disrupt sleep patterns and increase nocturnal waking frequency, worsened by the circadian disruption already produced by shift scheduling. These cycles include such as menstrual and menopausal fluctuations, for example (Abate et al., 2023). Among workers in the Philippines, women on night shifts were 2.97 times more likely to experience frequent mental health symptoms than their male counterparts (Lu Francesca & Lu Leilanie, 2021). The authors place this finding within a structural context: Employers in Philippine export processing zones reportedly prefer female workers on the basis that they are perceived as more compliant and easier to manage, a

phenomenon coined the “docility factor” (Lu Francesca & Lu Leilanie, 2021). Multinational companies operating in these zones have been found to exploit deregulated labor laws common in LMICs, creating poor working conditions that disproportionately affect women. Workers, often female, frequently accept higher workloads and bad conditions in order to maximize income, with 97.2% reporting overtime work driven by financial necessity rather than choice (Lu Francesca & Lu Leilanie, 2021). This intersection of gender, economic vulnerability and general labor conditions transforms what might appear to be an individual health outcome into a systemic one, a point that will be developed further in the discussion.

Among nursing populations specifically, gender specifically interacts with burnout. In a Palestinian oncology nursing cohort, male nurses reported significantly higher depersonalization scores ($p = .003$) than their female counterparts (Jawabreh et al., 2025). The authors interpret this as a culturally specific coping strategy: in the context of terminal care in a male dominated society, emotional detachment may function as a self-protective mechanism through which male nurses manage the intense emotional demands of their work. Female nurses in the same cohort, by contrast, experienced significantly higher emotional exhaustion and reduced personal accomplishment, with unmarried nurses and those without children also demonstrating higher burnout scores, a pattern the authors attribute to reduced access to social support systems and coping resources (Jaradat et al., 2025). The picture that emerges is one in which gender shapes not only the magnitude of burnout but the form it takes, with women more likely to experience emotional exhaustion and men more likely to respond through detachment.

Age and Experience

Age presents a more complex and at times contradictory pattern across the included studies. In the Pakistani healthcare cohort studied by S. Shahzad et al. (2025), age emerged as the strongest predictor of occupational stress, with professionals in the 26 to 45 and over 45 age groups reporting significantly higher stress levels than those aged 18 to 25 (S. Shahzad et al., 2025). A similar trend was observed by Chandra et al. (2023), who found a negative correlation between age and rational abilities in the late phase of their study, with older workers reporting higher disturbances in rational function nine months into the study period (Chandra et al., 2023). By contrast, Surani et al. (2015) found no statistically significant correlation between age and poor sleep quality in their cohort of junior physicians in Karachi, while gender emerged as the dominant predictor in that population (Surani et al., 2015). These inconsistencies across studies likely reflect a more complex relationship between different factors such as age, years of experience and accumulated occupational exposure, warranting further research.

The relationship between professional experience and health outcomes is also complex. In Nigerian hospitals, poor sleep quality was most prevalent among nurses with five or fewer years of experience. This finding is consistent with the general pattern identified across studies suggesting that junior workers suffer more of the sleep burden, possibly due to less favorable scheduling and limited ability to negotiate shift preferences (Aliyu et al., 2017). Among oncology nurses in Palestine, younger nurses under 30 and those with five or fewer years of experience exhibited significantly greater burnout and lower personal accomplishment

(Jawabreh et al., 2025), while in Egypt, younger nurses under 30 and female nurses showed significantly higher levels of fatigue in initial assessments. The authors connect this to combined pressures of high stress clinical work and traditional domestic roles (El-Khawaga et al., 2025). In Cameroon, however, the opposite pattern emerged for sleep specifically: paramedical personnel with more than five years of seniority were at higher risk of poor sleep (OR = 1.67), suggesting that cumulative exposure to shift work over a longer career may eventually erode the physiological resilience that younger workers may have (Ndongo et al., 2024).

Career motivation also affects burnout risk in ways that intersect with age. Among nurses in Pakistan, entering the profession by choice served as a protective factor against burnout (OR = 0.3837), while nurses over the age of 30 faced a 23% higher risk of burnout than their younger counterparts (M. N. Shahzad et al., 2019). This may reflect the accumulated toll of years of shift work or the growing weight of family and financial responsibilities mid-career.

Marital Status and Family Responsibilities

Marital status emerges as a significant but variable predictor across the included studies. Being married was independently associated with severe fatigue among Egyptian nurses (AOR = 2.8), likely a result of the combination of demands from clinical shift work and domestic responsibilities. Again, it is particularly women who hold the higher share of household labor in the regional context (El-Khawaga et al., 2025). In the same cohort, high burden was independently associated with being unmarried (AOR = 2.2) and reporting insufficient income (AOR = 2.8), suggesting that the absence of a domestic partner may reduce access to emotional and practical support (El-Khawaga et al., 2025). Among non-surgical residents in the Philippines, being married was significantly associated with longer sleep duration, with the authors suggesting that the emotional support and domestic stability of marriage may offer a buffering effect on sleep quality (Alinab & Diamante, 2025). Marital status was also linked to higher stress in univariate analyses among Pakistani healthcare workers, alongside exposure to secondhand smoke and body weight as additional stressors (S. Shahzad et al., 2025).

The specific burden of family responsibilities on women in shift work contexts has been noted across multiple studies and connects directly to the gender findings discussed above. In Pakistan, young and unmarried nurses reported feeling particularly vulnerable to harassment during night shifts, while nurses with children described significant disruption to family life as a consequence of irregular scheduling (M. N. Shahzad et al., 2019). Taken together, these findings suggest that marriage carries a dual and context dependent potential: Where domestic responsibilities are equally shared and emotional support is present, it may help with the psychological and sleep related issues of shift work. However, where the burden of household labor falls on one partner, it complements rather than alleviates occupational fatigue.

Educational Level and Professional Role

Education and professional role are less consistently examined across the included studies but can be seen as meaningful predictors in several contexts. Highly educated nurses in Egypt were at significantly higher risk for severe fatigue (AOR = 2.2 for bachelor's degree or higher), which

the authors attribute to the greater clinical and administrative responsibilities typically assigned to more qualified staff (El-Khawaga et al., 2025). This relates back to the job satisfaction paradox identified by Mukherjee et al. (2022), in which higher professional responsibility generates stress even among workers who find their work meaningful. University level education was also identified as an independent risk factor for poor sleep in the Tunisian general population cohort (Msaad et al., 2024). In Moroccan hospitals, working in the Intensive Care Unit was identified as the most demanding environment, showing the strongest associations with high stress and emotional exhaustion compared to other departments (Amellah et al., 2025). Nurses were found to be more vulnerable than doctors, reporting significantly higher levels of stress and emotional exhaustion, likely due to closer patient contact and heavier workload demands (Alinab & Diamante, 2025). Among surgical residents, sleep quality was found to be the poorest of any medical subgroup, as documented in earlier chapters. In contrast, working hours led to lower total sleep duration among non-surgical residents (Alinab & Diamante, 2025).

Migration and Social Displacement

A dimension that receives relatively limited attention in the included literature but still deserves acknowledgment is the situation of migrant healthcare workers. Ugwu et al. (2024) note that migrating health workers may face unique challenges as they enter unfamiliar work cultures, institutional norms and professional hierarchies, often without access to the social support systems including family networks, community ties or established friendships (Ugwu et al., 2024). The intersection of migration, social isolation and occupational stress in LMIC healthcare workforces remains insufficiently studied and the experiences of migrant workers within these systems may differ substantially from those of local staff. This is a dimension that deserves greater attention in future research.

5.7 Social Impacts

The consequences of shift work extend well beyond the individual worker and the occupational setting. It permeates family life, social relationships, financial stability and cultural identity. While previous chapters have addressed the physiological and psychological toll of irregular scheduling, the social dimension of it deserves its own section. Shift work does not merely make workers tired and unwell, it affects the time and energy available for relationships roles and activities outside of work. Across the included studies, the social impacts of shift work in LMICs emerge as both personal and structural, shaped by cultural expectations, economic necessity and the presence or absence of support.

Disruption to Family and Social Life

The most immediate and widely reported social consequence of shift work is the disruption of family and personal relationships. Among Bangladeshi factory workers studied by Ahasan et al. (1999), the figures are striking: 75% reported disturbances to family life, 72% reported marital problems and 65% described restricted social lives as a direct consequence of their shift schedules. Additionally, 80% struggled with restricted leisure time and difficulties maintaining friendships (Ahasan et al., 1999). These figures suggest that for the majority of shift workers

in this cohort, the social costs of irregular scheduling were not mere inconveniences but fundamental disruptions of their daily lives.

This disruption functions through several intersecting mechanisms. In Pakistan, where family norms are strongly oriented toward collective values and shared domestic routines, the inconsistency between a night worker's schedule and the daytime rhythms of family life creates particular pressure: Workers frequently compromise their sleep in order to participate in family activities and maintain social bonds, effectively trading biological recovery for relational work (Akhtar & Butt, 2022). This dynamic illustrates a tension that runs throughout the social impacts literature: the same workers who are most physiologically in need of rest are often the ones who sacrifice it because of cultural norms. Drawing on the Theory of Role Strain, M. N. Shahzad et al. (2019) offer a theoretical framework for understanding this dynamic among nurses in Pakistan: Nurses deplete their emotional and physical energy reserves at work, leaving insufficient resources for family duties. Without strong family support to help replenish that energy, the resulting work and family conflict creates rapid exhaustion and burnout (M. N. Shahzad et al., 2019). The social and the occupational aspects are thus not separate but deeply interpenetrating ones.

Social Support as a Protector and Risk Factor

The presence or absence of social support emerges across multiple studies as one of the most powerful moderators of shift work related health outcomes. Ugwu et al. (2024) found that perceived social support acted as a crucial aid, significantly diminishing anxiety and stress caused by demanding work schedules. For workers with lower levels of social support, the negative relationship between shift scheduling and physical health outcomes, including sleep quality, was even more pronounced, suggesting that social isolation does not merely add to occupational strain but amplifies it (Ugwu et al., 2024).

The specific sources of support matter too. Among nurses in Pakistan, unfavorable support from the working environment increased the risk of burnout by 5.39 times, while unfavorable family support increased it by 3.91 times (M. N. Shahzad et al., 2019). These are among the largest effect sizes documented in the review for any single predictor of burnout, underscoring how central both workplace culture and family environment are to the psychological sustainability of nursing in LMIC contexts. Perhaps most strikingly, if a nurse's family expressed embarrassment about their profession, that nurse was 6.14 times more likely to experience burnout (Verma et al., 2018). This figure that reveals the profound vulnerability created by social stigma around nursing as an occupation, particularly in societies where the profession may carry associations of low status.

In surgical training environments, institutional culture itself can become a barrier to support seeking. Alinab & Diamante (2025) suggest that the prevailing culture in surgical residency may actively discourage residents from seeking support from supervisors, contributing to higher rates of social isolation (Alinab & Diamante, 2025). This highlights not only a social impact of shift work, but how culture and social surroundings in which the workers are integrated shape the work climate itself.

Economic Stress

The social impacts of shift work cannot be fully understood without considering the economic conditions that push employees into such surroundings. In many LMIC contexts, shift work is not simply scheduling format but an economic necessity. Among Indian textile workers, 37.0% of workers refused to give up shift work despite its health costs because the schedule allowed them time to work second jobs and increase their income (Ranawat & Srivastava, 2017). Among Egyptian nurses, insufficient income was one of the strongest predictors of perceived burden, with financial insecurity significantly adding to the physical exhaustion of nursing work (El-Khawaga et al., 2025). Contractual nurses in India similarly experienced higher stress and job insecurity that contributed to elevated injury risk (Verma et al., 2018).

These economic dynamics connect directly to the structural conditions of LMIC labor markets discussed in earlier chapters. Healthcare systems in countries such as India already operate under severe constraints, with poor nurse to population ratios and limited qualified human resources placing large demands on staff (Verma et al., 2018). Workers in these systems are simultaneously indispensable and economically vulnerable.

5.8 Interventions

The literature included in this review reveals a striking asymmetry: while the evidence documenting the harms of shift work and sleep dysfunction in LMICs is quite substantial, evidence for implemented interventions within these contexts is remarkably sparse. Only one study in the review documents a structured, evaluated intervention program conducted in an LMIC setting. The remainder of the literature offers recommendations, observations about protective factors and calls for systemic change. Although valuable in their own right, the translation of these recommendations into practice remains limited. This gap is itself a finding of significance and its implications will be addressed in the discussion.

A Participatory Approach in Vietnam

The most substantive intervention evidence in this review comes from Kawakami et al. (2001), who documented a participatory, action-oriented program designed to improve night and shift work conditions at a gas cylinder manufacturing factory in Vietnam. The intervention was grounded in the WISE framework (Work Improvement in Small Enterprises), a training program developed by the International Labour Organization that emphasizes locally available resources and worker wisdom as the primary drivers improvement (Kawakami et al., 2001). This methodological choice is significant: rather than imposing externally designed solutions, the WISE approach treats workers and managers as active participants in implementing change, a model that may be particularly appropriate in LMIC contexts where resource constraints limit access to costly external interventions (Kawakami et al., 2001).

The initial situation was as documented in earlier chapters: Night shift workers at the factory showed behavioral signs of sleepiness including body shaking and involuntary short sleep episodes. Productivity on the night shift was substantially lower than on morning shifts and the risk of explosive accidents from workers falling asleep at high pressure control panels had been

identified as a serious and immediate safety concern (Kawakami et al., 2001). The intervention process began with an advisory meeting in which researchers presented baseline findings on fatigue levels and productivity to both managers and workers, facilitating a structured dialogue. This participatory style positioned workers' experiential knowledge as a valuable input into the design of solutions (Kawakami et al., 2001).

The most consequential outcome of the participatory process was a fundamental restructuring of the shift schedule. The factory abandoned its continuous three shift system, which had included long midnight shifts and replaced it with a discontinuous two shift system running from 06:00 to 14:00 and 14:00 to 22:00, effectively eliminating night work entirely. Sunday operations were also discontinued, establishing a regular weekly rest day for the entire workforce (Kawakami et al., 2001). These scheduling changes addressed the root cause of the documented fatigue and safety risks rather than attempting to manage their symptoms and represent the kind of structural intervention that the broader literature consistently identifies as the most effective approach to shift work related harm.

Alongside the scheduling overhaul, the intervention implemented a series of low-cost technical and environmental upgrades designed to reduce physical strain and workplace hazards. Height adjusted vehicle beds and conveyors were introduced to reduce manual lifting demands. Machine clamps were redesigned to hold cylinders more securely and new safety valves were installed for feeding operations. The work environment was improved through measures including watering the factory roof to reduce heat exposure, increasing natural light and ventilation and establishing a dedicated rest corner and recreation facilities. Technical instructions and control panel labels were rewritten in the local language, reducing the cognitive load and error risk associated with operating machinery described in a foreign language (Kawakami et al., 2001).

The methodology used to evaluate the intervention was systematic and multi-dimensional. Researchers employed time study observation methods, recording workers' postures every five minutes and tracking behaviors such as yawning, body shaking and leg shaking as objective indicators of sleepiness. Five workers per shift completed a 30-item fatigue questionnaire every two hours, covering drowsiness, concentration difficulties and physical symptoms. Productivity was measured by counting the number of oxygen cylinders filled per shift compared to company production records spanning from 1995 to 1997. A follow up visit conducted three months after the intervention confirmed that improvements had been sustained (Kawakami et al., 2001).

The outcomes were positive across all measured dimensions. Following the switch to the two-shift system and the elimination of night work, the factory maintained good production records while removing the sleepiness related explosive accident risks that had been identified at baseline. The roof watering was specifically highlighted as a highly effective, low cost local solution to the problem of environmental heat (Kawakami et al., 2001). The authors also reflect on a broader implication of the intervention's success: While other studies in the region have noted that employers prefer what they characterize as "docile" workers, the Kawakami et al.

(2001) findings demonstrate that participatory dialogue, in which workers' knowledge and experience are genuinely valued, produces better safety and health outcomes than an approach based on control.

Naturally Occurring Protective Practices: Napping

Beyond the structured Kawakami intervention, several studies document naturally occurring practices that workers have adopted to manage the demands of shift work, the most prominent of which is napping during shifts. Among Tunisian shift nurses studied by Merchaoui et al. (2017), the use of naps during shifts was sufficiently widespread. It appeared to equalize Work Ability Index scores between shift and day workers. Among Ethiopian nurses, 69.4% reported taking naps during night shifts (Abate et al., 2023), indicating that this is a relatively common adaptive behavior.

However, the protective effect of napping appears to have limits that become apparent over the course of a career. Merchaoui et al. (2017) found that despite widespread napping, work ability declined significantly with job seniority within the shift work group, suggesting that coping mechanisms that provide meaningful protection in the short term are insufficient to prevent long-term physiological deterioration. This finding has direct implications for intervention design: Napping should be understood as a valuable but ultimately partial mitigation measure, not a substitute for structural scheduling reform. On the basis of their findings, Merchaoui et al. recommend the implementation of planned 20-minute naps during shifts, supported by dedicated nap rooms that are quiet, safe and located close to clinical units.

Protective Scheduling and Environmental Factors

Several studies identify scheduling arrangements and workplace conditions that function as protective factors against the worst outcomes of shift work, even where these have not been implemented as deliberate interventions. Among Moroccan hospital workers, administrative fixed daytime schedules acted as a protective factor, significantly reducing the likelihood of high stress and emotional exhaustion compared to rotating or night shift arrangements (Amellah et al., 2025). The absence of sleep disorders was similarly identified as a powerful protective factor in the same cohort, lowering the odds of high perceived stress by 76% and high emotional exhaustion by 50%. Among commercial drivers in Ghana, higher levels of supervisor support and job autonomy were associated with a significant decrease in road traffic crashes, as these resources enabled drivers to better manage their workload and take necessary rest breaks when needed (Amoadu et al., 2023). In operating room settings, roughly 59% of clinicians reported good workplace relationships and managerial support despite high overall stress levels (Yosef et al., 2022) This points to the buffering role that positive institutional relationships can play even in high pressure environments.

Recommendations from the Literature

The majority of intervention relevant content in the included studies takes the form of recommendations rather than implemented programs. There is a gap between knowledge and

institutional change. These recommendations nonetheless represent a valuable idea of what could be done and are worth documenting.

At the level of scheduling and organizational design, several studies advocate for fundamental restructuring of shift systems. Ghammam et al. (2025) call for the adoption of fatigue risk management protocols based on those used in the aviation industry, incorporating systematic incident reporting and evidence-based scheduling designed to minimize circadian disruption. Critically, the authors emphasize that responsibility for shift scheduling and intervention must rest with institutions and management rather than being displaced onto individual workers. Ugwu et al. (2024) similarly advocate for systemic policy changes including a rethinking of shift lengths and rest periods and call for the integration of self-care modules into medical training to build protective capacity among the new workforce. Amellah et al. (2025) emphasize the urgent need for organizational reforms including reduced on call duties and rotating ICU staff assignments, particularly in anticipation of future crisis periods such as pandemics. Akhtar & Butt (2022) suggest that managers offer flexible shift systems, alternate working day arrangements and remote working options where feasible.

Ghammam et al. (2025) make perhaps the most structurally direct recommendation in the review: that understaffing be treated as the primary intervention target, on the grounds that addressing chronic staff shortages would do more to reduce the burden on individual workers than any strategy. This recommendation connects directly to the systemic conditions documented across earlier chapters: the below WHO nurse to population ratios in Egypt, the chronic understaffing in Nigeria and Palestine and the resource scarcities in Tunisia. It frames the intervention strategy as a matter of political prioritization.

Beyond scheduling, the literature identifies a range of supportive measures that should accompany structural reform. Ghammam et al. (2025) highlight the importance of quality-of-life interventions targeting physical activity, stress management, social connection and work life balance. The authors note that maintaining high physical and mental quality of life is associated with a 90 to 92% reduction in the risk of developing chronic fatigue. Ghammam et al. further note that non work factors including adequate childcare, financial support and chronic stress reduction must be incorporated into any intervention framework. The lives of shift workers extend beyond the workplace and the conditions of those lives shape their capacity to withstand occupational demands. M. N. Shahzad et al. (2019) emphasize that retaining nurses and ensuring healthcare quality in Pakistan will require improvements not only to workplace support systems but to broader societal attitudes toward nursing as a profession, reducing the stigma and family embarrassment that the study identified as among the strongest predictors of burnout. Finally, Abate et al. (2023) note that in Ethiopia, no policies currently exist to prevent shift work related sleep disorders, a condition that makes the case for urgent organizational change.

6. Discussion

This systematic review set out to examine the effects of sleep deprivation on the physical performance and health of shift workers in low- to middle-income countries (LMICs) and to evaluate the extent to which physical activity represents a feasible and effective intervention for mitigating these effects. What emerged from the review, however, is a picture considerably more complex than any single research question could fully capture. Sleep deprivation is not a variable that can be isolated among the other conditions of shift work, especially in the LMIC context. It is one part of occupational, physiological, psychological, social and structural factors that together constitute a major public health challenge across LMICs. The following discussion addresses each research question before placing the findings within this broader context and identifying potential holes for future research and policy.

Research Question 1: How Does Sleep Deprivation Affect the Physical Performance and Work Capacity of Shift Workers in LMICs?

The evidence reviewed consistently demonstrates that sleep deprivation among shift workers in LMICs produces substantial reductions in physical performance and work capacity across a range of occupational contexts. Among industrial workers, the effects are visible in direct productivity: night shift workers at a Vietnamese gas cylinder factory produced only 2.8 cylinders per hour compared to 4.5 during morning shifts, a decline directly attributed to fatigue and involuntary sleepiness (Kawakami et al., 2001). Among healthcare workers, performance impairment has more clinical consequences: Anesthesia residents in Cairo showed significant slowing of reaction time and reduced mental flexibility following a single night shift, with performance equivalent to legal alcohol intoxication documented after 24 or more consecutive hours of wakefulness (Abdelhamid et al., 2020). Fatigue has been estimated to contribute to between 44,000 and 98,000 hospital deaths annually and in industrial settings, sleep deprived workers monitoring high pressure equipment have been documented falling asleep at their posts (Kawakami et al., 2001).

Beyond these immediate performance effects, the review documents a pattern of cumulative physical decline associated with sustained shift work. Ranawat & Srivastava (2017) highlight that it is not sleep loss alone but the irregularity of shift scheduling that impairs health. The disruption of consistent biological and social rhythms produces physiological consequences that accumulate over a career in ways that regular but demanding daytime work does not. Symptoms such as dizziness and breathlessness appeared earlier in the careers of shift workers than daytime workers, with onset within two to five years, suggesting that the physical toll of shift work is not merely a long-term cumulative outcome but begins relatively early in a career. Work ability has been found to decline significantly with seniority among shift workers even when coping strategies such as napping are employed. This indicates that the potentially protective effects of individual behaviors are insufficient to counter the demands of long term shift work (Merchaoui et al., 2017).

The physical performance consequences of sleep deprivation are further escalated by the working conditions that coexist with shift schedules in many LMIC contexts. Long working

weeks of 70 to 80 hours or more, chronic understaffing that forces workers to cover additional shifts and the absence of adequate safety equipment all intensify the exposure to harm that sleep deprived workers face. In Ethiopia, over half of injured industrial workers reported a sleep disorder and the highest proportion of injuries occurred during night shifts (Debela et al., 2022; Sime & Worku, 2020). Fatal injury rates in lower-income countries are estimated to be three to four times higher than in richer nations, yet occupational health remains a neglected national priority across much of the LMIC world (Sime & Worku, 2020).

Research Question 2: What Are the Documented Health Consequences of Sleep Deprivation Among Shift Workers in LMICs?

The documented health consequences of sleep deprivation among shift workers in LMICs are extensive, multifactorial and in many cases severe. They span physiological, cognitive, psychological and social areas and they interact with one another in ways that make the total burden substantially greater than any single dimension on its own.

Physically, shift workers in LMICs face elevated rates of hypertension, cardiovascular disease risk, obesity, gastrointestinal dysfunction and nutritional deficiency. Among textile workers in India, nearly half of shift workers were classified as Stage I hypertensive and more than twice as likely as daytime workers to fall into the high-risk category for cardiovascular disease (Ranawat & Srivastava, 2017). Dietary disruption, irregular mealtimes, elevated caffeine and stimulant use and higher rates of smoking and alcohol consumption exacerbate these risks, while the bidirectional relationship between obesity and sleep dysfunction creates cycles of deteriorating health that become increasingly difficult to stop over time (Ranawat & Srivastava, 2017).

Cognitively, sleep deprivation impairs reaction time, executive function, rational reasoning and sustained attention in ways that are both immediately dangerous and cumulative over a career. Chandra et al. (2023) found that sleep disturbances predicted impaired rational abilities nine months later, suggesting that cognitive harm from chronic sleep loss does not fully reverse between shifts but accumulates over time. Among healthcare workers, 67.3% of a Tunisian cohort experienced mental fatigue severe enough to impair the clinical decision-making capacity required for safe patient care (Ghammam et al., 2025).

Psychologically, the review found elevated rates of anxiety, depression, stress, burnout and chronic fatigue across virtually every population studied. Night shift workers were 2.13 times more likely to experience frequent mental health symptoms than day workers in the Philippines (Lu Francesca & Lu Leilanie, 2021) and experiencing problems during night shifts was associated with a 3.9-fold increase in burnout risk in Pakistan (M. N. Shahzad et al., 2019). Chronic fatigue was associated with up to a 6-fold increased risk of depression (Ghammam et al., 2025), while burnout in healthcare settings contributes to early retirement and training attrition that worsens the staff shortages driving the problem in the first place (Yosef et al., 2022).

Socially, shift work disrupts family life, marriages, leisure time and social participation in ways that extend the harm of sleep deprivation well beyond the workplace. The absence of social

support amplifies the physiological and psychological consequences of shift scheduling, while cultural pressures lead workers to sacrifice sleep in order to maintain social bonds (Akhtar & Butt, 2022).

It is important to acknowledge that sleep deprivation, while a central and well-documented mediating mechanism, is rarely the only factor at work. This review repeatedly encountered findings in which burnout, workload, occupational stress, economic troubles and structural resource constraints were equally or more prominent drivers of the health outcomes documented. Adjobimey et al. (2022) found that shift work did not emerge as an independent predictor of occupational stress in their multivariable model. Rather, it was the combination of sleep loss and heavy workload that produced harm. The 78.4% prevalence of occupational stress among operating room clinicians documented by Yosef et al. (2022) reflects not only sleep deprivation but the sustained demands of vigilance, clinical responsibility, fear of litigation and institutional instability. Sleep is an important part of this picture but it cannot be addressed in isolation from the broader occupational and structural conditions within which shift workers live and work. A comprehensive approach to the health of shift workers in LMICs must treat sleep as one element of a larger and deeply interconnected challenge, one that also encompasses workload management, mental health support and economic security.

It is also worth noting that several studies in this review surfaced health concerns beyond the sleep and fatigue focus of the research questions that point toward other potential areas of study. Workplace violence toward healthcare workers, for instance, is a documented occupational hazard in many LMIC settings that intersects with the stress and burnout dynamics described throughout this review. Also, the differing vulnerability of nurses, who are consistently more stressed and fatigued, compared to doctors, suggests that profession specific analyses would add meaningful insights to the general picture understanding. These dimensions fall outside the scope of this review but represent important directions for future research.

Research Question 3: To What Extent Does Physical Activity Mitigate the Negative Health Outcomes of Sleep Deprivation in Shift Workers?

The evidence reviewed provides only a limited and indirect answer to this research question, for reasons that are themselves revealing. Among the included LMIC studies, physical activity was rarely examined as a deliberate intervention. Ndongo et al. (2024) considered physical activity as a potential moderator of cardiometabolic risk among workers with poor sleep in Cameroon but found no statistically significant association. This null finding, while not definitive, suggests that physical activity alone may be insufficient to offset the cardiometabolic consequences of shift work related sleep dysfunction in this population. Ghammam et al. (2025) identified physical activity as a target area for quality-of-life improvement, noting that boosting physical health and reducing obesity could mitigate chronic fatigue risk and that maintaining high physical and mental quality of life was associated with a 90 to 92% reduction in chronic fatigue risk. However, this finding reflects the protective value of good overall health status rather than the effect of a specific physical activity intervention.

The broader physical activity intervention literature reviewed in the theoretical background offers more systematic evidence, but with important limitations. The meta-analysis from Shrestha et al. (2026) demonstrates that physical activity interventions in LMICs produce small but statistically significant improvements in activity intensity, with larger effects associated with digital delivery, multi-component design and professional leadership. However, the overall certainty of this evidence is rated as low to very low and effects on sedentary time and total activity duration are non-significant. The specific question of whether physical activity interventions improve sleep quality or mitigate the health consequences of sleep deprivation in shift workers remains largely unanswered by the existing LMIC literature.

The evidence reveals a more fundamental issue, however, and it concerns the feasibility of addressing research question 3 at all. The assumption that physical activity can serve as a meaningful intervention for shift work related health outcomes presupposes that workers have the capacity, time and energy to be physically active. This presumption is consistently challenged by the selected studies. Workers in the Botswana feasibility study reported being too tired to exercise after their shifts, with night shifts specifically identified as disrupting sleep to the point where additional physical activity felt impossible (Monnaatsie et al., 2023). The sequential mediation chain identified by Akhtar & Butt (2022), in which night shifts disrupt work life balance, which generates stress, which causes insomnia, which reduces performance, leaves little room for a physical activity intervention. When the primary drivers of poor health are chronic understaffing, working 70 to 80 hours or more per week and the physiological demands of night work itself, recommending physical activity as a solution risks placing the burden of improvement on individual workers rather than on the systems that generate the harm.

This does not mean that physical activity is irrelevant as an intervention component. The evidence suggests it has genuine potential as part of a multi-component approach, particularly if integrated into the workday itself rather than added to workers already burdened off-shift time. A good example of this is the digitally supported framework tested by Monnaatsie et al. (2023). But the evidence clearly does not support physical activity as a primary or standalone solution to the health consequences of shift work and sleep deprivation in LMICs. The issue is structural before it is behavioral and interventions that do not address the structural conditions will be limited.

Research Question 4: Can Structured Exercise Programs Be Considered a Feasible Intervention to Improve Health and Well-being Among Shift Workers in LMICs?

The honest answer according to the reviewed studies is: potentially, but they are not yet realistic in most LMIC shift work contexts. Considerably more research is needed before structured exercise programs can be recommended as a practical intervention in these settings.

The Monnaatsie et al. (2023) study in Botswana represents the closest available evidence to a direct feasibility test in an African shift work population. Its findings are cautiously encouraging: the intervention achieved 66% reach among targeted workers, maintained a 15% dropout rate, was fully delivered as intended, met the expectations of 94% of participants and

generated willingness among participants to recommend it to colleagues. These are meaningful indicators that suggest digitally supported, individually tailored physical activity programs can be feasible in the region. The use of fitness tracking technology as both an intervention tool and a recruitment incentive also offers a good model for future programs operating in contexts where institutional resources for wellness programming are limited.

However, the study by Monnaatsie et al. (2023) proved that work related fatigue was the dominant barrier to actual behavior change, limiting workers' ability to translate awareness and motivation into sustained physical activity. The intervention was conducted over a single 24-day shift cycle, raising serious questions about whether the behavior changes observed would persist beyond the study period. Management involvement, identified by participants as a critical missing element, points to the need for institutional commitment beyond individual worker motivation.

Beyond Botswana which, while being a close representative example, is not an LMIC, the evidence base for structured exercise programs in LMIC shift work populations is effectively non-existent. The systematic review found no studies from true low or lower middle income country settings that evaluated a structured physical activity intervention among shift workers with sleep dysfunction as an outcome. This is a significant gap and it limits the conclusions that can be drawn from this systematic review. The heterogeneity of LMIC contexts, which span from industrial workers in Bangladesh, to healthcare professionals in Ethiopia, to call center employees in Pakistan and to commercial drivers in Ghana, means that assumptions from one cannot be compared to another without context specific testing.

What the Evidence Really Shows

Across all four research questions, a common thread emerges: The health burden documented in this review is not primarily a consequence of individual behaviors or biological vulnerabilities. It is the product of structural conditions specific to LMIC labor markets and health systems and that will not be meaningfully addressed by interventions that target individual workers in isolation.

Chronic understaffing is likely the most impactful of these conditions. In Egypt, the nurse to population ratio falls significantly below WHO recommendations, forcing existing staff to work excessive hours and additional shifts (El Khawaga et al., 2025). Similarly, in Nigeria, resource scarcities and overwhelming patient loads intensify the effects of night shifts beyond what scheduling alone could fix (Ugwu et al., 2024). In Tunisia, chronic understaffing also forces workers into extended hours that combine with sleep deprivation and workload (Ghammam et al., 2025). In Palestine, chronic staff shortages and overcrowding elevate burnout risk to levels that individual coping strategies cannot address (Jawabreh et al., 2025). Ghammam et al. (2025) state this conclusion directly: understaffing is the primary intervention target and addressing it would do more to reduce the burden on individual workers than any individually focused strategy. This recommendation is strongly supported by the collected evidence of this review.

Economic uncertainty shapes workers' relationship to harmful conditions in ways that make individual behavior change unrealistic. Workers in Bangladesh remained in shift systems they disliked because job scarcity and fear of unemployment constrained their choices (Ahasan et al., 1999). Workers in India refused to give up shifts because second jobs possible through shift work were economically necessary (Ranawat & Srivastava, 2017). Contractual workers across multiple settings faced elevated health risks without the institutional protections that might otherwise buffer them (Lu Francesca & Lu Leilanie, 2021; Verma et al., 2018). In the Philippines, the exploitation of deregulated labor laws by multinational companies created working conditions that disproportionately harmed women, who accepted them out of financial necessity rather than choice (Lu Francesca & Lu Leilanie, 2021). These are not individual failures of health behavior. They are the predictable outcomes of labor market structures that prioritize cost reduction over worker welfare.

The COVID-19 pandemic, which features in several of the included studies, exposed and amplified these structural vulnerabilities in ways that are unlikely to have fully resolved. Additional workload, institutional instability and the psychological burden of practicing in crisis conditions worsened outcomes that were already severe and the studies conducted during or after the pandemic period consistently document higher rates of burnout, stress and sleep dysfunction than pre-pandemic situations (Amellah et al., 2025; Yosef et al., 2022). The resilience of health systems in LMICs to future crises will depend in part on whether or not the occupational health of their workforces is treated as a systemic priority.

Methodological Observations and Limitations of the Literature

Several methodological observations emerge from this review that are worth noting for future research. The majority of included studies are relatively recent, with a notable concentration of publications from 2022 onwards. This suggests growing research interest in the occupational health of LMIC shift workers but also reflects the relatively new state of this evidence base. Much remains to be done and the recency of many findings means that there is a lack of long-term evidence on outcomes.

Most studies relied on self-reported measures of sleep quality, fatigue and health outcomes, introducing the possibility of bias. Objective measures such as biological markers or measurements from wrist watches remain rare in this literature, limiting the precision. Cross sectional designs dominate, making it difficult to establish the effects of individual factors such as sleep, stress, work environment or social pressures, making exact causes difficult to determine. The heterogeneity of populations, settings and outcomes across studies also limits the extent to which findings can be generalized across contexts.

Profession specific analyses could represent a promising direction for future research. This review found consistent evidence that nurses bear a disproportionate amount of the occupational health burden compared to physicians, with higher stress, greater emotional exhaustion and more severe sleep dysfunction. The differences between surgical and non-surgical residents, between anesthetists and general practitioners and between industrial workers and healthcare professionals all suggest that summarizing across professional

categories hides meaningful variation in exposure and vulnerability. Future research that separates findings by profession, specialty and employment type will provide a more accurate evidence base for targeted intervention.

7. Conclusion

This review was intended as an examination of sleep deprivation and physical activity among shift workers in LMICs. It became, however, a broader account of the occupational health of shift workers in resource constrained settings, one in which sleep deprivation is a central and consequential mechanism but only a part of a larger picture. The effects of shift work on sleep are inseparable from its effects on diet, cardiovascular health, cognitive function, mental health, family life, economic security and the structure of the LMIC work environment itself. Sleep deprivation is an important element of this larger challenge, but it cannot be solved on its own and interventions that treat it as an isolated variable will fall short.

The evidence for physical activity as an intervention in this context is promising in principle but underdeveloped in practice. The capacity for physical activity is constrained by conditions such as exhaustion, long hours, understaffing and economic pressure. The Botswana feasibility study offers early and cautiously encouraging evidence that digitally supported physical activity programs can be acceptable and deliverable in African shift work populations, but much more research is needed before structured exercise programs can be recommended as a practical solution.

The primary finding of this review is that the health of shift workers in LMICs is fundamentally a structural problem requiring structural solutions. Addressing understaffing, reforming shift scheduling, improving safety conditions, extending health policies and reducing the economic uncertainty that traps workers in harmful conditions are the interventions most needed. Individual strategies, such as physical activity, sleep hygiene education, napping programs and mental health support, all have a role to play but only if they are embedded within, rather than offered as substitutes for, the systemic changes that the evidence demands.

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Appendix

The following search terms were used for research in the three chosen databases (PubMed, Swisscovery, Google Scholar). As stated in the methodology section of this paper, the Google Scholar bread search was skipped after initial screening:

Database	Search focus	Search string (as applied in database)	Filters applied	Results (as of December 2025)
PubMed	Broad search	("shift work" OR "night work" OR "rotating shifts") AND ("sleep" OR "sleep deprivation" OR "sleep loss" OR "circadian" OR "fatigue") AND ("developing countries" OR "low-income countries" OR "middle-income countries" OR LMIC* OR "low-middle-income countries")		15
Swisscovery	Broad search	("shift work" OR "night work" OR "rotating shifts") AND ("sleep" OR "sleep deprivation" OR "sleep loss" OR "circadian" OR "fatigue") AND ("developing countries" OR "low-income countries" OR "middle-income countries" OR LMIC* OR "low-middle-income countries")	Available Online Open Access	998
Google Scholar	Broad Search	("shift work" OR "night work" OR "rotating shifts") AND ("sleep" OR "sleep deprivation" OR "sleep loss" OR "circadian" OR "fatigue") AND ("developing countries" OR "low-income countries" OR "middle-income countries" OR LMIC* OR "low-middle-income countries")		10200
Google Scholar	Physical activity mitigating effects / Interventions	"shift work" AND (sleep OR "sleep deprivation" OR circadian OR fatigue) AND ("physical activity" OR exercise OR training) AND (cardiovascular OR metabolic OR obesity OR stress OR "mental health") AND ("developing countries" OR LMIC)		5110

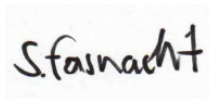
Figure 4: Table of database search terms

Statement of Authorship

I hereby certify that I have completed the submitted work independently and have not used any resources other than those indicated in the work. All passages that have been taken verbatim or paraphrased from sources have been marked as such. Furthermore, I confirm that the submitted work has not been submitted to any other university as a seminar paper, project or thesis or as part of such work. Furthermore, I declare that I have marked all text passages that were written with the aid of AI-supported programs accordingly and have provided a reference to the AI-supported program used. The work may be checked for plagiarism and AI-supported programs using appropriate software. In the event of justified suspicion of unauthorized or unmarked use of AI in written performance assessments, the candidate is obliged, upon invitation, to cooperate in clarifying the suspicion, e.g. by participating in an interview. I acknowledge that unfair conduct may result in the work in question being graded with a grade of 1 or 'fail' or in exclusion from the program (in accordance with §25 of the regulations for the Master's program in 'Sport, Exercise and Health' at the Medical Faculty of the University of Basel dated 19 December 2016).

Date: 10.6.2026

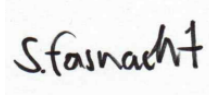
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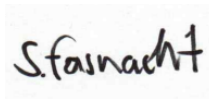


AI Statement

Artificial Intelligence (AI), such as Gemini and Claude AI, was used for organization of personal notes during the writing process and for grammar checks. All research, note taking, collecting relevant information and writing of body texts was done manually by the author themselves.

Date: 10.6.2026

Signature:



Sleep deprivation and its impact on the health of shift workers from low- and middle-income countries: A systematic literature review

Sullivan Fasnacht

Supervisor: Dr. Ivan Müller

1 | Background

Shift work disrupts the body's circadian rhythm, leading to sleep dysfunction and a wide range of adverse health outcomes — with shift workers showing an almost 200% increase in poor sleep quality compared to non-shift workers (Thach et al., 2020). While evidence is well developed in high income countries, LMIC workers remain significantly understudied despite facing a disproportionate burden, including:

- Chronic understaffing and working weeks of 70–80+ hours
- Economic precarity and limited occupational health infrastructure
- Higher rates of sleep disorders than counterparts in wealthier settings

2 | Method

A systematic review was conducted following PRISMA guidelines, drawing on searches of PubMed, Swisscovery, and Google Scholar. Studies were included if they addressed shift workers in Low or Lower-Middle Income countries. Following screening of 92 studies by title and abstract, 30 were included, covering:

- Healthcare, industrial, and service sector populations
 - Settings across Africa, South and Southeast Asia, and the Middle East
- Findings were synthesized into an overview table, as well as narratively. The review was conducted by a single researcher, which represents a limitation in terms of selection subjectivity.

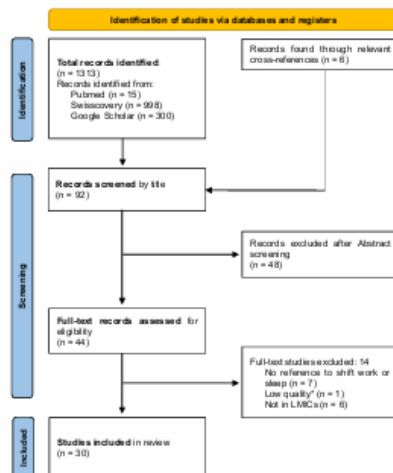


Figure 1: PRISMA Flow Chart of included studies

*Language errors and inconsistencies

3 | Results

Poor sleep prevalence ranged from 48% to 85% across included studies, well above the global average industrial for industrial employees of 36%. Key findings across domains:

- **Occupational performance:** Post-shift cognitive impairment equivalent to legal alcohol intoxication (Abdelhamid et al., 2020); sleep disorders more than doubled injury risk; fatigue implicated in up to 98,000 annual hospital deaths
- **Physical health:** Elevated rates of hypertension, cardiovascular disease, obesity, and gastrointestinal dysfunction
- **Mental health:** Night shift workers 2x more likely to experience mental health symptoms; >50% of nurses reported burnout; chronic fatigue linked to a sixfold increased depression risk
- **Vulnerable groups:** Female workers, junior and contractual staff consistently most affected

Only one implemented intervention was identified in LMIC settings (Kawakami et al., 2001). The remaining literature consisted of recommendations rather than evaluated programs, with understaffing identified as the primary intervention priority.

Poor Sleep Quality by Country

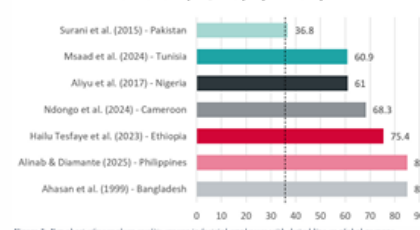


Figure 2: Bar chart of poor sleep quality among industrial employees with dotted line as global average

4 | Discussion

The findings confirm severe and consistent health consequences of shift work across physical, cognitive, psychological, and social domains. However, sleep deprivation cannot be addressed in isolation — chronic understaffing, heavy workloads, and economic precarity were equally prominent structural drivers of harm. No included LMIC study evaluated a structured physical activity intervention targeting sleep dysfunction, and the one study examining physical activity as a moderator found no significant effect. Key implications:

- Physical activity holds theoretical promise but fatigue is the dominant barrier to participation
- Structural reform — addressing understaffing and scheduling — must precede individual interventions
- Considerably more LMIC-focused longitudinal research and intervention trials are needed

Literature

Abdelhamid, B. M., Omar, H., Hassan, M. M., Embaby, S. A., Rady, A., & Mohamed Aly, H. (2020). Effects of partial sleep deprivation following night shift on cognitive functions of Egyptian anesthesiologists: prospective observational study. *Egyptian Journal of Anaesthesia*, 36(1), 61–68. <https://doi.org/10.1080/11101849.2020.1768630>

Kawakami, T., KOGI, K., & KHAI, T. T. (2001). HOW A SMALL ENTERPRISE IMPROVED THE CONDITIONS OF NIGHT AND SHIFT WORK USING LOCAL RESOURCES. *Journal of Human Ergology*, 30(1–2), 173–178. <https://doi.org/10.11183/jhe.1972.30.173>

Thach, T.-Q., Mahirah, D., Dunleavy, G., Zhang, Y., Nazeha, N., Rykov, Y., Nah, A., Roberts, A. C., Christopoulos, G. I., Soh, C.-K., & Car, J. (2020). Association between shift work and poor sleep quality in an Asian multi-ethnic working population: A cross-sectional study. *PLoS ONE*, 15(3), e0229693. <https://doi.org/10.1371/journal.pone.0229693>