REVIEW ARTICLE

Shift Work And Associated Health Consequences: A Review

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ABSTRACT

This literature review aims to examine the complex relationship between engaging in shift work and its subsequent health sequelae, while also shedding light on fields of research that require further investigation. Indexing services (i.e., Scopus and PubMed) were used to identify pertinent studies, prioritizing original research, review articles, and meta-analyses from 2018 to 2023. Papers not published in English or where full-text translation was not available, research conducted solely on non-human populations, as well as proposal and opinion papers, were excluded. Papers published before 2018 and those with a sample size of 50 participants or fewer were also omitted. The author conducted a thorough evaluation of each study to ensure its relevance and significance. After deduplication of the search results and implementation of the exclusion criteria, 51 papers were shortlisted for this review. The keywords used for the literature search were “shift work”, “health”, “night shift”, “cardiovascular”, “circadian, cancer”, “disease”, “dose-response relationship”, and “long working hours”. The results showed that shift work significantly impacts various aspects of health, presenting risks in the areas of cardiovascular health, cancer susceptibility, circadian rhythm, immunity, metabolism, reproductive health, and mental well-being. Shift workers have increased risks for diabetes, hypertension, adverse cardiac events, circadian dysrhythmia, metabolic syndrome, mental health disorders, and even certain types of cancer. Shift work exhibits significant associations with sexual and reproductive dysfunction in both sexes, including elevated risks for miscarriages and preterm birth. In conclusion, the findings underscore the need for comprehensive health interventions and further research to understand the intricate relationships between shift work and long-term health consequences.

Keywords: Shift work; night shift; disease; healthy lifestyle; dose-response relationship

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Highlights:

1. Disruption of circadian rhythm due to shift work contributes to various health issues, including altered melatonin levels, immune dysfunction, and metabolic disturbances.
2. There is a critical need for longitudinal studies to explore interventions and workplace policies that can mitigate the adverse health effects of shift work.
3. Addressing the multifaceted impact of shift work on health requires a holistic approach that considers factors like circadian rhythm optimization, workplace support, and tailored interventions.

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INTRODUCTION

The United States Department of Health and Human Services and the National Institute for Occupational Safety and Health propose standard methods for structuring shift work, one of which involves dividing the 24-hour day into contiguous 8-hour blocks. For instance, the first shift spans from 9 a.m. to 5 p.m., the second shift from 5 p.m. to 1 a.m., and the third shift from 1 a.m. to 9 a.m. The other method divides the day into 12-hour blocks, with the first shift spanning from 7 a.m. to 7 p.m. and the second shift from 7 p.m. to 7 a.m. While variations exist in defining "shift work," it generally pertains to working hours outside of the traditional business hours, which are typically around 9 a.m. to 5 p.m. (Reinganum & Thomas, 2023).

According to other sources, the term "shift work" refers to a job with working hours that do not coincide with normal daytime hours, which are generally considered to be between 7 a.m. and 6 p.m. (Redeker et al., 2019). Although this type of work can be simply broken down into evening and night shifts, there are quite a lot of variables to consider for making additional distinctions. These variables include internal institutional policies that determine the duration of shifts for employees, such as 8-hour, 10-hour, or 12-hour shifts. For the purposes of this research, shift work was defined as work that is carried out at non-conventional hours, excluding the daylight hours of 7 a.m. to 6 p.m

Although there has not been an up-to-date global repository of statistics on the number of people engaged in shift work around the world, it is possible to make estimates by extrapolating from several regional analyses where data are available. For instance, the United States Bureau of Labor Statistics (2019) found that around 16% of the total waged/salaried workforce engaged in shift work

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throughout the year 2019. Similarly, in a report published by the International Agency for Research on Cancer Working Group on the Identification of Carcinogenic Hazards to Humans (2020), it was found that approximately 11 million people in the United States frequently engaged in night work between the hours of 1 a.m. and 5 a.m. The data were collected from workers who implied that they had worked regularly for more than five times within the last 30 days.

It was found that British and French workers who were employed in shift work made up 11.5% and 16.4% of the total workforce in their respective countries during the years of 2018 and 2015, respectively (Trades Union Congress, 2018; Houot et al., 2022). In April 2022, a Canadian Labour Survey found that 1.7% of people between the ages of 15 and 69 worked a night shift. However, it is important to note potential confounding factors that could influence this number, such as the seasonality of employment trends and the possibility of biases in the survey respondent population (Gill et al., 2023).

The data presented clearly indicate that a significant percentage of the global population is engaged in shift work. This is extremely important because, despite numerous claims and immense discussions regarding the long-term health sequelae of shift work, there is a scarcity of statistically relevant research pieces on the subject. There has been a lot of discussion regarding shift work due to its overall health consequences, including weakened immune system, potentially carcinogenic nature, circadian dysrhythmia, and cardiovascular risks. This paper aims to synthesize the statistically relevant and most up-to-date findings of recent studies. The objectives of this literature review are threefold. First, the primary objective is to synthesize and condense the significant findings from current studies and form a comprehensive review of our understanding on this subject. Second, this paper aims to provide guidance for clinical decision-making, specifically aiding clinicians in identifying preventable sequelae that have been observed as a consequence of shift work. Lastly, this paper aims to expose the shortcomings of current research in the subject and shed some light on the gaps where our collective knowledge is lacking and further research is required.

OBJECTIVE

Research methodology for the literature review

A literature review was conducted by initially searching for papers on indexing services, i.e., Scopus and PubMed. Pertinent studies were identified, with a priority for original research, review articles, and meta-analyses. The exclusion criteria comprised papers that were not published in English or lacked full-text translation, research exclusively conducted on non-human populations, research proposals, and opinion papers. Papers that were published prior to 2018, as well as those investigating the effect of shift work on a sample size of 50 participants or less, were also excluded. Additionally, papers that failed to reject the null hypothesis were excluded in order to ensure that this review only includes statistically significant findings. The author meticulously evaluated the studies obtained from the literature search to ensure that they were relevant and significant. After removing duplicates and implementing the exclusion criteria, a total of 51 papers were selected to be reviewed in this paper. The literature search was

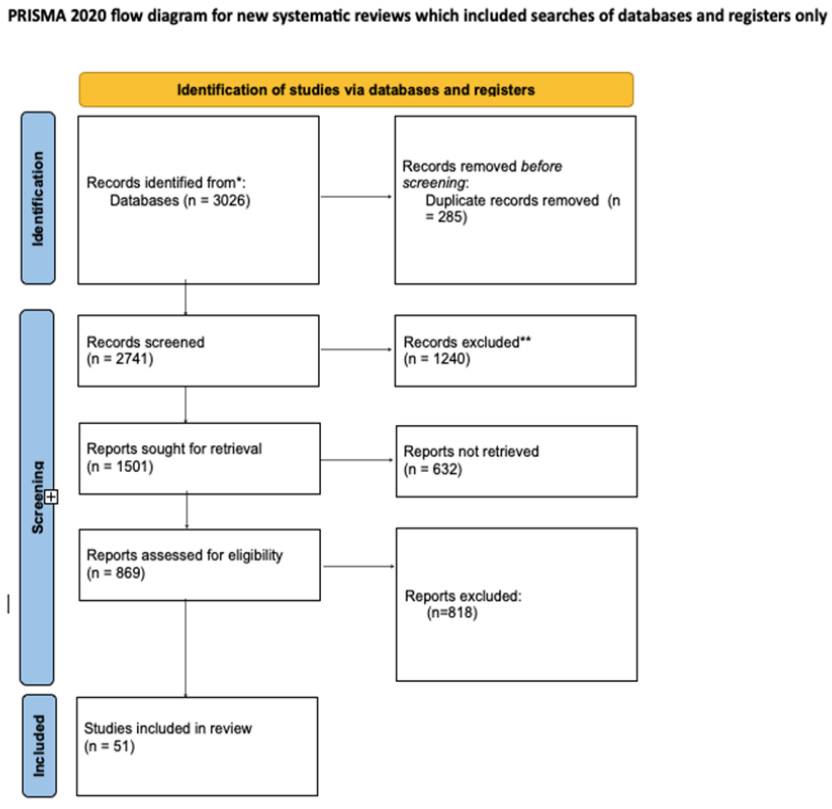

Figure 1. PRISMA flow diagram for the literature search

performed using the following keywords: "shift work", "health", "night shift", "cardiovascular", "circadian, cancer", "disease", "dose-response relationship", and "long working hours". It is important to note that the literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). Figure 1 shows the flow diagram illustrating the process of conducting the literature search.

Overview of The Consequences of Shift Work

Shift work, characterized by non-traditional working hours that extend beyond the standard 9-to-5 framework, has become a prevalent aspect of modern employment across various industries. The 24/7 nature of certain professions, such as in the fields of healthcare, emergency services, hospitality, and manufacturing, necessitates continuous operations. These industries compel a significant portion of the workforce to engage in irregular and rotating shifts. While shift work is essential for maintaining societal functions, a growing body of literature suggests that it may be linked to a myriad of long-term health consequences. Numerous studies have explored the impact of shift work on various physiological and psychological aspects, including sleep patterns, circadian rhythm, and metabolic functions. This literature review seeks to comprehensively examine and synthesize existing research to elucidate the intricate relationship between shift work and its potential long-term health sequelae, shedding light on the underlying mechanisms and implications for public health.

Cardiovascular Sequelae of Shift Work

A study conducted by Skogstad et al. (2023) compared shift-work industrial workers to their day-shift counterparts over a three-year follow-up period. The study showed that shift workers had a reversible increase in the smooth muscle tone of arterial walls, leading to an augmented pulse wave velocity. Additionally, the shift workers exhibited increased levels of inflammatory biomarkers, such as C-reactive protein (CRP), especially in atherosclerotic tissue. This, in turn, contributed to an accelerated rate of disease progression. Taking the aforementioned data into account, it was found that the shift workers also had a greater degree of arterial stiffness, which could potentially lead to systemic hypertension and other cardiovascular sequelae down the line (Skogstad et al., 2023).

Similarly, a study carried out by Su et al. (2021) reported the consequences of shift work on cardiovascular health. Compared to a cohort of individuals who work regular day shifts, those who had ever been exposed to shift work showed a relative risk of 1.18 for cardiovascular mortality, with a 95% confidence interval (CI) of 0.94–1.47. Although heterogeneity was noted in the findings, there was no evidence of strong biases. Therefore, the findings suggest that shift work is in fact related to an increased risk of cardiovascular morbidity as compared to a cohort of workers engaged in daytime work (Su et al., 2021).

An analysis performed by Johnson et al. (2020) on the Nurses' Health Study (I and II) datasets, which included 22–24 years of follow-up, revealed intriguing findings. Nurses who had worked one to four days of shift work in the past month exhibited a median high-density lipoprotein (HDL) cholesterol level that was 4.4 mg/dL higher than their day-shift counterparts (Johnson et al., 2020). However, nurses who had recently engaged in five or more days of shift work did not demonstrate the same result. Unfortunately, since this study was simply a statistical analysis on datasets, the exact reasons for the attenuation of HDL levels with increasing frequency of shift are not well understood. The cause, whether biases or homeostatic mechanisms, remains unknown as of now. Shift work was also found to be associated with an increased risk for hypertension. This risk was mildly attenuated if the influence of genetic predisposition was taken into account. Nevertheless, the association between shift work and increased risk for hypertension remained statistically significant, as indicated by a p-value for trend (ptrend) below 0.001 (Xiao et al., 2022).

Interestingly, it was shown that being engaged in shift work, both in recent times and throughout one's lifetime, is associated with an increased risk of atrial fibrillation. This elevated risk was not attenuated even after accounting for genetic predisposition. Participants who worked an average of 3–8 night shifts per month and had worked for 10 years or more experienced a statistically significant increased risk of developing atrial fibrillation, with a hazard ratio (HR) of 1.22 and 95% CI of 1.02–1.45 (Wang et al., 2021). Regular night-shift work was also found to cause an increased risk for congestive heart disease (CHD), although such a correlation was not observed in the case of stroke due to congestive heart failure (CHF). That being said, although shift work has been shown to increase the risk of cardiovascular disorders, more focused research is required in order to establish the degree to which refraining from shift work may serve as a modifiable risk factor and to what degree it may be effective in preventing cardiovascular disorders.

In a study conducted by Bigert et al. (2022) on another cohort of nurses, it was found that the risk for cerebrovascular disease was increased in participants that had worked 30 or more night shifts in the past year (HR=1.44, 95% CI=1.04–1.99). Interestingly, this risk was further elevated for participants who had worked three or more consecutive night shifts on 15 or more occasions in the past year (HR=1.69, 95% CI=1.18–2.42). Similarly, participants who returned to work less than 28 hours after a night shift on 30 or more occasions in the past year were also found to have an increased risk for cerebrovascular disease (HR=1.52, 95% CI=1.10–2.10). This demonstrates that not only does shift work pose various detrimental health effects, specifically on cardiac and vascular health, but also suggests that there may be an additive effect at play in this relationship. More consecutive days of shift work or less time off between shift-work days demonstrated an elevated risk for cerebrovascular disease. Another study conducted by Kader et al. (2022) found that an increased number of consecutive days working the night shift was associated with a higher risk of developing ischemic heart disease. However, this finding was attenuated when accounting for confounders, such as adjustments to the total number of night shifts. This may hint that the perceived effect is attributed to the demanding or intense nature of night shift work rather than just its "shift work" aspect.

Shift work is often accompanied by "quick returns", which refers to returning to work sooner than 28 hours after a shift-work day. The effect of quick returns was also observed in the aforementioned study investigating the increased risk of ischemic heart disease in shift workers. It was found that non-night shift workers (i.e., people working the afternoon or evening shifts) showed an increased risk of ischemic heart disease when they had a history of frequent

quick returns in the past year. However, the observed effect in nighttime shift workers could not be extrapolated once confounders were accounted for (Kader et al., 2022). The additive effects of shift work warrant immediate further research because they may have important implications for labor law recommendations regarding the scheduling of shift work.

In a similar vein of cumulative impacts, research conducted by Torquati et al. (2018) demonstrated that following the initial five years of engaging in shift work, each subsequent five-year period of continued shift work contributed to a 7.1% elevated risk of cardiovascular disease events (95% CI=1.05–1.10). It was shown that the risk of any cardiovascular event was 17% higher in shift workers compared to daytime workers. Furthermore, the risk for coronary heart disease morbidity was 26% higher in shift workers in comparison to daytime workers (1.26, 95% CI=1.10–1.43, I2=48.0%). This so-called additive effect was also seen in the relationship between shift work and the incidence of cancer, as discussed in the next section.

Association between Shift Work and Cancer

In contrast to individuals working regular daytime hours, those with a history of any exposure to shift work exhibited an increased risk of cancer mortality, with a relative risk of 1.04 (95% CI=1.00–1.08) (Su et al., 2021). It was also shown that exposure to night shift work increased the risk of breast cancer morbidity by 2.9%. A much higher risk of 8.6% was observed in a cohort of female employees who had been working night shifts for ten years or longer (Wei et al., 2022). This indicated an additive effect, similar to the one we explored in the previous cardiovascular section. Although no significant biases were found in the studies, the underlying cause of this observed additive effect remains unknown. A plausible explanation for this phenomenon could be disruptions to the circadian rhythm that cause changes to cellular deoxyribonucleic acid (DNA) and the immune system, as discussed in the following section on circadian rhythm and immunity.

A recent study carried out by Manouchehri et al. (2021) showed that flight attendants who worked long overnight flights had a higher risk of developing breast cancer compared to those who worked during the day, with a relative risk of 1.13 (95% CI=1.03–1.24, p=0.008, I2=71.3%). Yet, another study reported by Arafa et al. (2021) revealed that rotating shift work contributed to an increased risk of developing esophageal cancer in male workers. There is a myriad of possible explanations for these findings. For one, disruptions in the circadian rhythm cause dysfunction of the circadian genes, which are part of the immunological system of the gastrointestinal tract. Furthermore, melatonin has been shown to be an esophagoprotective compound, and its concentrations may be disrupted in shift workers (Majka et al., 2018).

It is well known that shift workers commonly resort to using alcohol as a means to sleep better. Shift work is classically associated with a disrupted circadian rhythm that lowers the overall quality of sleep and delays the onset of sleep. Allthough alcohol consumption may initially seem to improve sleep quality by reducing sleep-onset latency, it ultimately diminishes the overall quality of sleep and further disrupts the overall health of the individual. Additionally, alcohol consumption is highly linked with esophageal cancer. However, it must be mentioned that accounting for confounders, such as body mass index (BMI), smoking behavior, and alcohol consumption, did not reduce the strength of the relationship between esophageal cancer and shift work (Arafa et al., 2021).

In 2019, the International Agency for Research on Cancer formed a team of 27 scientists, who concluded that night shift work should be classified as Group 2A. The classification suggests that working the night shift is probably carcinogenic for humans (Ward et al., 2019). The basis for this assertion was derived from empirical evidence collected from human subjects as well as strong and sufficient evidence found in experimental animals. The studies discussed in this section are a demonstration of how shift work, either directly or via the influence of associated factors, can have deleterious effects on overall health. For instance, shift workers may not have as frequent and easy access to healthcare facilities as their day-working counterparts. As a result, they may face an uphill battle in the primary prevention of otherwise preventable diseases and even eventual mortality.

Shift Work, Circadian Rhythm, and Immunity

Research conducted by Wei et al. (2020) has demonstrated that shift workers experience disrupted levels of melatonin, a compound believed to be linked to the pathophysiological development of various cancers in cases of shift work. The secretion of melatonin is intricately tied to the inherent circadian rhythm, with light being the most powerful synchronizer (Boivin et al., 2022). In individuals following typical daytime work schedules, melatonin is mainly released at night and remains at minimal levels during the day. Conversely, shift workers who are exposed to heightened levels of nocturnal light experience suppressed melatonin secretion during daylight hours. Melatonin plays a pivotal role in oncoprotection through diverse mechanisms. Firstly, it exhibits direct organ-protective effects, as exemplified in the previously mentioned case of esophageal cancer. Secondly, it functions as an inhibitor of tumor cell proliferation. Additionally, melatonin reduces oxidative DNA damage and modulates estrogen levels.

In a study undertaken by Bergerson et al. (2022), shift workers showed lower methylation of certain genes that are intrinsically linked to the internal circadian rhythm. This finding further cements the linkage between shift work and the disruption of circadian rhythm. In addition to the noted circadian dysrhythmia, accelerated aging was also noted on a cellular level in shift workers. This sheds light on yet more evidence that shift workers endure epigenetic disruptions instead of maintaining normal homeostasis.

Circadian rhythm is intimately associated with the intrinsic immunity response and general homeostasis of the human body. A variety of homeostatic processes, such as macrophage function, tissue leukocyte count, magnitude of immune response, and histamine release, can exhibit the circadian oscillations. It has been shown that chronic inflammatory states, autoimmune states, and asthma are associated with disruption to the intrinsic circadian clock. This disruption may potentially have a role in the development of oncological diseases (Waggoner, 2020).

The expression of various immunological cell types, such as interferon gamma (IFNγ), interleukin 2 (IL-2), interleukin 4 (IL-4), interleukin 6 (IL-6), and cluster of differentiation 40 ligand (CD40L), has been shown to be closely linked to the expression of the so-called internal “clock genes” or the intrinsic circadian rhythm. It is important to emphasize that not only are immunological cells closely linked to the circadian rhythm, but the

expression of various DNA repair genes also relies on an internal circadian rhythm (Jin et al., 2023). This information is of immense importance in relation to the previously discussed section on how shift work and the subsequent circadian dysrhythmia may be linked in the pathogenesis of cancers. In fact, keeping in line with the theme of shift work and immunological functionality, shift workers were also shown to have a higher likelihood of moderate-severe asthma than their day-working counterparts (Maidstone et al., 2021b).

Shift workers were found to be more susceptible to testing positive for coronavirus disease 2019 (COVID-19). Additionally, it was shown that shift work and having a BMI above 30 were two of the most significant variables in determining susceptibility to infection (Loef et al., 2022). According to Rizza et al. (2021), shift workers exhibited a 37% higher risk of testing positive for COVID-19 compared to other cohorts. Yet another study conducted by Swanson et al. (2023) found more than a two-fold increase in the risk of susceptibility to COVID-19 among shift workers. Shift work was also found to be associated with an increased risk for acquiring a nosocomial COVID-19 infection. Consequently, it warrants extra precautions in the care of shift workers (Maidstone et al., 2021a). Although a direct causal relationship has not been established, this immunological susceptibility to infection may be attributed to the circadian dysrhythmia experienced by shift workers and the subsequent intrinsic immunological disruption. All of these findings contribute to the mounting evidence showing that shift work is intricately associated with a dysfunction in immunity, which in turn presents a higher risk for infectious processes and even cancer.

Metabolic Effects of Shift Work

The disruption of circadian rhythm and intrinsic homeostatic pathways causes subsequent disruptions to the metabolic processes of the human body. Shift work has been shown to be independently associated with a two-fold increase in the risk of developing metabolic syndrome (Lim et al., 2018). This association may be helpful for the early screening, diagnosis, and management of shift workers who are at an elevated risk for metabolic syndrome. Additionally, shift work has been linked with an increased risk of type 2 diabetes mellitus. It was found that an increased frequency of night shifts per month is associated with an even higher risk of developing type 2 diabetes mellitus.

In a separate study conducted by Civelek et al. (2023), it was found that shift workers with type 2 diabetes mellitus had poorer glycemic control compared to daytime workers. Additionally, the study showed that insufficient sleep among the shift workers led to an insulin-resistant state in adipocytes. It has been commonly observed that shift workers experience reduced quality of sleep and increased latency of sleep onset.

Obesity has also been linked with a disruption in the natural circadian rhythm, leading to a vicious feedback cycle between obesity, metabolic dysfunction, and circadian disruption. These findings indicate that there is a bidirectional relationship between obesity and circadian disruption (Wang et al., 2022). This relationship becomes potentially important in understanding metabolic sequelae of shift work. However, further research is required to fully explore this subject.

There has been an observed association between shift work and a significantly higher rate of bone turnover. This association raises concerns over the potential or accelerated development of osteoporosis in shift workers Bukowska-Damska et al. (2022). Furthermore, a study conducted by Martelli et al. (2022) revealed that shift workers exhibited lower levels of vitamin D compared to their day-working counterparts. It has been demonstrated that low vitamin D levels are linked to increased susceptibility to a myriad of diseases, including type 2 diabetes mellitus, tuberculosis, and certain types of cancer (Chang & Lee, 2019). These findings suggest that shift work may pose a risk for accelerated osteoporotic risk in the future. Nevertheless, these findings can prompt clinicians to surveil their regular patients that engage in shift work to promptly treat metabolic deficiencies and promote the primary prevention of fractures, osteoporosis, and metabolic disorders.

According to the findings of the presented studies, shift work does not only exhibit a statistically significant relationship with an increased risk for obesity, dyslipidemia, and insulin resistance, but also with the risk of developing osteoporosis and cancer (Shah et al., 2021). Although there has been a critical finding that shift work impairs metabolism, the current uncertainty surrounding whether physical activity can attenuate the subsequent weight and body composition changes resulting from impaired metabolism warrants further research (IARC Working Group on the Identification of Carcinogenic Hazards to Humans, 2020).

Reproductive and Mental Health Sequalae of Shift Work

Shift work has been found to cause several intriguing effects on both reproductive and mental health. Sponholtz et al. (2021) conducted a study involving a cohort of African-American female workers who had experienced any lifetime exposure to shift work. The study revealed that the female shift workers had a 20% lower fecundability compared to their counterparts who were not exposed to shift work. The fecundability ratio for female workers who frequently worked in the shift schedule was even lower, further providing evidence of an additive dose-related relationship.

Pregnant women who engaged in night-shift work were found to have a greater risk of a miscarriage as opposed to pregnant women who worked during the day. The observed relationship indicated a dose-response pattern between shift work and miscarriage in women during gestational age of 3–21 weeks (Begtrup et al., 2019). An increased risk of preterm birth was also found in women who frequently worked shift-based hours as well as those who worked three or more consecutive night shifts (Stock et al., 2019). Similarly, individuals who had quick returns to work, particularly less than 28 hours, demonstrated a three to four times increase in the risk of experiencing preterm birth during the first trimester.

In a study conducted by Michels et al. (2020), increased concentrations of luteinizing hormone were noted in female workers who participated in shift work. This finding further adds to the ongoing narrative that shift work may be a contributing factor in the decline of reproductive health and the disruption of ovarian function. Furthermore, there was a statistically significant finding showing that female shift workers who had accumulated 20 or more months of shift work in the last two years experienced menopause at an earlier age compared to women who did not participate in shift work. This observation was further magnified in

women who were under the age of 45 (Stock et al., 2019).

In a study conducted by Rodriguez et al. (2020), it was discovered that up to 20% of shift workers suffered from shift work sleep disorder (SWSD), a circadian disorder that generally presents with excessive sleepiness or insomnia. Male shift workers who experienced this disorder exhibited poorer erectile function than daytime workers. The subset of male shift workers who were specifically assigned to night shifts exhibited even more severe erectile dysfunction. These findings suggest that clinicians should consider sleep disturbances and circadian disorders caused by work schedules when examining the etiology of erectile dysfunction. Research conducted by Balasubramanian et al. (2020) revealed that shift workers suffering from a circadian disorder have more significant hypogonadal symptoms compared to daytime workers. In addition, shift workers exhibited lower levels of pregnenolone and testosterone in comparison to workers engaged in daytime hours (Bracci et al., 2023).

According to Torquati et al. (2019), shift workers were found to have an overall increased risk of experiencing adverse mental health outcomes, specifically depressive symptoms. There was a stronger relationship between shift work and mental health problems in female workers. Shift workers also scored higher in terms of cynicism, exhaustion, and poor efficacy (Gu et al., 2023). Despite the current lack of full comprehension of the complex interplay between mood disorders and circadian disruption, there is a recognized relationship between the two variables. As of now, it is not possible to comment on the causality pathway of this relationship, as well as which causes the other, mood disorders disrupting circadian rhythm or a disrupted circadian rhythm causing a mood disorder (Walker et al., 2020).

Research reported by Walker et al. (2021) uncovered some sort of link between schizophrenia and a circadian disruption, including altered circadian gene expression and low melatonin levels, in individuals suffering from paranoid schizophrenia. However, this association is not comprehensively grasped and necessitates additional investigation. Factors directly related to or resulting from shift work were also found to be associated with increased levels of anxiety. The factors under analysis included poor sleep quality due to the usage of medication, elevated stress and fatigue before, during, and after shift work, and inadequate recovery times after a shift (Li et al., 2022).

Another study carried out by Booker et al. (2020) found that shift work was strongly linked to anxiety and depression, the latter of which was associated with an increased time spent off work due to sick leave. This finding raises several questions regarding the long-term efficiency of employing workers to shift work and subsequently witnessing an increased proportion of workers taking days off from work to recover. Although having employees work around the clock by dividing the schedule into a day shift and alternate shifts may seem to be the most efficient management tactic on paper, this finding elucidates the need for further research, as the opposite approach might be more efficient.

In research conducted by Son & Lee (2021), shift workers were found to demonstrate a significant increase in the likelihood of suicidal ideation. This is a probable consequence resulting from their higher vulnerability to work-related stress and inadequate sleep. This is immensely important and poses compelling questions regarding the safety of shift work for modern-day employees. Therefore, additional research is vital to immediately investigate this matter. All in all, there are a lot of hypothesized detrimental reproductive and mental health effects of shift work that require further research for validation. Employers should also take these effects into consideration when coming up with more health-conscious work schedules.

DISCUSSION

This paper presents a comprehensive overview of the intricate relationship between shift work and various health consequences, encompassing cardiovascular health, cancer, circadian rhythm disruption, immunity, metabolism, reproductive health, and mental health. This discussion section synthesizes the key findings, addresses implications, and highlights areas for further research.

The literature review suggests a compelling association between shift work and the incidence of cardiovascular morbidity. Shift workers may exhibit increased arterial stiffness, inflammatory biomarkers, and a higher risk of hypertension (Xiao et al., 2022; Skogstad et al., 2023). The evidence presented, including the nurse cohort analysis and the association between shift work and atrial fibrillation, supports the notion that shift work may contribute to adverse cardiovascular outcomes (Wang et al., 2021). The additive effects of shift work on consecutive days, along with the long-term cumulative impact, underscore the need for targeted interventions and further investigation into the modifiability of these risks.

There is a concerning link between shift work and an elevated risk for cancer, particularly breast cancer and esophageal cancer (Arafa et al., 2021; Manouchehri et al., 2021). The additive effect observed in cancer mortality emphasizes the importance of understanding the underlying mechanisms (Wei et al., 2022). The findings regarding the effects of shift work on cancer should prompt further exploration into circadian disruption, DNA changes, and potential preventive measures. The classification of night-shift work as "probably carcinogenic to humans" by the International Agency for Research on Cancer highlights the urgency for workplace interventions and health policies to address the impact of shift work (Ward et al., 2019).

The disruption of circadian rhythm, as evidenced by altered melatonin levels and gene methylation, presents a plausible explanation for the observed associations between shift work and cancer as well as compromised immunity (Wei et al., 2020; Bergerson et al., 2022). Additional discussions on this matter should delve into the implications of circadian dysrhythmia on immune response and inflammation, as well as its potential role in the susceptibility to diseases and infections such as asthma and COVID-19. Further research is needed to elucidate the precise mechanisms and therapeutic interventions for the health consequences that arise from shift work.

Shift work has been associated with metabolic syndrome, type 2 diabetes mellitus, and increased bone turnover (Lim et al., 2018; Bukowska-Damska et al., 2022). These associations raise concerns over the long-term metabolic health of shift workers. Furthermore, the bidirectional relationship between obesity and circadian disruption signifies potential avenues for preventive strategies (Shah et al., 2021). However, the unclear role of physical activity in mitigating metabolic changes caused by shift work necessitates further exploration (IARC Working Group on the Identification of Carcinogenic Hazards to Humans, 2020).

Shift work poses adverse effects on reproductive health, including an increased risk of experiencing miscarriage, preterm birth, erectile dysfunction, and altered hormone concentrations (Begtrup et al., 2019; Stock et al., 2019; Michels et al., 2020; Rodriguez et al., 2020). This evidence underscores the importance of considering the adverse effects of shift work in family planning. Further discourse on this subject should address the potential impact of shift work on workforce demographics and the need for tailored healthcare support for individuals engaged in shift work. The implications of shift work on mental health, including increased risk of depression, anxiety, and suicidal ideation, emphasize the importance of workplace mental health programs and tailored interventions.

There is an urgent need for more large-scale, longitudinal research in this field. Future research directions should focus on exploring the effectiveness of interventions, such as circadian rhythm optimization strategies and workplace policies, to mitigate the health risks associated with shift work.

This paper covers a wide range of health impacts associated with shift work, including cardiovascular health, cancer, metabolism, reproductive health, and mental health. This breadth of review provides a holistic take on the potential consequences of shift work. Additionally, the paper references a variety of studies from different regions and industries, which enhances the credibility of its conclusions and provides a global perspective to its findings. This literature review was methodically conducted by utilizing reputable databases, i.e., Scopus and PubMed, and employing clear exclusion criteria to ensure the relevance and quality of the selected studies. The paper not only synthesizes current findings but also highlights areas where further research is needed, which can guide future studies and policy-making. This literature review only includes studies that have a fair and equitable gender proportion of participants where possible. Lastly, this paper emphasizes findings with statistical significance by excluding studies that failed to reject the null hypothesis, thus enhancing the reliability of the conclusions drawn.

Excluding studies that did not find significant results might lead to a publication bias, as it does not consider potentially important null findings that could provide a more balanced understanding of the topic. Also, the exclusion of papers based on biases that might influence the findings could be subjective. This paper uses a vast range of regional studies to draw effective conclusions. However, generalization is not possible, as most studies on this topic are regional and not global or conducted on a diverse enough cohort to warrant unbiased generalization of results. Further research is ultimately required in order to attain results that accurately reflect a global scale.

CONCLUSION

This literature review highlights the substantial health impacts of shift work on cardiovascular, oncological, immunological, metabolic, reproductive, and mental health. The key findings for cardiovascular health indicate increased risks for arterial stiffness, elevated levels of inflammatory biomarkers, hypertension, atrial fibrillation, and cardiovascular diseases. Shift work is classified as "probably carcinogenic to humans" due to its association with cancer development, particularly breast cancer, esophageal cancer, and overall cancer mortality. Immune dysfunction resulting from shift work leads to greater susceptibility to moderate-severe asthma and coronavirus disease 2019 (COVID-19). Shift work doubles the risk of metabolic syndrome and increases the risks for type 2 diabetes, obesity, and vitamin D deficiency. It also increases the risks for miscarriages, preterm births, earlier menopause, erectile dysfunction, and more significant hypogonadal symptoms. Additionally, many shift workers experience depressive symptoms, anxiety, and sleep disorders. These findings underscore the multifaceted impact of shift work on health and highlight the urgency for targeted interventions, workplace policies, and further research. A holistic approach is necessary to address the complex interplay between circadian rhythm, immunity, metabolism, and mental health. In summary, shift work poses significant health risks across multiple domains, emphasizing the need for targeted interventions and further research to mitigate these impacts and inform shift scheduling policies.

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CONFLICT OF INTEREST

There are no conflicts of interest to be declared.

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AB is the sole author of this paper and was responsible for the conceptualization and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, provision of administrative, technical, or logistic support, as well as the collection and assembly of data.

REFERENCES

Arafa A, Eshak ES, Iso H, Muraki I, Tamakoshi A (2021). Night work, rotating shift work, and the risk of cancer in Japanese men and women: The JACC Study. Journal of Epidemiology 31(12): JE20200208. doi: 10.2188/jea.JE20200208.

Balasubramanian A, Kohn TP, Santiago JE, Sigalos JT, Kirby EW, et al. (2020). Increased risk of hypogonadal symptoms in shift workers with shift work sleep disorder. Urology 138: 52–59. doi: 10.1016/j.urology.2019.10.040.

Begtrup LM, Specht IO, Hammer PEC, Flachs EM, Garde AH, et al. (2019). Night work and miscarriage: A Danish nationwide register-based cohort study. Occupational and Environmental Medicine 76(5): 302–308. doi: 10.1136/oemed-2018-105592.

Bergerson L, Fitzmaurice C, Knudtson T, McCormick H, Yu AM (2022). A simulated shift work schedule does not increase DNA double-strand break repair by NHEJ in the drosophila Rr3 system. Genes 13(1): 150. doi: 10.3390/genes13010150.

Bigert C, Kader M, Andersson T, Selander J, Bodin T, et al. (2022). Night and shift work and incidence of cerebrovascular disease – A prospective cohort study of healthcare employees in Stockholm. Scandinavian Journal of Work, Environment & Health 48(1): 31–40. doi: 10.5271/sjweh.3986.

Boivin DB, Boudreau P, Kosmadopoulos A (2022). Disturbance of the circadian system in shift work and its health

impact. Journal of Biological Rhythms 37(1): 3–28. doi: 10.1177/07487304211064218.

Booker LA, Sletten TL, Alvaro PK, Barnes M, Collins A, et al. (2020). Exploring the associations between shift work disorder, depression, anxiety and sick leave taken amongst nurses. Journal of Sleep Research 29(3). doi: 10.1111/jsr.12872.

Bracci M, Zingaretti L, Martelli M, Lazzarini R, Salvio G, et al. (2023). Alterations in pregnenolone and testosterone levels in male shift workers. International Journal of Environmental Research and Public Health 20(4): 3195. doi: 10.3390/ijerph20043195.

Bukowska-Damska A, Skowronska-Jozwiak E, Kaluzny P, Lewinski A (2022). Night shift work and osteoporosis - Bone turnover markers among female blue-collar workers in Poland. Chronobiology International 39(6): 818–825. doi: 10.1080/07420528.2022.2037626.

Chang SW, Lee HC (2019). Vitamin D and health - The missing vitamin in humans. Pediatrics & Neonatology 60(3): 237–244. doi: 10.1016/j.pedneo.2019.04.007.

Civelek E, Civelek DO, Akyel YK, Kaleli Durman D, Okyar A (2023). Circadian dysfunction in adipose tissue: Chronotherapy in metabolic diseases. Biology 12(8): 1077. doi: 10.3390/biology12081077.

Gill J, Hardy V, Marosi C (2023). Quality of employment in Canada: Night work, 2022. Retrieved from https://www150.statcan.gc.ca/n1/pub/14-28-0001/2023001/article/00008-eng.htm.

Gu H, Lee J, Hwang Y, Kim J, Lee S, et al. (2023). Job burnout among workers with different shift regularity: Interactive factors between sleep, depression, and work environment. Frontiers in Public Health 11. doi: 10.3389/fpubh.2023.1131048.

Houot M-T, Tvardik N, Cordina-Duverger E, Guénel P, Pilorget C (2022). A 34-year overview of night work by occupation and industry in France based on census data and a sex-specific job-exposure matrix. BMC Public Health 22(1): 1441. doi: 10.1186/s12889-022-13830-5.

IARC Working Group on the Identification of Carcinogenic Hazards to Humans (2020). Night shift work. IARC Monographs on the Identification of Carcinogenic Hazards to Humans, No. 124. International Agency for Research on Cancer, Lyon. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK568199/.

Jin Y, Wang Z, Huang S, Liu C, Wu X, et al. (2023). Identify and validate circadian regulators as potential prognostic markers and immune infiltrates in head and neck squamous cell carcinoma. Scientific Reports 13(1): 19939. doi: 10.1038/s41598-023-46560-8.

Johnson CY, Tanz LJ, Lawson CC, Schernhammer ES, Vetter C, et al. (2020). Night shift work and cardiovascular disease biomarkers in female nurses. American Journal of Industrial Medicine 63(3): 240–248. doi: 10.1002/ajim.23079.

Kader M, Selander J, Andersson T, Albin M, Bodin T, et al. (2022). Night and shift work characteristics and incident ischemic heart disease and atrial fibrillation among healthcare employees – A prospective cohort study. Scandinavian Journal of Work, Environment & Health 48(7): 520–529. doi: 10.5271/sjweh.4045.

Li Y, Wang Y, Lv X, Li R, Guan X, et al. (2022). Effects of factors related to shift work on depression and anxiety in nurses. Frontiers in Public Health 10. doi: 10.3389/fpubh.2022.926988.

Lim YC, Hoe VCW, Darus A, Bhoo-Pathy N (2018). Association between night-shift work, sleep quality and metabolic syndrome. Occupational and Environmental Medicine 75(10): 716–723. doi: 10.1136/oemed-2018-105104.

Loef B, Dollé MET, Proper KI, van Baarle D, Lifelines Corona Research Initiative, et al. (2022). Night-shift work is associated with increased susceptibility to SARS-CoV-2 infection. Chronobiology International 39(8): 1100–1109. doi: 10.1080/07420528.2022.2069031.

Maidstone RJ, Anderson SG, Ray DW, Rutter MK, Durrington HJ, et al. (2021a). Shift work is associated with positive COVID-19 status in hospitalised patients. Thorax 76(6): 601–606. doi: 10.1136/thoraxjnl-2020-216651.

Maidstone RJ, Turner J, Vetter C, Dashti HS, Saxena R, et al. (2021b). Night shift work is associated with an increased risk of asthma. Thorax 76(1): 53–60. doi: 10.1136/thoraxjnl-2020-215218.

Majka J, Wierdak M, Brzozowska I, Magierowski M, Szlachcic A, et al. (2018). Melatonin in prevention of the sequence from reflux esophagitis to barrett's esophagus and esophageal adenocarcinoma: Experimental and clinical perspectives. International Journal of Molecular Sciences 19(7): 2033. doi: 10.3390/ijms19072033.

Manouchehri E, Taghipour A, Ghavami V, Ebadi A, Homaei F, et al. (2021). Night-shift work duration and breast cancer risk: An updated systematic review and meta-analysis. BMC Women's Health 21(1): 89. doi: 10.1186/s12905-021-01233-4.

Martelli M, Salvio G, Santarelli L, Bracci M (2022). Shift work and serum vitamin d levels: A systematic review and meta-analysis. International Journal of Environmental Research and Public Health 19(15): 8919. doi: 10.3390/ijerph19158919.

Michels KA, Mendola P, Schliep KC, Yeung EH, Ye A, et al. (2020). The influences of sleep duration, chronotype, and nightwork on the ovarian cycle. Chronobiology International 37(2): 260–271. doi: 10.1080/07420528.2019.1694938.

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ: n71. doi: 10.1136/bmj.n71.

Redeker NS, Caruso CC, Hashmi SD, Mullington JM, Grandner M, et al. (2019). Workplace interventions to promote sleep health and an alert, healthy workforce. Journal of Clinical Sleep Medicine 15(04): 649–657. doi: 10.5664/jcsm.7734.

Reinganum MI, Thomas J (2023). Shift work hazards. StatPearls. StatPearls Publishing, Treasure Island. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/37694838.

Rizza S, Coppeta L, Grelli S, Ferrazza G, Chiocchi M, et al. (2021). High body mass index and night shift work are associated with COVID-19 in health care workers. Journal of Endocrinological Investigation 44(5): 1097–1101. doi: 10.1007/s40618-020-01397-0.

Rodriguez KM, Kohn TP, Kohn JR, Sigalos JT, Kirby EW, et al. (2020). Shift work sleep disorder and night shift work significantly impair erectile function. The Journal of Sexual Medicine 17(9): 1687–1693. doi: 10.1016/j.jsxm.2020.06.009.

Shah A, Turkistani A, Luenam K, Yaqub S, Ananias P, et al. (2021). Is shift work sleep disorder a risk factor for metabolic syndrome and its components? A systematic review of cross-sectional studies. Metabolic Syndrome and Related Disorders. doi: 10.1089/met.2021.0070.

Skogstad M, Aass HCD, Sirnes PA, Mamen A, Skare Ø, et al. (2023). Influence of shift work on arterial stiffness and systemic inflammation: A 3-year follow-up study in industry. Journal of Occupational & Environmental Medicine 65(4): 284–291. doi: 10.1097/JOM.0000000000002779.

Son J, Lee S (2021). Effects of work stress, sleep, and shift work on suicidal ideation among female workers in an electronics company. American Journal of Industrial Medicine 64(6): 519–527. doi: 10.1002/ajim.23243.

Sponholtz TR, Bethea TN, Ruiz-Narváez EA, Boynton-Jarrett R, Palmer JR, et al. (2021). Night shift work and fecundability in late reproductive-aged African American women. Journal of Women's Health 30(1): 137–144. doi: 10.1089/jwh.2019.8166.

Stock D, Knight JA, Raboud J, Cotterchio M, Strohmaier S, et al. (2019). Rotating night shift work and menopausal age. Human Reproduction 34(3): 539–548. doi: 10.1093/humrep/dey390.

Su F, Huang D, Wang H, Yang Z (2021). Associations of shift work and night work with risk of all-cause, cardiovascular and cancer mortality: A meta-analysis of cohort studies. Sleep Medicine 86: 90–98. doi: 10.1016/j.sleep.2021.08.017.

Swanson GR, Schwartz BA, Joyce C, Keshavarzian A (2023). Binge drinking alcohol and circadian misalignment in night shift nurses is associated with decreased resiliency to COVID-19 infection. Alcohol: Clinical and Experimental Research 47(5): 908–918. doi: 10.1111/acer.15052.

Torquati L, Mielke GI, Brown WJ, Burton NW, Kolbe-Alexander TL (2019). Shift work and poor mental health: A meta-analysis of longitudinal studies. American Journal of Public Health 109(11): e13–e20. doi: 10.2105/AJPH.2019.305278.

Torquati L, Mielke GI, Brown WJ, Kolbe-Alexander T (2018). Shift work and the risk of cardiovascular disease. A systematic review and meta-analysis including dose–response relationship. Scandinavian Journal of Work, Environment & Health 44(3): 229–238. doi: 10.5271/sjweh.3700.

Trades Union Congress (2018). Number of people working night shifts up by more than 150,000 in 5 years. Retrieved from https://www.tuc.org.uk/news/number-people-working-night-shifts-more-150000-5-years.

U.S. Bureau of Labor Statistics (2019). Job flexibilities and work schedules summary. Retrieved 9 December 2023, from https://www.bls.gov/news.release/flex2.nr0.htm.

Waggoner SN (2020). Circadian rhythms in immunity. Current Allergy and Asthma Reports 20(1): 2. doi: 10.1007/s11882-020-0896-9.

Walker WH, Walton JC, DeVries AC, Nelson RJ (2020). Circadian rhythm disruption and mental health. Translational Psychiatry 10(1): 28. doi: 10.1038/s41398-020-0694-0.

Walker WH, Walton JC, Nelson RJ (2021). Disrupted circadian rhythms and mental health. In: Handbook of Clinical Neurology (DF Swaab, F Kreier, PJ Lucassen, A Salehi, RM Buijs eds). Elsevier. doi: 10.1016/B978-0-12-819975-6.00016-9.

Wang N, Sun Y, Zhang H, Wang B, Chen C, et al. (2021). Long-term night shift work is associated with the risk of atrial fibrillation and coronary heart disease. European Heart Journal 42(40): 4180–4188. doi: 10.1093/eurheartj/ehab505.

Wang S, Lin Y, Gao L, Yang Z, Lin J, et al. (2022). PPAR-γ integrates obesity and adipocyte clock through epigenetic regulation of Bmal1. Theranostics 12(4): 1589–1606. doi: 10.7150/thno.69054.

Ward EM, Germolec D, Kogevinas M, McCormick D, Vermeulen R, et al. (2019). Carcinogenicity of night shift work. The Lancet Oncology 20(8): 1058–1059. doi: 10.1016/S1470-2045(19)30455-3.

Wei F, Chen W, Lin X (2022). Night-shift work, breast cancer incidence, and all-cause mortality: An updated meta-analysis of prospective cohort studies. Sleep and Breathing 26(4): 1509–1526. doi: 10.1007/s11325-021-02523-9.

Wei T, Li C, Heng Y, Gao X, Zhang G, et al. (2020). Association between night-shift work and level of melatonin: Systematic review and meta-analysis. Sleep Medicine 75: 502–509. doi: 10.1016/j.sleep.2020.09.018.

Xiao Z, Xu C, Liu Q, Yan Q, Liang J, et al. (2022). Night shift work, genetic risk, and hypertension. Mayo Clinic Proceedings 97(11): 2016–2027. doi: 10.1016/j.mayocp.2022.04.007.

in in subjects with type 2 diabetes and chronic kidney disease. Diabetes, Obesity and Metabolism 15(5):463–473. https://doi.org/10.1111/DOM.12090.

Zinman B, et al. 2015. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. New England Journal of Medicine 373(22):2117–2128. https://doi.org/10.1056/NEJMoa1504720.