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CARDIOVASCULAR RISKS IN NIGHT SHIFT WORKERS: A SYSTEMATIC REVIEW OF EVIDENCE AND IMPLICATIONS FOR OCCUPATIONAL HEALTH SCREENING

RESEARCH PAPER - LITERATURE REVIEW

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ABSTRACT

Background: Shift work is an essential and large part of the European Union economies. A large portion of the working population in the member states has or will be working night shifts in their lifetime. Considering the large prevalence of a rather new phenomenon of night work, it has been researched whether it impacts the health outcomes of the most common cause of morbidity and mortality in Europe, namely, circulatory diseases.

Aim: The aim of this paper is to review the relevant literature to elucidate the definition of night shift work, prevalence, proposed pathophysiology, and effect on cardiovascular and cerebrovascular mortality and morbidity.

Materials and Methods: Structured literature review, where cohort studies that show the hazards of shift work, night work were clearly defined in accordance with the definition set by the European Commission Working Time Directive were selected for analysis. Key words "night shift work", "cohort analysis", "ischaemic heart disease", "atrial fibrillation" and "stroke" were used in NIH MEDLINE and Elsevier databases to find relevant articles. The findings were compared to the guidelines stated by Sweden, which serves as the reference member state for the European Union in this paper. Finally, in this paper, suggestions or amendments to the policies mandated in the reference country of Sweden were provided.

Results: There is an increased risk for ischaemic heart disease in night-shift workers in an exposure-response association. There seems to be a threshold of exposure to night shift before a tangible risk is induced. There is an association between ischaemic heart disease and quick returns from night shift, the number of night shifts per year and the number of consecutive night shifts taken. There is increased cardiovascular cause-specific mortality with night shift. There is an increased risk for cerebrovascular events with night shift. There is conflicting evidence about the association of night shift and atrial fibrillation.

Conclusions: Night shift is a risk factor for circulatory disease. It is proposed that desynchronization of circadian rhythms is the pathophysiology behind it. Poor sleep might be a contributing factor. The current guidelines set by the reference country Sweden are not aligned with the results to adequately screen for circulatory disease in the night shift population. There is a need for increased frequency of health assessments for all night workers, as well as introducing a risk stratification based on the evidence of an exposure-response relationship between night shift and cardiovascular morbidity and mortality.

KOPSAVILKUMS

Ievads. Maiņu darbs ir būtiska un plaši izplatīta Eiropas Savienības ekonomiku sastāvdaļa. Liela daļa darba ņēmēju dalībvalstīs savas dzīves laikā ir vai būs nodarbināti nakts maiņās. Ņemot vērā šī salīdzinoši jaunā nakts darba fenomena plašo izplatību, ir pētīts, vai tas ietekmē veselības iznākumus, kas saistīti ar visbiežākajiem saslimšanas un mirstības cēloņiem Eiropā, proti, asinsrites sistēmas slimībām.

Mērķis. Šī darba mērķis ir pārskatīt un apkopot atbilstošo zinātnisko literatūru, lai noskaidrotu nakts maiņu darba definīciju, izplatību, patofizioloģiju un ietekmi uz kardiovaskulāro un cerebrovaskulāro mirstību un saslimstību.

Materiāli un metodes. Tika veikts strukturēts literatūras pārskats, kurā analīzei tika izvēlēti kohortu pētījumi, kuros nakts maiņu darbs bija skaidri definēts saskaņā ar Eiropas Komisijas Darba laika direktīvas noteikumiem. Atslēgvārdi "night shift work", "cohort analysis", "ischaemic heart disease", "atrial fibrillation" un "stroke" tika izmantoti, meklējot attiecīgos rakstus NIH MEDLINE un Elsevier datubāzēs. Iegūtie rezultāti tika salīdzināti ar Zviedrijas noteiktajām vadlīnijām, kas šajā darbā kalpo kā references dalībvalsts Eiropas Savienībā. Visbeidzot, darbā ir sniegti priekšlikumi un iespējamie grozījumi politikās, kas ir spēkā references valstī Zviedrijā.

Rezultāti. Konstatēts paaugstināts išēmiskās sirds slimības risks ar ekspozīcijas-iznākuma saistību. Iespējams, pastāv ekspozīcijas slieksnis, pēc kura risks kļūst klīniski nozīmīgs. Išēmiskās sirds slimības risks ir saistīts ar ātru atgriešanos pēc nakts maiņas, nakts maiņu skaitu gadā un secīgo nakts maiņu skaitu. Nakts maiņu darbs ir saistīts ar paaugstinātu kardiovaskulāras izcelsmes mirstību, kā arī ar palielinātu cerebrovaskulāro notikumu risku. Savukārt dati par nakts maiņu darba saistību ar priekškambaru mirdzaritmiju ir pretrunīgi.

Secinājumi. Nakts maiņu darbs ir asinsrites sistēmas slimību riska faktors. Ierosinātais patofizioloģiskais mehānisms ir cirkadiānā ritma desinhronizācija, savukārt slikta miega kvalitāte var būt kā papildu veicinošs faktors. Pašreizējās references valsts Zviedrijas vadlīnijas nav pietiekami saskaņotas ar jaunākajiem datiem, lai efektīvi nodrošinātu asinsrites sistēmas slimību skrīningu nakts maiņu darbiniekiem. Ir nepieciešams palielināt veselības pārbaužu biežumu visiem nakts darbiniekiem un ieviest riska stratifikāciju, balstoties uz pierādījumiem par ekspozīcijas-iznākuma attiecībām starp nakts darbu un kardiovaskulāro saslimstību un mirstību.

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List of Abbreviations

WTD – Working Time Directive

EU – European Union

EC – European Commission

NIH – National Institute of Health

AM – Ante Meridiem

CR – Constant Routine

LPS – Lipid polysaccharide

CDC – Centre of Disease Control

INTRODUCTION

This is a literary review of the associated cardiovascular risk of working during the night and working shift work, which is a reality awaiting any aspiring physician.

In the European Union, there are 20 pillars of social rights which are placed in order to uphold living and working conditions in the Union member countries. The most relevant principle for this paper is principle 10 about health and safety: "Workers have the right to a high level of protection of their health and safety at work. […]" (European Comission, 2003). It is further clarified to protect the rights of workers in Article 31 of the Charter of Fundamental Rights of the European Union about fair and just working conditions. In article 31, it is written: "Every worker has the right to working conditions which respect his or her health, safety and dignity." (European Comission, 2003).

Article 31 was grounds for the EU's Working Time Directive (WTD) to be written to put forward binding laws to guarantee that the European Union member states respect the rights of workers. The most recent edition of the Working Time Directive, which is still legally binding, was written in 2003. In the Directive, it is decreed that workers must not work more than 48 hours on average for each 7-day period, including overtime. It mandates rest breaks for shifts longer than 6 hours. It sets minimal rest periods and minimal paid annual leave. When it comes specifically to the night shift, the protection the Directive sets is in recital numbers 7 and 9.

In the WTD No. 2003/88/EC, recital numbers 7 and 9, it is written:

- "(7) Research has shown that the human body is more sensitive at night to environmental disturbances and also to certain burdensome forms of work organisation and that long periods of night work can be detrimental to the health of workers and can endanger safety at the workplace." (European Comission, 2003)
- "(9) It is important that night workers should be entitled to a free health assessment prior to their assignment and thereafter at regular intervals and that whenever possible they should be transferred to day work for which they are suited if they suffer from health problems." (European Comission, 2003)

These recitals give reasoning and purpose behind the legally binding articles given in the Directives. In these recitals, it is evident that working night shifts can be detrimental to one's health and, therefore, health assessments for night workers are essential and should be provided free of

charge. In the industrial economies, eliminating night shift work is not feasible, and studies show that a substantial part of the working population is working night shifts as of 2023.

The aim of this study is to elucidate the proposed health impact of night shift work and the recommended health assessments based on this knowledge. The scope of this study will be limited to the diseases of the circulatory system, since it constitutes the biggest share of the causation of morbidity and mortality in Europe (Eurostat, 2025). It was the main reason for 32.4% of all deaths in the region, accounting for almost every third death (Eurostat, 2025). Diseases of the circulatory system were defined as "[…] those related to high blood pressure, heart disease and diseases of veins and arteries" (Eurostat, 2025). Ischemic heart diseases, such as myocardial infarction and cerebrovascular events like stroke, constituted the two main causes of death from diseases of the circulatory system.

The tasks of this study are as follows:

- Explore the definitions concerning Night and Shift work as ascertained in the European Working Time Directive
- Outline the history and prevalence of night work in Europe
- Explore the pathophysiology of health effects caused by night work
- Investigate the effect on cause-specific mortality and morbidity concerning the circulatory system caused by night shift work in Europe
- Explore the screening recommendations in place in European Union member states
- Give suggestions to change the recommendations

MATERIALS AND METHODS

The tasks of this literary review were achieved by compiling the primary research findings of the cardiovascular effects of night work. The inclusion criteria for the research are Cohort studies undertaken in Europe and wherein the definitions are according to the ones set forward by the European Working Time Directive. The time period for the studies should be in the modern contemporary period (meaning the time period following the second world war). The studies were found using the NIH Medline function for accessing medical journals and finding relevant articles. Furthermore, Riga Stradins University access to Elsevier services was used to find relevant articles. Key words "night shift work", "cohort analysis", "ischaemic heart disease", "atrial fibrillation" and to were used to find the relevant articles. Exclusion criteria were if the study was performed outside of Europe, did not conform to the EC WTD definition of night work, was not published in English, or where the reference cohort was not permanent day workers.

RESULTS

1. Night Shift Overview

1.1 Definition according to the European Working Time Directive

According to the European Working Time Directive (WTD) No. 2003/88/EC "shift work means any method of organising work in shifts whereby workers succeed each other at the same work stations according to a certain pattern, including a rotating pattern, and which may be continuous or discontinuous, entailing the need for workers to work at different times over a given period of days or weeks" (European Comission, 2003). Often these shifts are divided into morning, evening and night shifts, where the two former shifts are 8 hours in length and overlapping, whereas the latter is longer at 10 hours. This is often due to higher workloads during the midday and less during the night, however, this is not always the case. According to the Directive No. 2003/88/EC, "night time" is a period agreed upon, which is no less than 7 hours, which includes the time interval of midnight to five AM (European Comission, 2003). A night worker according to the Working Time Directive is: "(a) on the one hand, any worker, who, during night time, works at least three hours of his daily working time as a normal course; and (b) on the other hand, any worker who is likely during night time to work a certain proportion of his annual working time, as defined at the choice of the Member State concerned" (European Comission, 2003).

To illustrate the use of the definitions, this paper will use the member state Sweden as an example. In Sweden, a night shift is any shift that is taken wherein at least 3 hours worked fall between the hours 22:00 and 06:00, which is in accordance with criterion (a) set forward by the European Working Time Directive (Arbetsmiljöverket).

Furthermore, in Sweden, for a worker to be considered a night worker, they must expect one third of all shifts taken within the year to fall into the definition of night shift. Therefore, criterion (b) in Sweden is that 33% of all annual shifts must be considered night shifts in accordance with criterion (a) for the worker to be considered a night shift worker and therefore be entitled to the protective regulations set forward by the European Working Time Directive (Arbetsmiljöverket).

1.2 History

Work in the early industrialized European countries used to be longer than the present-day ones, according to data collected by economic historians Michael Huberman and Chris Mins and published on Oxford University's collaborated non-profit organization: Our World in Data (Giattino & Ortiz-Ospina, 2020).

In 1870, in these early industrialized European countries, workers worked an average of 60–70-hour workweeks for 50 weeks in the year (Giattino & Ortiz-Ospina, 2020). Furthermore, these factories often had increased fixed costs, such as ovens at steel manufacturing, which caused companies to introduce shift work to ensure 24/7 operations and reduce costs and due to increased international competition that came with increased international trade (LaDou, 1982). Furthermore, with advanced technology, many industries started to require 24/7 operation. Some of the early adopters of the shift work were the steel industries, pulp, paper production and petroleum extraction (LaDou, 1982).

The workdays have gotten shorter from 12-hour workdays six days of the week to the now 8-hour workdays 5 days a week (LaDou, 1982). However, the number of shift workers has increased dramatically throughout the years in industrialized countries and has become necessary in many industries (Taylor, 1972).

In Great Britain, the proportion of shift workers in the manufacturing sector alone rose from 12.5% to 25% of all workers between 1954 and 1968, respectively (Taylor, 1972). This was a trend seen also in other in more sectors of the economy and was representative of increased shift work in the increasingly industrialized Britain as a whole (Taylor, 1972).

Shift work, especially night shift work, has long been known to be disruptive for the circadian rhythm and result in chronic sleep deprivation (Taylor, 1972). This has logically raised concerns about the negative health impact on workers.

Despite the lack of evidence at the time, it was strongly believed by many shift workers that shift work had a negative impact on their health (Taylor, 1972; Blyton, 1970). There has been a great interest in investigating the impact of shift work and night work throughout the century as it has become more and more prominent in many industries.

1.3 Prevalence of night work in Europe

The European Labour Force Survey has estimated that in 2023, 18% of the employed population between the ages of 15 and 64 in the 27 countries of the European Union is working shift work (Eurostat, 2025). It is estimated that 7.7% of the same working population in 2023 is working night shifts (Eurostat, 2025). The health concern and the topic of this literary review of working night shifts are therefore relevant to a large part of the European working population.

One pertinent sector that needs to offer its services around the clock is healthcare. For the hospital to work at all times, there is a need for shift work of nurses, doctors, guards, technicians, ambulance workers and more. However, there are many more services that are offered around the clock. Nightclubs, bars, restaurants, grocery stores, public transport, gas stations, airlines with

transmeridian flights and even delivery services are just some that can be named. A well-known colloquial expression for New York is that it is the “City that never sleeps”; the essence of this idea can, in the opinion of the author, be extended to the modern industrial world. The convenience of being serviced at night has gone from a seldom luxury to something akin to a necessity.

2. Pathophysiology of Health Effects Caused by Night Shift Work

Many internal physiologic changes in the human body follow a 24-hour pattern, giving rise to the name circadian rhythm from the Latin "*circa dies"*, translated to "about a day". Humans are diurnal, meaning we are active during the day cycle and sleep during the night cycle. Disruption from this circadian rhythm is thought to be a factor in the morbidity caused by shift work and especially night work (LaDou, 1982).

Most of our knowledge about the circadian rhythm comes from investigations based on animals and seldomly humans. There are three main forms of circadian rhythm investigations that are conducted (LaDou, 1982):

(1) Entirely depriving the person or animal from the day and night light cycle
(2) Increasing or decreasing artificially the day or the night light cycle
(3) Inverting the sleep and wake cycle

Based on these studies, it has been shown that the endocrine system changes rhythmically and predictably and like so also the urine outflow, the metabolism, including its effect on drug absorption, metabolism and elimination, haematopoiesis and more (LaDou, 1982).

Different rhythms take different amounts of time to shift to accommodate the change in the night and day cycle. For example, the minimum body temperature shifts to the new sleep period after seven or more days (Taylor, 1972; LaDou, 1982; Tiberge, 2003).

An empirical study on circadian rhythm can be made with trans meridian flights, wherein passengers experience circadian rhythm desynchronization, colloquially called jet lag (Tiberge, 2003). Studies have shown that 60-70% of airplane crew experience sleep disturbance after crossing a time zone (Manfredini et al., 1998). It is known that sleep resynchronizes rather quickly, cortisol rhythm on the other hand requires a day per hour of desynchronization for time shifts greater than 6 hours (Tiberge, 2003). In other words, assuming a night shift displaces the day and night cycle by 8 hours, it would take eight days or approximately a week to resynchronize the cortisol rhythm.

It has furthermore been shown that phase delays are faster to recover from than phase advances (Tiberge, 2003). In other words, for flight crew, flying eastward and elongating the day is preferred over westward flights. Similarly, for shift workers, going from night shift to day shift is preferred over transitioning from night shift to afternoon shift.

Modern studies performed in the twentieth century with the help of gene sequencing, knockout mutations and rigorous experimental protocols has charted the intricate details of the physiology of our endogenous circadian rhythm.

It has been found that "Circadian rhythms are driven by molecular clocks centered around core clock genes such as BMAL1, CLOCK and NPAS2 […]" (Chellappa et al., 2019) which can be altered in a positive and negative feedback fashion from changes in behavior or in the environment. These genetic clocks are ubiquitous and present in almost every cell including cardiomyocytes and they oscillate in 24-hour cycles (Chellappa et al., 2019). Furthermore, it was found that the Suprachiasmatic nucleus functions as a central clock and can modulate the circadian rhythm of peripheral tissues through rhythmic secretion of Melatonin and Cortisol (Chellappa et al., 2019).

It has been found that disruption of the circadian rhythm due to either mutation of 'clock' genes as shown in mice experiments with knock out mutations or due to misalignment caused by disruption of behavior (e.g. untimely physical activity, mental stress or meals) or environment (e.g. light & dark cycle) increased cardiovascular risk (Chellappa et al., 2019).

The internal circadian rhythm has been further studied in human experiments through the use of protocols such as the Constant Routine (CR) protocol wherein participants remain awake in dim light (less than 5 lux) to remove the effect of environment, and under isocaloric evenly spaced meals to remove the effect of behavior on circadian rhythm. In such a way the experiments were able to isolate endogenous circadian desynchronization and study its effects by having the participants undergo sleep and awake cycles that are longer or shorter than the physiological 24-hour periods. Circadian rhythm desynchronization in both endogenous (gene mutation or disruption in absence of environmental or behavioral change in CR protocols) and due to behavior/environment in experiments have been shown to increase risk of cardiovascular events (Chellappa et al., 2019). Studies in mice undergoing CR protocols have shown "[…] decreased levels of cardiomyocytes and vascular smooth muscle cells hypertrophy, as well as a compensatory reduced expression of key genes in cardiac hypertrophic pathways (*ANF, BNP, ACE,* and *collagen*)." (Chellappa et al., 2019). These effects was reversible once they were subject to 24-h light and dark cycles again. However, it has also been shown in hamsters that circadian rhythm desynchronization can also lead to irreversible cardiac fibrosis formation (Chellappa et al., 2019).

Moreover, in mice studies undergoing circadian distruption and being exposed to LPS endotoxins, an exaggerated pro-inflammatory response from the immune system has been established (Chellappa et al., 2019). This gives another inflammatory mechanism to circulatory

disease due to increased sensitivity to inflammation caused by infection in people that undergo circadian desynchronization.

Contemporary population studies further find evidence for the circadian desynchronization as the mechanism for pathogenesis (Chen et al., 2022). It is known that Melatonin, a hormone secreted by the pineal gland is partially responsible for timely sleep and therefore for internal regulation of the circadian rhythm (Chen et al., 2022). It has been theorized that a disruption of Melatonin secretion may be pathogenic. A 12-year prospective study was performed by Chen et al. (2022) in Sweden wherein a cohort of night shift workers with a mutation of Melatonin receptor that delays melatonin activity and therefore delays sleeping was compared with their night shift colleagues with no such mutation. It was found that the Melatonin receptor mutation that reduces the circadian desynchronization of night shift was a statistically significant protective factor in the incidence of cerebrovascular events (Chen et al., 2022).

Other than the circadian desynchronization, sleep deprivation by itself is known to be a cause of increased mortality (Knutsson et al., 1986; Manfredini et al., 1998; Chen et al., 2022). Shift work is known to be disruptive to sleep, both in quality and quantity (Taylor, 1972; Knutsson et al., 1986; Manfredini et al., 1998; Chen et al., 2022).

3. Primary Studies Overview

3.1 Night shift and Cardiovascular mortality

The first study on the impact of shift work on mortality was conducted in 1949, a retrospective cohort study of the age of death of workers at Norsk Hydro comparing shift workers and permanent day workers. There was no association of shift work with increased mortality or reduced life expectancy found (Thiis-Evensen, 1949).

The first retrospective cohort study on mortality of shift work on a national level was conducted by Taylor (1972) and published in the British Journal of Industrial Medicine. Intrigued by the study performed by Thiis-Evensen (1949), he sought to use the newly popularized "[…] cohort mortality analysis […]" (Taylor, 1972) to investigate the effect of working night shift on life expectancy. By contacting the Confederation of British Industry and occupational physicians, they found 10 companies that were eligible to be included in their study. To be included in the study, they needed payroll data which included hours worked for at least 10 years of manual labour between 1946 and 1968. In total 8 603 manual workers were included. It was found that although deaths caused by cardiovascular diseases in the shift workers were greater than those of day workers, it was not statistically significant. It was also found that the shift workers had more deaths from cardiovascular disease than expected when compared to national data on cardiovascular mortality, although this too was not a statistically significant increase. It was concluded in the study that shift work did not decrease life expectancy.

A large prospective cohort study was conducted to further investigate the association of night shift exposure with mortality based on the Swedish Twin Registry managed by the Karolinska Institute (Åkerstedt et al., 2020). 42 731 twins of advanced age (41–99 years old) were included in the study. Advanced age participants were chosen to maximize the exposure to night shift as well as to ensure enough mortality events for a statistically significant analysis to be performed. Each patient was interviewed once between 1998 and 2003, and a questionnaire was filled out, including self-reporting the lifetime exposure to night work, wherein months where at least one night shift was worked were counted. Covariables that were included in the questionnaire were: educational level, tobacco consumption, alcohol consumption, exercise/sedentary lifestyle, occupation (stratified into blue-collar and white-collar professions), body mass index, coffee consumption, presence of hypertension, light comorbidity (e.g., migraine), and severe comorbidity (e.g., neoplasm, ischemic event or infarction). The follow-up period from inclusion was 18 years; the cause of death was discerned from the Swedish national board of health and welfare registry. When adjusted for all aforementioned covariates, the hazard ratio for mortality due to circulatory

diseases was 1.17 (CI 95% 1.04 – 1.31) for night shift workers when compared to workers who have never worked night shift. When stratified by lifetime exposure to night shift, it was found that night shift exposure of 1-5 years did not cause a statistically significant increase in deaths caused by circulatory diseases, but that exposure for more than 5 years did. When comparing monozygotic twins, the results were not statistically significant. However, when comparing dizygotic twins, the hazard ratio for death due to circulatory disease was 1.16 (CI 95% 1.01 – 1.33).

3.2 Night shift and ischemic heart disease

An early study on the health impact of shift work and night work was that made by Anthon Aanonsen in Western Norway (Aanonsen, 1964; Blyton 1970; Taylor, 1972). It was a retrospective cohort study where he compared the medical records of workers at three factories. He identified and compared three main groups of workers: permanent day workers, usual shift workers and shift workers who had turned to permanent day work. He found no significant difference in heart diseases between these groups (Aanonsen, 1964).

Despite the lack of evidence at the time, it was strongly believed by many shift workers that shift work had a negative impact on their health (Taylor, 1972; Blyton, 1970). There has been a great interest to investigate the impact of shift work and night work throughout the century as it has become more and more prominent in many industries. With a growing body of evidence throughout the years, there are now many qualitative and peer-reviewed studies on the topic showing the negative health outcomes associated with night work (Erren, 2019; Schernhammer et al., 2001; Pan et al., 2011; Li et al., 2023; Chen et al., 2022).

The studies that followed explored the topic deeper, hypothesizing that although shift work and night work might not contribute to mortality, they might contribute to morbidity (Taylor, 1972).

A prospective cohort study was conducted in Stockholm and published in The Lancet in 1986, where the researchers tried to "[…] determine whether shift workers differ from day workers in incidence of coronary heart disease" (Knutssson et al., 1986). Shift work in this study was compatible with the modern WTD definition set by the European Commission. The shift work was in a 4-week pattern and included day shift, afternoon shift and night shift, which then ended with a week free from work before repeating another 4-week work week for up to 21 years. 504 male papermill workers of only Swedish descent were followed for 15 years, comparing the incidence of ischemic heart disease between the shift workers and permanent day workers. The results in this study were adjusted for age and exposure to rotating shift work. There was no statistically

significant increase in risk for ischemic heart disease at exposure 1-10 years. A statistically significant increase in risk for ischaemic heart disease at exposure to shift work of between 11-20 years was found. At 11-15 years of exposure to shift work, the relative risk for ischaemic heart disease was 2.2 (p=0.04), and at 16-20 years of exposure the relative risk was 2.8 (p=0.03). The authors in this study identified that there was a statistically significant increase in smoking (p=0.034) and divorced marital status (p=0.035) in the shift working cohort. They decided to perform a multiple logistic regression to explore the predictors of ischaemic heart disease in the shift workers, and it was found that neither smoking nor marital status had a statistically significant explanatory effect on the negative health outcome. Only age and exposure to shift work were statistically significant. It was also found that when exposure to shift work was not adjusted for in the analysis, the relative risk for ischaemic heart disease for shift workers was 1.4, but statistically insignificant. Furthermore, when following the workers for another 5 years, the trend of exposure-related increase in relative risk for ischemic heart disease was broken. The authors suggested that there was a selection bias and that the workers less fit for night work would seek day work after 15 years, forming a new form of *survivor cohort*, explaining this break in the trend. Some limitations that can be noted in this study are the lack of participants of the female sex and the lack of permanent shift workers. When some of the workers' self-assessed exposure to night shift was compared to available records, it showed that 17% of the employees over- or underestimated their exposure by more than one year.

A prospective study of healthcare workers excluding physicians was constructed in the Stockholm region of Sweden to explore the hazard ratio of night work with ischemic heart disease and atrial fibrillation (Kader et al., 2022). The study included over 30,000 healthcare workers employed in the Stockholm region between the years 2008 and 2016. The terms "night" and "night shift work" in this study are in accordance with the Working Time Directive set by the European Commission. The data was collected using a register-based and computerized exposure data system wherein each worker reported in exactly the hours worked and at which times of the day. The hazard ratios were then calculated using the exposure to night work during the year. It was found that permanent night shift workers had a hazard ratio of 1.61 when compared to the permanent day shift workers. The dose-dependent hazard ratio for shift workers per 10-night shifts taken annually was 1.03 (CI 1.00 – 1.05). Interestingly, it was found that consecutive night shifts (≥3 nights in a row) were a contributing factor for ischemic heart disease, with a trend test per 10 consecutive night 3-day or more night shifts hazard ratio of 1.06 (CI 1.00 – 1.20). The strength of this study, when compared to the previous studies, is in its number of participants, as well as

including workers of both sexes. Furthermore, it did not rely on self-reported data on exposure to night work.

A study was conducted in Denmark, similarly to the one by Kader et al. (2022), wherein 254,031 healthcare workers were followed between 2007 and 2015 through health records at a national registry and through payroll data of start and end times for each and every shift worked (Vestergaard, 2023). Unlike the study conducted by Kader et al. (2022), this study included no permanent night shift workers, and the average night shifts taken by the workers was < 2 shifts monthly and on average, for a duration of less than 4 years. The results were "[…] stratified by sex and adjusted for age, calendar year, diabetes, family history of cardiovascular disease, educational level, indicators for obesity, hypercholesterolaemia, and hypertension" (Vestergaard, 2023). It was found that when compared with male permanent day workers, male workers with night shift, regardless of exposure, had an adjusted incident rate ratio of 1.22 (CI 95% 1.07 – 1.39). There was a trend for increased incidence with exposure by the number of night shifts taken per month ($p=0.03$). Similarly, there was also a trend for increased incidence with exposure by cumulative annual night shifts ($p=0.01$). Furthermore, there was also a trend for years of rotating night shifts ($p<0.01$). Finally, there was also a trend for years with night shift exposure ($p<0.01$) and the number of consecutive night shifts ($p=0.03$). No such trends were observed for females, only when stratified by age, a statistically significant increase in incidence rate ratio of 1.83 (CI 95% 1.21 – 2.76) was found.

3.3 Night shift and atrial fibrillation

Atrial fibrillation is the most common cardiac rhythm disturbance in the world and is linked with morbidity. Atrial fibrillation is a risk factor for the development of several diseases. By causing turbulence in the heart, it increases the risk of cardioembolic stroke. It is also linked with the development of dementia (Kader et al., 2022).

Atrial fibrillation episodes are most common in the mornings and evenings, following a circadian rhythm (Kader et al., 2022). This raises the question if the disruption of the circadian rhythm is a risk factor for atrial fibrillation.

A retrospective cohort study was undertaken using the UK biobank to study the association of night shift work and incidence of atrial fibrillation. It included 283,657 participants aged 40-69 between 2006 and 2010. Out of the participants, only 75,391 were eligible for inclusion by self-reporting their lifetime employment in a questionnaire. It was found that when adjusted for age and sex, night shift workers had a hazard ratio of 1.16 (CI 95% 1.02–1.32) when compared to self-reported permanent day workers (Wang et al., 2021).

An improved prospective cohort study was performed in Sweden by using data from administrative IT system, wherein each and every worker must clock in and out daily (Kader et al., 2022). Since this data is fundamental to payroll, it is in the best interest of both the employer and the employee that it is as accurate as possible. In this study, the hazard ratio for atrial fibrillation of permanent night workers compared to day workers were 0.78 (CI 95% 0.49-1.23), and no statistically significant trend for increased incidence of atrial fibrillation was found with frequency of night work or frequency of long work weeks (defined as weeks exceeding 45 hours of work).

3.4 Night shift and cerebrovascular events

Using the same cohort registry of nurses and nursing assistants as Kader et al. (2022), over 30,000 healthcare workers were followed prospectively in Stockholm Sweden between 2008 and 2016 to investigate the relation of cerebrovascular events with night shift and shift work (Bigert et al., 2021)**.** Similarly, as to Kader et al. (2022), exposure to shift work and night work was established using a computerized employee-registry, wherein the employee will clock in and out every shift and have their payroll adjusted accordingly.

One year of night shift work only yielded a hazard ratio of 1.39 (CI 95% 0.88 – 2.21) compared to day shift workers, which is not statistically significant. However, for those who worked >30-night shifts in one year compared to those who have never worked night shift, the hazard ratio was 1.44 (CI 95% 1.04 – 1.99)

Consecutive three or more-night shifts in a year increased the risk of a cerebrovascular event occurring during the year by 5.3% per occurrence when compared to the population that never have worked night shift. The hazard ratio was 1.053 (CI 95% 1.013 – 1.095) per frequency of three or more-night shift occurrence.

Quick returns to night shift from previous shift, defined as night shift starting within 28 hours of ending previous shift caused a hazard ratio of cerebrovascular events of 1.006 (1.001-1.011) per occurrence in a year.

Interestingly, whereas there was a hazard ratio of 1.083 (CI 95% 1.031 – 1.139) per year night shift worked, the hazard ratio was only statistically significant after 5 years of night shift exposure. When stratified for exposure, 1-5 years of night work with a mean exposure of 2.6 years did not yield a statistically significant increase in incidence of cerebrovascular events. At 5 years or higher, the hazard ratio was, however, statistically significant at 1.87 (CI 95% 1.27 – 2.77).

3.5 Overview of the results of the studies

The association between disease and night shift work has long been debated (Colligan, 1980). For illustration, it was at the time noted by Michael J Colligan (1980) working at the United States Centre of Disease Control (CDC): "Although there is some evidence to suggest that shiftwork may adversely affect individual well-being (e.g., Wyatt & Marriott, 1953; Thiis-Evensen, 1958; Dirken, 1966), equally compelling evidence suggests that it does not (Harrington, 1978; Taylor & Pocock, 1972)."

The early studies on the topic of cause-specific mortality performed by Thiis-Evensen (1949) and Taylor (1972) found no such statistically significant decrease in life expectancy, neither due to all-cause mortality nor cause-specific mortality due to circulatory disease. However, when studies started adding adjustment for age and exposure as for example in the study performed by Åkerstedt et al. (2020), such an association was found.

Furthermore, in regard to exposure to night-shift work, in the study performed by Knutsson et al. (1986), Bigert et al. (2021) and Åkerstedt et al. (2020) there seemed to be no increased hazard for morbidity or mortality due to circulatory disease for workers with minimal exposure to night shift. This seems to support the idea that there is a threshold that needs to be reached before there is a significant health impact of night-shift work (5 years in the Karolinska Twin registry study by Åkerstedt et al. (2020), 5 years in the study by Bigert et al. (2021) study and 10 years in the study performed by Knutsson et al. (1986)).

When comparing mortality and morbidity from night shift workers at large with day shift workers, it dilutes the night shift cohort by including the workers who can-not tolerate night shift and change back to day work. A study by Knutsson et al. (1986) showed that 63% of workers change from shift work to day work within 3 years due to intolerance, either due to ailments (gastrointestinal or other) or social stress (Knutssson et al., 1986). Workers take the night shift voluntarily and are legally protected to be allowed to switch to day work if they cannot work the night shift due to health reasons. This creates a preselection in the night shift cohort, where, after some time, only the healthy workers remain. Despite this preselection causing a misrepresentation, a statistically significant increase in cause-specific circulatory mortality and morbidity has been found (Knutsson et al. 1986; Åkerstedt et al., 2020). Moreover, a statistically significant increase in mortality due to circulatory disease in dizygotic twins at high exposure to night shift not only supports the threshold theory but also suggests a cause-and-effect relationship between night shift exposure and mortality due to circulatory disease. The Karolinska Twin registry study performed by Åkerstedt et al. (2020) furthermore also illustrates that the negative impact night shift has on

lifestyle (increased alcohol and tobacco consumption, sedentary lifestyle, etc.) can not explain the increased cause-specific mortality.

Night shift not only causes increased cause-specific mortality but also increased morbidity. Similarly to when the association of night work and mortality was first found when addressing cofactors, the same is true for the association of night shift and morbidity. Study performed by Aanonsen (1964) found no significant association, whereas the studies that adjusted for cofactors such as by Knutsson et al. (1986) and Kader et al. (2022) and Vestergaard et al. (2023) found a statistically significant increase in cardiovascular morbidity with increased night shift exposure. For ischemic heart disease (myocardial infarction, coronary heart disease), studies show that there is an exposure and effect correlation between night shift and ischemic heart disease (Knutsson et al.,1986; Kader et al., 2022; Vestergaard et al., 2023). This association is found even when risk factors such as hypercholesterolemia are accounted for, albeit doing so is controversial since hypercholesterolemia can be caused by the night shift itself and is proposed as one of the pathophysiological mechanisms (Knutssson et al., 1986; Vestergaard et al., 2023). Social distress and riskful behaviour can also be caused by night shift; nonetheless, when adjusted for consumption of tobacco, alcohol, and marital status, it was found not to be statistically significant. Risk factors inherent to night shift that have been identified in the studies are frequency of consecutive night shifts (three or more in a row), frequency of total night shifts taken per annum, and aggregate exposure in the form of how many years of night shift have been worked (Kader et al., 2022; Vestergaard et al., 2023). There seems to be a threshold of exposure before there is an increased risk of ischemic heart disease events. And in the case of Knutsson et al. (1986), there seems to be a survivor population after 20 years of exposure, wherein working night shift seems to be a protective factor for ischemic heart disease. This was explained by a process of survival of the fittest, where the cohort is culled of those workers who can not tolerate the night shift. In the case of the study performed in Denmark by Vestergaard et al. (2023), the study found no significance in increased ischemic heart disease in female workers in large without stratification for age, even though the similar study by Kader et al. (2022) found such an association. This can similarly be explained by the cumulative exposure of night shifts (average 4 years, less than 2 night shifts a month) might not have reached the exposure needed for an effect to be observed.

As for the world's most common cardiac rhythm disorder, atrial fibrillation, the studies have been conflicting. A large study using the UK biobank has found such an association (Wang et al., 2021) , whereas the study made in Stockholm by Kader et al. (2022) found no such association. The latter is one of the few studies that has been performed without reliance on the self-reporting of night shift exposure, making it more qualitative with less recall bias. Furthermore,

it is known that atrial fibrillation episodes follow a circadian rhythm; therefore, the pathophysiology of night shift with cicardian dysynchronzation gives a convincing reason for suspecting that night shift may be a risk factor for atrial fibrillation and thusly supporting the findings of Wang et al. (2021) in the UK biobank study.

Although it is not certain if night shifts may increase the incidence of atrial fibrillation, which is a cause of cardioembolic stroke, ischemic and hemorrhagic stroke has been found to be associated with high exposure (>30-night shifts per annum) of night work (Bigert, et al., 2021). Increased incidence of stroke has also been seen in those that have cumulative exposure of 5 years or more of night-shift, further lending credence to the exposure threshold theory. Moreover, quick return from night shift (return to work within 28 hours of the previous night shift) has been identified as a risk factor associated with cerebrovascular events.

4. Screenings in the European Union member states

Swedish guidelines for screening of night workers are mandated to those who are projected to work for at least 3 months with night shifts or for workers who work at least 33% of their yearly shifts classified as night shifts. According to section 29 of the Swedish Work Environment Authority´s provisions on Medical Examinations in Working Life (AFS 2023:15), chapter 7-9: all night workers are entitled to at the start of their night shift employment, every 6th year until the age of 50 and thereafter every 3 years a health checkup (Arbetsmiljöverket). These checkups are mandated to include (ViSiDa, 2025):

- Questionnaire. Including the presence of angina pectoris
- Blood pressure and pulse measurements
- Height, weight and waist circumference
- Clinical blood status; blood sugar including HbA1c; cholesterol; liver function tests; and TSH. For men above 50, PSA is included.
- Visual and hearing assessment
- ECG
- Consultation about lifestyle, including smoking and alcohol habits

There are no Europe-wide guidelines for the health assessment of night shift workers, only that they are obligatory to be provided by the companies at the start, and at intervals of night shift employment and at no cost to the employees. It is up to each member country to set national guidelines or for the individual companies for the interval of the health assessments, as well as what these assessments shall entail.

In Appendix 1, there can be seen a summary of the mandated minimum frequency of health assessment of member states in the European Union that the author could find. Most countries allow for more frequent assessments at the discretion of local occupational health specialists. However, some countries do not have mandated minimum intervals at all that protect night-shift workers, and those intervals are to be instead set solely by the discretion of the occupational health personnel at the companies themselves.

One case study of companies having their own internal guidelines is Lufthansa. They started introducing 24/7 services in their Frankfurt operations (International Labour Organization, 2004). They incentivized the permanent night work positions with a higher salary compared to their current ones. However, they maintained a strict voluntary opt-in policy for the permanent night shift positions. They mandated a day off work after two consecutive night shifts worked and

offered health assessments by their local occupational health physician yearly for those who accepted the permanent night shift contracts. The workers were allowed to go back to the permanent day shift if they gave the company a four-week notice. They found no increased cardiovascular morbidity in their new permanent night shift workers (International Labour Organization, 2004). Although it is doubtful that any meaningful biostatistical analysis can be extracted from this internal study. The sample size of 45 day-shift workers serving as the reference population and being compared to 17 night-shift workers, with a follow-up and exposure of 1 year, may be considered too short and with a sample size too small. Furthermore, the referenced population are in fact, rotating-shift workers converted to day-shift workers. They are thus not night-shift work 'naïve'.

For simplicity, this paper will be using the European Union member state of Sweden as a reference for the whole EU. This is due to it having clear mandatory health assessment components and frequencies that lend themselves well to comparison and scrutiny, and recommendations, as the purpose of this paper.

When looking at the mandatory components of the Swedish health assessment, there are investigations that are not related to cardiovascular health, which can be explained by night shift being known to be disruptive to many human systems. For example, night shift is classified as a group 2a Carcinogen, explaining why PSA screening for prostate cancer is included in the mandatory screening program in Sweden (Erren, 2019). Since this literary review is focused on night shifts effect on circulatory diseases, only the screening criteria pertinent to this group of diseases will be discussed further. In Sweden, the relevant health assessment components for this paper are:

- Questionnaire that includes lifestyle factors (exercise, smoking, alcohol consumption, presence of angina pectoris)
- Height, weight and waist circumference
- Blood pressure and pulse measurements
- Hb1Ac and cholesterol
- ECG

A questionnaire is a cheap and effective way to identify vascular risk factors. Some predisposing factors for vascular events are not alterable. Examples of non-alterable predisposing factors are increased age, ethnicity (African American and Southeast Asian descent (Wereski, 2022; Brown, 2023; Yusuf, 2004) is known to be predisposed to atherosclerotic coronary artery disease) and female gender (Wereski, 2022; Brown, 2023; Yusuf, 2004). These are constants and

unique to each worker. However, there are also predisposing factors that are important to be aware of as these can be addressed by the occupational specialists and the workers themselves (Wereski, 2022; Brown, 2023; Yusuf, 2004). These alterable predisposing factors are easily identified in the questionnaire.

Low education is a risk factor; these patients do not know when to seek healthcare, and thus the guided anamnesis-taking for angina pectoris is one way of addressing this risk factor (Wereski, 2022; Brown, 2023; Yusuf, 2004). Another is smoking, which is a known risk factor in a myriad of diseases and conditions; circulatory diseases are no different. For those workers who are identified as smokers, assistance in smoking cessation is imperative. Similarly, alcohol over-consumption is a risk factor. Interestingly, low to moderate alcohol consumption has been shown to be protective for myocardial infarction, whereas any consumption higher than that paradoxically increases the risk of a myocardial infarction occurring (Wereski, 2022; Brown, 2023; Yusuf, 2004). Therefore, identification of the level of alcohol consumption through the questionnaire and seeking to aid in reducing the consumption when it is above acceptable levels is recommended. Lastly, a sedentary lifestyle is associated with poor cardiovascular health and an increased likelihood of cardiovascular events. Promoting aerobic exercise and strength exercises in those identified as having a sedentary lifestyle should be attempted.

Obesity is a well-known risk factor for cardiovascular and cerebrovascular disease, and weight and height measurements for calculating body mass index and waist circumference are both easy ways to evaluate obesity. In addition to the previously mentioned exercise, weight reduction procedures such as gastric bypass or perhaps more likely GLP-1 analogue medications may be added for those workers who are obese.

Another mandatory component of the Swedish health assessment of night workers that is also cheap to conduct is blood pressure and pulse measurements. Hypertension is a big component of morbidity and a risk factor for cerebrovascular events as well as cardiovascular events. Frequent measurements of blood pressure to ensure that essential hypertension is treated if and when it develops is an important preventative action that can not be understated when it comes to circulatory diseases, and especially in night working cohorts, which pose a larger risk of these events occurring. When it comes to pulse measurements, an irregular and fast pulse is a cheap screening factor for further testing with electrocardiography and telemetry for cardiac rhythm disorders.

Furthermore, the the blood tests that are mandatory in Sweden will be scrutinized. Another alterable predisposing factor for circulatory events is hypercholesterolemia and hyperglycaemia, either due to the onset of diabetes or due to poor management of already existing diabetes. Since

Hb1Ac is indicative of the average glycemic level in the blood over the last three months, it is a good tool for the purpose of evaluating the glycemic control for compliance in the diabetic cohort of night workers, as well as being diagnostic for diabetes itself. Furthermore, hypercholesterolemia is not only a known predisposing factor in vascular disease, but it can also be caused by night work in itself, making it even more relevant to test for it and to evaluate the need for giving cholesterol-lowering medications.

Lastly, electrocardiography (ECG) is a cheap, quick, non-invasive and important diagnostic test that can be done anywhere. A standard twelve-lead ECG will show how the electric signals travel, which can be evaluated for conduction abnormalities. It also shows cardiac rhythm abnormalities such as atrial fibrillation or flutter, supraventricular tachycardias, and supraventricular extrasystoles. Furthermore, it can also show the presence of past ischaemia with a pathological Q wave, indicating scar formation in the heart. It can moreover show the presence of ventricular hypertrophy and strain, aiding in the diagnosis of long-standing hypertension with organ damage.

5. Discussion of Screenings Systems

It is now clear that there is an association between circulatory disease morbidity and night shift exposure based on the results of the studies included in this literature review. As for the health assessment mandated by the European Commission in the Working Time Directive, there are no mandatory included components in the health checkups, nor the frequency at which they should be conducted. Because of the lack of European Union wide mandated policies, Sweden will serve as a reference for the EU.

Night work is an independent risk factor of cardiovascular and cerebrovascular events, even when adjustment for other known predisposing factors is done; therefore, by carefully screening and decreasing other predisposing factors of circulatory diseases, the hazard of working night shift on cardiovascular health can be improved towards being comparable to that of the general population. The Swedish health assessments for night shift workers do just that, and it includes many cheap and highly effective screening components. However, it fails to adequately cover atrial fibrillation. Electrocardiography (ECG) gives a snapshot of the conductive state of the heart and its rhythm; it may not elucidate the presence of paradoxical atrial fibrillation, which is a risk factor for cardioembolic strokes. Telemetry or Holter would provide more sensitive diagnostics for atrial fibrillation while still being non-invasive and safe for the workers, although at a higher cost. Albeit it is important to keep in mind that the studies on the association of night shift work and atrial fibrillation are not conclusive, and, therefore, the need for sensitive screening for it perhaps is not relevant.

What is perhaps more interesting is the frequency of the health assessments. Starting the screening process before the night shift is important to adjust the non-fixed predisposing factors for circulatory disease prior to adding night shift as a fixed predisposing factor. The second health assessment occurs after 6 years. Since the articles included in this study suggests that there might be a threshold of night shift exposure before there is a tangible increase in the risk for morbidity and mortality, the delay before the second health assessment might be logical. Some of the studies included in this paper has shown that five years of exposure has been necessary before the risk for adverse circulatory health effects start to be seen. Furthermore, in Knutsson et al. (1986) study, it was found that a majority of workers will not tolerate night shift within three years; therefore, allowing the night shift worker population to properly establish before the second screening might also be beneficial cost-wise.

The third health assessment being after 12 years is problematic. Partly because the definition of a night worker per Swedish law is very selective of a small cohort. Only those who have 33%

of their total shifts worked on the night shift are protected by the mandated health assessments. In other words, those with a disproportionately high exposure to night shifts are the ones who get these health assessments and at these intervals. It has now been established, based on the studies examined in this paper, that there is a dose-response relationship between exposure to night shift and adverse cardiovascular and cerebrovascular health. Thusly, the workers will have a high exposure already at 6 years, and with many night shifts per annum, will be waiting for another 6 years before their next health assessment. The risk of an adverse health event occurring during this time is too great. It is known that every 10-night shift taken increases the risk of ischaemic heart disease by 3% according to the study conducted by Kader et al. (2022).

An increased frequency at the age of 50 years old is logical. Age is an important predisposing factor for circulatory diseases, and increasing the frequency of health assessments, as it poses a bigger risk for cardiovascular and cerebrovascular events, is a cost-effective screening triaging. Even though the night shift population in all the studies included in this paper was, on average, younger than the reference population and therefore the number of workers that may be eligible for the increased frequency is comparatively small, this is a great policy.

In the Danish national cohort study performed by Vestergaard et al. (2023), it was shown that even comparatively few night shifts are also a predisposing factor for adverse circulatory health. On average, 2-night shifts would be enough to increase the risk of ischaemic heart disease occurring. Most likely, the people who work so few night shifts would not be eligible to be called night shift workers and be protected by the mandated health assessments. The 33% of all shifts worked required to be night shifts is therefore seen as too restrictive to qualify for screenings.

What has been seen otherwise in these studies is that the character of the night shifts taken also plays a big role in how big a health risk they pose. Those who work many consecutive night shifts, have early return from night shifts, and those who have many night shifts per annum are at a higher risk of poor circulatory outcomes.

Based on the findings in the articles included in this paper, there are some amendments to the screening program that can be recommended. It could be suggested that the screening should be stratified into low, medium and high-risk night shift workers. The character of the night shifts taken as well as the amount of night shifts worked should be considered when determining the risk level of the worker. The frequency of the health assessments should be fixed accordingly; those who work many shifts and shifts with bad character should be considered high-risk workers and should therefore also be compensated with more frequent health assessments. Those who are high risk might be considered for more diagnostic investigations such as carotid doppler,

telemetry/Holter or echocardiography, although the evidence for such procedures based on the articles included in this paper is weak.

CONCLUSIONS

- Night shift, according to EC WTD, is anyone who works 3 hours during the night for a number of shifts as defined by the member state. In Sweden, it is defined as 33% of shifts annually.
- Prevalence of night shift work in Europe is 7.7% of the working age population.
- Night shift work constitutes an independent hazard for cerebrovascular ischemic and haemorrhagic events, cardiovascular ischemic events, as well as cardiovascular and cerebrovascular cause-specific mortality with reduced life expectancy.
- Atrial fibrillation episodes occur in a circadian pattern; however, there is conflicting evidence on the risk of atrial fibrillation associated with night shift work.
- Pathogenesis of night shift work is circadian desynchronization. Sleep deprivation and inflammation are possibly further contributing pathogenetic mechanism.
- There seems to be a minimum exposure threshold before tangible risk from night shift is induced. That minimum exposure threshold is seemingly 5 years of at least 1 night shift a month.
- There is an exposure and effect model between the number of night shifts taken annually and adverse cardiovascular and cerebrovascular health. Further also an exposure and effect model between the number of 3 or more consecutive night shifts taken, and the number of quick returns from night shift (defined as return within 28h of the previous night shift) has been found.
- There is no EU-wide frequency for health assessments of night shift workers. Current frequency for health assessment of night shift workers in Sweden is far too infrequent and with too high inclusion criteria (33% of shifts being night shifts). As little as one night shift a month over a prolonged period constitutes a significant hazard.
- There should be risk stratification for night shift workers and health assessment frequency and investigations adjusted accordingly. Not only for age, but also for the character of night shift work.

PRACTICAL RECOMMENDATIONS

Based on the findings of this paper, suggestions for the amended frequency of health care screenings of night shift employees are the following:

1. Before starting night shift employment. No change from the current screening program. This health assessment is to reduce all the variable predisposing factors for cardiovascular and cerebrovascular disease before starting the night shift.
2. At 3 years of night shift employment. At this point, it is expected that the population that can tolerate night shift has formed, and these workers are more likely to keep working night shift; therefore, it is cost-effective to start more frequent screenings.
3. At 5 years of night shift employment. At this point, the exposure is high enough to be expected to have a statistically significant increased effect on cause-specific morbidity and mortality.
4. Further screening frequencies should be determined by the risk stratification of the worker (based on the number of night shifts per year, number of quick returns from night shifts and number of 3 or more consecutive night shifts taken) as well as their age.

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APPENDICES

Appendix 1: List of mandatory health assessments in European Union members states

Country	Minimum frequency of statutory health assessment
Sweden	Every 3 years; every 3 years from age 50
Denmark	Every 3 years
Latvia	Every 2 years; annually from age 50
Italy	Every two year
Estonia	Every 3 years
France	Every 3 years
Germany	Every 3 years; annually from age 50
Portugal, Finland, Lithuania, Netherlands, Belgium, Poland, Slovakia, Hungary, Czechia, Spain	No mandated statutory frequency

(Harth, 2022; Arbetsmiljöverket; Health group, 2025; Matthew Howse, 2022; Adlabor, 2003; DIÁRIO DA REPÚBLICA, 2019; Organisation of Working Time Act, 1997, 1993; Service Union United PAM, 2025; Riigikogu, 2025; An excerpt of the Labour Law, 2016; Socialinés apsaugos ir ministerija; Preventive medical examination, n.d; FEDERAL PUBLIC SERVICE, 2025; María Teófila Vicente-Herreroa, 2016; Serwis Rzeczypospolitej Polskiej, 2022; Government of Czechia, 2021; Slovak Republic - Slovakia, 2012; Changes to compulsory medical checks (update), 2024)

Declaration

I, Samer Fathalla Ali, hereby certify that this research paper on the topic

„Sirds un asinsvadu slimību riski nakts maiņu darbiniekiem: sistemātisks pierādījumu pārskats un praktiskas sekas arodveselības izvērtēšanā”

(title of the research paper in Latvian)

„Cardiovascular risks in night shift workers: a systematic review of evidence and implications for occupational health screening”

(title of the research paper in English)

is my own independent research. All other sources of data, definitions and quotations in my research paper are referenced accordingly. The text of this research paper has never been submitted in any way to any other National Examination Board for evaluation in its entirety or parts and has never been published in its entirety.

_____ /Samer, Fathalla Ali

(student’s signature) (name, surname)

28.10.2025