Can the health effects of shift work be mitigated? A summary of select interventions

Shift work, particularly work at night, has been linked to several possible adverse health effects, such as increased risk of work injuries (1) and sleepiness (2), as well as potentially longer-term or chronic impacts like cardiovascular disease (3), diabetes (4), and breast cancer (5-7). Disrupted work-life balance and psychological stress have also been observed more frequently in shift workers compared to non-shift workers (8). However, less is known about what strategies may be most effective in preventing these negative events. Researchers have tried different approaches to reduce the risk of adverse health effects in permanent night or rotating shift workers:

1. Schedule changes;
2. Controlled exposure to light and dark;
3. Behavioural interventions; and,
4. Drugs to promote sleep, wakefulness, or adaptation.

Key messages

- Mitigating the health effects of shift work is complex. Different approaches have been attempted to promote adaptation of the circadian rhythm to shift work, or to reduce risk factors for chronic disease.
- The most beneficial shift schedules for health were forward, quickly-rotating shifts and flexible working conditions.
- The combination of bright light treatment and wearing goggles or glasses to block or filter light may be more effective at promoting circadian adaptation than using either one of these approaches alone.
- Behavioural interventions are less studied compared to other types of interventions. There is some evidence that lifestyle changes and naps can improve physical health and quality of life.
- There was limited evidence that melatonin, hypnotics, or stimulants had positive effects on health.
- Further, high-quality research on large numbers of shift workers is needed.

In general, these interventions may be used to promote adaptation of the circadian rhythm to shift work. Behavioural interventions may also work more directly by reducing risk factors for chronic disease (e.g. diet and physical activity). The main results of some of these studies and reviews are summarized here, with a particular emphasis on preventing chronic disease in shift workers in the healthcare, manufacturing, and public safety sectors.

1. Schedule changes

As 24-hour work is unavoidable in a variety of industries, researchers have evaluated different shift schedules designed to reduce some of the negative health effects of working at night. Optimal shift schedules are aligned as much as possible with the circadian rhythm, promote adaptation of the circadian rhythm with shift work, reflect workers' needs and preferences, and meet organizational or productivity requirements. Flexible working conditions, which encompass work time control and self-rostering, gives workers a certain degree of control and choice over the duration, position, and distribution of their working times (9). Based on the literature to date, the following intervention types appear to have the most beneficial effects on the health of shift workers.

Intervention	Beneficial Effects Observed
Changing from backward (counter-clockwise) to forward (clockwise) rotation and changing the speed of rotation	↑ Total sleep length & leisure-time activity (10) ↑ Sleep duration & sleep quality (11) ↑ Sleep quality after the morning shift (12) Improvements in triglycerides, glucose, blood pressure, & sleep quantity & quality (13) ↓ Stimulant intake (14)

	No change of fatigue & sleepiness (14)
Changing from eight-hour to twelve-hour shifts	Increased sleep quantity & quality (15) ↑ Physical fitness & sleep quality (16) No change of blood pressure (16) ↑ Sleep quantity and quality after both night and day shifts (17)
Flexible working conditions, self-scheduling, "ergonomic shift scheduling principles"	Improved cholesterol levels (18) ↑ Health & work-life balance (19-22) ↑ Performance & worker motivation (9) ↓ Stress, absenteeism, and turnover (9) Minimal to no effects on direct organizational costs (19)

These studies reflect the wide variety of schedule changes that can be implemented in workplaces. Many were evaluated over the long-term (six months or more) in different types of shift workers, such as nurses, factory workers, and police officers. However, it is important to note that some schedule changes are not included in these studies, like the switch from twelve-hour to eight-hour shifts. Some of the key limitations of these studies are that they were generally conducted on small numbers of shift workers and they primarily used self-reported rather than objectively measured health outcomes. Nevertheless, the strongest positive health effects were measured for forward, quickly-rotating shifts and flexible working conditions. These results are consistent with a previous literature review about optimal shift schedules (19).

2. Controlled exposure to light and dark

Exposure to light at night is believed to be one of the most important pathways that links shift work to breast cancer and other health outcomes (23). In general, two approaches have been evaluated separately and in combination in shift workers to help their circadian rhythm adapt to shift work: exposure to bright light, and the use of light-blocking goggles or glasses while commuting and prior to sleep. To help the circadian rhythm adapt to shift work, bright light treatment during night work would ideally suppress melatonin release and increase body temperature and cortisol levels in workers on the night shift, whereas the use of light blocking goggles or glasses in the morning after night work would generate the opposite effects.

Intervention	**Beneficial Effects Observed**
Bright light treatment during night work or on days off work	Varying effects on sleep duration and sleep quality (24-25) Beneficial effects on body temperature, cortisol, and plasma melatonin concentration (26-28) No effect on melatonin or sleep time (29) Positive effect on sleep (30)
Light-filtering or light-blocking goggles or glasses in the morning immediately following night work	↑ Total sleep time (31-32)
Combination of bright light exposure and light-filtering or light-blocking goggles or glasses	Evidence of circadian adaptation (body temperature, melatonin, and cortisol) and improved total sleep time (33-36) ↑ Melatonin released during daytime sleep (37) ↑ Overall sleep efficiency (38) No changes of other sleep measures (38)

Generally, there were more studies that examined the health effects of bright light compared to those that focused on light-blocking or light-filtering goggles or glasses. Most of the bright light studies included detailed, laboratory-based measures of circadian adaptation indicators such as body

temperature, melatonin, and cortisol. Some studies measured sleep by both self-report and an objective measuring tool, which enhanced their validity. The strongest evidence that the circadian rhythm may have adapted to shift work was observed in workers who used a combination of bright light and light-blocking or light-filtering goggles or glasses. Even though these studies were conducted in small numbers of shift workers, they were relatively rigorous and are an important area for further research.

3. Behavioural approaches

Fewer studies have been published about strategies that workers themselves can undertake to improve health. Here, behavioural interventions generally encompass changes in shift workers' daily activities that are related to chronic disease and that may also be used to encourage circadian adaptation.

Intervention	**Beneficial Effects Observed**
Physical activity and lifestyle changes	↑ Strength, aerobic capacity, and sleep length (39-40) No change in body temperature during the night shift (39-40) Improved body composition, blood pressure and participation in physical activity (41)
Scheduled naps and education about sleep strategies	↑ Quality of life (42) No change in sleep time after the night shift (42) ↑ Deep sleep time when sleep strategies were adopted in the workplace (43)

There were fewer studies of behavioural changes compared to studies of other intervention types, even though one of these studies was conducted as early as 1988 (39-40). One study was a randomized controlled experiment in a large number of manufacturing workers. It provided strong, high-quality, and objective evidence that demonstrated the beneficial effects of a comprehensive lifestyle-based intervention on body mass index, blood pressure, and physical activity (41). Improved study designs and health measures are generally needed in this research area, particularly in studies that evaluate the health impact of scheduled naps and sleep education.

4. Drugs to promote sleep, wakefulness, or adaptation

Sleep-promoting agents

Melatonin is a hormone that is naturally produced by the body as part of the circadian rhythm. During the night time, when it is dark, higher levels of melatonin are released compared to the amount released during the daytime. Increased levels of melatonin cause sleepiness. Melatonin can also be produced synthetically and obtained over-the-counter or with a prescription to induce daytime sleep or to help align the circadian rhythm with working at night. Like melatonin, hypnotics such as zopiclone and nitrazepam are sleep-inducing and have been used to lengthen day time sleep following the night shift.

Intervention	**Beneficial Effects Observed**
Melatonin	↑ Sleep length in general (44), after night shifts and after days off (25) No effect on daytime sleep length and sleep quality (45)
Hypnotics	↑ Sleep length (46) ↑ Sleep onset (47)

Stimulants

Stimulants have been used prior to or during night work to increase alertness during the night shift. The dosage amount and timing of dose of these substances have been carefully controlled in order to avoid disrupting daytime sleep and to prevent drug adverse effects.

Intervention	Beneficial Effects Observed
Modafinil/Armodafinil	No changes in sleep, blood pressure, or circadian adaptation (48-50).
Caffeine	To our knowledge, no studies have looked at the influence of caffeine ingestion during the night shift on chronic health outcomes

Studies of melatonin, hypnotics, and stimulants showed mixed results. This could be due to different doses administered to workers and other factors such as variation of shift schedules and workers' adherence to the drug regimens. Despite these potential limitations, the main advantage of these studies is that they mostly used a randomized controlled design. In this study design, workers were randomly allocated to "treatment" or "no treatment" groups, which reduced potential biases and chance findings. However, because the dose (amount and time) was so carefully controlled, the findings from these studies may not be applicable to other groups of shift workers and need to be interpreted with caution.

Research needs and future directions

Evaluating preventive strategies in shift workers is a relatively new and evolving area of research. Overall, few high-quality intervention studies have been conducted on shift workers to date. Intervention studies that are done on large numbers of shift workers in their normal working conditions and workplaces are needed to detect strong, consistent, and meaningful changes in health effects. Future studies should add objective outcome measures to self-reported measures from participants. Intervention research should take into consideration potential biases and other possible lifestyle, work, and environmental factors that might be related to shift work and chronic disease.

Most research to date has focused on the four broad types of interventions described above. Other interventions, such as the 2003 the European Union Working Time Directive (51), remains to be evaluated with regards to chronic disease among shift workers. Outside of the research setting, shift workers may often wish to use more than one type of strategy to cope with the impacts of shift work on their health. For example, a rotating shift worker might drink coffee (caffeine) to help stay awake during the night shift and wear sunglasses on the morning commute home after the night shift to avoid exposure to bright light before sleeping. There are many potential combinations of interventions, and most remain to be evaluated in scientific studies.

As shift work becomes increasingly common, workers and their families, employers, policy-makers, and researchers need relevant and high-quality evidence about the effectiveness of different interventions. This summary highlights some current studies, the variation of intervention designs, and that there is no "one size fits all" solution. Innovative, evidence-based prevention efforts must be developed and evaluated to simultaneously meet the unique health needs of shift workers and the mandates of the organizations and industries in which they work. This is a promising area of research with many potential areas for further investigation.

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