A summary of research on shift work and health: Update

This document summarizes key findings from the literature on the possible health effects of shift work. It updates the literature review that was provided to participants in the 2010 symposium on this topic hosted by the Institute for Work & Health and the Occupational Cancer Research Centre.

Key messages

- People who work night shifts are likely to have shorter sleep duration and/or poorer sleep quality than regular day workers.
- Night shift workers probably have an elevated risk of breast cancer. There are also findings pointing to an elevated risk of other types of cancer.
- Numerous studies demonstrate that shift workers have an increased risk of heart disease.
- Some studies indicate an elevated risk of pre-term natal delivery, gastrointestinal disorders, and mental health problems among shift workers.
- Non-day shift workers face a higher risk of workplace injury than regular day workers.
- More research is needed to resolve some of the questions regarding the health effects of shift work.

Introduction

Shift work can be defined as "the organization of working time by different teams in succession to cover more than the usual 8-hour work day, up to a 24 hour period" (CAREX Canada 2012). Shift work makes up a large part of work in the Canadian economy. According to Williams (2008), shift work can be categorized as follows:

- Regular evening schedules (beginning after 3 p.m., ending before midnight),
- Regular night (beginning after 11 p.m., ending before 11 a.m.),
- Rotating (day to evening and/or night),
- Split (2 or more distinct work periods each day),
- On call (no pre-arranged schedule),
- Irregular shifts.

Data from Statistics Canada's General Social Survey and the Survey of Labour and Income Dynamics showed that nearly 20% of full-time workers aged 19-64 worked rotating, regular evening, or regular night shifts in 2005. About 45% of health-care workers and 66% of those in protective services (police, security guards) were shift workers, but also 40% of those in sales and service and 42% of those in occupations unique to primary industries such as agriculture, forestry and mining. The most common forms of shift work were rotating schedules (accounting for 36.3% of shift work in 2005) and irregular shifts (31.4 %). Figures for regular evening and regular night shifts were 11.5 and 8.1, respectively. The overall percentage of full-time workers who work shifts has not changed much since the early 1990s: it was 22.2 in 1992, 27.6 in 1998 and 25.5 in 2005.

For at least 50 years, researchers have been exploring the question of whether working shifts poses a health hazard. This document summarizes the findings of a selection of this research, including several articles that have reviewed aspects of this literature.

Theoretical Considerations

Disruption of the body's circadian rhythms is thought to be one of the main pathways for adverse health effects from shift work, particularly for work schedules that involve night work. Circadian rhythms are the body's biological cycles that recur at 24-hour intervals, including sleep-wake patterns, body temperatures and hormone levels.

Haus and Smolensky (2006) reviewed several possible effects of circadian rhythm disruption

on shift workers. It can result in insomnia or non-restorative sleep during the period of adjustment to a new schedule. It can also lead to changes in hormone levels, which can influence cell growth and division. Moreover, workers rarely become completely habituated to unusual shifts. Even after a long time on night shifts, only a minority of workers show adaptation of their circadian system to the nocturnal activity pattern, in part because night workers usually revert to the usual sleep/wake cycle on days off.

Fritschi and colleagues (2011) have outlined five potential pathways through which shift work can affect the risk of breast cancer. In one of these pathways, exposure to light at night may suppress the production of melatonin, which can then reduce melatonin's anti-cancer effects. Alternatively, shift work can desynchronize the body's sleep/wake cycle, which disturbs the rhythmic function of cells and organs within the body. Sleep disruption is another important outcome of shift work. It can lower immunity by activating the body's stress response, as well as suppress melatonin and lead to changes in metabolism. Shift work can also have adverse health effects through its potential impact on behaviour, such as poorer quality diet, less physical activity, or increased smoking or alcohol consumption. Bøggild and Knutsson (1999) report that shift workers are more likely than regular day workers to be smokers. Furthermore, shift work may reduce sun exposure, which decreases vitamin D levels and therefore its anti-cancer effects. These are some of the most important biological explanations, although there may be others. These pathways are not independent from each other as they likely interact in the development of cancer and other adverse health effects.

Finally, shift work may disrupt social and family relationships by putting the worker's daily pattern of work and rest out of phase with that of family, friends and the social life of the community. This social disruption can also contribute to psychological stress and other adverse health outcomes.

Overview of possible health effects

Costa (2003)[1] cites research findings that indicate that shift work (particularly, night work) can lead, in the short term, to sleep difficulties, digestive problems and anxiety. In the longer term, it can lead to gastrointestinal and cardiovascular diseases, and pregnancy complications. Stevens (1987) and Stevens and Rea (2001) have postulated and studied a possible link between shift work and breast cancer. Shields (2002) cites research suggesting an elevated risk of breast cancer, asthma, diabetes and epilepsy for shift workers.

In the rest of this summary, we look at research findings regarding possible links between shift work and the following health problems that are most commonly cited in the literature:

- Sleep disorders,
- Workplace injury,
- Cancer,
- Pregnancy complications,
- Gastrointestinal disorders,
- Cardiovascular disease,
- Psychological distress,
- Diabetes.

In interpreting the research, it is important to keep in mind the possibility of biases from three kinds of "selection" issues:

- Those most likely to be susceptible to health effects from shift work may be less likely to do such work.
- Those who develop health problems may drop out of a shift work schedule early.
- Shift workers could have worse health before starting a shift schedule, since they

[1] Costa's article is one of five on shift work and health in the same issue of *Occupational Medicine.*

typically have lower socio-economic status.

The first two possibilities would tend to lessen the association between shift work and health. The third would tend to increase it. These considerations speak to the importance of accounting for the initial health status of the workers, and then following them over time after they begin a shift schedule.

The importance of accounting for the possibility of selection bias is illustrated in one of the earliest studies on shift work and health, namely that by Aanonsen (1959). He compared medical records of men in 1952 at three factories in Norway. Aanonsen identified three groups: 345 day workers who had never worked shifts; 380 who worked mainly on a shift schedule; and 350 who had been working shifts but had since moved into day work. There was little difference between the first two groups in the frequency of nervous, digestive system or heart disorders. Shift workers had fewer work absences than day workers. However, among the third group, those who had been on shift work and later transferred to day work, there was a marked elevation in the incidence of nervous and digestive disorders.

Sleep disorders

The connection between shift work and sleep difficulties is recognized in the *Diagnostic and Statistical Manual of Mental Disorders*, which lists shift work sleep disorders as a sub-category of circadian rhythm sleep disorders.

Numerous studies, including an early literature review on shift work and health by Rutenfranz et al. (1977), have reported findings of sleep disruption associated with shift work. Sleep disruption includes reduced sleep duration and/or sleep quality.

In a 2003 review of research on the effects of shift work on sleep, Åkerstedt concluded that shift workers experience more sleep disturbances than day workers. Night shift workers will be trying to sleep when the circadian pattern promotes alertness, which interferes with and shortens sleep. They are also more likely than regular day workers to experience sleepiness during their work shift, particularly in the early morning, because work is occurring at a low point in alertness, performance, metabolism, and the circadian pattern in general.

Åkerstedt reported that the sleep pattern before an early morning shift, beginning around 6 a.m., is even more disrupted and shortened, due in part to the early rising time of 4 to 5 a.m. This also leads to increased sleepiness during the day.

Ursin et al. (2005) looked at data for 7,782 participants in a Norwegian survey conducted during 1997-1999, and found that shift workers reported shorter sleep duration than day workers.

While shift work sleep disorder is important in and of itself, it also has implications on other aspects of health. The build-up of "sleep debt", or a long period of shortened sleep, results in chronic fatigue. This has been shown to lead to increased work injuries (Niu et. al., 2011).

Workplace injury

Folkard and Tucker (2003) reviewed the literature on the relationship between shift work and work safety. They emphasized that studies of this relationship need to account for two possibilities: different exposure to risks on different shifts, and different injury reporting patterns for night workers than workers on other shifts. When such influences have been controlled for, the following trends emerged:

- The risk of "incidents" (defined as "accidents and injuries") is highest for night shift work, followed by afternoon and morning shift work.
- The risk of incidents rises about 20% from the first to the second hour of the night shift, but then falls steadily, except

for an upward blip between 3 a.m. and 4 a.m.
- Incident rates increase on successive night shifts: on average, the incident rate on the fourth night is 36% higher than on the first night. There is a much smaller increase in incident rates over successive morning or day shifts.

The risk of an incident increases markedly after more than eight hours on duty: the risk in the 12th hour is almost double than in the eighth hour (and more than double the average risk over the first eight hours on duty).

A study about shift work and injury among Canadian workers was recently conducted using data from the Survey of Labour and Income Dynamics and workers' compensation records (Wong et. al., 2011). It showed that an estimated 14.4% of excess work injury among women is due to night and rotating shift work, while 8.2% of excess work injury among men is due to night shift work. The rate of work injury in Canadian workers decreased overall between 1996 and 2006, but there were no decreases during this time for night shift workers.

Dembe et al. (2006) used data from the National Longitudinal Survey of Youth in the United States to examine the effects of different types of shift work on the combined incidence of work injury and illness, per year worked. They looked at the work experience of people in each year between 1987 through 2000, except 1991. Workers were between the ages of 22 and 30 at the start of the study. Controlling for age, gender, occupation, industry and region, Dembe et al. found that night, evening, rotating, and irregular shifts all were associated with an increased risk of occupational injury or illness compared with regular day shifts. The risk was elevated by 43% for evening shift workers, 36% for those working rotating shifts, and 30% for night shift workers.

Cancer

Schernhammer and Hankinson (2003) reviewed research on the link between exposure to light at night and breast cancer in shift workers. They concluded that "Observational studies provide fairly consistent evidence for a modest positive relation between different measures of light exposure at night and breast cancer risk." Examples of the research that they cited include the following:

- A Finnish study (Pukkala et. al., 1995) reported a significantly higher incidence of breast cancer in female flight attendants who had been working in the airline industry for 15 years or more. Similar findings were reported in a study of female flight attendants in Iceland (Rafnsson et al., 2001). A Norwegian study (Tynes et al., 1996) of female radio and telegraph operators with potential exposure to light at night also found an elevated risk of breast cancer. However, these studies contained only a few controls for other possible causes of breast cancer.
- Schernhammer et al. (2001) evaluated data from 78,562 U.S. nurses who worked on rotating night shifts (at least three nights per month). Researchers controlled for a number of known breast cancer risk factors such as age, menopausal status, number of children, body mass index and family history of breast cancer. Women who worked for 1-29 years on rotating night shifts had a risk of developing breast cancer that was 8% higher relative to those who had no history of night shift work. For nurses working 30 or more years on night shifts, the risk was 36% higher.
- Schernhammer et al. (2006) also found that another group of nurses who had worked for more than 20 years in rotating night shifts had a 79% higher risk of

developing breast cancer than nurses who did not work nights.

An expert Working Group was convened in 2007 by the International Agency for Research on Cancer (IARC) to review the carcinogenicity of shift work. The Working Group concluded that, "shift-work that involves circadian disruption is probably carcinogenic to humans" on the basis of "limited evidence in humans" and "sufficient evidence in experimental animals" (Straif et al., 2007, p.1065). It is important to note that the focus of the Working Group's evaluation was eight studies of breast cancer in humans (including the studies led by Schernhammer noted above). Of these eight studies, three were conducted in nurses. Generally, the risk of breast cancer was elevated in nurses who had worked shift work for 20 to 30 years. There were a limited number of studies of other cancer sites considered in the IARC assessment.

The links between shift work and breast cancer remains an active area of research. For example, researchers studied the link between shift schedules and breast cancer in a selected group of nurses in Denmark. Nurses who worked for long-term day-night rotating shifts had a 2.6-fold increased risk of breast cancer. This was higher compared to the risks of breast cancer from all of the other rotating shift systems (Hansen and Stevens 2012). In a separate follow-up study of over 4000 women from Denmark, women who worked shifts involving night work had a nearly two-fold elevated risk of breast cancer. In comparison, women who worked shifts without night work had a 23% increased risk of breast cancer. These risks were about the same when the researchers separately examined women who were 60 years of age and older. The subjects included in this study worked in a wide range of industries such as transportation, public administration, telecommunication, sales, paper and pulp, and manufacturing (Knutsson et al., 2012), which is an important improvement over previous studies that focused on nurses.

Prior to and since the IARC evaluation, studies have examined different populations of shift workers and other types of cancers. For example, one Canadian study demonstrated that working night shifts may increase the risk of several different types of cancer in men. Compared with men who reported that they had never worked at night, the odds of non-Hodgkin lymphoma and lung, colon, bladder, prostate, rectal, pancreatic cancers were higher in men who had ever worked at night. These increased risks varied from as low as 1.74 for bladder cancer, to as high as 2.77 for prostate cancer. There was no evidence that a longer duration of night work was associated with increasing risk (Parent et al., 2012).

Schernhammer et al. (2003) found evidence of elevated risk of colorectal cancer for female nurses who had been on rotating night shifts for 15 years or more. Using data from the same study population of nurses, Schernhammer and colleagues (2011) also reported that working 10 years or more of rotating night shifts was related to a 44% reduction in the risk of melanoma. Women with darker hair had significantly lower risk of skin cancer compared to women with lighter hair. Exposure to sunlight appeared to have a negligible effect, which points towards a potential genetic component that may underlie skin cancer risk. With regards to reproductive cancers, women who worked for 20 years or more of rotating night shifts had a 47% higher risk of endometrial cancer. This effect was particularly pronounced for obese women, who had nearly two-fold increased risk of endometrial cancer compared with obese women who did no night work (Viswanathan et al., 2007). On the other hand, no relationships between rotating night shift work and ovarian cancer were found in this group of nurses (Poole et. al., 2011).

Kubo et al. (2006) looked at the incidence of prostate cancer among 14,052 working men in Japan who were initially interviewed between

1988 and 1990 and then followed up until the end of 1997. After adjustment for other factors that may affect cancer risk, the authors found that those working rotating shifts had a significantly higher risk of prostate cancer than day workers, but there was no significant increase in risk for those on fixed night shifts. The authors suggested that rotating shift workers may experience greater disruption in circadian rhythms.

One potential explanation is that working at night might increase the risk of cancer because of disrupted melatonin levels. Production of this hormone is reduced as a result of light exposure during times when melatonin secretion would normally be at its peak (Stevens, 1987; Stevens and Rea, 2001). Results from experimental studies on rodents (such as that by Blask et al., 2002) support a link between melatonin and tumour suppression, especially for breast tumours.

However, a study by Travis et al. (2004) casts some doubt on this hypothesis. They found no significant relationship between melatonin and the risk of breast cancer for either pre- or post-menopausal women on the island of Guernsey who were followed-up for the development of breast cancer for up to 24 years. However, the authors noted that the number of women included in their study was fairly small and that it is possible that the pattern of melatonin secretion over the course of the day, rather than the total quantity produced, affects the risk of breast cancer.

Pregnancy complications

Bonzini et. al. (2007) conducted a systematic review of the literature on the association between several possible pregnancy complications (pre-term natal delivery; low birth weight; and pre-eclampsia[2]) and various working conditions, including shift work or night work, which were grouped together. Regarding the relationship between shift/night work and low birth weight or pre-eclampsia, there were only two studies in each case, pointing to "no more than a moderate effect". Bonzini et al. concluded that the balance of evidence suggested a small effect of shift work on pre-term natal delivery. For the eight studies that met their criteria for higher quality, the combined estimates indicated a 26% increased risk of pre-term natal delivery for shift/night workers compared to day workers. Bonzini et al. grouped all types of shift work together, which means that it is possible that risks differ for the various types of shift work.

Gastrointestinal disorders

Rutenfranz et al. (1977) noted that "gastric and intestinal dysfunctions predominate in shift workers." They also cited findings of increased tobacco smoking and caffeine consumption by those who work at night.

In a review of various health disorders and shift work, Knutsson (2003) concluded the strongest evidence was for an association between shift work and gastrointestinal disease, coronary heart disease and pregnancy complications (miscarriage, low birth weight and preterm birth). He cites several studies reporting more gastrointestinal disorders among shift workers than day workers. For example, a Japanese study (Segawa et al., 1987) of 11,675 employees in factories, banks and schools found that gastric ulcers were more than twice as common among shift workers than day workers.

Knutsson and Boggild (2010) recently reviewed the evidence on shift work and gastrointestinal disorders. From the twenty studies that they included in their review, they found associations between shift work and gastrointestinal symptoms and peptic ulcer disease. There was relatively less information about gastroesophageal reflux disease, chronic inflammatory bowel diseases, or gastrointestinal cancers. Although their review represents shift

[2] Pre-eclampsia is characterized by high blood pressure and excessive weight gain, among other symptoms.

workers from different occupations and industries, many of the studies in the review did not account for other risk factors for gastrointestinal disorders, which limited their ability to draw conclusions.

Cardiovascular disease

Rutenfranz et al. (1977) concluded that "the incidence of cardiovascular disease and nervous symptoms does not seem to be higher than in the population at large." However, since then there has been considerable research on the subject. The *Scandinavian Journal of Work, Environment & Health* has published reviews of the literature on shift work and heart disease on three occasions, each a decade apart.

Kristensen (1989) concluded that shift workers had a 40% higher risk of heart disease compared with regular day workers – that is, a relative risk of 1.4 -- based on the findings of the higher quality studies.

Bøggild and Knutsson (1999), in their review of 17 studies, came to the same conclusion as Kristensen (1989). They reported a wide range of findings, with a risk ranging from 60% lower to 260% higher (relative risks were 0.4 to 3.6, with most estimates between 1 and 2). Most of the larger and more methodologically sound studies found a 40% higher risk of cardiovascular disease among shift workers, but four relatively large studies found no association. Bøggild and Knutsson concluded that the relative risk of 1.4 seems to be the "most reasonable risk estimate."

Frost, Kolstad, and Bonde (2009), in a systematic review, examined 14 articles, including two included in the two previous reviews. They found that "relative risk estimates varied from 0.64 to 2.25 [36% decrease to 125% increase], with most estimates around unity". They concluded that there was "limited evidence of a causal association between shift work and ischemic heart disease." They raised methodological concerns about all of the studies, including possible selection bias, problems of lumping together of different types of shift work, inadequate controls for other influences on heart disease and failure to look at the duration of exposure.

In the most recent systematic review published on this topic, Vyas and colleagues (2012) analyzed 34 studies that together included over 2 million people. They found that shift work was related to significantly higher risks of heart attack (23%) and ischaemic stroke (5%). There was also an elevated risk of coronary events (24%) although the studies of this health outcome were less consistent than the studies of heart attack and ischaemic stroke. Nevertheless, these increased risk estimates were still present when the authors controlled for other cardiovascular risk factors such as diet and smoking. Although this review is limited to some extent by the types of studies included and the different definitions of outcomes such as "coronary events", to date, it is the most comprehensive and current review of all available literature on shift work and cardiovascular disease.

Psychological distress

Jamal (2004), drawing on a cross-sectional study of 376 full-time workers in a Canadian city, noted that shift workers reported significantly higher burnout, emotional exhaustion, job stress and psychosomatic health problems (e.g. headaches, upset stomach, difficulty falling asleep) than workers on a regular day schedule.

Haines et al. (2008) cited several studies that pointed to an association between shift work and "psychological distress, depression, anxiety and burnout." The authors proposed that shift work may interfere with participation in family life, because of both scheduling and fatigue, which may increase the risk of depression. Only those who were married or cohabiting, had a least one child at home, and were working at least 20 hours a week in a paid job were included,

yielding 2,931 cases. They compared those working a regular daytime schedule with those working any other schedule. They first considered factors affecting the degree of work-to-family conflict. Then they analyzed factors that might cause major depression, based on interview responses, during the previous 12 months. They controlled for variables such as type of work contract (self-employed or salaried), hours worked, gender, age, educational attainment, whether or not spouse/partner had paid employment, number of children and age of youngest child. In the first model, Haines et al. found that shift work was significantly linked to work-to-family conflict; in the second, work-to-family conflict was found to significantly raise the likelihood of depression. Haines et al. estimated that about 70% of this effect is direct, and 30% through work-to-family conflict. Other mechanisms, such as social isolation, could be involved.

Bara and Arber (2009) used data from the British Household Panel Survey to examine the effects of shift work on mental health. Survey participants reported the number of years between 1995 and 2005 that they worked night shifts or a schedule with varied shift patterns. Mental health was assessed in two ways: through responses to the General Health Questionnaire and through a question about the presence of problems with anxiety or "depression or bad nerves" or "psychiatric problems."[3] They controlled for age, marital status, education, occupation and baseline mental health. They found that men who had worked nights for 4 or more years were more than twice as likely as men who had never worked nights to report mental health problems. However, working varied shifts did not have significant impact on men's mental health. For women, the results were almost the inverse of those for men: those working varied shifts for 4 or more years—2 years for the anxiety/depression measure—were more than twice as likely to report mental health problems compared to women who did not work varied shifts. Night work did not have a significant impact.

Diabetes

Suwazono et al. (2006) evaluated the relationship between shift work and the onset of diabetes among male workers in a Japanese steel company. They used records from the participants' medical examinations over the period 1991 to 2001. Those who had diabetes or certain other conditions before the start of the study were excluded, and other variables that could affect the risk of diabetes were controlled for in the statistical analysis. Suwazono et al. found that the risk of developing diabetes was significantly higher for workers on rotating shifts than it was for regular day workers.

Furthermore, shift workers may be more susceptible to developing metabolic syndrome, which encompasses diabetes, obesity, dyslipidemia, and abnormal blood pressure. Tucker et al. (2012) evaluated this association in a study of nearly 1000 male and female current or former shift workers. Participants who were or who had previously been shift workers were 78% more likely to show symptoms of metabolic syndrome, even after adjusting for age, sex, socioeconomic status, smoking, alcohol intake, perceived stress, and sleep difficulty. Participants who had more than ten years of rotating shift experience were 96% more likely to demonstrate symptoms of metabolic syndrome than day workers, even after adjusting for age and sex.

Conclusion

There is a relatively large literature on possible connections between shift work and several aspects of workers' health. In some of these areas, the research findings clearly point to an elevated risk of adverse health outcomes arising from shift work. In other areas, the research is less conclusive.

[3] Bara and Arber (2009, p.363).

- There is little dispute that people who work night shifts are likely to have shorter sleep duration and/or poorer sleep quality than regular day workers. There is also some indication of sleep disruption for those who work shifts that begin in the early morning.
- The risk of workplace injury appears to be higher for night shift work than on afternoon and morning shifts. The risk of incidents is particularly high in the second hour of a night shift.
- An expert Working Group of the IARC has concluded that "shift-work that involves circadian disruption is probably carcinogenic to humans." Most evidence is for breast cancer, and the growing body of research in this area suggests that other cancer sites may be involved.
- Past reviews have concluded that there was evidence of a causal link between shift work and heart disease, and the most recent and comprehensive review of this literature is consistent with this evidence.

There are several studies, in each case, that point to:

- A modestly elevated risk of pre-term natal delivery for shift workers;
- An elevated risk of gastrointestinal disorders; and,
- An association between shift work and mental disorders including depression.

Research on the health effects of shift work has continued to grow over time. Nevertheless, there are many unanswered questions and biological pathways that remain to be explored. We still need more high-quality studies to resolve some of the questions regarding the health effects of shift work, such as the possible role that hormone levels play in the connection between shift work and cancer risk. In particular, we need more studies that distinguish the different types of shift work, that examine the relative impact of different lengths of time spent on a shift work schedule, and that explore the question of whether some individuals are more susceptible than others to negative effects of shift work. This will require continued and dedicated efforts of researchers to unravel the complexities of shift work and health.

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