Scand J Work Environ Health. 2017;43(2):97–98. doi:10.5271/sjweh.3622

The mortality of shift workers

Is shift work associated with higher mortality risk? That question has been the subject of much discussion for decades. Mortality risk includes concerns that reflect not only incidence but also case fatality, treatment, information of death certificates, and competing causes of death – especially in advanced age. Although related, mortality and incidence are not the same as the former is broader.

Taylor & Pocock (1) performed the first study using modern epidemiological methods. The cohort included 8603 male manual workers followed for 12 years. The analysis presented results on indirect standardization, ie, the standardized mortality ratio (SMR) among day, shift, and ex-shift workers, using the general population as a reference. The results showed SMR of 97.3, 101.5 and 118.9 [95% confidence interval (95% CI) 99.0–141.7] for the three groups respectively (results calculated based on figures provided). The authors concluded that "the evidence we have obtained…leads to the conclusion that shift work appears to have no adverse effect upon mortality" (p206, 1). In the following years, that study has often been cited as evidence against increased mortality among shift workers. However, a reanalysis of the data casts doubt on the interpretation of the results, arguing that internal comparison between the three groups might indicate that shift work actually increases mortality risk (2).

Later studies have yielded inconsistent results. In a recent review of eight studies, five were negative. The meta-analysis showed an all-cause mortality risk of 1.04 (95% CI 0.97–1.11) for shift workers (3). Mortality studies on shift workers include a number of issues, which could explain the inconsistencies. Exposure to shift work has been measured in many ways. Often the exposure is determined at one point in time, and exposures before and after are not considered. Many individuals who start shift work often quit after a few years and change to day work. That process will result in a dilution of the day working group, which will consequently contain a mixture of day and shift workers. This leads to a misclassification of exposure that further leads to an underestimation of the risk associated with shift work.

Another issue is the "healthy worker effect", which is a term that describes the reduced morbidity and mortality in occupationally active individuals in comparison with the general population. This problem is common when mortality is measured with indirect standardization (SMR). Even SMR below one could indicate an increased mortality risk. As a result, real excesses in both morbidity and mortality due to harmful exposures at work might be wholly or partially masked (4).

Some studies have included participants who are middle-aged or even of advanced age (5). Ageing is a marker of the accumulation of different risks for deadly diseases. The role of shift work will therefore be diminished due to competing causes. An additional problem with including participants of an older age is that such participants constitute a cohort of survivors, ie, they have "survived" shift work and are probably less sensitive to that kind of exposure.

When specific outcomes are addressed there is also a problem with competing outcomes, especially among the elderly, who have a higher risk of dying from many different diagnoses. For example, if an individual is diagnosed with prostate cancer at the age of 70, and dies from stroke at 80, the death certificate will probably certify that the cause of death was stroke but the diagnosis of prostate cancer is not mentioned because it is not regarded as an underlying or contributory cause of stroke.

The Cox proportional hazards model is increasingly used in mortality studies. The model is appropriate under specific assumptions. The hazard function must be proportional over time, and there should be a linear relationship between the log hazard and each covariate. If those assumptions are tested it should be reported, but this is not always done.

In this issue of the *Scandinavian Journal of Work, Environment & Health*, Jørgensen and collegues report on the mortality of Danish nurses (6). The cohort consisted of 18 000 nurses who were followed for 18 years. They found an increased all-cause mortality among those who worked evening and night shifts. They also demonstrated significantly increased cardiovascular mortality for those working the night shift. Cancer mortality was increased by 15%, which, however, was not statistically significant. They also found increased mortality associated with working times for diabetes, Alzheimer's disease, and dementia, but these results were based on a small number of cases. This study strengthens the evidence of a connection between shift work and all-cause mortality. It also provides support for an association between shift work and mortality of cardiovascular disease.

The mechanisms responsible for the association between shift work and disease are probably complex and influenced by genetics, lifestyle, sleep, social stress, and disturbed circadian rhythms (7). Further epidemiological studies and experimental studies are needed to explain the causal pathways. One issue would be to find a better variable measuring the circadian phase. Shift work is not a valid proxy since previous studies have shown that shift workers do not always have a phase shift of the circadian rhythm (8, 9). Another problem to investigate would be whether the body is more sensitive or vulnerable as a result of shift work at certain ages.

Although there are still unsolved issues regarding the association between shift work and disease, we know enough to take preventative action. This work must be strengthened and extended to more employees who work shifts or have other "unsocial" working hours.

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