

Shift Work

HSE RR 446

The development of a fatigue / risk index for shift workers

There are no absolute measures to predict fatigue. The fatigue index allows planners to compare the likely effect on fatigue of different shift work regimes.

The report describes an algorithm for understanding fatigue in shift workers. The fatigue index is a way of rating the degree to which a given shift pattern affects fatigue when compared with another shift pattern. It is not possible to predict the actual degree of fatigue experienced; fatigue is subjectively assessed against scales such as the alertness-sleepiness scale.

In some circumstances fatigue can be related to risk of accident e.g. when fatigue results in micro sleeps in safety critical work. Fatigue could be linked to mental health, not least because tests of mental health could be influenced by fatigue [an effect which ought to be controlled for in research].

The fatigue model takes account of:

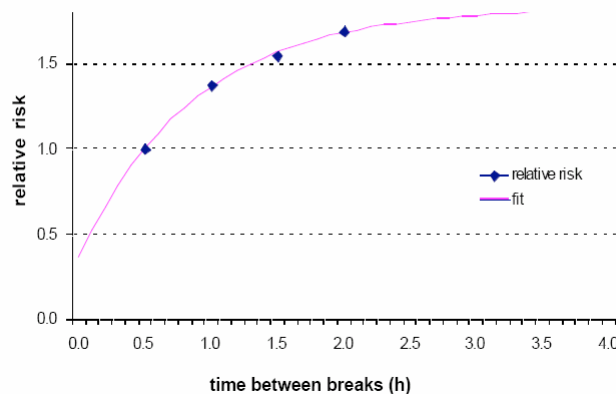
- Accumulation of fatigue: influenced by the overall schedule of shift work.
- Instant fatigue: influenced by time of start, shift length and circadian rhythms.
- Recovery: influenced by rest breaks and type of job.

As far as possible, the index was based on objective evidence from the science literature. The literature is derived from experiments e.g. response times and accuracy of response variation with sleep pattern.

Points from the evidence review.

- Four hours sleep is the minimum for sustained, but reduced, performance.
- A slow build up of sleep loss allows some adaptation; sudden changes in sleep loss have a greater effect on accuracy etc. performance measures.
- The first night shift is usually the one with the greatest impairment of performance.
- Short rest breaks improve alertness and performance, but the improvement would last less than an hour. Risk of an accident almost doubles by 2 hours after a rest break.

Figure D-2: Relative risk of continuous periods between breaks



- Longer breaks would be needed to reduce fatigue.
- The interval between successive shifts should be at least 16 hours if the break is to afford sufficient sleep.
- Once a shift pattern has been established for more than 2 weeks it takes 4 days for circadian rhythms to be fully adjusted to a new pattern.
- The character of the work and its environment can be very different from one shift to the next. This makes it very difficult to estimate risk scores associated with fatigue. Where comparison was possible, the morning shift tended to be associated with the fewest safety incidents, nights with the most. Increases in risk were of the order of 30%.
- Very roughly, it was observed that risk of an accident is approximately doubled when work during any week is more than 65 hours, when compared with those working less than 40 hours. There are many factors involved here, and number of hours may not be the appropriate or active variable.

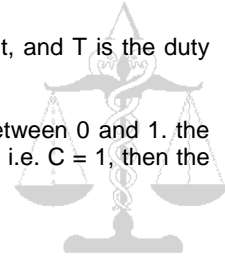
A large number of fatigue and risk factors have not been studied in sufficient depth, but indications from the available literature were used to inform judgements which were then incorporated in the fatigue algorithm. The absolute meaning of fatigue and risk scores in terms of accident and health risk must therefore be determined by further experimentation.

The final form of the Fatigue Index is given by:

$$FI = 100 \{1 - (1-C) (1-J-T)\}$$

where C is the cumulative fatigue component, J is the job type / breaks component, and T is the duty timing component. FI is the probability of fatigue.

In this formula, C, J and T correspond to probabilities and therefore take values between 0 and 1. The model shows, for example, the absolute value of breaks between shifts. If sufficient, i.e. C = 1, then the fatigue score is zero at the start of the next shift.



The final form of the Risk Index is given by:

$$RI = C * J * T$$

where C is the cumulative fatigue component, J is the job type / breaks component, and T is the duty timing component. C, J and T values are not the same in both indices.

The index has been normalised with respect to a typical two-day, two-night, four-off schedule.

The index tools are available in spreadsheet format based on Excel (it is available on the HSE web site). In guidance HSE suggest the tools are best used for risk assessing shift work (not permanent day shift work and only permanent night shift work with some caution). The outputs are not absolute but can be used to identify the relative degree of concern associated with different work patterns. By varying the inputs the user can evaluate the effect of different control options.

Comment

Interpretation of the outputs of these software models would require experience and time spent subjecting the models to sensitivity analysis. The outputs do not directly translate into accident risk or risk of development of illness but, with sufficient use, links of this sort could be made.

The models reflect the state of knowledge on fatigue and accident risk as a function of shift patterns but it remains possible that they have only partial explanatory value. That is, other factors which are not modelled here could be significant.

According to HSE there are 3.5 million shift workers in the UK. Prominent among the associated work types are emergency services, healthcare, the utilities, transport, manufacturing, entertainment and retail. HSG 256 provides guidance on reducing the risks of accidents in shift workers.
