Fatigue

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A Fatigue Management Programme: From Theory to Practice
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Introduction

Fatigue is receiving increasing attention as a safety issue in all modes of transportation (1-6). Several factors are probably contributing to this, including better scientific understanding of the causes of fatigue symptoms, more thorough analysis of safety incidents and accidents, and increasing work demands being placed on people, such as longer hours, more variable hours, and more night work.

Is Fatigue-Management Necessary?

The traditional approach to managing fatigue in the workplace has been through hours-of-work regulations. This grew out of the view that fatigue is a simple consequence of the amount of time spent working (7,8). Available evidence from the trucking industry suggests that this approach has not been very successful. For example, the US National Transportation Safety Board has found in its crash investigations that fatigue is the most common probable cause of fatal-to-the-driver truck crashes, being cited in 31% of cases (9). The Board has also concluded that driver fatigue is implicated in 30-40% of all heavy truck crashes (7). A major truck and bus safety summit meeting in the USA in 1995 identified fatigue as the number one truck safety issue (10). In its 1996 report to the New Zealand Parliament, the Transport Committee's Inquiry into Truck Crashes (11) concluded:

> "...driver fatigue is a largely unrecognised problem, especially in New Zealand, and may well rate with alcohol and excessive speed as a significant contributor to crashes."

Fatigue is a particular concern because there is evidence that fatigue-related motor vehicle crashes tend to have more severe consequences than other types of crashes. This may be associated with the fatigued driver's reduced ability to take evasive or corrective action (7,11-13).

It is also likely that the real contribution of fatigue to truck crashes is currently underestimated. There are a variety of reasons for this (12). Drivers involved in crashes may fail to recognise or acknowledge the effects of fatigue. The symptoms of fatigue may not be evident to police or witnesses at the scene. In addition, crash investigators often do not have sufficient understanding of fatigue to know what to look for, or what questions to ask. This reflects a failure in knowledge transfer. Although there is a considerable amount of scientific knowledge about fatigue, it has not been made very accessible to the trucking industry or the public. Crashes are not the only consequence of fatigue that is relevant to trucking. There is good evidence that driving skills deteriorate well before a driver literally falls asleep at the wheel, so that fatigue may affect such factors as fuel consumption, tire usage, and vehicle wear-and-tear.

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[1] *This paper presents work that is the result of a collaboration between the Sleep/Wake Research Centre and BP Oil NZ Ltd. The project team includes Trevor Seal, Logistics Manager, and Alister McKay, Transport Development Manager, BP Oil NZ Ltd, and Michelle Millar and Dr David Waite, Wellington School of Medicine.*

The Need For New Approaches

It is now clear that hours-of-work regulations address only part of the problem. Many fatigue symptoms, including impaired judgement, reaction time, and driving skills, are the result of sleep loss, and of trying to work against the circadian biological clock, which programmes sleep at night and wakefulness during the day (4,5,7,8,14,15). In effect, how long a person works may be less important than the time of day that they work, and when they have opportunities for sleep. The other major limitation of hours-of-work regulations is that they only address what happens at work. Fatigue can be influenced as much (or more) by the activities outside of work, as by what takes place during scheduled work hours.

These considerations have lead to new approaches to fatigue management. The integrated fatigue management programme described here is the result of a collaborative partnership between the Sleep/Wake Research Centre at the Wellington School of Medicine, and BP Oil NZ Ltd. It draws from experience in the aviation industry, and is an evolution of the approach developed by the NASA Fatigue Countermeasures Program (4-6). The approach is based on the understanding that, because of the circadian biological clock, fatigue is inevitable in any occupation where people sometimes have to work when they would normally be sleeping. Better work practices can reduce the safety and health consequences of fatigue, but they cannot eliminate it entirely. In this view, fatigue management becomes a shared responsiblity of regulators, companies, and individual drivers, all of whom need to act in a co-ordinated way to minimise its impact.

An Integrated Fatigue Management Programme

Identifying the "Hot Spots"

To manage fatigue effectively, it is esential to know when and how fatigue affects driver performance, and thus operational efficiency and safety. One aspect of this is incident and accident investigation. Assessing the role of fatigue in an incident or accident is not simple. There is no single measure of fatigue that can be taken (comparable to a blood alcohol level) to indicate the level of fatigue-related impairment that a person is experiencing.

To address this, we have developed a method of fatigue analysis that is based on a method pioneered by the National Transportation Safety Board in an aircraft accident investigation in 1994 (16). It relies on collecting information relevant to the physiological factors affecting fatigue, namely:

- how long a person had been awake at the time of the event;
- how much sleep they had in the previous 24 hours, compared to how much they would normally need to feel well-rested;
- how much sleep they had in the previous 72 hours, compared to how much they need, because the effects of insufficient sleep accumulate into a sleep debt;
- how long since they had the opportunity for two nights of unrestricted sleep (necessary to pay back a sleep debt);
- whether they suffer from a sleep disorder, such as sleep apnoea, which would disrupt their sleep and lead to excessive sleepiness;
- the time of day of the event, since people are most vulnerable to making fatigue-related errors in the early hours of the morning, with a second period of increased risk in the mid-afternoon.

For each individual involved in the event, a duty history, and where possible a sleep history, are collected for at least 3 days prior to the day of the event, together with information on the amount of sleep normally needed to feel well rested. When a sleep history is available, this information permits calculation of the duration of continuous wakefulness at the time of the event, and the amount of sleep loss (acute and cumulative) that an individual was operating under. When it is impossible to obtain a sleep history (for example after a fatal accident), some idea of sleep opportunities can be gained by looking at the duty history. However, this does not give information on whether a person actually slept during those opportunities.

It is also useful to have information on sleepiness risk factors (snoring, sleep disorders, Epworth sleepiness score) and the driver's self-assessment of his/her status at the time of the event. This information needs to be interpreted in the context of the type of incident/accident; and the type of human errors or failures that contributed to it. It is then possible to build an argument for the likely role of fatigue.

A 2-page form has been designed that complements the existing incident/accident investigation forms used by BP Oil NZ Ltd, together with a short manual that explains the rationale behind the method and how to use it. The next stage of this project is to accumulate information as incidents and accidents occur, and develop a centralised, de-identified database where trends and "hot spots" can be indentified. The Commercial Vehicle Investigation Unit and the Land Transport Safety Authority are also looking at implementing this method, to get a more accurate picture of the role of fatigue in truck crashes in New Zealand, prior to the possible introduction of regulatory changes.

There are other ways of gathering information about the effects of fatigue that do not rely on looking at such adverse outcomes. These include either: 1) monitoring drivers, for example, assessing how different rosters affect drivers' sleep, or what they find most difficult about a roster; or 2) monitoring vehicles to measure such factors as fuel consumption, speed etc. All these approaches serve to highlight where the safety margin is reduced because of fatigue, and where specific countermeasures can best be used.

Education to Improve Work Practices

1. Driver Education

Driver education is seen as a fundamental part of a fatigue management programme, since many critical decisions remain the responsibility of the individual driver. Education is perhaps the only legitimate way of addressing the potential impact of non work-related activities on fatigue, and the attendance of family members at education sessions is encouraged. Enabling drivers to develop better coping strategies, and in particular improved sleep, can be expected to have positive effects not only on safety and productivity at work, but also on overall health and well-being outside the workplace.

We have developed a driver education package based on a 2-hour live presentation accompanied by a handout covering all the presented materials. It aims to:

- explain the current state of knowledge about the physiological mechanisms that underlie fatigue, and how trucking operations affect them;
- demonstrate how this knowledge can be applied to improve driver sleep, alertness, and performance; and
- recommend scientifically-validated alertness management strategies, including strategies to assist drivers to arrive at work in the best possible (least fatigued) condition, and strategies to help maintain their alertness once they are at work.

An initial version of the presentation was "field-tested" with a group of eight experienced drivers and four managers from BP Oil NZ Ltd, who provided invaluable input on both content and style. The group rated the overall presentation highly (average rating 4.3 on a scale from 1=poor to 5=excellent). They felt that the information would help drivers cope better with shift work (average rating 4.2 on a scale from 1=no help at all to 5=extremely helpful). Half the group indicated that they were quite likely to make changes to improve their alertness, based on the presentation, and 40% said that they would definitely make changes. Most (11/12) participants indicated that there should be recurrent training on alertness management every 1-3 years.

As a quality control measure, anyone intending to run driver education courses is required to attend a 2-day train-the-trainers workshop. The first day of the workshop focuses on the causes and effects of inadequate sleep, and on the effects of work demands, particularly shift work, on the circadian biological clock. The second day addresses fatigue-related performance impairment in trucking, incident/accident investigation, and strategies for managing fatigue. It also includes a presentation of the 2-hour training module, the provision and review of training materials, and the discussion of implementation issues. Trainers are asked to have all participants complete brief, anonymous questionnaires before and after each training session, and to provide copies to the Sleep/Wake Research Centre. These will be used to assess the short-term effectiveness of knowledge transfer, and to provide guidance for the development of subsequent refresher training.

Better education can help counter the widely-held view that fatigue is somehow an indication of personal inadequacy, rather than a normal consequence of certain work demands on human physiology. However, unless drivers are comfortable discussing fatigue-related issues openly, it is very difficult to develop a systematic approach to fatigue management. It is therefore very important that managers foster an environment of trust in which drivers can be confident that their interests will be fairly addressed, if they come forward with fatigue-related concerns.

2. Management Education

Managers at all levels need to have a sound understanding of the causes and consequences of fatigue if they are to design, implement, and maintain successful fatigue management strategies. A common knowledge base is also fundamental if fatigue-related issues are to be dealt with in co-operation with the workforce, rather than in an adversarial context, which is often the case at present (for example, in contract negotiations or in attribution of culpability for accidents).

A 1-day intensive fatigue management workshop has been developed specifically for managers. It covers:

- the current state of knowledge about the physiological mechanisms that underlie fatigue, and how trucking operations affect them;
- fatigue-related performance impairment in trucking;
- incident/accident investigation; and
- strategies for monitoring and managing fatigue.

Participants also receive a comprehensive information package for future reference.

At the first workshop, attended by BP Terminal Managers, participants identified a series of specific management fatigue management strategies that fell into three categories: 1) creating a supportive environment; 2) identifying the driver who is having fatigue-related problems; and 3) managing the driver who is having fatigue-related problems. Some of the more generic strategies include: facilitating access to education sessions for drivers and their families; involving drivers in decision-making about rosters; regular, open communication between managers and drivers; and having consistent company policies and procedures for identifying and managing drivers who are having fatigue-related problems, and making sure that those policies and procedures are known to all drivers.

Fitness For Driving

Drivers working for BP Oil NZ Ltd are required to undergo annual medical examinations to confirm their fitness for driving. Until now, these examinations have not included any information about, or discussion of, fatigue-related issues. As part of the fatigue management programme, they will now include preliminary screening for excessive daytime sleepiness (the Epworth Sleepiness Scale; refs 17,18), as well as risk factors for sleep apnoea (snoring every night, upper body obesity and large neck size), and an opportunity for drivers to discuss their fatigue-related concerns. Drivers are being familiarised with the measures, and the reasons for collecting this new information, through the driver education package.

This strategy raises a number of issues concerning the assessment of fitness for driving and suggestions, or requirements, for treatment of chronic fatigue-related problems. As a general principle, it is envisaged that sleep disorders or other chronic fatigue-related problems should be handled, from an occupational health perspective, in a comparable manner to other health issues such as diabetes or cardiovascular illness. This is a new area of occupational medicine, and the challenges are many. However, with the implementation of education programmes designed to heighten driver awareness of these issues, it is essential that fair and effective strategies are developed to handle possible occupational health outcomes.

The Role of Rostering

Well-designed rosters are clearly an integral part of any fatigue management programme. In the present programme an initiative to develop a set of rostering guidelines was undertaken for two reasons. First, there is support within BP for giving drivers greater autonomy in the design and manning of rosters. Guidelines would provide outer limits for this exercise. Second, with increasing use of sub-contractors and owner drivers, it was felt that rostering guidelines, as part of contracts, would help standardise working conditions across the workforce and ensure adherence to acceptable rostering practices.

This exercise was based on the understanding that there are no perfect rostering solutions to cover 24 h 7-day a week operations, and that individual drivers will respond differently to the same roster, because of their different individual characteristics and life circumstances (19). The rostering recommendations also aimed to address some specific issues that were identified in a survey of fatigue and rostering practices among tanker drivers in 6 Australasian companies (20).

The following initial recommendations are under consideration.

- The longest shift should not exceed 12 h, and the longest night shift should not exceed 10 h.

  In the survey, among drivers working days (fixed or rotating), 34% reported that their longest day shift lasted 14 h. Among drivers working nights (fixed or rotating), 59% reported that their longest night shift lasted 12 h, and 14% reported working night shifts of 14-14.5 h. For drivers working rotating day/night shifts (63% of the sample), higher sleepiness levels were associated with longer average shift lengths, and longer maximum duration of the night shift.

  Drivers on night shift are particularly vulnerable to the effects of fatigue because they are most likely to be suffering from sleep loss, and are trying to work when the circadian drive for sleep, and error vulnerability, are maximal (8,14,15,21,22). In this context, it is important to note that a National Transportation Board study comparing fatigue-related and non fatigue-related single vehicle trucking accidents

(7) found that driving at night with a sleep deficit was far more critical than simply driving at night.

While these recommendations are physiologically sound, they raise the issue that, with a maximum 12 h day shift and 10 h night shift, expensive assets (trucks) are not used to their full potential (24 h/day), so that this may increase costs. However, the details of this need to be examined, because trucks are rarely on the road 24 h a day in these operations, and reducing fatigue may produce economies in terms of driving efficiency, as well as reducing costs associated with incidents and accidents.

- No driver shall work more than 5 consecutive shifts without a break that allows 2 nights of unrestricted sleep.

  In the survey, only 43% of drivers had 2 full days off every 4-6 days, and 25% did not get 2 consecutive days off in less than 14 days. Some reported that the frequency of 2-day breaks varied seasonally, and three drivers reported having a 2-day break only when on annual leave.

  The rationale in restricting the number of consecutive shifts is that it limits the accumulation of sleep debt. Two nights of unrestricted sleep are normally required for sleep to return to normal after sleep loss (23). Without an adequate opportunity for recovery, the effects of sleep loss (increasing sleepiness and performance impairment) presumably continue to accumulate from one shift cycle to the next. Ultimately, sleepiness will become overwhelming, leading to the possibility of falling asleep inadvertently at the wheel (21,24).

- The timing of shift changes should be considered carefully.

  In the survey, a common pattern was to have 12 h day shifts and 12 night shifts, with shift changes at 3-4 am and 3-4 pm. On the one hand, this gives the night shift more chance to sleep in the morning, before the circadian drive for wakefulness reaches its maximum (25,26). On the other hand, it requires the "day" shift to get up very early, and could cause considerable sleep loss. It is generally hard to fall asleep earlier than usual in the evening (for physiological reasons), so it can be hard to compensate for early wakeup times.

  In addition to the sleep opportunites for different shifts, there are important logistical considerations that influence the preferred timing of shift changes, including availability of loading facilities and local traffic patterns, particularly in major cities.

- The restrictions on shift durations and the number of consecutive shifts lead to a maximum work week of 60 h, with an average of 55 h for drivers working rotating shifts.

  For many drivers in the survey, this would represent a reduction in work hours and in salary. It could also represent an increased cost for some operations, where extra drivers would need to be added.

- Permanent night shift should be avoided.

  There is no strong evidence that permanent night shift increases physiological adaptation to night work, or health and safety on the night shift (14,15,26,27). On the other hand, there is considerable evidence that sleep loss, and subjective and objective measures of sleepiness and fatigue are greatest on the night shift (8,21,26). Permanent night work also minimises drivers' contact with managers, who are mostly day workers, and complicates access to training opportunities. It reduces opportunities for regular contact with people who are not night workers, potentially impoverishing the family and social support networks of permanent night workers, which may be important in coping with shift work (17,27,28).

- Rosters should be regular and predictable. This facilitates regular sleep patterns for different types of shifts, and planning for family and social activities.

- There should be a fair distribution of free weekends, since this is preferred time off for most people.

These recommendations are still being debated. It is already clear that there will need to be a mechanism for negotiating temporary exceptions, particularly because there is marked seasonal variation in demand in some operations. Thus, for example, at times of peak demand, there may be strong logistical arguments for some 14-h day shifts. In this case, one could argue for working fewer than 5 shifts before a 2-day break. On very long duty days, the distribution of workload may be particularly important in minimising the effects of fatigue. The use of breaks, and organising the order of deliveries (keeping shorter driving periods to the end of the run) are possibilities. The aim is to enable flexibility without compromising safety.

This exercise also illustrates why there are no magic formulae for good rosters. Each operation, and often each location, presents different demands. Whatever the roster, the people working it have unique insights on how it affects their performance at work, and the organisation of their lives outside of work. Consultation is widely recognised as a crucial element in successful roster design.

Concluding Remarks

The issue of driver fatigue in trucking operations will become more critical as more companies move to 24-hour operations, in response to market forces. There are no simple solutions to this problem. Fatigue has multiple causes, different types of operations impose different demands, and individuals react differently to those demands. Effective fatigue management will require co-ordinated action on the part of regulators, companies, and drivers.

The programme described here is an example of fatigue management within a company. It is predicated on a relationship of trust and open communication between drivers and management, which is not easy to obtain or to maintain.

It is reasonable to expect that better fatigue management can bring benefits (safety, health, and economic) for all parties, and that those benefits can extend to other areas of life outside the workplace. However, fatigue management interventions of the type proposed here have not often been implemented and even less often assessed for their effectiveness. There are many challenges. Nevertheless, it is clear that effective fatigue management is a key part of maintaining an efficent, healthy, motivated workforce, with the associated gains in safety, productivity and competitiveness that this can offer.

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