

A good night's sleep for a hard day's work? Truck driver sleep patterns, sleepiness and work patterns

Hamish Mackie¹, Domineco Kalasih²

¹Mackie Research and Consulting Ltd / TERNZ Ltd, Telco Building, 16 Kingston St, Auckland

hamish@mackieresearch.co.nz

²Z Energy, Level 2, Willeston Centre, 22-28 Willeston St, PO Box 2091, Wellington 6140

dom.kalasih@z.co.nz

Abstract

As part of a programme of research to understand truck driver health and well-being issues, two studies have focussed on truck driver sleep and sleepiness. In the first study within the log-transport sector, actigraph (12 drivers) and sleep diary data (45 drivers) revealed that many drivers were exhibiting fatigue risk factors including: less than six hours sleep in the past 24 hours, Less than 14 hours sleep in the last 48 hours, being awake for more than 16 hours and driving between the hours of 1-6 am.

A similar study in the fuel transport sector was carried out to measure drivers' sleep patterns, perceptions of sleep, alertness and shift type effects, using a sleep diary and questionnaire (84 drivers). Many drivers demonstrated similar fatigue risk factors to the log truck drivers, although they tended to achieve slightly more sleep and report less sleepiness than log truck drivers. Practical recommendations for fatigue prevention and healthy lifestyles among drivers were also given.

Overall, many drivers achieved less sleep than is optimal, and in rare instances, drivers reported very low levels of sleep (e.g. 0-3 hours sleep) per 24 hours. Drivers reported that the start of their shift rotation (first day back to work after a break) was a particularly challenging time.

A number of suggestions to mitigate sleep issues, work-time sleepiness and fatigue were developed in conjunction with the companies who participated in this study. This included regular (3-4 monthly) screening for sleep and fatigue problems, taking a supportive approach and a driver 'engagement' exercise (checklist, truck check or meeting) at the start of the shift rotation.

Between the two studies, it is clear that truck driver sleep and sleepiness is problematic. However, there are a number of potentially effective industry led initiatives that could be trialled and implemented. Further investigation of the wider benefits and costs of implementing some of these initiatives could be carried out to determine their merits.

Key words: Sleep, fatigue, truck driver, crash risk

1. Introduction

Commercial driving can be challenging due to long working hours, early starts and shift work, all within a safety critical industry where mistakes can endanger lives and be very costly. Commercial driver crash risk, and indicators of crash risk, increases with driving duration (with detrimental effects starting after 5-8 hours driving) and the presence of other circadian and extended wakefulness risk factors (SafetyNet 2009).

An initial programme of enquiry, commissioned by the Log Transport Safety Council and ACC has sought to understand the health and wellness challenges that commercial drivers face (Mackie and Baas 2008). This work has led to the implementation and evaluation (Mackie 2010) of the 'Fit for the Road' programme and includes a number of further practical

recommendations for improvement. Part of this work has focussed on identifying driver performance, sleep and fatigue issues. Fatigue and sleepiness among commercial drivers has been documented in New Zealand (Charlton and Baas 2000) and overseas (SafetyNet 2009) and remains a serious road safety issue (Gander et al. 2006). In Australia it is estimated that one in three articulated truck crashes involved fatigue, and one in six where the truck driver was the fatigued party (CARRS-Q, 2011). However, it may be that the contribution of fatigue in crashes is under-reported (National Road Safety Committee).

Within the range of driver issues associated with commercial driving, fatigue is of particular concern (SafetyNet 2009) and, in New Zealand, is fuelled by very long shift hours (14-15 hours per day including breaks and commuting) and sometimes very early start times (12-3am are common for log truck drivers and other shift drivers). These very challenging working conditions mean that truck drivers are likely to exhibit a number of fatigue risk factors (Gander et al. 2006) and are therefore more likely to make errors (Belenky, et al. 2003).

The amount and time of sleep (among other factors) are important predictors of fatigue (Gander et al. 2006) and repeated restricted sleep causes reduced psychomotor performance and risk of lapses, even after two days of restored sleep (Belenky et al. 2003). There is therefore a rationale for understanding the sleep patterns of commercial drivers in order to understand the risk factors that may be related to driver fatigue and possible crash risk. Further work could then be carried out to address these factors accordingly.

The objective of these separate but related studies was to measure the sleep patterns and sleepiness of truck drivers in the log transport and fuel haulage sectors, explore the organisational causes of sub-optimal sleep and sleepiness and suggest improvements for the industry.

2. Method

2.1. Study 1 – Log truck drivers

Log truck drivers in New Zealand typically work during weekdays with weekend days off. Working their maximum services hours (13 plus breaks and commuting) is common and their driving involves a mixture of bush and highway driving, often starting at 12-3am. Most drivers are paid on an hourly rate.

For this study there were two main stages of data collection:

- 1) Validation of a sleep diary using activity monitors
- 2) A survey of drivers and 7-day sleep diary

Drivers were recruited, based on their willingness to participate, from companies that were listed in the Log Transport Safety Council's database. They were all based in the central North Island of New Zealand. For stage 1, each of 12 drivers wore an Actical activity monitor and completed a sleep diary for 7 days. Some questions related to fatigue were also included as a questionnaire, accompanying the sleep diary.

An activity monitor (Figure 1) is a wrist worn device that is commonly used to estimate sleep and physical activity by measuring movement (acceleration). Sleep time and duration is estimated by calculating the period of time at which movement remains below a pre-determined threshold. Most people, move in their sleep as they change position and enter various sleep stages, however there is a noticeable difference in the activity pattern of someone who is asleep compared with when they are awake.



Figure 1. Activity monitor similar to those used in the study

Algorithms, which detect physical movement pattern changes over a period of time, can be used to determine whether a person is asleep or awake or a graphical representation of physical activity over time (actigram) also shows when a person is likely to be awake and sleeping.

Following the validation of the sleep diary (shown in the next section), a sleep diary was completed and returned by 45 (out of 120) drivers (a 38% response rate), recruited from the same companies outlined above. The driver's average (SD) age was 46(11) years. In order to aid comprehension it was designed so that it was similar to the layout of a driver's log book. Drivers were required to shade the time that they were asleep over the previous 24-hour period starting at 7pm each day. Drivers were also asked to mark when they went to bed, exercised, ate food and consumed alcohol. Finally drivers were asked to rate the quality of their previous night's sleep using a 1-5 scale. A further questionnaire asked drivers about their age, living arrangements, all Epworth Sleepiness scale (ESS) questions, how often they felt tired when driving, how often they pulled over to nap during the working day and the times of the week they felt at most risk of fatigue (along with reasons for their score). Finally, drivers were asked what could be done to make tiredness or fatigue less of a problem for log truck drivers. Some of the questions were deliberately included as identical to questions that were used in a previous study (Mackie and Baas 2008), allowing the findings of the two studies to be considered together to create stronger overall findings.

2.2. Study 2 – Fuel haulage drivers

Fuel haulage drivers typically work shifts, with the most common being 3x3x3 (three days, three nights, three off) pattern, with shift lengths typically of 12 hours. Drivers mostly work in teams on a truck that has a 24/7 utilisation (except for scheduled maintenance downtime). Drivers are paid on a salary basis.

In this study a sleep diary and survey was developed and posted to 206 fuel haulage drivers from one company. A total of 84 drivers responded, giving a response rate of 41%. The driver's average(SD) age was 50(9) years. The survey asked drivers a range of questions including their age, living arrangements, commuting time, on the job naps, current shift structure, as well as questions about the riskiest times of their shift rotation in terms of fatigue or tiredness. Drivers were also asked what they believe could be done to make tiredness and fatigue less of an issue for drivers.

The ESS was used (all questions) to evaluate drivers' predisposition for daytime sleepiness and the Stamford Sleepiness Scale was used to indicate present alertness (at the time of completing the survey).

The sleep diary required drivers to shade the times that they went to bed, the time that they went to sleep and awoke, as well as the times that they worked, ate and took alcohol. Drivers were also asked to rate the quality of their night's sleep.

Following the analysis of the sleep diary data and questionnaire, discussions were held with the respective transport operators to discuss the findings and possible approaches to addressing any issues.

3. Results

3.1. Study 1 – Log truck drivers

3.1.1. Actigraph and sleep diary data

An example of the actigraph data is shown in Figure 2. Sleep is estimated from the periods of relative inactivity (shown by the shaded area in this example).

Figure 2. Example actigram over 24 hours for one of the drivers.

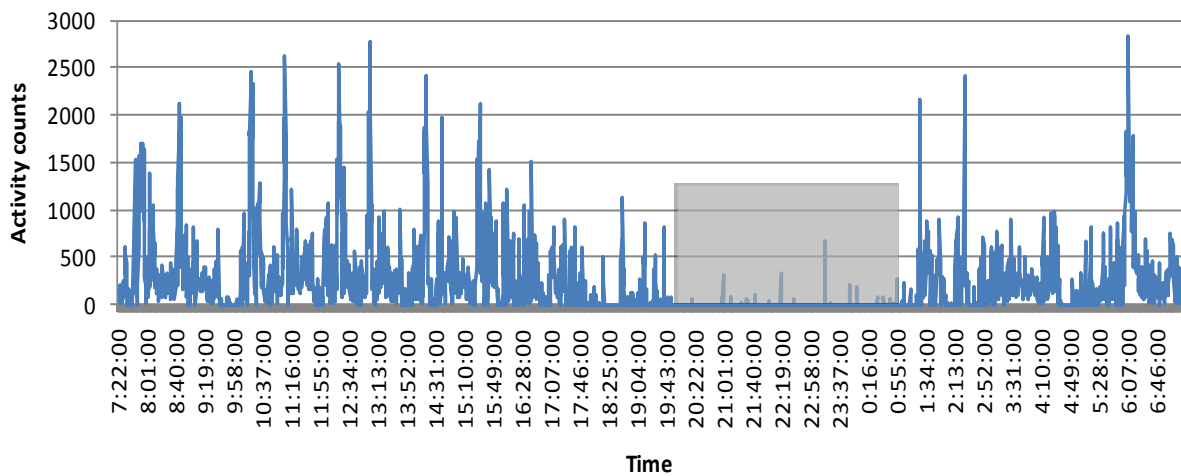


Table 1 shows that at a group level, the activity monitor and sleep diary produce similar results, which means that the wider use of the diary is likely to be effective for measuring group sleep patterns. Correspondence between the two measures was better for weekdays but poorer for weekends. This may be due to the less structured sleep patterns that occur during the weekend (such as staying up late and sleeping in), which may be harder to recall and detect.

Table 1. Comparison of activity monitor and sleep diary data for 12 log truck drivers

Data collection method	Average weekday Sleep (per 24 hr)	Average weekend Sleep (per 24 hr)
Activity monitor	5hrs 31min	8hrs 54min
Sleep diary	5hrs 33min	8hrs 38min
	Weekday	Weekend
Average difference between methods*	2min	-16min
Average absolute difference between methods	27min	1hr 30min

* a positive number indicates a higher diary estimate

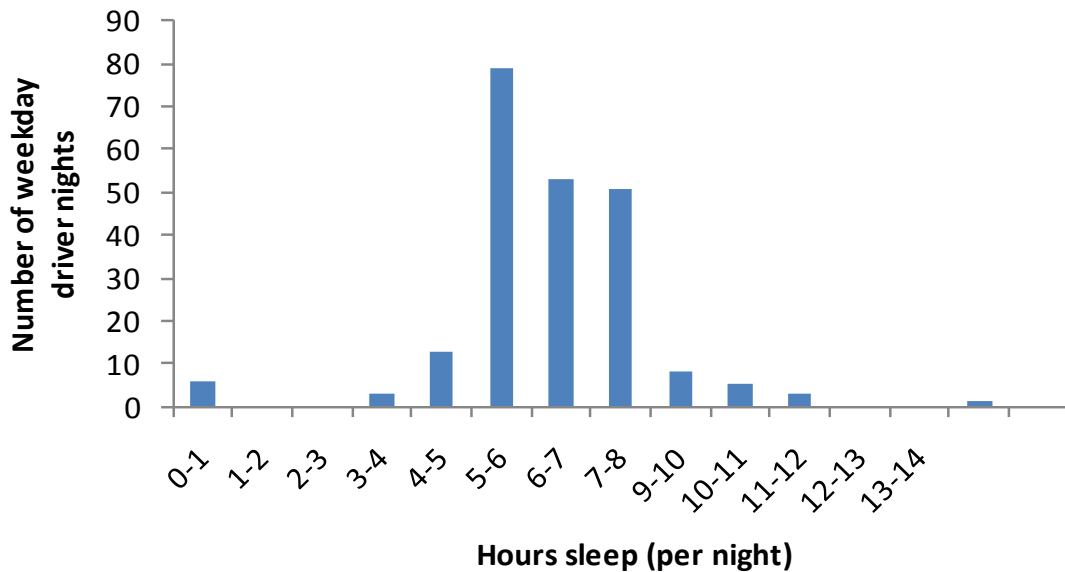
For the larger cohort of 45 drivers, a summary of the sleep diary findings is presented in Table 2 and the distribution for weekday (working) night's sleep is presented in Figure 3.

- The average weeknight's time to sleep for log truck drivers was approximately 8:40pm and the average wake time was approximately 3:00am
- The average weeknight's sleep duration was approximately 6hrs 15-30mins, higher than the average measured for the 12 actigraph examples. However, it should be noted that approximately 43% of driver nights were between 3-6 hours per night and the highest number of weekday driver nights were in the 5-6hr sleep category.
- The sleep patterns shown in the survey of 45 drivers is comparable to a previous survey of 225 log truck drivers (Mackie and Baas 2008). In this previous larger survey drivers reported an average weeknight's sleep of (6hrs 1min. The present study showed an average weeknight's sleep of 6hrs 17mins and with day-time naps included 6hrs 25mins.
- The average sleep rating for weekday sleeps was 3.5/5 and the average for weekend sleeps was 3.9/5. Of all sleeps, 11% were rated as a 1 or 2 out of 5

Table 2. Summary data from sleep diary for 45 log truck drivers

Mean age of drivers who completed sleep diary	46 years (std dev 11)
Total number of 'sleeps' (total sleep in 24 hrs)	300
Overall mean 24 hr sleep duration:	6.9 hours (std dev 2.05)
On-duty mean 24 hr sleep duration	6.36 hours (Std dev 1.66)
Off-duty mean 24 hr sleep duration	8.22 hours (Std dev 2.47)
Number of restricted sleeps (up to and including 5 hours):	41 (14%)
Proportion of sleeps less than 'optimal' (up and including 7 hours)	185 (62%)

Figure 3. Distribution of sleep duration (including day naps) for week-day driver-nights



3.1.2. Log truck driver survey

Epworth sleepiness scores for the drivers (average 7.13) was remarkably similar to the average score (7.30) reported in a previous questionnaire of 225 drivers (Mackie and Baas 2008). In the present study 25% of drivers had an Epworth score of greater than 10, a threshold that is given to indicate possible fatigue issues.

An overwhelming majority of drivers reported feeling sleepy or drowsy while truck driving “now and then” (71%) compared with “never” (18%), “fairly regularly” (7%), “Quite often” (4%), “most of the time” (0%) or “almost always” (0%).

The riskiest times of the week for “tiredness, fatigue or loss of attention” reported by drivers was Friday am/pm followed by Monday am. For log truck drivers this represents the beginning and end of their working week. While Friday am/pm tiredness is understandable given the hours that the drivers work, the high risk attributed to Monday am is less so. Drivers generally explained that they often have difficulty switching from the weekend, back into ‘work mode’.

3.2. Study 2 – Fuel Haulage Drivers

3.2.1. Sleep diary data

A summary of the sleep diary findings for fuel haulage drivers is presented in Table 3 and the distribution for working night’s sleep is presented in Figure 4. Note that due to the different work patterns of log truck drivers and fuel tanker drivers, and slightly different requirements of the studies, the method of presentation of the results differs slightly. However, the same sleep diary tool was used for each driver group.

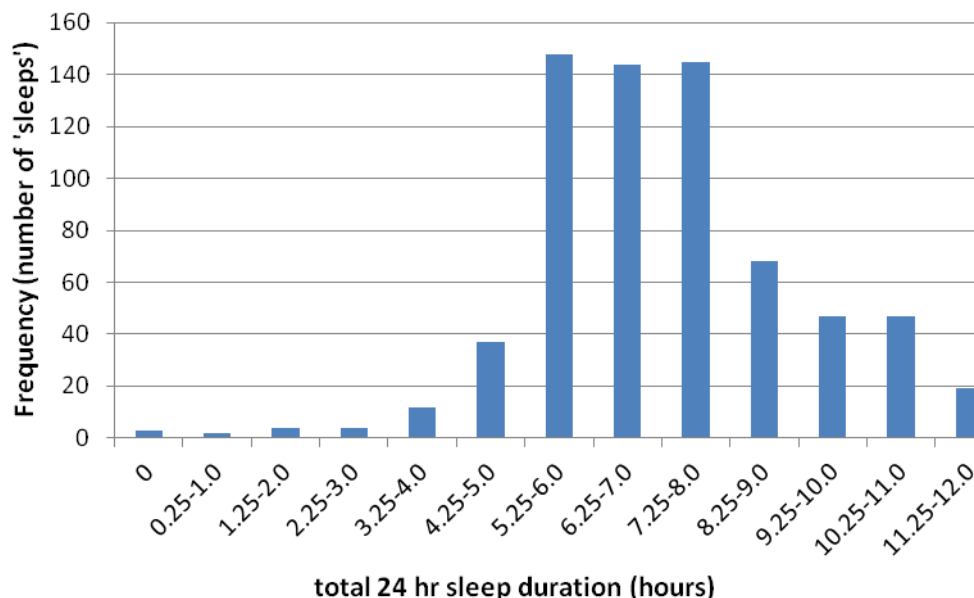
- The mean wake-up time for day shift drivers was 2:55am
- While the bulk of the sleeps are between 5-8 hours, there are also relatively large numbers of longer duration sleeps (up to 12 hours or more), mostly associated with days off when drivers are recovering
- One driver reported achieving no sleep prior to work and in rare instances drivers reported between 1-3 hours’ sleep. A more detailed investigation of these examples revealed that these drivers went on to work the next day.

Table 3. Summary data from sleep diary for fuel tanker drivers

Mean age of drivers who completed sleep diary	50 years (std dev 9)
Overall mean 24 hr sleep duration:	7.3 hours (std dev 2.17)
On-duty mean 24 hr sleep duration	6.9 hours (Std dev 1.77)
Off-duty mean 24 hr sleep duration	8.4 hours (Std dev 2.56)
Proportion of restricted sleeps (up to and including 5 hours)	9%
Proportion of sleeps less than 'optimal' (up to and including 7 hours)	51%

- A further analysis of 3x3x3 shift drivers (three days, three nights, three off) with other shift types (eg days only or nights only) found that 3x3x3x achieved less sleep (19 minutes), more variation in sleep time, and a higher proportion of 'high risk' sleeps (5 hours or less). The 3x3x3x drivers also rated their sleeps less positively than other drivers.

Figure 4. Distribution of sleep duration (including day naps) for all 24 hour driver-nights (days on and off duty).



3.2.2. Driver Survey

The most common commuting duration for drivers was between 10-30 minutes. Interestingly, Epworth scores for fuel tanker drivers was much lower (better) than for log truck drivers (mean 4.7 compared with 7.1 for log truck drivers). The most prevalent Stamford Sleepiness Scale rating was "feeling active, vital, alert or wide awake" (42%) and "functioning at high levels, but not at peak, able to concentrate" (36%).

The majority of drivers (61%) reported that they often pull over for a nap because they are too sleepy to drive. This majority indicates that this behaviour is acceptable within the company, which is positive. On the other-hand the fact that so many drivers need to pull over because they are too sleepy may indicate a systemic issue with driver sleep, fatigue and/or work schedules.

The start of the shift rotation was reported as the riskiest time of a driver's work cycle. This is similar to the pattern reported by log truck drivers, where the start of the working week was reported as the second riskiest time of the week. For log-truck drivers the start of the working week is also a time of elevated crash risk. The key reason given for this risk by the fuel haulage drivers was adjusting to the working cycle after having time off. This is very similar to the reasons stated by log truck drivers. Fewer working hours and better managing shift patterns were the key suggestions for making tiredness and fatigue less of a problem for drivers.

4. Discussion

4.1. Sleep duration and wake times

Between the findings of the log and fuel haulage studies, it appears that the average night's sleep for drivers is about 1-1.5 hours less than is optimal (e.g. 5-6 hours per sleep). Other research suggests that this is likely to affect the performance of drivers (Belenky et al. 2003) which may place them (and the motoring public) at increased crash risk. On rare occasions, it also appears that drivers are working while extremely sleep deprived (0-3 hours sleep).

Two key considerations for sleep duration are as follows:

1. Are drivers getting enough sleep on an on-going basis so that they do not accumulate sleep debt and a predisposition for errors and lapses while driving and performing other tasks? The findings of this study suggests that for many drivers, an accumulation of sleep debt over the period of their shift rotation is likely.
2. How should drivers be managed when they have severe sleep deprivation (e.g. 0-3 hours' sleep) for any one 'sleep', considering that a driver's performance following this level of sleep deprivation is likely to be comparable with a driver who is legally intoxicated with alcohol. For fuel haulage, existing company policy advises drivers to call in for time off in the event of severe sleep deprivation. An ongoing focus might be to encourage drivers to follow this, perhaps using positive incentives.

For both log transport and fuel drivers, waking up for work in the early hours of the morning is very common. Together with restricted night's sleep, it is likely that many drivers have key risk factors for fatigue, as described by Gander et al. (2006):

- Less than six hours sleep in the past 24 hours (acute sleep loss)
- More than 12 hours awake (extended wakefulness)
- More than a week without two good night's sleep in a row (cumulative sleep debt)
- Operating between the hours of 00:00 and 08:00 (least functional part of the circadian clock cycle)

Accordingly, psychomotor performance is likely to be affected (Belenky et al. 2003), which is likely to affect drivers' ability to drive a truck safely. It is acknowledged that there is likely to be a range in individual abilities to cope with the demanding work schedules common to truck driving and those who are naturally more able to cope with such work schedules are likely to self-select for truck driving. But the present studies suggest that there are a number of drivers within the industry who struggle with their work patterns. These drivers may turn to other coping mechanisms such as stimulants, which may offer short-term benefits, but may ultimately be detrimental to them and others. It may also be that tired or sleepy drivers are

simply operating with less margin for error in their day to day work and other parts of the system are prevent crashes or other serious incidents happening. In the rare occasions of system failures, crashes may be more likely for drivers carrying a sleep debt or exhibiting other fatigue risk factors.

4.2. Sleep quality

This study has not specifically measured sleep quality apart from subjective reporting of quality for each night's sleep by drivers. Sleep quality is an important consideration that warrants further consideration within commercial driving operations. Sleep apnea is a relatively common condition of which commercial drivers may have a particular predisposition, given their relative tendency to be overweight (Mackie and Baas 2008). Any recommendation to address sleep or fatigue issues with commercial driving operations should consider sleep quantity, time of sleep and sleep quality.

4.3. Driver sleepiness

An interesting contradiction in this study, is the relatively good scores from the Epworth sleepiness scale for fuel haulage drivers compared with log truck drivers and scores reported from previous New Zealand commercial driver studies (Charlton and Baas 2000). This difference may be explained partly by the slightly fewer hours of work that fuel haulage drivers complete each day (12 hours compared with 13 for log truck drivers). Also the fuel haulage company used for this study did have a number of policies which may help to explain their drivers' relatively lower tendency for sleepiness, including:

- Compulsory leave within every 3 months (and generous leave provisions)
- Agreed flexible start times
- High absenteeism (sick leave) is not penalised. Drivers are encouraged and not penalised if they call in sick because they do not feel fit to work

5. Conclusions and recommendations

5.1. Conclusion

Two studies have quantified sleep patterns and explored issues related to sleepiness and fatigue among log truck and fuel haulage drivers. Many of the drivers in these studies are not getting the sleep required to maintain alertness and therefore possibly safe driving performance.

It is important to examine the underlying causes of inadequate truck driver sleep. While it could be argued that sleep is potentially an issue across populations in most developed societies, shift patterns common to many truck driving operations may add further pressure on sleep routines. Obvious factors are 12-15 hour working days starting in the early hours of the morning. Other factors are likely to include variable shift patterns and the transition from days off to work days.

5.2. Recommendations

It is suggested that the following areas of truck driver shift work may require further investigation or the development of workable solutions:

- Overall working hours (particularly during night shifts)
- Start times (generally, variability, flexibility)
- The transition between shift types (e.g. from days to nights or from days off to days)
- Matching shift rotations to individual and team preferences
- Putting procedures in place to deal with severe sleep deprivation (e.g 0-3 hours sleep)

Potential solutions to shift problems were discussed with the operators who participated in this study. Some specific solutions to help reduce fatigue and sleepiness while driving may include:

- Flexible start times at the beginning of the working week or shift rotation.
- A driver 'engagement' exercise at the start of the shift rotation such as a checklist or meeting, to aid in the transition from their time off.
- A 2-3 hour window for shift start times (e.g. between 3-6am), agreed by teams, to offer flexibility and account for personal preferences
- A 'no-service' period where no driving takes place during some of the worst hours for driving (e.g. between 1-3am). However, the benefits of reducing fatigued driving would need to be considered against the current benefits of driving during these hours, such as reduced traffic/stress and reduced complaints about vapours from nearby residents (in the case of fuel haulage)
- Internal investigation of the wider financial and social costs and benefits of fewer driving hours per 24-hour period (e.g. 11 instead of 12 hour shifts). Experience suggests that relatively small reductions may lead to large improvements in driver's ability to cope with job demands.
- A joint responsibility approach should be taken, whereby both management and drivers have roles in managing sleep and driver performance issues.
- Clear expectations and support for drivers. Drivers need to know that their company takes fatigue and sleep issues seriously.
- Sleep and fatigue monitoring within periodic personal health checks. This could include screening for insomnia, sleep apnea or sleepiness while working. A coaching approach (rather than a disciplinary approach) should be taken in general, yet severe examples (such as working after not sleeping the night prior to a shift) should not be tolerated.

It should be noted that many transport operators are already taking steps to address fatigue issues. However, fundamental human requirements need to be considered at all levels of the transport system (drivers through to the government) when considering commercial driver work patterns and potential fatigue or reduced alertness.

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