Sleep, driving and the workplace

HM Engleman PhD, Research Fellow

Neil J Douglas MD DSc FRCPL PRCPE, Professor of Respiratory and Sleep Medicine

Department of Sleep Medicine, University of Edinburgh

Clin Med 2005;**5**:113–7

Sleepiness is increasingly recognised as a major preventable cause of accidents on the road and in the workplace.[1-23] It contributes to up to 20% of road traffic accidents (RTAs), with sleep-related RTAs claiming an excess morbidity and mortality similar to that from alcohol-related accidents. Sleepy driving is a known risk factor for RTAs: sleepy drivers have more frequent RTAs, and drivers at fault in RTAs are more likely to be sleepy. RTAs and occupational accidents are associated with sleep deprivation, both quantity and quality, arising from various lifestyle and occupational causes, either social (work/recreational pattern, shift work) or medical sleep disorders. Extended night driving and short sleep duration are linked with sleep-related RTAs by younger drivers, and sleep-related breathing symptoms with those of older professional drivers. Shift working, long hours and short sleep have deleterious effects on accident rates across demographic categories. Driving impaired by sleepiness of any cause is an offence, but most causes of persistent excessive daytime sleepiness are treatable with psychological or medical interventions.

Sleepiness and its causes (Fig 1)

Sleepiness is a homeostatic neurobiological response to accruing sleep debt from sleep of insufficient quantity or quality and is reversed only by recouping restorative sleep. As time accumulates since sleep was last acquired, subjective sleepiness and performance deficits increase, especially on long, boring or monotonous tasks such as motorway driving.[1] The main causes of sleepiness in the community are lifestyle and occupational factors[1,2,5,6,8,10,11,14-16,18,19,21,22,24] and medical sleep disorders, such as obstructive sleep apnoea/hypopnoea syndrome (OSAHS)[3,12,18,20,23,25,26] or narcolepsy.[27,28]

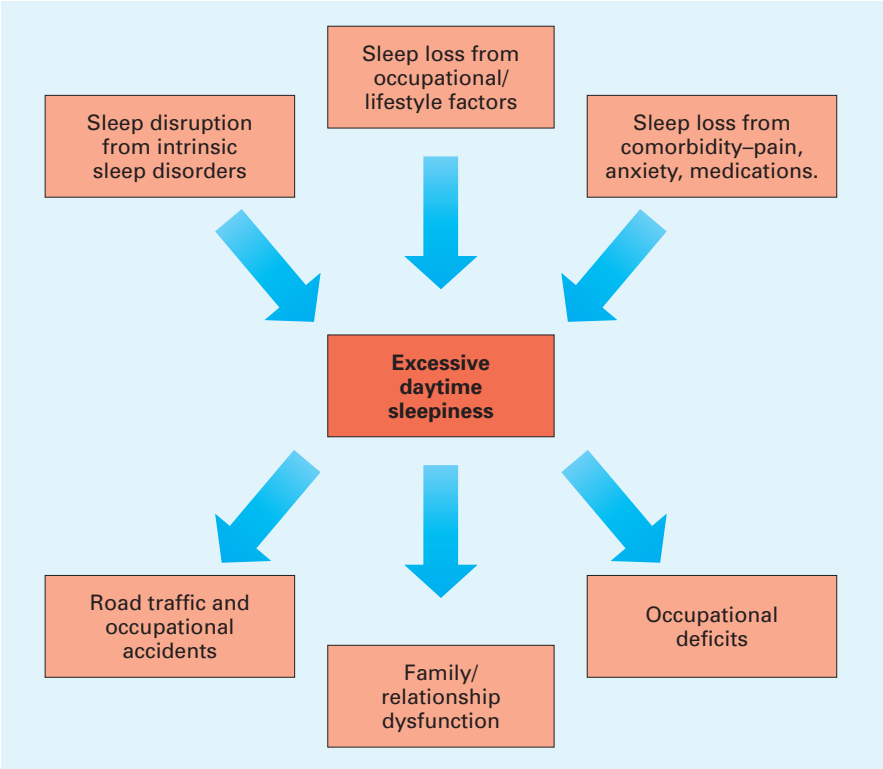

Fig 1. Causes and consequences of sleep deficit.

Social factors

Both lifestyle and occupational factors can produce acute or chronic sleep debt. Voluntary sleep loss or curtailment may be a habitual recreational weekend pattern or an episodic working pattern for some,[3,4,7,8,18,27,29] with extended wakefulness invoking cumulative performance deficits and increasing accident liability, producing a circadian peak in RTAs at 4 am.[1,2,5,7,19] Epidemiological and cohort studies have shown an association of long working hours, night work and rotating shift work with poor sleep, excessive sleepiness and higher RTA rates[2,6,8-11,24] and errors at work.[8,11] Extended, irregular and antisocial hours act as desynchronisers of circadian rhythms of wakefulness and sleep.

Medical disorders of sleep

The commonest medical cause of sleepiness in the community is OSAHS, affecting 4% of men and 2% of women of middle age.[12] Symptoms of OSAHS include heavy snoring, breathing pauses and oxygen desaturations during sleep, events which disrupt the continuity and quality of sleep achieved. Patients with severe OSAHS experience chronic partial sleep deprivation, particularly of restorative slow-wave and rapid eye movement sleep stages, and consequently suffer excessive daytime sleepiness with Epworth Sleepiness scores typically above 12 (Table 1).[28]

Other medical causes of sleepiness include periodic limb movement syndrome (PLMS), with limb jerking during sleep, and the uncommon sleep disorder narcolepsy. Narcolepsy has a maximum estimated prevalence of 50 per 100,000 (at least 100 times less common than OSAHS),[27,28] but the sometimes irresistible sleep episodes and cataplexy associated with narcolepsy can represent a

Key Points

- Traffic and occupational accidents are linked to poor sleep and cumulative sleep debt
- Sleep-related road traffic accidents (RTAs) comprise up to 20% of all accidents, peaking at 4 am
- Sleep-related RTAs are disproportionately injurious and expensive
- Many drivers responsible for accidents are sleepier than other drivers, and sleepy drivers have increased accident liability
- Younger men, shift workers and sleepy snorers are at increased risk of sleep-related accidents

KEY WORDS: cognitive performance, narcolepsy, obstructive sleep apnoea/hypopnoea syndrome, occupational accidents, shift work, sleep, sleep apnoea syndromes, sleepiness, traffic accidents

serious danger to patients and those around them.

Both these sleep disorders can be effectively treated – OSAHS with continuous positive airway pressure (CPAP), PLMS and narcolepsy with pharmacological treatments.

Other factors

Other individual factors such as age, ill health and medications can reduce nocturnal sleep quality and produce daytime sleepiness. The duration, quality and quantity of sleep obtained tend to deteriorate with age even in healthy normals, while complaints of insomnia increase in prevalence with lifespan. Insomnia may occur in ill health, either mental or physical, especially with anxiety or pain. Prescribed medications may also promote sleepiness either directly through central nervous system effects or indirectly by disrupting sleep.

Sleepiness and road traffic accidents

Whether from medical or lifestyle causes, sleepiness is estimated to cause 10–20% of RTAs[1,5] in liberal definitions (absence of other causes) and 0.5% in strict definitions[2] of sleep-related RTAs. Sleepiness-related RTAs are more costly economically[13] and more injurious than those from other causes,[1,5,7,10] producing an excess mortality and morbidity similar to that from alcohol-related RTAs.[5,14] The exacerbated harm accruing from sleep-related accidents may arise in part from a grossly delayed or even absent braking response, so that evasive reaction in the face of a crash is poor.

Studies of driving simulator performance have assessed driving skills in the laboratory both in sleep-deprived normals[30] and in patients with disorders of excessive sleepiness.[25,26] The scale of driving impairment with sleep loss or sleep disorders was similar to that in normal subjects intoxicated by alcohol.[25,26,30]

In case-control and cross-sectional studies, drivers judged responsible for traffic collisions are more likely to be sleepy.[7,15,16] Conversely, studies of sleepy drivers show they are also more likely to have been involved in RTAs.[14,17,18]

The impact of sleepiness on driving safety is acknowledged and regulated in UK guidelines,[29] which state that driving while compromised by sleepiness from any cause is an offence. However, in recognition of the reversibility of sleepiness of medical causes, the guidelines permit the renewal of car, passenger-carrying vehicle (PCV) and large-goods vehicle (LGV) licences for patients with OSAHS after adequate CPAP treatment and control of symptoms. Successful CPAP treatment is satisfied by objective time-clock validation of regular CPAP use, control of daytime sleepiness symptoms (Epworth score <11) (Table 1) and resolution of sleepiness while driving. Objective machine-on or mask-on usage is logged by many CPAP units, and differences in time clock readings at

Table 1. Epworth Sleepiness Scale.[28]

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently, try to work out how they would have affected you had they occurred.

Use the following scale to choose the most appropriate number for each situation:

0 = no chance of dozing
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

Situation	Chance of dozing
Sitting and reading	☐
Watching TV	☐
Sitting inactive in a public place (eg a theatre or a meeting)	☐
As a passenger in a car for an hour without a break	☐
Lying down to rest in the afternoon when circumstances permit	☐
Sitting and talking to someone	☐
Sitting quietly after a lunch without alcohol	☐
In a car, while stopped for a few minutes in traffic	☐
Total (score range 0–24)	☐

follow-up used to calculate average hours of use per night. CPAP use of 4–5 hours per night is sufficient for many, while less has been linked with CPAP rejection.

Risk factors for sleep-related road traffic accidents

Statutory accident registers show a circadian peak in sleep-related accidents around 4 am[1,14,19] coinciding with the diurnal nadir in wakefulness, overlaid with a sleep debt accrued since sleep was last acquired 18 or more hours previously. The modal sleep-related crash occurs in the early hours after extended wakefulness by a young male driver.[1,2,5,7,9,14,19]

Population studies also show excess RTAs in night- and shift working drivers,[6,9,10] those working long hours or in multiple jobs, with short sleep durations and drowsiness while driving.[2,9] Other cross-sectional studies highlight the component of road accident risk relating to the symptoms of breathing irregularities in sleep and daytime sleepiness, associated with OSAHS.[4,6,12]

Risk factors for occupational accidents

Accidents in the workplace represent a related arena and area of concern for sleep-related accidents. Individuals at greatest risk of injury will include those working with heavy machinery or at heights, but sleep deprivation can also provoke critical and catastrophic errors by executive workers. Swedish longitudinal research has incorporated national survey outcomes and occupational accident registers[20,21] to show links between poor sleep and accidents. Significant predictors of the 166 fatal occupational accidents in the 47,860 Swedes sampled were shared with attributes of sleep-related RTAs. These were male gender, difficulties in sleeping and non-day work, with relative risks of 2.3, 1.9 and 1.6, respectively.[21]

In another Swedish study, 2,000 working-age men were followed up 10 years after a survey of snoring and daytime sleepiness, during which 12% had reported occupational accidents.[20] Workplace accidents were significantly associated with snoring and daytime sleepiness (symptoms of OSAHS), with a doubled risk of an occupational accident.

Occupational groups at risk of accidents

Hospital staff and professional drivers are among the most extensively surveyed occupational groups, in whom error-free performance is critical but work environment can be subject to extended shifts, night work and short sleep. For medical and nursing staff, reports of RTAs and near-miss traffic collisions driving home after duty[12,15,16,36] and of errors at work while on duty[8,11] are elevated in night- and shift workers[8,11,22] and in those gaining five or fewer hours of sleep per night.[11,22] A subsidiary factor in accident liability after sleep debt may be interindividual differences in tolerance to extended hours and circadian shifts.[6,22] While some shift workers maintain a healthy sleep pattern, others are less adaptable to antisocial hours and experience worse deterioration in sleep quantity and daytime performance, carrying increased associated risks of accidents.[2,6,9,10]

Professional drivers of buses,[6.18] lorries,[4,6,18,23] taxis[10] and cars represent a population of critical interest due to their greater mileage and exposure to accident situations and because of the greater potential damage of accidents involving PCVs and LGVs.[29]

A sample of almost 8,000 Australian taxi drivers had a high rate of hospitalisation or death (10%) in work-related collisions, but odds of these occurring were raised to 1.6 by night work.[10] In 1,389 Swedish professional long-haul drivers, worse sleep debt and raised daytime sleepiness (Epworth score >10) increased the odds of self-reported accidents off-work sixfold and doubled those occurring at work (Table 1).[18] Similar findings are reported for UK LGV drivers, in whom sleepiness and symptoms and signs of OSAHS were linked with accident rates.[4]

Half of 593 Australian long-haul LGV drivers interviewed reported falling asleep while driving.[6,14,17,18] The responses showed five underlying factors reflecting working schedules:

- poor sleep on the road
- daytime sleepiness
- sleep-breathing disorder symptoms
- nocturnal sleepiness, and
- driving experience.

Each of these factors was significantly linked with increased odds ratios for having fallen asleep at the wheel.

Sleep screening of professional drivers[23] has estimated a prevalence of 60% of disordered breathing during sleep, 24% excessive daytime sleepiness and 16% for the intersection of these symptoms (comprising OSAHS). Similar statistics for OSAHS (17%) are found in others who drive for a living.[18]

Clinical assessment of sleepiness

As a subjective symptom, sleepiness is best evaluated by combining self-rating instruments and patient interview (Tables 1–3) to assess a history, severity

Table 2. Assessment of sleepiness.

Self-ratings	Epworth Sleepiness Score Sleep diary
Clinical interview: dimensions of sleepiness	Driving distances at work? Operating heavy machinery at work? Sleepy while driving and/or working? Situational and motivational factors in sleepiness Functional impairments from sleepiness Lifestyle/occupational contributants to short sleep Adaptability to sleep deprivation and phase shifts Risk assessment to patient and community
Other factors	Demographics: age, gender, weight Concurrent health problems Medications

and functional impact. The clinical causes of sleepiness divide between behavioural and medical disorders. Behavioural disorders include occupational or life style-linked sleep restriction, insomnia and circadian rhythm dysfunction, while medical disorders most commonly considered are OSAHS, PLMS and narcolepsy.

The Epworth Sleepiness Scale (Table 1) assesses chronic sleepiness with sleep tendency ratings. Scores range 0 (none) to 24 (extreme) daytime sleepiness, with an average score of about 5 ± 4 standard deviations in healthy working normals.[27] An elevated score of 11 or above is seen in 11% of Australian workers[27] and 25% of older, independently-living Americans.[31]

A sleep diary (Table 3) can record typical hours of work, rest and sleep to assess sleep hygiene and medical symptoms. High ratings (3+ nights/days per week) for waking unrefreshed, daytime napping, sleepiness or sleepy driving should elicit further interview, especially with sleep-related breathing symptoms. Sleepy driving of any frequency should be discussed in interview, and patients advised of their responsibilities to inform the Driver and Vehicle Licensing Authority (DVLA) of any impairment due to sleepiness.[29] The DVLA will in most cases permit driving once effective treatment such as CPAP for OSAHS is instituted.

Self-ratings can fail to register unacknowledged sleepiness or that resisted through personality, situation or motivation. Partner evaluations of sleepiness and sleep symptoms can be helpful. The clinical interview can also supply detail of individual dimensions of sleepiness and cofactors such as age, gender, weight, occupation, driving mileage, work and recreation patterns and medical history contributing to the risk of sleep-related accidents (Table 2).

Sleep hygiene factors such as inadequate sleep duration (<6 or less hours/night) may be demonstrated by diary entries. Accruing sleep debt may also be evidenced by catch-up sleep of 12 or more hours/night during off-duty periods, Behavioural sleep loss such as insomnia from work or recreational causes may in some cases be remedied by simple sleep hygiene and behavioural modifications. In chronic insomnia, cognitive behavioural treatments appear most effective.[32]

A medical sleep disorder may be suspected in daytime sleepiness with adequate sleep time (7 or more hours/night). Frequent heavy snoring and/or breathing pauses during sleep may be a marker for OSAHS, rhythmic leg jerks for PLMS and daytime cataplexy for narcolepsy. In all these, sleep studies at home or in the sleep laboratory can enable diagnosis and implementation of effective treatments.

Table 3. Sleep diary.

1 **Work pattern** (*Please circle all that apply)*

Usual work schedule — Not working/All days/All nights/Rotating shifts/>60 hrs/week

2 **Sleep pattern** *(Please write responses on dotted line)*

Hours in bed on working days	..... hours in bed
Hours in bed on non-working days	..... hours in bed
Hours asleep on working days	..... hours sleeping
Hours asleep on non-working days	..... hours sleeping

3 **Sleep disorders symptoms** *(Please tick one for each)*

	Every night	3+ nights/ week	1–2 nights/ week	Less than weekly	Rarely/ never
Falling asleep difficult	❑	❑	❑	❑	❑
Broken sleep	❑	❑	❑	❑	❑
Heavy snoring	❑	❑	❑	❑	❑
Breathing pauses during sleep	❑	❑	❑	❑	❑
	Every day	**3+ days/ week**	**1–2 days/ week**	**Less than weekly**	**Rarely/ never**
Awake unrefreshed	❑	❑	❑	❑	❑
Daytime naps	❑	❑	❑	❑	❑
Daytime sleepiness	❑	❑	❑	❑	❑
Sleepy while driving	❑	❑	❑	❑	❑

Conclusions

Sleep debts incurred by restricted or poor quality sleep induce daytime sleepiness. Multiple pathways connect accident liability with sleepiness, arising from sleep debt incurred by short sleep, extended hours, shift work or medical sources of sleep disruption.

References

1 Horne JA, Reyner LA. Sleep related vehicle accidents. *BMJ* 1995;**310**:565–7.

2 McCartt AT, Ribner SA, Pack AI, Hammer MC. The scope and nature of the drowsy driving problem in New York State. *Accid Anal Prev* 1996;**28**:511–17.

3 Maycock G. Sleepiness and driving: the experience of U.K. car drivers. *Accid Anal Prev* 1997;**29**:453–62.

4 Maycock G. Sleepiness and driving: the experience of heavy goods vehicle drivers in the UK. *J Sleep Res* 1997;**6**:238–44.

5 Philip P, Vervialle F, Le Breton P, Taillard J, Horne JA. Fatigue, alcohol, and serious road crashes in France: factorial study of national data. *BMJ* 2001;**322**:829–30.

6 McCartt AT, Rohrbaugh JW, Hammer MC, Fuller SZ. Factors associated with falling asleep at the wheel among long-distance truck drivers. *Accid Anal Prev* 2000;**32**:493–504.

7 Connor J, Norton R, Ameratunga S, Robinson E *et al.* Driver sleepiness and risk of serious injury to car occupants: popula-

tion based case control study. *BMJ* 2002;**324**:1125.
8 Gold DR, Rogacz S, Bock N, Tosteson TD *et al.* Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. *Am J Public Health* 1992;**82**:1011–14.
9 Stutts JC, Wilkins JW, Scott Osberg J, Vaughn BV. Driver risk factors for sleep-related crashes. *Accid Anal Prev* 2003;**35**:321–31.
10 Lam LT. Environmental factors associated with crash-related mortality and injury among taxi drivers in New South Wales, Australia. *Accid Anal Prev* 2004;**36**:905–8.
11 Baldwin DC Jr, Daugherty SR. Sleep deprivation and fatigue in residency training: results of a national survey of first- and second-year residents. *Sleep* 2004;**27**: 217–23.
12 Young T, Blustein J, Finn L, Palta M. Sleep-disordered breathing and motor vehicle accidents in a population-based sample of employed adults. *Sleep* 1997;**20**: 608–13.
13 Douglas NJ, George CF. Treating sleep apnoea is cost effective. *Thorax* 2002;**57**:93.
14 Pack AI, Pack AM, Rodgman E, Cucchiara A *et al.* Characteristics of crashes attributed to the driver having fallen asleep. *Accid Anal Prev* 1995;**27**:769–75.
15 Lardelli-Claret P, Luna-Del-Castillo J de D, Jimenez-Moleon JJ, Rueda-Dominguez T *et al.* Association of main driver-dependent risk factors with the risk of causing a vehicle collision in Spain, 1990-1999. *Ann Epidemiol* 2003;**13**:509–17.
16 Kingshott RN, Cowan JO, Jones DR, Flannery EM *et al.* The role of sleep-disordered breathing, daytime sleepiness, and impaired performance in motor vehicle crashes – a case control study. *Sleep Breath* 2004;**8**:61–72.
17 Masa JF, Rubio M, Findley LJ. Habitually sleepy drivers have a high frequency of automobile crashes associated with respiratory disorders during sleep. *Am J Respir Crit Care Med* 2000;**162**(4 Pt 1):1407–12.
18 Carter N, Ulfberg J, Nystrom B, Edling C. Sleep debt, sleepiness and accidents among males in the general population and male professional drivers. *Accid Anal Prev* 2003;**35**:613–17.
19 Akerstedt T, Kecklund G, Horte LG. Night driving, season, and the risk of highway accidents. *Sleep* 2001;**24**:401–6.
20 Lindberg E, Carter N, Gislason T, Janson C. Role of snoring and daytime sleepiness in occupational accidents. *Am J Respir Crit Care Med* 2001;**164**:2031–5.
21 Akerstedt T, Fredlund P, Gillberg M, Jansson B. A prospective study of fatal occupational accidents – relationship to sleeping difficulties and occupational factors. *J Sleep Res* 2002;**11**:69–71.
22 Steele MT, Ma OJ, Watson WA, Thomas HA Jr, Muelleman RL. The occupational risk of motor vehicle collisions for emergency medicine residents. *Acad Emerg Med* 1999;**6**:1050–3.
23 Howard ME, Desai AV, Grunstein RR, Hukins C *et al.* Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. *Am J Respir Crit Care Med* 2004;**170**:1014–21.
24 Marcus CL, Loughlin GM. Effect of sleep deprivation on driving safety in housestaff. *Sleep* 1996;**19**:763–6.
25 George CF, Boudreau AC, Smiley A. Simulated driving performance in patients with obstructive sleep apnea. *Am J Respir Crit Care Med* 1996;**154**:175–81.
26 Hack MA, Choi SJ, Vijayapalan P, Davies RJ, Stradling JR. Comparison of the effects of sleep deprivation, alcohol and obstructive sleep apnoea (OSA) on simulated steering performance. *Respir Med* 2001;**95**:594–601.
27 Johns M, Hocking B. Daytime sleepiness and sleep habits of Australian workers. *Sleep* 1997;**20**:844–9.
28 Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;**14**:540–5.
29 Carter T, Major H, Wetherall G, Nicholson A. Excessive daytime sleepiness and driving: regulations for road safety. *Clin Med* 2004;**4**:454–6.
30 Dawson D, Reid K. Fatigue, alcohol and performance impairment. *Nature* 1997;**388**: 235.
31 Gottlieb DJ, Yao Q, Redline S, Ali T, Mahowald MW. Does snoring predict sleepiness independently of apnea and hypopnea frequency? *Am J Respir Crit Care Med* 2000;**162**(4 Pt 1):1512–17.
32 Morin CM, Culbert JP, Schwartz SM. Nonpharmacological interventions for insomnia: a meta-analysis of treatment efficacy. *Am J Psychiatry* 1994;**151**:1172–80.