Best Practice Rostering, Shift Work and Hours of Work for Resident Doctors: A Review

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1 Introduction

1.1 Scope of this Report

This review is provided at the request of the National Resident Doctors Engagement Group (NREG). The terms of reference specified that it should include literature from the last 10 years and from both the health sector and non-health sector workforces. An initial literature search restricted to papers written in English and published between 01/01/2002 and 01/06/2012 resulted in 14,485 papers for consideration. An initial screening for potential relevance left 9,651 eligible for review.

The terms of reference also specified that the NREG is particularly interested in:

- Patient safety (likelihood of making mistakes);
- Health and wellbeing of staff (health and safety issues);
- Effectiveness of staff to do their job (reduction in efficiency);
- Meeting training needs;
- Job satisfaction; and
- Popularity with staff (work/life balance).

These dimensions are highly specific to the Resident Doctors workforce and greatly limit the relevance of studies with other workforce groups. Restricting the search to Resident Doctors (and all variants of this title) resulted in 1004 papers which were considered for this review.

This report is divided into two main sections. The first covers the literature review, while the second addresses strategies in addition to rostering that are also relevant to the issues of interest listed in the terms of reference.

1.2 Physiological Considerations in Rostering

Shift work requires sudden shifts in a person’s sleep/wake cycle relative to the 24-hr day/night cycle. A shift worker’s circadian biological clock is drawn back towards its preferred orientation with sleep at night by the unchanged day/night cycle and social participation with day-active people. In addition, most shift workers revert to sleeping at night on their days off.

As a result, the circadian clock rarely adapts fully to shift work. Wakefulness may be required during the ‘biological night’, when the circadian clock is actively promoting sleep and physical and mental performance capacity reach their daily minimum. Conversely, sleep may be required during the ‘biological day’ when the circadian clock is actively promoting wake and sleep is truncated.

Restricted sleep in turn causes cumulative, dose-dependent degradation in waking performance and mood. Recovery from the cumulative effects of sleep lost over consecutive days of sleep restriction requires at least two consecutive nights of unrestricted sleep.

From a physiological perspective, shift work can be defined as any work pattern that requires an individual to be awake when they would normally be asleep if their day was totally unscheduled. The more a work pattern overlaps a person’s usual sleep time, the more rapidly they will accumulate a sleep debt across consecutive work days, and the more frequently they will require a recovery opportunity of at least two consecutive nights of unrestricted sleep.
A second factor that affects sleepiness and performance at work is a homeostatic pressure for sleep that builds up across wakefulness and is dissipated exponentially during sleep. Long work periods that extend wakefulness beyond about 16 hrs result in high levels of homeostatic sleep pressure associated with reduced alertness and performance.

From a physiological perspective, the ideal work pattern is day work with unrestricted sleep at night. Thus, rosters that cover 24/7 activities always involve compromise. Figure 1 summarises potential effects of rosters on individual doctors, and the mechanisms through which patient safety and practitioner health and well-being can be degraded.

![Figure 1: Links between rosters, safety, and health](image-url)
2 Literature Review Method

2.1 Literature Search

A multi-database search was conducted using Cochrane Library of Systematic Reviews; EBSCOhost interface of Academic Search Premier, Australia/New Zealand Reference Centre, CINAHL Plus, Health Business Elite, Health Source and PsycINFO; Google Scholar; Ovid interface of MEDLINE and PreMEDLINE; Pubmed; Scopus; and Web of Knowledge interface of Web of Science and Current Contents Connect. (The PreMEDLINE database contains in process and other non-indexed citations of MEDLINE.)

2.1.1 Factors related to rostering

An initial search was conducted of factors relating to rostering. As ‘roster’ is a multi-factorial concept, keywords were extended to the following Medical Subject Headings (MeSH) term: sleep disorders, circadian rhythm. The MeSH term was exploded to include all sub-headings. For all databases where searching by MeSH terms was not available, terms were entered as keywords. Additional keywords searched were: roster*; shift work; shiftwork; work schedule*; work scheduling; work condition*; work environment*; work pattern*; work hours; hours of work; duty hour*; extended wakefulness; and extended hours. Additionally, the keyword “shift” along with any of the keywords – duration; length; night; consecutive; and rotation – was used to identify a subset of specific shift-work related articles. It is acknowledged that the term ‘roster’ may be also be described by additional keywords. However, preliminary searches with broader keywords resulted in more than 100,000 papers to consider for review. Keywords were therefore chosen to focus searches on articles relating only to work patterns.

2.1.2 Additional search terms

Terms and keywords related to rostering were combined with the following MeSH terms: accidents; accidents, occupational; accidents, traffic; biological clock*; burnout, professional; chronobiology disorders; circadian rhythms; delivery of health care; education; efficiency, organisational; fatigue; health; health care; job satisfaction; medication errors; medical errors; mental fatigue; motor skills; muscle fatigue; needlestick injuries; occupational diseases; occupational health; occupational injuries; patient safety; personal satisfaction; personnel staffing and scheduling; psychomotor performance; quality assurance; quality assurance, health care; quality of health care; quality of life; rest; risk; risk factors; risk management; safety; sleep; sleep deprivation; stress, psychological; task performance and analysis; time and motion studies; time management; work schedule tolerance; work simplification; and wounds and injuries. All MeSH terms were exploded to include all sub-headings. For all databases where searching by MeSH terms was not available, terms were entered as keywords.

Additionally, terms and keywords related to rostering were combined with the following keywords: burnout; burn out; care; circadian; chronobiology; effectiveness; efficiency; error*; family life; health; healthcare; health care; performance; personnel satisfaction; quality; rest; recovery; satisfaction; scheduling; sleep; sleep restriction; social life; staffing; stress; supervision; task; training; tolerance; wellbeing; work life balance; workload*; and work load*.

The review was restricted to papers written in English, involving human participants and published between 1 January 2002 and 1 June 2012. This resulted in 14,485 citations for overall consideration.
After broad screening of all citations for potential relevance, 9,651 were eligible for possible review. These included papers investigating work patterns in both the health and non-health sectors. In order to restrict the review to a reasonable number of papers, only citations related to junior doctors were considered. This resulted in 1,004 citations eligible for possible review.

2.2 Literature Reviewed
All abstracts considered potentially relevant were read and assessed against a set of inclusion/exclusion criteria to determine their relevance for full paper review. Criteria for inclusion in the review were guided by the requirements of NREG. Therefore, included in the review were papers that considered the effects of factors relating to work patterns on:

- Safety, including patient safety
- Health and wellbeing of staff
- Performance
- Training needs
- Work life balance, including job satisfaction and quality of life

Abstracts were excluded if they were not original research or did not address the review topics. This resulted in 393 papers for full paper review.

Each full paper was assessed for the relevance of its contents, methodology, participants, and peer-review. Papers were excluded from the review if:

- they did not address the review topics
- the methodology was seriously flawed
- the paper was not peer-reviewed
- the vast majority of the supporting references were not peer-reviewed
3 Literature Review

A substantial number of the papers considered in full paper review investigated the impact of mandatory work hour regulations, such as the European Working Time Directive (EWTD) ("Working Time (Amendment) Regulations," 2003) and the Accreditation Council for Graduate Medical Education (ACGME) approved standards (2003, 2011). While these papers also considered aspects of the review topics of interest, the vast majority summarised outcomes pre- and post-implementation of work hour limitations, often without describing any aspects of the work patterns undergoing change. Moreover, consideration of the impact of work hour limitations was often as a dichotomous variable; in general, a ‘traditional’ schedule versus a ‘modified’ schedule in response to mandatory regulations. A large proportion of this literature described neither the baseline schedule nor the modifications made to meet the regulatory standards.

This review considers only those papers where aspects of work patterns were measured in relation to the review topics of interest.

3.1 Safety

3.1.1 Patient outcomes

A number of studies have retrospectively observed differences in patient outcomes before and after implementing an alteration to an established work schedule. These studies varied considerably in their work schedule alterations (and detail provided thereof), ranging from limitation of on-call shift length to implementation of night and/or day ‘float’ schedules. Comparison of the patient outcomes in an intensive care unit (ICU) before and after implementation of a night ‘float’ schedule demonstrated no change in adverse outcomes over an 11 month period (Schenarts et al., 2005). Likewise, no change in patient morbidity or mortality was observed after implementation of a day ‘float’ schedule in an inpatient cardiology team (Bhavsar et al., 2007), in a gastroenterology team after transition to night ‘float’ (McCoy, Halvorsen, Loftus, McDonald, & Oxentenko, 2011), or after implementation of 14-hour rotating shifts in an ICU (Afessa et al., 2005). However, patient mortality and the number of major complications significantly decreased after implementation of a night ‘float’ schedule in a surgical ward (Privette et al., 2009). These studies broadly categorised patient outcomes by intervention group and control group. Their comparability is limited by the large degree of disparity in specific aspects of the work schedules.

Yaghoubian et al. (2010; 2010) considered patient outcomes by shift type and duration. There were no differences observed in morbidity or mortality between daytime (performed between 6am-10pm) and night-time (10pm-6am) operations, where the junior doctor had been working for more than 16 hours in trauma surgery (Yaghoubian, Kaji, Putnam, et al., 2010) or acute care surgery (Yaghoubian, Kaji, Ishaque, et al., 2010). The day/night effect in these studies may have been clouded by other physiological factors known to affect performance across the day.

In a survey of 821 residents (response rate 57%), those who worked more than 80 hours per week were more likely to report an adverse patient event in the last week (30%), than those who worked less than 80 hours (18%, p=.007) (Jagsi et al., 2005). Ellman et al. (2005) observed no difference in mortality and complication rates in patients of residents who are ‘sleep deprived’ compared to those
who are not. However, ‘sleep deprivation’ was not a standard measure but instead an assumption of extended wakefulness based on time of surgery and time of subsequent surgeries. Sleep and wake were not measured in this study.

3.1.2 Medical error
Landrigan et al. (2004) have demonstrated that a reduction in work hours significantly reduced serious medical errors. In a randomised trial, a traditional schedule (with 24-hour extended shifts) was compared with an intervention schedule (with a 16-hour day and 16-hour night shift) and a reduction in overall hours of work. Using trained chart observers to shadow interns, it was shown that more serious medical errors were made during the traditional schedule than the intervention schedule (136.0 versus 100.1 per 1000 patient days, p<0.0001). Serious medical and medication error rates were higher during the traditional schedule. A subsequent web survey of 2,737 residents (response rate 80%) examining work patterns, medical error and adverse events has shown that compared to those who did not worked shifts of extended duration (≥ 24 hours), those who worked 1-4 shifts of extended duration per month (OR 4.0) and those who worked 5 or more shifts of extended duration per month (OR 6.7) were more likely to report a fatigue-related medical error (Laura K. Barger et al., 2006).

In a survey of 1,412 New Zealand junior doctors (response rate 66%) and considering work patterns in the previous two weeks, Gander et al. (2007) reported that 66% of junior doctors could recall making a fatigue-related clinical error in their career, and 42% could recall making a fatigue-related error in the past six months. Night work in the last fortnight (≥ 3 in one week versus ≤ 1 in both weeks, OR 1.37), working shifts of extended duration (2 or more shifts of ≥ 14 hours in the past week, OR 1.10), inadequate breaks between shifts (>1 in at least a week versus none, OR 1.27) and work schedule changes (change in last week versus none, OR 1.27) were independent predictors of reporting a fatigue-related clinical error in the past six months. A fatigue-risk matrix was developed to quantify fatigue-related risk based on a number of work pattern characteristics. Those who scored as significant (OR 1.31) and high risk (OR 1.85), compared to low risk, were more likely to report a fatigue-related clinical error.

A number of specific aspects of work patterns have been considered in relation to medical error, with mixed findings. Comparison of a traditional schedule (12.5-hour night shifts, 9-hour day shifts) with an intervention schedule (9-hour day and night shifts) demonstrated a reduction in medical error during the intervention (Cappuccio et al., 2009). Although, no statistical comparisons were made, this reduction was observed alongside an overall increase in total sleep time in the intervention schedule. A transition to a work schedule with no shift greater than 30 hours in duration resulted in a reduction in prescribing errors (Parthasarathy, Hettiger, Budhiraja, & Sullivan, 2007).

Junior doctors who work more than 80 hours per week were 1.61 times more likely than those who worked 80 or less hours to report a medical error which resulted in an adverse patient outcome (Baldwin, Daugherty, Tsai, & Scotti, 2003). Junior doctors who on average slept 5 hours or less per night were 1.74 times more likely than those who slept longer to report making a serious medical error, and 2.02 times more likely to have been named in a malpractice suit (Baldwin & Daugherty, 2004). Davydov et al. (2004) found no correlation between hours since start of shift and prescribing error. Similarly, Hendey et al. (2005) found no difference in prescribing error for orders written
overnight (on-call), post-call or off-call. In advanced cardiac life support (ACLS) algorithm scenarios, error rates were observed to decrease with extended wakefulness (Sharpe et al., 2010). However, these findings were likely significantly clouded by the lack of consideration of circadian rhythm factors that are known to influence performance across the day.

### 3.1.3 Motor vehicle accidents

In a web survey of 2,737 residents (response rate 80%), Barger et al. (2005) investigated work patterns and motor vehicle accidents (MVA). The risk of a crash (OR 2.3) and a near-miss crash (OR 5.9) was significantly greater when commuting after a shift of extended duration (≥24 hours) than after a non-extended shift. Gander et al. (2007) observed that 24% of New Zealand junior doctors had fallen asleep while driving home, and 66% reported feeling close to falling asleep at the wheel in the past 12 months. When considering work patterns in the last fortnight, working more than 10 days in the previous 14 days (OR 1.10), working two or more shifts of extended duration (≥14 hours) (OR 1.10), night work (2 shifts in one week (OR 1.08); ≥ 3 in one week (OR 1.53) versus ≤ 1 in both weeks) and work schedule changes (in one week (OR 1.60); in both weeks (OR 1.78) versus none) were independent predictors of reporting feeling sleepy at the wheel in the past 12 months. A fatigue-risk matrix was developed to quantify fatigue-related risk based on a number of work pattern characteristics. Those who scored as significant (OR 1.53) and high risk (OR 2.33), compared to low risk, were more likely to report feeling sleepy at the wheel.

A transition to a work schedule with no shift greater than 30 hours in duration resulted in a reduction in fewer residents reporting feeling sleepy before driving home, and feeling sleepy while driving (Parthasarathy, et al., 2007). Similarly, transition from a traditional 24-hour, every fourth night on-call schedule to a rotating 14-hour day/night shift schedule, with limited on-call requirements, was associated with fewer reported MVA and near miss MVA (Mautone, 2009).

### 3.1.4 Injury

Two studies have investigated the impact of work pattern on the risk to junior doctors of injury from sharp objects. A survey of percutaneous injury in 2,737 residents (response rate 80%) indicated that percutaneous injury were more likely to occur during extended duration shifts (>20 hours) than non-extended (OR 1.61) (Ayas et al., 2006). Percutaneous injury was more likely (OR 2.04) to occur at night (11.30pm-7.30am) than during the day (7.30am-3.30pm). Fisman et al. (2007) conducted interviews in 350 junior doctors exploring work patterns, needlestick injury and self-reported fatigue. The likelihood of reporting fatigue at the time of the injury was inversely associated with hours of sleep in the previous week, and hours of sleep the previous night. Junior doctors were more likely to report fatigue at the time of injury if they were on rotation requiring in-house call, or if they had had less than their usual amount of sleep the night before. Fisman et al. (2007) predicted that 25% of all needlestick injuries could be avoided if fatigue was eliminated.

### 3.2 Health and wellbeing

#### 3.2.1 Sleep and sleepiness

Several studies have investigated the impact of work patterns on sleep and sleepiness in junior doctors. Increased hours of work was associated with decreased hours of sleep (Baldwin & Daugherty, 2004; Baldwin, et al., 2003; Bismilla et al., 2011; Cappuccio, et al., 2009; Lockley et al., 2004; Parthasarathy, et al., 2007; Taoda, Nakamura, Kitahara, & Nishiyama, 2008). In a study of sleep patterns in New Zealand registrars (Poynter, Garden, & Young, 2012), 8% had less than 5 hours
sleep before arriving for a night shift, 34% experienced 17 hours or more of continued wakefulness during a night shift, and 4% experienced 24 hours or more of continued wakefulness during a night shift. The first night in a block of night shifts was associated with a greater frequency of extended wakefulness. Corresponding results were seen in a study of 78 Australian doctors (Ferguson et al., 2010) Forty one percent of shifts were preceded by less than 5 hours sleep in the previous 24 hours. Those who were starting a night shift were more likely (OR 2.95) to start work with less than 5 hours sleep in the previous 24 hours. Likewise, in 28 New Zealand anaesthesia trainees, 11% of 24 hour periods that included day shifts and 23% of 24 hours periods that included night shifts were associated with at least a 2 hour decrease in sleep, compared with days off work (Gander, Millar, Webster, & Merry, 2008).

In a prospective study of 72 internal medicine residents, Lockley et al. (2004) compared a traditional on-call schedule with an intervention schedule that included a modified-call in addition to day and night shifts, which aimed to reduce hours of work and shift length. A reduction in weekly hours of work was associated with increased hours of sleep. There was a strong correlation between increased hours of work and decreased sleep, with a predicted loss of 19.2 minutes of sleep per night for each additional hour of work per week. There was a reduction in the percentage of work hours preceded by fewer than 4 hours sleep (31% versus 13%) and 2 hours sleep (19% versus 6%) in the previous 24 hours between the traditional schedule and intervention schedule, respectively. Attentional failures were measured as slow rolling eye movements apparent alongside confirmed waking electroencephalography (EEG). (Slow rolling eye movements are indicative of quiet drowsiness and/or the transition from drowsiness to sleep EEG.) Twice as many attentional failures occurred on night shifts of the traditional schedule than intervention schedule, and 1.5 times as many attentional failures occurred on day shifts of the traditional schedule compared with the intervention schedule.

The amount of on-call sleep per night may change over time. In a prospective study of on-call residents, minutes of on-call sleep increased across the academic year and increased slightly (4 minutes) across a rotation with each subsequent on-call shift (V. M. Arora et al., 2008). Regardless, considerably less sleep is gained on on-call than non-call nights (Puvanendran, Venkatramani, Jain, & Farid, 2005; Rose, Manser, & Ware, 2008; Saxena & George, 2005). Difficulties falling asleep have been observed during sleep periods on a night-shift rotation compared to sleep following day shifts (Cavallo, Jaskiewicz, & Ris, 2002).

Alterations to work patterns have produced mixed findings with respect to sleep. Bismilla et al. (2011) observed no difference in on-call sleep between a 28-hour on-call schedule and a 24-hour on-call schedule with handover. Correlates with actual hours at work (time on duty) were not reported. Increased total sleep time was observed after the transition from a traditional schedule (12.5-hour night shifts, 9-hour day shifts) to an intervention schedule (9-hour day and night shifts) (Cappuccio, et al., 2009). The transition from a traditional on-call with night ‘float’ support schedule to a day/night rotating shift schedule was associated with a decrease in self-reported total sleep time (Chua, Gordon, Sectish, & Landrigan, 2011). However, this result is potentially clouded by small participant numbers, and discrepancies in data collection method between the traditional and intervention schedules.
In a survey of 1,412 New Zealand junior doctors, Gander et al. (2007) reported that 30% were excessively sleepy. Hours of work (≥ 70 hours versus < 50 hours, OR 1.54), night work (2 shifts in one week (OR 1.51); ≥ 3 in one week (OR 1.53) versus ≤ 1 in both weeks) and work schedule changes (in one week (OR 1.35); in both weeks (OR 1.81) versus none) were independent predictors of reporting being excessively sleepy. A fatigue-risk matrix was developed to quantify fatigue-related risk based on a number of work pattern characteristics. Those who scored as significant (OR 1.85) and high risk (OR 3.54), compared to low risk, were more likely to report being excessively sleepy.

Howard et al. (2002) investigated sleep and sleepiness in three conditions: a baseline condition in which residents were studied on a traditional work schedule (with five on-call shifts per month and no preceding on-call in the previous 48 hours); immediately post-call (sleep was permitted on-call); and in an extended sleep condition (in which residents were instructed to maximise their sleep for 4 days and report to work at a later start time (10am). Objective sleepiness was decreased in the extended sleep condition, when compared with baseline and post-call. Subjective sleepiness was significantly greater in the post-call condition, compared with baseline and extended sleep. The generalisability of these findings is limited by the small participant numbers (n=11).

Arora et al. (2006) compared the effects of a nap opportunity in a 30-hour on-call shift versus a traditional no-nap work schedule. Those who were permitted to nap obtained approximately 41 minutes more sleep and reported less fatigue, than those who were on the traditional schedule. Interns had opportunity to forward their pager to the night-float physician to gain ‘protected sleep time’. In instances where this occurred, 42 minutes of sleep was gained for each hour of cover.

As with other areas, the impact of alterations to work patterns on sleepiness has produced a range of findings. Both subjective and objective sleepiness have been shown to increase across a month-long ICU rotation (Parthasarathy, et al., 2007). Junior doctors are sleepier post-call than at the beginning of their on-call shift (Reddy et al., 2009). In this small number of residents, sleep onset latencies of less than 5 minutes were observed in 30% of individuals at the beginning of their on-call shift and 70% of individuals post-call. (A sleep onset latency of less than 5 minutes is indicative of excessive sleepiness.) There was poor correlation between self-rated and objective sleepiness post-call; residents had a poor ability to measure their own level of impairment. Residents are sleepier during their on-call shift than during a post-call day (Rose, et al., 2008). Increased sleepiness was associated with increased hours of work and decreased hours of sleep (Taoda, et al., 2008). In a comparison of a traditional 24-hour on call schedule with a modified 12- to 16-hour on-call schedule, Hanlon et al. (2009) demonstrated no difference in Epworth Sleepiness Scale (ESS) scores. (The ESS is an 8-item scale investigating sleepiness in recent times.) Sleepiness increased as frequency on-call increased. Likewise, Friesen et al. (2008) observed no association between hours of work and fatigue (rated on the Chalmer fatigue score) in a survey of 66 interns (response rate 59%).

Tucker et al. (2010) investigated a range of different aspects of work patterns and found that fatigue increased with the number of consecutive night shifts. Additionally, those that only had one rest day after a block of consecutive night shifts (as compared to two or more rest days) reported significantly greater fatigue on their first day shift following the block of nights. Short breaks (< 10 hours) in between shifts were associated with decreased sleep time after long shifts and increased fatigue on daytime shifts. Increased hours of work was associated with increased fatigue on night shifts.
3.2.2 Burnout and stress
A number of aspects of work patterns lead to increased burnout and/or stress in junior doctors. A survey of 914 Australian doctors reported that 70% of respondents reported high levels of stress at work (Markwell & Wainer, 2009), however the response rate in this survey was low (22%). Increased stress was associated with increased hours of work (Baldwin & Daugherty, 2004; Kasi et al., 2007; Martini, Arfken, & Balon, 2006), as well as workload (measured by patient load) (Wrenn, Lorenzen, Jones, Zhou, & Aronsky, 2010), perceived stress and decreased sleep quality (Friesen, et al., 2008). Individuals with poor coping skills were more likely to report stress (Kasi, et al., 2007). Focus groups with 23 interns indicated that frequent call during night shift, increased hours of work and heavy workload were most commonly reported as causes of stress (Lam, Wong, Ip, Lam, & Pang, 2010). In a survey of 617 residents, Lue et al. (2010) reported that sleep deprivation, the need to remain alert on-call, and heavy workload were among the top five reasons highlighted by residents as causing stress. In this study, there was a low correlation between weekly work hours and burnout measured on the Malasch Burnout Inventory (MBI).

3.2.3 Mood
There is scant research investigating the impact of work patterns on mood in junior doctors. Considering acute changes in mood, Kiernan et al. (2006) investigated aspects of mood (with the POMS questionnaire) after both an on-call shift and a night off-call. No differences were observed in any aspect of mood. Decreased mood (on the POMS: tension, depression, anger, vigor, fatigue and confusion) was observed during call compared with post-call days (Rose, et al., 2008).

3.2.4 Physiological stress
A small number of studies have examined the relationship between work patterns and physiological stress. Mean heart rate was elevated while working on-call compared with being off-call (and with no clinical responsibilities) (Tendulkar et al., 2005). It is not known how on-call work compares with other shift types. Extended shifts were associated with acute inflammation and endothelial dysfunction, compared with non-extended shifts (Zheng, Patel, Hryniewicz, & Katz, 2006). Parshuram et al. (2004) measured distance walked (via pedometer), conducted urinalysis for specific gravity and ketones, and recorded an electrocardiograph (via Holter monitor) in 11 fellows while working on-call (35 shifts). Comparing heart rate variability in the fellows with ‘norms’ reported by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology, 1996), the authors surmised that there was a trend towards sympathetic predominance in these fellows. Ketonuria was observed on 21% of the shifts.

3.3 Performance
Junior doctor performance has generally been measuring using simulation, psychomotor vigilance tasks, and cognitive functioning and working memory tasks. Studies in these areas have produced mixed findings and have considered varying aspects of work patterns.

3.3.1 Clinical task simulation
In a series of 7 night shifts, performance in a simulated laparoscopic task deteriorated with each consecutive night, with residents taking longer to complete tasks and making more errors (Daniel R. Leff et al., 2008). Leff et al. (2010) also examined changing performance in a small number of residents (n=7), across a simulated on-call shift from 10pm until 8am the following morning.
Measured at 2-hourly intervals, subjective sleepiness increased until 4am and then plateaued. In general there was no difference from baseline in visuomotor performance or cognitive functioning. In contrast to these findings, Hegar et al. (2011) and Lehmann et al. (2010) observed little decline in performance on a laparoscopic simulation task across a 24-hour on-call shift.

Subjective sleepiness increased and performance in a laparoscopic simulation task decreased the morning following a post-call shift, compared with the morning of the on-call shift (Eastridge et al., 2003). Most notable was an increase in the number of errors made post-call. Comparing laparoscopic simulation performance pre- and post-day and night shifts, Brandenberger et al. (2010) observed worsened movement smoothness and increased error rate in night shift residents. A decrease in cognitive performance was observed pre- and post-shift in both the day and night shift conditions, and post-night shift performance was worse than that post-day shift. Worsened performance on night versus day shift has also been observed in simulation exercises in emergency department registrars (Marcus, Liew, & Knott, 2010) and anaesthetic residents (Cao et al., 2008).

3.3.2 Driving simulation
Performance post-call while working excessive hours appears to be worse than when at the legal driving alcohol limit and working moderate hours. Arnedt et al. (2005) assessed post-call performance during a light call rotation (average 44 hours per week); during a light call rotation after consuming alcohol to a peak blood alcohol concentration of 0.05 g%; during a heavy call rotation (average 80 hours per week); and during a heavy call rotation after consuming a placebo drink. Residents on light call obtained on average more sleep in the previous 7 days than those on heavy call (7 hours 32 minutes versus 6 hours 17 minutes), as well as in the 24 hours prior to each test. Sleepiness was increased in all conditions when compared with light call; heavy call with placebo was worse than light call with alcohol. Reaction time on a psychomotor vigilance task (PVT) was worse in all conditions when compared with light call, and there were no differences between light call with alcohol and heavy call with placebo. In a driving simulation exercise, lane position variability was greater in all conditions compared with light call; no difference was observed between light call with alcohol and heavy call with placebo. A similar pattern was seen with an increased frequency of off-road (leaving the road) manoeuvres in all conditions compared with light call. Ware et al. (2006) have observed no difference between post-call and off-call in lane position and speed variability during a driving simulation task.

3.3.3 Psychomotor vigilance task
Comparing residents who work in-house call with those who do not have any call obligations, Saxena et al. (2005) demonstrated that residents on-call had slower reaction times and increased lapses on a psychomotor vigilance task (PVT). There was no difference in reaction time pre- and post-call. Slower reaction times and increased lapses have been observed in residents performing a Standardised Number Connection Test after 24 hours on-call, compared with after a day shift (Qureshi, Ali, Hafeez, & Ahmad, 2010). In New Zealand anaesthesia trainees, post-night shift PVT reaction times were worse than post-day shift times (Gander, et al., 2008). Increased time at work was associated with slower reaction times. Additionally, increased time since waking was associated with slower reaction times when working a night shift, compared with a day shift.
3.3.4 Cognitive and memory task
Comparing performance after a 30-hour on-call shift with that after a 12-hour night ‘float’ shift, Matthews et al. (2006) observed no difference in attention, memory, reasoning or information processing. Similarly, no difference in memory or learning speed was observed across or after day or night shifts in a small number (n=6) anaesthesia registrars (Griffiths, McCutcheon, Silbert, & Maruff, 2006), and no difference in measures of attention have been observed during night ‘float’ shifts compared with day shifts (Cavallo, Ris, & Succop, 2003). Reimann et al. (2009) reported no difference in information processing measured prior to a day shift, or immediately after a 24-hour on-call shift or 12-hour night shift. In contrast, Lee et al. (2003) reported a decrease in ability to hold short term memory and information processing speed in surgical trainees after an 28-hour overnight on-call shift, compared with a 12-hour night shift. A decline in attention, information processing, motor skills and clinical decision making performance has also been observed in post-call compared with a ‘rested’ state immediately prior to the on-call shift (Flinn & Armstrong, 2011). Likewise, compared with a pre-shift rested state, working memory performance decreased post-night shift in anaesthesia residents (Bartel, Offermeier, Smith, & Becker, 2004) and during a 30-hour one night in four on-call rotation in internal medicine residents (Gohar et al., 2009). However, these studies are substantially limited in that they do not consider physiological factors that are known to affect performance across the 24-hour day. Coburn et al. (2006) demonstrated no effect of a 30 minute break on attention and working memory in anaesthesia residents. This 30 minute break was provided between 12pm and 1.30pm during a 7.30am to 4pm day shift.

3.3.5 Productivity
Few studies have evaluated productivity in junior doctors. Using a simple measure of patients evaluated per hour of work, Jeanmonod et al. (2008) have demonstrated that there is no difference in productivity between day and night shift, but increased productivity in residents working 9-hour shifts compared with 12-hour shifts. Using a more complex computerised monitoring system, this group has demonstrated that productivity declines with increased time spent on duty (Jeanmonod, Brook, Winther, Pathak, & Boyd, 2009).

3.4 Training needs
Studies investigated the impact of work pattern on the training of junior doctors are clouded by a number of limitations. A substantial proportion of the literature examines the perceptions of junior doctors and their colleagues with regard to training, in most part after implementation of work hour limitations. A number of studies have assessed patient or operative caseload immediately before and after implementation of a change in work schedule. Few studies have examined objective evidence of deficits in training in junior doctors.

3.4.1 Perceptions of the impact of work patterns on training
Surveys investigating the impact of a transition from a traditional on-call schedule to a night ‘float’ schedule on training have produced mixed findings. Junior doctors perceptions in these surveys have included benefit from the work schedule change (Vaughn et al., 2008); decline in quality of training (Izu, Johnson, Termuhlen, & Little, 2007; B. D. Kelly, Curtin, & Corcoran, 2011; Lefrak, Miller, Schirmer, & Sanfey, 2005) or time spent teaching (Lin, Beck, & Garbutt, 2006; Mazotti, Vidyarthi, Wachter, Auerbach, & Katz, 2009); or no perceived change in the quality of training (Lin, et al., 2006). Surveys of junior doctors on the impact of transition from a traditional on-call schedule to a modified on-call schedule (with limited on-call shift length) have indicated no difference in perceived
quality of training (Hanlon, et al., 2009; Landrigan et al., 2008). A day ‘float’ schedule has been associated with perceived improvement in quality of training compared with a traditional on-call schedule (Roey, 2006) and a night ‘float’ schedule (Suryadevara, Zandifar, Guyer, & Kellman, 2008). Conflicting findings are observed in studies investigating attendance at educational sessions. Bismilla et al. (2011) reported no change in attendance in a transition from a 28-hour on call schedule to a 24-hour on-call schedule. However, a survey of 163 residents (response rate 71%) indicated decreased time spent attending education sessions in a transition from a traditional on-call schedule to a night ‘float’ schedule (Luks, Smith, Robins, & Wipf, 2010). Baldwin et al. (2004) have reported increased satisfaction with educational experience with increased daily hours of sleep.

3.4.2 Operative caseload
Examination of operative caseload before and after implementation modified work schedule in order to adhere to mandated work hour regulations has also produced mixed findings. A number of studies have suggested a decrease in operative caseload after transition from a traditional on-call schedule to a night ‘float’ schedule (Blanchard, Amini, & Frank, 2004; R. J. Kelly, Jr. & Senkowski, 2009; Sim, Wrigley, & Harris, 2004). This is in contrast to other studies which have reported no change in caseload when transitioning from a traditional on-call schedule to a modified on-call schedule, with night ‘float’ support (McElearney et al., 2005), to a night ‘float’ schedule (Hutter, Kellogg, Ferguson, Abbott, & Warshaw, 2006; Zahrai et al., 2011), or to a full rotating shift schedule (Al-Rawi & Spargo, 2009). A comparison of residents working on a day/night shift schedule with those working a night ‘float’ schedule showed no difference in operative caseload (Abraham, Freitas, Frangos, Frankel, & Rabinovici, 2006).

3.4.3 Examination scores
In general, studies examining the impact of a transition from a traditional on-call schedule to a night ‘float’ schedule have indicated an improvement in American Board of Surgery In-Training Examination (ABSITE) scores (Barden, Specht, McCarter, Daly, & Fahey, 2002; Hutter, et al., 2006). Mautone (2009) has reported no statistical change (but a trend towards improvement) in American Board of Pediatrics In-Training/Certifying Examination scores after transition to a night ‘float’ schedule with on-call shift support, from a traditional on-call schedule.

3.5 Work life balance
3.5.1 Job satisfaction
Few studies have investigated the impact of work patterns on job satisfaction. Mautone (2009) reported increased job satisfaction after transition from a traditional on-call schedule to a night ‘float’ schedule, with on-call support. Suryadevara et al. (2008) reported increased satisfaction with a day ‘float’ schedule compared with a night ‘float’ schedule.

3.5.2 Work life balance
Tucker et al. (2010) have reported that increased weekly hours of work were associated with increased work-life interference. This difference was particular apparent in those working more than 48 hours compared to those working less.

Gander et al. (2007) developed a fatigue-risk matrix to quantify fatigue-related risk based on a number of work pattern characteristics. From a survey of work patients in the previous two weeks in 1,366 New Zealand junior doctors (response rate 63%) (Gander, Briar, Garden, Purnell, &
Woodward, 2010), a dose-dependent relationship was observed in those who scored as significant and high risk, compared to low risk, with respect to problems with their social life (OR 1.96), problems with their home life (OR 1.56), problems with personal relationships (OR 1.46), and problems with other commitments (OR 1.84). Night work (≥ 3 shifts in at least one week versus ≤ 1 in both weeks) and work schedule changes (in both weeks versus none) were independent predictors of reporting problems with work life balance. Qualitative analysis of written comments on the impact of work patterns on work life balance highlighted that difficulty in being able to commit to regular activities away from work (10.5%), being too tired to maintain activities away from work (8.9%), work interference on life outside work (particularly on weekends) (8.7%), having insufficient time to spend with family (8.0%), and problems resulting from having to work and study (6.1%) were the most common issues experienced.

3.5.3 Quality of life
There is scant research on the impact of work patterns on quality of life. Zahrai et al. (2011) measured quality of life using the SF-36 and have observed that compared with a traditional on-call schedule, a night ‘float’ schedule was associated with decreased physical functioning, social functioning, and bodily pain. From a questionnaire with dichotomous variables (yes/no), Vaughn et al. (2008) reported a perceived increased in quality of life, increased time to spend with family and increased time to spend socialising after transition to a night ‘float’ system from a traditional on-call system.

3.6 Summary of findings
While it is possible to draw some generalisations from these studies, there are several common methodological issues that limit the confidence with which those generalisations can be applied. In particular, most studies fail to take into account that performance changes across the 24-hour day under the influence of the circadian biological clock in the hypothalamus, independent of specific aspects of work patterns. The comparability of studies is also limited by the use of different outcome measures between studies, and the lack of a systematic effort by researchers to describe work schedules. A considerable number of the studies in this review investigate a change in a specific aspect of a work schedule immediately before or after change implementation. However, these studies often rely on individuals recalling their experience pre- and post-intervention. In addition, they often have short and varying durations for monitoring the effects of change, they do not allow time for system stability to develop after a work schedule change, and they do not take into account the Hawthorne effect. Studies examining the effect of work patterns in the health of junior doctors are intrinsically difficult because health outcomes are multi-factorial and the effects of workplace exposures may take years to affect health, while house surgeons at least change rosters as they change clinical specialties, and there is a lack of long-term objective monitoring.

From the studies in this review, there is reasonable consistent evidence that decreased patient and junior doctor safety, decreased sleep and increased sleepiness, decreased subjective health and wellbeing, decreased performance and poor work life balance are associated with:

- Increased hours of work
- Working night shift compared with day shift
- Increased shift length
- Working more consecutive nights
• **Decreased sleep**

Although the findings are somewhat conflicting, there is also reasonable evidence to conclude that, compared with working long hours on-call, working on a night ‘float’ schedule or scheduled night shifts is associated with increased patient and junior doctor safety, and improved work life balance. Furthermore, it is reasonable to conclude that a reduction in hours of work increases total sleep time, which in turn has been associated with improved safety, health and wellbeing, performance and work life balance outcomes.

There is no robust evidence that altering aspects of work patterns, including hours of work, impacts junior doctor training. However, there is now clear evidence to suggest that sleep is required for learning and memory consolidation (Walker, 2008; Walker & Stickgold, 2004). Thus, work patterns which allow adequate opportunity for sleep can be expected to have a positive impact on training.
4 Managing Rostering versus Managing Fatigue Risk

4.1 Introduction
Good rosters seek to make the most effective use of staff to cover the required work. They should contribute to multiple goals including improved patient care and safety, increased productivity, and improved RMO’s satisfaction, health and retention. However, while good rostering is necessary to achieve these goals, it is not sufficient. This section of the report considers the broader picture of shift work and fatigue management and additional strategies that would be beneficial in achieving these goals.

4.2 Definitions and Legal Requirements

4.2.1 Shift Work
Many different types of rosters are possible to provide 24/7 cover, using different combinations of:

- shift start times, durations, and end times;
- number of consecutive shifts before a break of at least 24 hrs;
- frequency and duration of breaks during and between shifts; and
- whether successive shifts begin earlier (backward rotation) or later (forward rotation), or always occur at the same time of day (fixed shifts); and
- for rotating shift systems, how frequently, and by how much, shift times change (the speed of rotation).

There is no universally agreed way to categorise this vast range of possible rosters, or indeed to define what shift work is, compared to ‘non-shift work’. From a physiological perspective, shift work can be defined as any work pattern that requires an individual to be awake when they would normally be asleep if their day was totally unscheduled.

Interestingly, in the advice on its website about shift work, the Department of Labour (DOL) avoids trying to define shift work. It argues that managing shift work is necessary to minimise workplace fatigue, which is explicitly identified in the Health and Safety in Employment Amendment Act (2002) as a workplace hazard.

4.2.2 Fatigue
From a scientific perspective, the definition of fatigue is the subject of some ongoing debate. However, use of the term ‘fatigue’ is widespread and long-standing in occupational health and safety. The following definition is based on international regulatory standards for managing pilot fatigue in commercial aviation.¹

Fatigue is a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a person’s alertness and ability to work safely and efficiently.

As a hazard, fatigue is considered a potential source of harm to employees. The Health and Safety in Employment Act (1992) requires employers to:

- take all practicable steps to prevent harm occurring to employees; and
- adopt a systematic approach to identifying, assessing, and controlling hazards at work.

Employees are responsible for reporting fit for work, behaving safely in the workplace and contributing to health and safety management, including reporting potential hazards they encounter. The Department of Labour’s on-line guidance highlights the shared employer/employee responsibility for fatigue risk management in the workplace. It also acknowledges that fatigue is affected by activities outside of work and states that this places an obligation on employees to:

- use opportunities for recuperation responsibly; and
- ensure that the personal lifestyle choices they make don’t pose a risk of harm to themselves or other people at work.

4.3 A Tool for Assessing the Likelihood of Fatigue on a Given Roster
The Australian Medical Association’s National Code of Practice for Hours of Work, Shift Work, and Rostering for Hospital Doctors (2005) proposes a checklist for assessing the likelihood that a doctor’s roster will generate fatigue (Appendix A). In a 2003 national survey of New Zealand RMOs (1366 RMOs working ≥ 40 hrs per week, 63% response rate), we validated a risk assessment matrix based on an earlier version of the AMA matrix. Total risk scores could range from 0-20 (Table 2) and differed between specialties but were comparable for men and women.

Total risk scores were divided in thirds (lower, medium, higher fatigue risk). After controlling statistically for demographic variables, increasing total risk scores independently increased the risk of a number of self-reported outcomes that map to the issues identified in the terms of reference for the present report (Table 3). In each case, the lower risk category was the reference value. For example, RMOs in the higher risk category were 1.85 times more likely to report recalling a fatigue-related error in the last 6 months, compared to those in the lower risk category. Odds ratios (ORs) in bold are statistically significant.

This risk assessment matrix is based on subjective data and has limitations. However, it is a tool validated for New Zealand RMOs and could be used to assess the fatigue risk associated with different rosters. Values for risk factors 1-7 and 9 (Table 2) could be derived from the planned roster. However, risk factors 8 and 10 were based on the RMOs’ subjective assessment. Appendix 2 provides a survey that could be completed retrospectively or prospectively by RMOs as an audit to evaluate the fatigue risk associated with their rosters.

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Table 2: Fatigue risk assessment matrix for rosters (2003 survey of 1366 NZ RMOs working ≥ 40 hrs/week)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Lower risk (0 points)</th>
<th>Significant risk (1 point)</th>
<th>Higher risk (2 points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hours worked</td>
<td>&lt; 50 hrs</td>
<td>50-70 hrs</td>
<td>&gt; 70 hrs</td>
</tr>
<tr>
<td>2. Shift length</td>
<td>All shifts &lt; 10 hrs</td>
<td>0-1 shift ≥ 14 hrs</td>
<td>At least 2 shifts ≥ 14 hrs</td>
</tr>
<tr>
<td>3. Extended shifts</td>
<td>No shift longer than</td>
<td>At least 1 shift longer than</td>
<td>At least 1 shift ≥ 24 hrs</td>
</tr>
<tr>
<td></td>
<td>scheduled, all shifts &lt; 24 hrs</td>
<td>scheduled but &lt; 24 hrs</td>
<td></td>
</tr>
<tr>
<td>4. On call</td>
<td>On call 0-2 days</td>
<td>On call 3-6 days</td>
<td>On call 7 days</td>
</tr>
<tr>
<td>5. Night duty</td>
<td>0-1 night duty</td>
<td>2 night duties</td>
<td>≥ 3 night duties</td>
</tr>
<tr>
<td>6. Breaks &lt; 10 hrs</td>
<td>0 breaks &lt; 10 hrs</td>
<td>1-2 breaks &lt; 10 hrs</td>
<td>More than 2 breaks &lt; 10 hrs</td>
</tr>
<tr>
<td>7. 24-hr breaks</td>
<td>No 24-hr breaks</td>
<td>One 24-hr breaks</td>
<td>No 24-hr breaks</td>
</tr>
<tr>
<td>8. Schedule change</td>
<td>No change, predictable schedule</td>
<td>Change, predictable schedule</td>
<td>Change, unpredictable schedule</td>
</tr>
<tr>
<td>9. Sleep at night (2300-0700)</td>
<td>6-7 nights</td>
<td>4-5 nights</td>
<td>0-3 nights</td>
</tr>
<tr>
<td>10. Enough sleep</td>
<td>6-7 days</td>
<td>4-5 days</td>
<td>0-3 days</td>
</tr>
</tbody>
</table>

Table 3: Total fatigue risk score as an independent predictor of worse safety and health outcomes

<table>
<thead>
<tr>
<th>Outcome Variable (% RMOs reporting this outcome)</th>
<th>Lower Risk (0-6) OR (95% CI)</th>
<th>Medium Risk (7-9) OR (95% CI)</th>
<th>Higher Risk (10-20) OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall a fatigue-related clinical error, last 6 months (42%)</td>
<td>1.00 1.31 (0.95-1.80)</td>
<td>1.85 (1.35-2.53)</td>
<td></td>
</tr>
<tr>
<td>Close to falling asleep at the wheel, last 12 months (66%)</td>
<td>1.00 1.53 (1.10-2.13)</td>
<td>2.33 (1.65-3.30)</td>
<td></td>
</tr>
<tr>
<td>Excessive daytime sleepiness (30%)</td>
<td>1.00 1.85 (1.30-2.63)</td>
<td>3.54 (2.51-4.98)</td>
<td></td>
</tr>
<tr>
<td>Work patterns cause problems with social life (61%)</td>
<td>1.00 1.92 (1.43-2.58)</td>
<td>3.83 (2.79-5.28)</td>
<td></td>
</tr>
<tr>
<td>Work patterns cause problems with home life (52%)</td>
<td>1.00 1.92 (1.40-2.64)</td>
<td>3.37 (2.43-4.67)</td>
<td></td>
</tr>
<tr>
<td>Work patterns cause problems with personal relationships (42%)</td>
<td>1.00 1.51 (1.13-2.04)</td>
<td>2.12 (1.57-2.86)</td>
<td></td>
</tr>
<tr>
<td>Work patterns cause problems with other commitments (46%)</td>
<td>1.00 1.92 (1.41-2.61)</td>
<td>3.06 (2.23-4.19)</td>
<td></td>
</tr>
</tbody>
</table>

4.4 Supervision as a Fatigue Mitigation

The 2003 national survey also found that, after controlling for work patterns and demographic factors, RMOs who felt that they often or always had adequate supervision at work were less likely to report adverse effects than those who felt that they never, rarely, or sometimes had adequate supervision (Table 4). Odds ratios (ORs) in bold are statistically significant. This ‘protective effect’ of RMOs receiving what they considered to be adequate supervision on a regular basis was independent of their actual work pattern, suggesting that providing good supervision is a robust fatigue mitigation strategy.
Table 4: Adequate supervision as an independent predictor of better safety and health outcomes

<table>
<thead>
<tr>
<th>Outcome Variable (% RMOs reporting this outcome)</th>
<th>Never/rarely/sometimes (reference category)</th>
<th>Often/always OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall a fatigue-related clinical error, last 6 months (42%)</td>
<td>1.00</td>
<td>0.68 (0.51-0.91)</td>
</tr>
<tr>
<td>Close to falling asleep at the wheel, last 12 months (66%)</td>
<td>1.00</td>
<td>0.60 (0.43-0.82)</td>
</tr>
<tr>
<td>Excessive daytime sleepiness (30%)</td>
<td>1.00</td>
<td>0.67 (0.50-0.91)</td>
</tr>
<tr>
<td>Work patterns cause problems with social life (61%)</td>
<td>No univariate relationship</td>
<td></td>
</tr>
<tr>
<td>Work patterns cause problems with home life (52%)</td>
<td>1.00</td>
<td>0.76 (0.56-1.02)</td>
</tr>
<tr>
<td>Work patterns cause problems with personal relationships (42%)</td>
<td>1.00</td>
<td>0.57 (0.43-0.75)</td>
</tr>
<tr>
<td>Work patterns cause problems with other commitments (46%)</td>
<td>1.00</td>
<td>0.78 (0.58-1.04)</td>
</tr>
</tbody>
</table>

4.5 Other Strategies Recommended by the AMA

The AMA guidelines list the following types of risk controls to minimise the risk of work-related fatigue:

i. Design principles for schedules (see Appendix 3);
ii. Information, supervision, consultation and training;
iii. Facilities and services; and
iv. Monitoring and review.

4.5.1 Education and Training

The inclusion of education and training is widely accepted as a fundamental requirement for fatigue risk management. The AMA guidelines provide details on content that needs to be covered in information and training sessions for RMOs. In the 2003 survey of NZ RMOs, only 14.7% had ever had any education on personal strategies for coping with the effects of shift work and extended hours. A number of courses are available, and the Sleep/Wake Research Centre is planning to develop an on-line training programme that RMOs can complete when it suits them. (In airlines, pilots are paid a specified amount of time for completion of on-line training, which can be monitored.) With regard to consultation, the AMA guidelines propose that doctors should be involved in the development of rosters.

4.5.2 Facilities and Services

The AMA guidelines also propose that hospitals should provide:

- Rest areas in which doctors can take short breaks from duty.
- Locker rooms and showers.
- Suitable facilities for doctors when required on the hospital campus to enable a minimum of 8 hours of undisturbed sleep between shifts or to have short naps within long shifts.

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• Access to suitable catering facilities providing nutritional food and beverages consistent with diet guidelines that maximise the ability to work shifts and extended hours.
• Access to counselling services to assist in any issues arising from the disruption of individual, family or social patterns caused by shifts or extended hours.
• Access to advice on diet and physical exercise.

Table 5 summarises RMOs responses in the 2003 survey, about the facilities to which they had access.

Table 5: Availability of different facilities in the 2003 survey of NZ RMOs

<table>
<thead>
<tr>
<th>Type of Support</th>
<th>No</th>
<th>Yes, but I don’t use it</th>
<th>Yes, and I use it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest area for short breaks</td>
<td>21.2%</td>
<td>29.4%</td>
<td>49.5%</td>
</tr>
<tr>
<td>Bed for napping or sleep</td>
<td>61.8%</td>
<td>19.9%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Healthy food at all hours</td>
<td>76.3%</td>
<td>4.8%</td>
<td>19.0%</td>
</tr>
<tr>
<td>Personal counselling services</td>
<td>43.4%</td>
<td>55.1%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

4.6 Fatigue Risk Management Processes Recommended by the AMA

The AMA guidelines provide recommendations for monitoring and review of work scheduling and unanticipated workloads, incident reporting and investigation, and record keeping. However, they do not explicitly link the recommended fatigue risk assessment and mitigation strategies together with these processes. The next section describes a Fatigue Risk Management System which combines these elements in a continuous improvement loop.

4.7 Fatigue Risk Management Systems

Fatigue risk management systems (FRMS) are an approach that combines the latest scientific knowledge with state-of-the-art safety management. FRMS are based on data-driven processes that:

1) routinely monitor fatigue levels;
2) identify where fatigue is a hazard; and
3) assess the level of risk that a given fatigue hazard represents; and
4) where necessary, put in place controls and mitigation strategies, and monitor to make sure that they manage the risk at an acceptable level. These include organisational strategies (including good rostering), and personal strategies. (An employer can help employees improve their personal strategies for reducing fatigue by providing education and training).

These processes are closed loop, because the effectiveness of current mitigation strategies is measured by the ongoing monitoring of fatigue levels. They are summarised in Figure 2. Properly implemented, these processes would meet the requirements on employers under the Health and

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Safety in Employment Amendment Act (2002) to adopt a systematic approach to identifying, assessing, and controlling fatigue hazards at work.  

Figure 2: Basic fatigue risk management processes

4.7.1 Fatigue Monitoring and Hazard Identification
FRMS relies on fatigue monitoring. Collecting data is not sufficient – it must also be analysed and where necessary, acted upon. This requires commitment of resources from the DHB. There are two kinds of data that are typically used for fatigue monitoring:

1. routinely collected organisational information (such as rostering and payroll data, sick leave data, etc); and
2. information provided by staff, either in voluntary reporting systems (staff are required by the HSE act to report fatigue hazards they encounter at work), or by RMOs agreeing to complete surveys or participate in fatigue monitoring studies where there is a particular concern (relating to a group, not an individual).

Staff must be able to trust that information they provide will be used to improve safety, not to attribute blame. In this context, commercial aviation has clear guidelines about an effective safety reporting culture. To encourage open and honest reporting of fatigue hazards by all personnel involved in an FRMS, an employer must clearly distinguish between:

- unintentional human errors, which are accepted as a normal part of human behaviour and are recognised and managed within the FRMS; and
- deliberate violations of rules and established procedures. An employer should have processes independent of the FRMS to deal with intentional non-compliance.

6 Full FRMS also includes another loop – safety assurance processes that check whether fatigue levels are meeting external standards set by company policy or by regulations. These processes track safety performance indicators (SPIs) based on the data coming from fatigue monitoring in Figure 1 and integrate management of fatigue risk with the management of other hazards across the organisation.
Achieving this trust is likely to be a challenge in some contexts. Another challenge is the rotation of RMOs through different speciality areas that have different rostering patterns and practices. Presumably the FRMS would need to operate hospital-wide, although issues might well arise and be dealt with within particular specialties or departments.

**Routine Organisational Data**
Existing rosters can be evaluated for their likely contribution to fatigue using the risk assessment matrix developed in our 2003 national survey of RMOs’ work patterns (see Appendix 1). Where a particular roster stands out as representing a high fatigue risk, mitigation strategies need to be considered. As discussed above, changing the roster is not the only possible mitigation strategy.

The roster actually worked can differ considerably from what was planned. In many organisations, payroll records can be matched with planned rosters to highlight the frequency of occurrence of fatigue risk factors (for example exceeding maximum shift lengths, working additional shifts, etc). This may not be possible for RMOs, however it may be possible to examine whether weekly work hours paid differs from the planned category of weekly work hours (categories A-F in the MECA). The AMA guidelines recommend that the schedule of actual hours worked should be reviewed at least monthly to identify opportunities to reduce or eliminate risks, and that this review should involve doctors or their representatives.

The number of RMOs in many hospitals is likely to be insufficient to track sickness absences as a potential measure of workforce fatigue.

**Information Provided by Staff**

**Voluntary Fatigue Reports**
Voluntary fatigue reports and routine operational data are the two sources of data that are routinely collected in an FRMS. More intensive monitoring of RMOs (see below) would only be carried out when warranted, for example to better understand a potentially serious hazard and/or to evaluate the effects of major roster changes.

An effective fatigue reporting system requires an effective reporting culture. It needs to:

- use forms that are easy to access, complete, and submit;
- have clearly understood rules about confidentiality of reported information;
- have clearly understandable voluntary reporting protection limits;
- include regular analysis of the reports; and
- provide regular feedback to staff about decisions or actions taken based on the reports, and lessons learned.

A fatigue report form (either paper-based or electronic) should include information on recent sleep and duty history (minimum last 3 days), time of day of the event, and measures of different aspects of fatigue-related impairment (for example, validated alertness or sleepiness scales). It should also provide space for written commentary so that the person reporting can explain the context of the event and give their view of why it happened. Appendix 4 provides an example.
Error/Incident Reports
Where the department has a systematic error reporting programme, reports can provide valuable data on fatigue-related risk, but only if the report form asks appropriate questions to enable the role of fatigue to be analysed. The questions in Appendix 5 were added to the Australian Incident Monitoring Study (AIMS) forms for a study of the role of fatigue in anaesthesia incidents.7

Staff Surveys
Staff surveys can be used periodically to audit fatigue levels among RMOs. It is important to use validated measures in surveys. Some common examples are given in Appendix 6. RMOs’ confidence in the confidentiality of their data is likely to be a very important factor in their willingness to participate in surveys and to provide complete information on questionnaires.

A limitation of retrospective surveys is that the information gathered is subjective, and therefore its reliability is open to question. Reliability is a particular issue when RMOs are asked to accurately recall details of past events, feelings, or sleep patterns. This is not to question RMOs’ integrity – inaccurate recall of past events is a common and complex human problem. Concerns about whether some RMOs might exaggerate in their responses, for personal or industrial reasons, should be minimal in an effective reporting culture. In addition, extreme ratings are obvious when compared with group averages.

RMO Monitoring Studies
Fatigue-related impairment affects many skills and has multiple causes, so there is no single measurement that gives a total picture of a doctor’s current fatigue level. The most important thing to consider in choosing fatigue measures is the expected level of fatigue risk. All measures require resources (financial and personnel) for data collection and analysis. Limited resources need to be used effectively to identify fatigue hazards and to prioritize where controls and mitigations are most needed. Balance needs to be maintained between gathering enough data for well-informed fatigue risk management decisions and actions, and the additional demands that data collection can place on doctors (sometimes described as ‘participant fatigue’). Appendix 7 introduces some commonly used measures in fatigue monitoring studies.

Risk Assessment
Risk assessment in FRMS should follow standardised risk assessment processes. The investment of resources in reducing fatigue risk needs to be evaluated in the broader context of the range of other occupational health hazards that must be managed in a hospital.

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5 Conclusions

As outlined in Section 3.6 (Summary of findings), although some generalisations can be drawn from the review of the literature, no firm conclusions can be made on the best work patterns to improve patient or junior doctor safety or junior doctor health and wellbeing, performance, training or work life balance. As previously noted, it may be surmised that in general, increased hours of work, working night shifts compared with day shifts, increased shift length, working more consecutive night shifts and decreased sleep are associated with poorer outcomes for junior doctors and their patients. However, the significant confounds in studies examining work patterns limit applicability of these findings to any particular work schedule.

In general, there are no perfect solutions (magic bullets) for rosters to cover 24/7 services. However, fatigue risk management systems (FRMS), which integrate scientific knowledge on sleep and circadian physiology with modern safety management practices for each workplace, offer a scientifically defensible approach to achieving the goals set out in the terms of reference for this work, as well as meeting the requirement under the Health and Safety in Employment Amendment Act to manage fatigue risk in the workplace.
6 References


Accreditation Council for Graduate Medical Education. (2003). *Common program requirements for duty hours.* Chicago, IL: ACGME.

Accreditation Council for Graduate Medical Education. (2011). *Common program requirements. Effective: July 1, 2011.* Chicago, IL: ACGME.


Rose, M., Manser, T., & Ware, J. C. (2008). Effects of call on sleep and mood in internal medicine residents. *Behav Sleep Med*, 6(2), 75-88.


### Appendix 1: AMA Fatigue Risk Assessment Checklist

#### Table A1.1: AMA risk assessment checklist for rosters

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are doctors regularly scheduled to work more than 10-hour shifts?</td>
</tr>
<tr>
<td>2</td>
<td>Do doctors work through a full shift cycle (i.e. 24 hours or more) at least once in a 7-day period?</td>
</tr>
<tr>
<td>3</td>
<td>Do doctors work more than 14 consecutive hours in any one period (including overtime and recalls) at least twice a week?</td>
</tr>
<tr>
<td>4</td>
<td>Is the minimum period of rest between scheduled work less than 10 hours?</td>
</tr>
<tr>
<td>5</td>
<td>Are the total hours worked</td>
</tr>
<tr>
<td></td>
<td>• in a 7-day period more than 70 hours (including overtime and recalls)?</td>
</tr>
<tr>
<td></td>
<td>• in a 14-day period more than 140 hours?</td>
</tr>
<tr>
<td></td>
<td>• in a 28-day period more than 280 hours?</td>
</tr>
<tr>
<td>6</td>
<td>Is the minimum non-work time</td>
</tr>
<tr>
<td></td>
<td>• in a 7-day period less than 88 hours?</td>
</tr>
<tr>
<td></td>
<td>• in a 14-day period less than 176 hours?</td>
</tr>
<tr>
<td></td>
<td>• in a 28-day period less than 352 hours?</td>
</tr>
<tr>
<td>7</td>
<td>Is there less than a 24-hour break free of work in a 7-day period?</td>
</tr>
<tr>
<td>8</td>
<td>Are there less than two 24-hour breaks free from work in a 14-day period?</td>
</tr>
<tr>
<td>9</td>
<td>Are there less than eight 24-hour periods free from work in a 28-day period?</td>
</tr>
<tr>
<td>10</td>
<td>Are doctors rostered for on-call duty more than once every three days?</td>
</tr>
<tr>
<td>11</td>
<td>Does the shift rotation move anti-clockwise?</td>
</tr>
<tr>
<td>12</td>
<td>Does the shift rotation change direction and speed over a 28-day period?</td>
</tr>
<tr>
<td>13</td>
<td>Have the actual hours worked and the times at which they have been worked in the last 28 days varied from the posted roster by more than 25%?</td>
</tr>
<tr>
<td>14</td>
<td>Is a doctor scheduled for more than three night shifts in a 7-day period?</td>
</tr>
<tr>
<td>15</td>
<td>Is a doctor rostered for on-call duty comprising more than 24 hours of the minimum 88 hours free from work in a 7-day period?</td>
</tr>
<tr>
<td>16</td>
<td>Is a doctor scheduled to work night shifts whilst peak educational and training requirements have to be met?</td>
</tr>
</tbody>
</table>
Appendix 2: Survey for Evaluation of the Fatigue Associated with a Particular Roster

This survey gathers the information needed to evaluate a roster using the risk assessment matrix validated in the 2003 national survey of New Zealand RMOs.  

ROSTER EVALUATION SURVEY

In the last 7 days (including today)

<table>
<thead>
<tr>
<th>How many hours did you work in total?</th>
<th>&lt; 50 hrs</th>
<th>50-70 hrs</th>
<th>&gt; 70 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often did you work a duty less than 10 hrs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you work a duty lasting at least 14 hrs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you work longer than your rostered duty?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you work 24 hrs straight or longer (include time on call but not called in)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often were you on call?</td>
<td>Was not on call</td>
<td>1-2 days</td>
<td>3-6 days</td>
</tr>
<tr>
<td>(include time on call but not called in)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often were you on night duty (any time between 2300 and 0700) or a duty that extended beyond 2300?</td>
<td>0-1 nights</td>
<td>2 nights</td>
<td>3 or more nights</td>
</tr>
<tr>
<td>How often did you have a break shorter than 10 hrs between two duty periods? (include being on call, but not called in, as duty time)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you have a break of at least 24 hrs between two duty periods?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did your roster change, through work beyond rostered hours, additional duties, or roster alterations?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Did your roster change so much that it became unpredictable?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>On how many nights were you able to sleep between 2300-0700 hrs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On how many nights did you get enough sleep to feel fully rested?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you for taking the time to complete this survey

---


Appendix 3: AMA Design Principles for Scheduling

- Minimise the occasions on which doctors are required to work more than 10 hours in a period.
- Ensure that minimum breaks between shifts enable doctors a minimum 8 hours continuous sleep before resuming duty.
- Ensure that any period of extended hours is compensated with a longer break before resuming a shift.
- Use a forward shift rotation to minimise individual adaptation problems.
- Avoid rapid shift changes such that at least a 24-hour break is provided before rotating to a new shift.
- Ensure doctors have regular time (a minimum of 24 hours) free of work in a 7-day period in which unrestricted sleep is possible.
- Minimise consecutive night shifts in order to limit reductions in performance levels caused by circadian rhythm imbalances.
- Ensure that longer breaks between and following night shift are provided.
- Account for ‘covering contingencies’ caused by sickness or absences.
- Maximise the opportunity to breaks within shifts.

Other risk control strategies for managing workloads include:

- Where practicable, complex tasks should be scheduled during the day and routine and administrative tasks should be minimised or redesigned to ensure that doctors can focus on core duties in their working time.
- Undertake complex tasks early in the shift where practicable.
- The allocation of staff numbers to peak times and demands is a fundamental factor in minimising exposure to risks associated with extended working hours. Numbers and types of doctors should be rostered on the basis of predictable demands for services by daily, weekly, seasonal, and annual trends.
- Replacing or substituting rostered doctors where extended hours have created a risk to doctor health and safety and patient welfare.
- Deferring non-urgent work to allow appropriate rest and recuperation for doctors.
## Appendix 4: Example of a Fatigue Report Form

### Fatigue Report Form

**If confidentiality required tick here**

<table>
<thead>
<tr>
<th>Name</th>
<th>Professional status (please circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 House surgeon</td>
</tr>
<tr>
<td></td>
<td>2 Senior House Officer</td>
</tr>
<tr>
<td></td>
<td>3 Registrar</td>
</tr>
<tr>
<td></td>
<td>4 Other</td>
</tr>
</tbody>
</table>

### WHEN DID IT HAPPEN?

<table>
<thead>
<tr>
<th>Date of report</th>
<th>Time of event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roster description</th>
<th>Start time</th>
<th>End time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### WHAT HAPPENED?

**Describe how you felt (or what you observed)**

Please circle how you felt

1. Fully alert, wide awake
2. Very lively, somewhat responsive, but not at peak
3. OK, somewhat fresh
4. A little tired, less than fresh
5. Moderately let down, tired
6. Extremely tired, very difficult to concentrate
7. Completely exhausted

Please mark the line below with an ‘X’ at the point that indicates how you felt

[ ] alert  [ ] drowsy

### WHY DID IT HAPPEN?

<table>
<thead>
<tr>
<th>Fatigue prior to duty?</th>
<th>How long had you been awake when the event happened?</th>
<th>hrs</th>
<th>mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes / No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors at home</th>
<th>How much sleep did you have in the 24 hrs before the event?</th>
<th>hrs</th>
<th>mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes / No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work demands</th>
<th>How much sleep did you have in the 72 hrs before the event?</th>
<th>hrs</th>
<th>mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes / No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Roster change | | |
|---------------| | |
| Yes / No      | | |

**Other comments**

### WHAT DID YOU DO?

**Actions taken to manage or reduce fatigue**

### WHAT COULD BE DONE?

**Suggested corrective actions**

---

### Appendix 5: Supplementary Questions for Error/Incident Report Forms
To be completed for all incidents.

1. Time of day of the incident?  □□:□□
   Please use 24-hr clock

2. At the time of the incident:
   a. How long had you been on duty?  □□.□□ hrs
   b. How long since you last slept?  □□.□□ hrs

3. How many hours in total did you work in the
   3 days before the day of the incident  □□.□□ hrs

4. How many hours of sleep did you have (in total) in the 24 hrs before the incident?  □□.□□ hrs

5. How many hours of sleep did you normally need (on an undisturbed night) to feel fully rested?  □□.□□ hrs
Appendix 6: Retrospective Surveys

Retrospective surveys are a comparatively cheap way to obtain information from groups of doctors on a range of topics such as:

- demographics (age, experience, gender, etc);
- amount and quality of sleep on days off and on shifts;
- experience of fatigue on duty; and
- views on the causes and consequences of fatigue on duty.

Wherever possible, validated scales and standard questions should be used for gathering information on common topics such as sleep problems. This enables the responses of doctors to be compared across time, or with other groups.

For example, the Epworth Sleepiness Scale is a validated tool for measuring the impact of sleepiness on daily life. It is widely used clinically, to evaluate whether an individual is experiencing excessive sleepiness, information is available on its distribution in large community samples, and it was used in the 2003 national survey of NZ RMOs. Figure A6.1 shows the Epworth Sleepiness scale. The crewmember is asked to rate each situation from 0 ‘would never doze’ to 3 ‘high chance of dozing’, for a total possible score of 24. Scores above 10 are generally considered to indicate excessive sleepiness. Scores above 15 are considered to indicate extreme sleepiness.

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.

<table>
<thead>
<tr>
<th>EACH LINE</th>
<th>PLEASE TICK ONE BOX ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>would never doze</td>
<td>slight chance</td>
</tr>
<tr>
<td>Sitting and reading .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>watching TV .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sitting inactive in a public place (eg. theatre, meeting) .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>Lying down in the afternoon when circumstances permit .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sitting and talking to someone .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sitting quietly after a lunch without alcohol .....0 ☐</td>
<td>☐</td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in traffic .....0 ☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Figure A6.1: The Epworth Sleepiness Scale

Another common measure used in the 2003 RMO survey is the Social and Domestic Survey module of the Standard Shiftwork Index (Figure A6.2). In the RMO survey, scores of 3-4 were considered indicative of work patterns causing a problem.

In general, to what extent do your work patterns cause you problems with your:

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social life (e.g. outings, sporting activities, etc.)</td>
<td>0 □</td>
<td>1 □</td>
</tr>
<tr>
<td>Home life (e.g. jobs around the house, looking after children, etc)</td>
<td>0 □</td>
<td>1 □</td>
</tr>
<tr>
<td>Personal relationships</td>
<td>0 □</td>
<td>1 □</td>
</tr>
<tr>
<td>Other commitments</td>
<td>0 □</td>
<td>1 □</td>
</tr>
</tbody>
</table>

**Figure A6.2: Social and Domestic Survey Module of the Standard Shiftwork Index**

Appendix 2 contains a short survey for evaluating the fatigue risk associated with rosters.

---

Appendix 7: Real-Time Fatigue Monitoring

A7.1 Subjective Ratings
The following things should be considered when choosing rating scales for monitoring RMOS' fatigue and sleepiness on duty.

i. Is the scale quick and easy to complete?
ii. Is it designed to be completed at multiple time points, e.g., across a duty period?
iii. Has it been validated? For example, has it been shown to be sensitive to the effects of sleep loss and the circadian body clock cycle under controlled experimental conditions?
iv. Is it predictive of objective measures such as performance or motor vehicle crash risk?
v. Has it been used in other studies, and are the data available to compare fatigue levels?

The following two scales meet these criteria.

A7.2 The Karolinska Sleepiness Scale (KSS)
This scale asks people to rate how sleepy they feel right now. Any of the values from 1-9 can be ticked, not only those with a verbal description.

```
1 = extremely alert
2
3 = alert
4
5 = neither sleepy nor alert
6
7 = sleepy, but no difficulty remaining awake
8
9 = extremely sleepy, fighting sleep
```

Figure A7.1: The Karolinska Sleepiness Scale (KSS)

Subjective sleepiness and fatigue ratings are relatively cheap and easy to collect and analyze. Furthermore, how a crewmember feels is likely to influence their decisions about when to use personal fatigue countermeasure strategies. On the other hand, subjective ratings do not always reliably reflect objective measures of performance impairment or sleep loss, particularly when a

---

person has been getting less sleep than they need (sleep restriction) across several consecutive nights.

### A7.3 The Samn-Perelli Fatigue Scale

This scale asks people to rate their level of fatigue right now, and is a simplified version of the Samn-Perelli Checklist.  

![Figure A7.2: The Samn-Perelli Fatigue Scale](image)

1 = fully alert, wide awake  
2 = very lively, responsive, but not at peak  
3 = okay, somewhat fresh  
4 = a little tired, less than fresh  
5 = moderately tired, let down  
6 = extremely tired, very difficult to concentrate  
7 = completely exhausted, unable to function effectively

### A7.2 Objective Performance Measurement

A range of objective performance tests are used in laboratory studies, but they usually measure very specific aspects of performance (for example, reaction time, vigilance, short-term memory, etc), not the complex combinations of skills needed by doctors on duty. Nevertheless, some simple performance tests are considered ‘probes’ or indicators of an individual’s capacity to carry out his or her duties.

The following things should be considered when choosing performance tests for monitoring doctors during duty.

I. How long does the test last?  
II. Can it be completed at multiple time points (e.g., a number of times across a duty period), without compromising a doctor’s ability to meet work requirements?  
III. Has it been validated? For example, has it been shown to be sensitive to the effects of sleep loss and the circadian body clock cycle under controlled experimental conditions?  
IV. Is it predictive of more complex tasks? (Unfortunately, there is very little research addressing this question at present.)  
V. Has it been used in other studies, and are the data available to compare performance levels?

---

One performance test that meets these criteria is the Psychomotor Vigilance Task or PVT. In the most widely used version of the PVT, the test lasts for 10 minutes and is carried out on a purpose-built hand-held device. However, some recent studies are using a 5-minute version of the PVT programmed on a Personal Data Assistant (PDA) device.

For example, the 10-minute PVT test was used in a study that tracked the sleep and performance of 28 anaesthesia residents across a 2-week period in two NZ hospitals. Findings included that reaction times were slower at the end of night shifts than at the end of day shifts, and that poorer performance at the end of night shifts was associated with longer shift length, longer time since waking, greater acute sleep loss, and more total work in the past 24 hours.

The PVT does not measure important skills such as situation awareness and decision-making. On the other hand, more complex tests to measure these types of skills usually require many practice trials before they can be considered fully learnt and ready to be used for measuring changes due to fatigue. The PVT does not require practice trials, except to make sure that RMOs know how to operate the testing device.

A7.3 Monitoring Sleep

Sleep can be monitored across rosters using subjective sleep diaries and/or by objective measures such as actigraphy or polysomnography. All these measures have been used successfully in previous studies of RMOs and they each have strengths and weaknesses.

Sleep diaries are cheap compared to objective forms of sleep monitoring. However, information from paper diaries needs to be manually entered into databases, which can slow down the process of getting answers to a particular question, and analysis of diary data has costs associated. Sleep diaries are known to be less reliable than objective sleep monitoring. They are used to help interpret objective sleep data, as described below.

An actigraph is a small device worn on the wrist that contains an accelerometer to measure movement and a memory chip to store ‘activity counts’ at regular intervals (for example every minute). Depending on the amount of memory available, they can be worn for weeks to months before the data need to be down-loaded to a computer for analysis. Figure A7.3 shows an example of an older style actigraph.

There are a number of manufacturers of actigraph devices, and each type comes with custom software that scans through the activity record and decides (based on a validated algorithm), whether the person was asleep or awake in each recorded epoch (for example every minute). Some devices have light sensors and some also have a regular watch face so that the wearer does not need to wear a normal watch as well, to keep track of time.

---


Figure A7.4 shows ‘sleep propensity curves’ derived from the actigraphy recordings of 25 anaesthesia registrars in the study which provided the PVT data above. These curves describe the percentage of registrars asleep at any time across the 24-hour day. When they were working day shifts, sleep was largely confined to 23:00-09:00. When they were working nights, sleep was split between the night time and the daytime (in one hospital, the night shift was relatively quiet and registrars were allowed to sleep at work). On days off, registrars tended to sleep in later in the morning.

---

A. Day shift

![Graph showing percentage of anaesthesia registrars asleep across the 24-hour day (double plotted).]

B. Night shift

![Graph showing percentage of anaesthesia registrars asleep across the 24-hour day (double plotted).]

A. Days Off

![Graph showing percentage of anaesthesia registrars asleep across the 24-hour day (double plotted).]

Figure A7.4: Percentage of anaesthesia registrars asleep across the 24-hour day (double plotted)