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Title Page

Postpartum fatigue and driving: Maternal subjective sleep and performance impairments when undertaking safety-sensitive tasks.

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Abstract

This paper reports on a prospective study investigating the prevalence of maternal postpartum fatigue and sleepiness and highlights the potential increased crash risk faced by mothers when driving in the postpartum period. Twenty-four mothers from across Australia completed a sleep and driving diary for seven consecutive days at three time points; when their baby was 6, 12 and 18 weeks old. The results showed that the mothers' sleep varied within the sample, however on average sleep disruption and lack of sleep consolidation was experienced. A high proportion of the mothers reported fatigue and sleepiness impacting their functioning early in the postpartum period, with sleepiness being more enduring throughout the period. Of concern, a high proportion of driving journeys undertaken by the mothers were during high levels of sleepiness, particularly early in the postpartum period and during late night and early hours of the day. These findings have highlighted the need to educate mothers about the potential increased safety risk of driving during the postpartum period and identified key information that should be conveyed.

Keywords:

Postpartum, sleepiness, sleep, driving, Karolinska Sleepiness Scale.

Highlights:

- Novel investigation examining postpartum fatigue and sleepiness and the impact on safety-sensitive activities, such as driving.
- Assessment at three time periods revealed that a high proportion of driving events occurred at times when the mothers were experiencing high levels of sleepiness.
- Overall, inadequate sleep, rather than simply lack of sleep, appears to be a better description of sleep in the postpartum period, which has important implications when undertaking safety-sensitive activities, such as driving.

Title: Postpartum sleepiness and sleepy driving in Australian mothers

It is well documented that fatigue and sleep-related driving are important contributory factors in serious injury and fatal crashes (Åkerstedt, 2000; Horne & Reyner, 1995). Within the transport industry, fatigue and sleepiness have been reported to be the largest recognisable and preventable causes of incidents, exceeding the rate of drug- and alcohol-related incidents (Åkerstedt, 2000). It has been suggested that 20.0% of all motorists have fallen asleep at least once whilst driving (Shapiro & Dement, 1993). Australian society currently has a high reliance on the use of motor vehicles to carry out regular daily activities. In 2011, Australia recorded 1.7 registered motor vehicles per household (Australian Bureau of Statistics).

There has been a push to reduce the number of crashes that may be a result of driver fatigue or sleepiness on Australian roads (e.g. Department of Transport and Main Roads, 2010). Fatigue has been defined as “*a subjective sense of low energy and/or exhaustion*” (Martin & Fiorentino, 2013). Conversely, inadequate sleep may not always lead to fatigue, but rather may result in sleepiness, which can be defined as “*a subjective state of feeling the desire to sleep or an objective state of the inability to maintain wakefulness,*” a similar but conceptually different construct from fatigue (Martin & Fiorentino, 2013). Fatigue-related crashes have often been reported on monotonous roads with speed limits over 100km/hr (Horne & Reyner, 1995; McCartt, Ribner, Pack, & Hammer, 1996; Sagberg, 1999). However, sleepiness-related crashes can also occur in lower speed zones, such as in urban areas. One investigation of crashes occurring in speed zones of 60 km/h or less used data extracted from Queensland Transport’s road crash database over a 6 year period (Armstrong, Smith, Steinhardt, & Haworth, 2008). The results indicated that almost a quarter of the crashes attributed to “fatigue/fell asleep” resulted in a fatality or hospitalisation due to hitting an object or a parked vehicle, or colliding with another vehicle head-on. Another large ($N = 1,609$) telephone survey of Australian drivers that asked participants about their involvement in any fatigue-related incidents in the prior five years found that two-thirds of respondents reported driving while feeling sleepy during the survey period, and 3.4% of males and 1.5% of females reported being involved in a sleep-related crash in the past five years (Armstrong, Obst, Livingstone, & Haworth, 2009).

Almost two decades ago researchers and clinicians acknowledged the need to review the guidelines for people with sleep disorders (mainly narcolepsy and sleep apnea) and their ability to drive (Pakola, Dinges, & Pack, 1995). There are currently laws and regulations about obstructive sleep apnea and driving in numerous jurisdictions within the United States of America (Krishnan & Patil, 2013). In Queensland, Australia *Jet's Law* requires any drivers with a medical condition that could impact their driving to report the condition to the licencing authority, including sleep disorders (Department of Transport and Main Roads, 2013). The inadequate sleep obtained by those with sleep apnea is due to high sleep disruption, and in turn lack of sleep consolidation, which often results in excessive physiological sleepiness (George, 2007) and potentially fatigue. Excessive physiological sleepiness has been shown to place drivers in significantly greater crash risk than alert drivers (Drake, Roehrs, Breslau, Johnson, Jefferson, Scofield, & Roth, 2010).

Mothers in the postpartum period are a population with potential performance decrements when undertaking safety-sensitive activities, such as driving, which has been somewhat overlooked to date. Fatigue is the most frequent complaint from women following childbirth (Carty, Bradley, & Winslow, 1996; Gjerdingen, Froberg, Chaloner, & McGovern, 1993; Martell, 2001; O'Reilly, 2004; Pugh & Milligan, 1993; Ruchala & Halstead, 1994). Postpartum fatigue has been described by researchers as a mother's feelings of exhaustion and reduced ability to perform mental and physical activities during the postpartum period (Pugh & Milligan, 1993; Rubin, 1975; Runquist, 2007; Troy & Dalgas-Pelish, 2003). Mothers commonly attribute inadequate sleep as the main factor contributing to their fatigue in qualitative research (Runquist, 2007) and positive relationships have been found between inadequate sleep and fatigue in quantitative studies (e.g. Rychnovsky & Hunter, 2009). The Australian Bureau of Statistics recorded 297,072 mothers gave birth to 301,617 babies in 2011; highlighting the great number of mothers that could possibly be experiencing increased fatigue or sleepiness throughout the course of a year due to caring for an infant.

The sleep patterns of many women change dramatically from pre-conception to post-birth (Gay, Lee, & Lee, 2004; Swain, O'Hara, Starr, & Gorman, 1997). A recent review of infant sleep literature found that at one month of age, on average infants sleep between 3 and 4.5 hours at longest (Henderson, France, Owens, & Blampied, 2010). As such, parents are often required to attend to their

infants throughout the night when they would usually be asleep, thus experiencing high levels of sleep disruption, lack of consolidated sleep or potential sleep reduction. A large study ($N = 505$) measuring infant sleep patterns and maternal fatigue found that approximately one quarter of the mothers reported that at four weeks postpartum their infant woke three times or more between 10pm and 6am (Dennis & Ross, 2005). Suggestions in the literature to address this issue include encouraging mothers to nap during the day or “sleep when your baby sleeps”, to compensate for sleep lost during the night (Mindell & Owens, 2003). Inevitably, reports from new mothers early in the postpartum period indicate that they do not sleep for long periods at night or during the day because of the variability in the frequency, timing and length of their baby’s sleep (Martell, 2001). However, some research has actually found that a large number of mothers obtain a similar amount of sleep to the general population, however the sleep patterns look dissimilar (e.g. Montgomery-Downs, Insana, Clegg-Kraynok, & Mancini, 2010; Swain et al., 1997).

To ensure this important population of postpartum women are not placed under unnecessary safety risk they need to be provided with the necessary information to make informed safety decisions. The aim of this study was to raise the awareness of the potential safety risks of driving during the postpartum period when fatigue and sleepiness levels are often elevated. Therefore, this study assessed mothers’ sleep, sleepiness and fatigue during the first 18 weeks postpartum, as well as driving prevalence with corresponding self-reported sleepiness, in order to identify pertinent information that could be used to educate mothers about these potential risks.

Method

Participants

Ethical clearance was granted from the University Human Research Ethics Committee. Twenty-four mothers participated in the current study and were recruited from through advertisements at the university and in a local newspaper. The mean age of the sample was 30.21 years ($SD = 4.87$ years). All mothers had given birth to a single infant between March and December 2008. To control for common causes of fatigue in the postpartum period, apart from caring for an infant, all mothers were screened. None of the mothers had been diagnosed with anaemia or hypothyroidism, developed

infections in the weeks following childbirth, or experienced a major depressive episode in their lives. All mothers physically provided informed consent to participate in the study.

In terms of relationship status, 23 of the mothers were married or in de facto relationships and one mother was single. Sixteen mothers (66.7%) had children other than their newest addition. The sample was well educated with 18 of the mothers (75.0%) having completed post high school study.

Materials

The participants completed a sleep/wake diary that was purpose designed for this study for seven consecutive days. On a 24-hour scale, the participants indicated the times they were asleep each day. Additionally, on a 24-hour timeline, the participants indicated any driving journeys and their corresponding sleepiness level using scores from the Karolinska Sleepiness Scale (KSS; Åkerstedt & Gillberg, 1990). The KSS is a measure of instantaneous sleepiness and is measured on a nine-point Likert scale, with one denoting very alert, three denoting alert, four to six being neither alert nor sleepy, seven being sleepy, and nine being very sleepy. The KSS was chosen as it has been demonstrated in a driving simulator that falling asleep at the wheel was always preceded by an increased KSS score (Reyner & Horne, 1998), and previous research allows for the nine-point scale to be converted to an odds ratio of the associated crash risk, thus allowing inferences to be made regarding the crash risk of potential drivers (see Åkerstedt, Connor, Grey, & Kecklund, 2008).

Design

This study employed a repeated measures fixed follow-up design. That is, the participants completed the sleep/wake diary and questionnaire at three specified time points; when their infant was 6, 12, and 18 weeks old.

Procedure

A sleep/wake diary and questionnaire was sent out to each participant before each of the three assessment periods to be completed and then returned. Thus, the participants completed the diaries in the comfort of their own home and completion of the diary took approximately five minutes per day. To compensate participants for their time, each was given a \$20 department store gift card upon completion of each assessment period.

Results

Mothers' postpartum sleep, sleepiness and fatigue

Statistical analyses of the mothers' sleep variables across the three assessment periods were conducted using the non-parametric Friedman Test as the data for these variables was not normally distributed. For these analyses, as well as the sleepiness and fatigue variables, the sample size was reduced to 17 due to missing data.

Sleep duration

At 6 weeks postpartum, the mean sleep duration for the 7-day assessment period was 52 hours and 19 minutes ($SD = 8.05$ hours), and there were no significant differences in mean sleep duration across the three assessment periods, $\chi^2(2, n = 17) = 0.12, ns$. As shown by the ranges displayed in Table 1, the amount of sleep obtained noticeably varied across the sample. Of note, the lower value of the ranges indicate that at 6, 12 and 18 weeks postpartum there was at least one mother who only received 36, 38.75 and 41 hours of sleep respectively, for the entire 7-day period.

Sleep disruption

As shown by the number of night awakenings in Table 1, the night time sleep of all mothers was disrupted during the 6 weeks postpartum assessment week. The mean number of night awakenings experienced by the mothers was 13 ($SD = 3.18$) at 6 weeks postpartum, with a trend to a slight reduction during the subsequent assessment weeks. However, this trend was not statistically significant as no significant differences were found in the mean number of night awakenings across the three time periods, $\chi^2(2, n = 17) = 1.61, ns$. Notably, inspection of the standard deviations and ranges in Table 1 indicates an increase in the variability across the sample over the three assessment periods.

Sleep consolidation

Extrapolating the longest sleep periods experienced by the mothers during each assessment period provided an indication of the amount of consolidated sleep obtained. For the 7-day assessment period at 6 weeks postpartum, the mean longest sleep period was 5 hours and 16 minutes ($SD = 1.37$ hours), which increased in the subsequent weeks. The Friedman Test indicated there was a statistically significant difference in mean longest sleep period across the three time periods, $\chi^2(2, n$

= 17) = 11.56, $p = .002$. For post hoc analysis, a Wilcoxon Signed Rank Test revealed a statistically significant increase in mean longest sleep period from 6 weeks to 12 weeks postpartum, $z = -2.701$, $p = .007$, with a medium effect size ($r = .46$). The increase in mean longest sleep period from 12 weeks to 18 weeks postpartum was not statistically significant ($z = -1.20$, *ns*). There was wide variability in the longest sleep period obtained across the sample during all three assessment weeks. The lower values of the ranges indicate that at 6, 12 and 18 weeks postpartum there was at least one mother who did not have a sleep period that lasted longer than 3, 3.5 and 3 hours, respectively.

Table 1. Means, standard deviations and ranges for sleep variables at week 6, week 12, and week 18 postpartum

	Week 6		Week 12		Week 18	
	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range
Sleep duration	52:19 (8:03)	36:00 - 66:00	51:52 (6:47)	38:45 - 66:00	52:06 (6:11)	41:00 - 67:00
Night awakenings	13.00 (3.18)	6 - 17	11.35 (5.94)	0 - 21	11.59 (7.32)	2 - 25
Longest sleep period	5:16 (1:22)	3:00 - 8:00	6:26 (1:36)	3:30 - 9:30	6:59 (1:46)	3:00 - 9:00

Self-reported fatigue and sleepiness

Participants were asked to rate how frequently fatigue, due to being physically or emotionally worn out or exhausted, interfered with performing their daily activities at each assessment period. In addition, participants were asked to rate how frequently sleepiness, due to lack of sufficient sleep, interfered with performing their daily activities at each assessment period. A comparison of the percentage of responses for fatigue and sleepiness across all three assessment periods is provided in Figure 1.

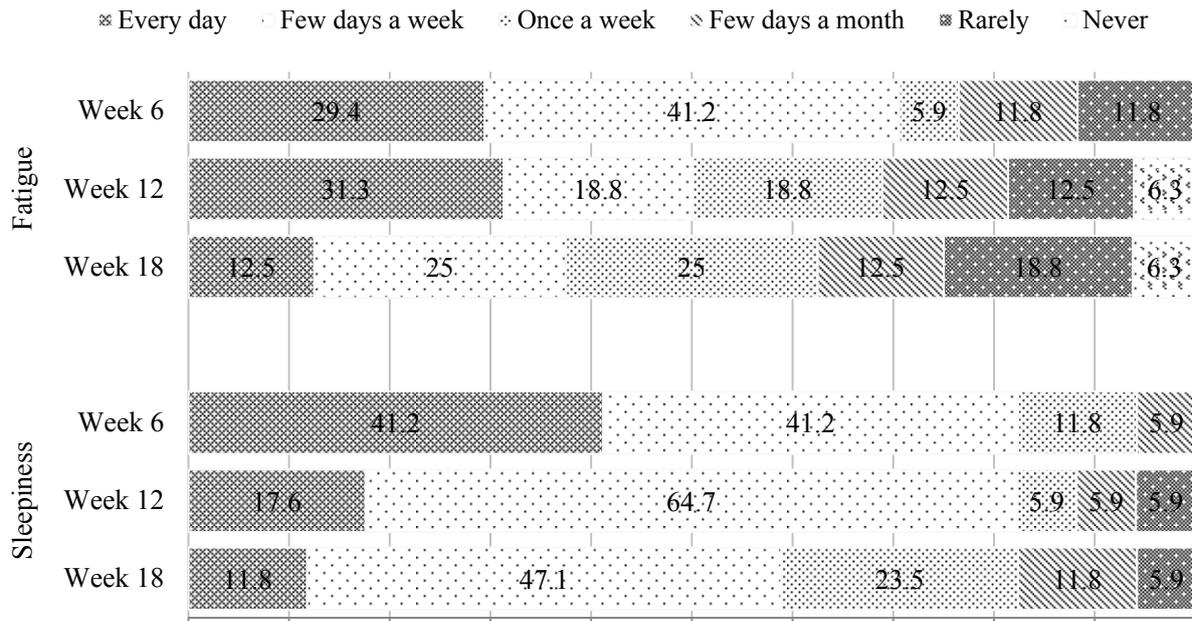


Figure 1. Percentage of mothers indicating how frequently fatigue and sleepiness interferes with daily activities at week 6, week 12, and week 18 postpartum

There were a small percentage of mothers who indicated that fatigue did not impact them during postpartum weeks 12 and 18 (6.3%). The percentage of participants who stated that fatigue interfered *every day* or *a few days a week* decreased from postpartum week 6 (70.6%) to week 12 (50.1%) and again in week 18 (37.5%). A high proportion of mothers indicated that sleepiness interfered with their tasks *every day* during postpartum week 6 (41.2%), and then noticeably reduced during week 12 (17.6%) and again during week 18 (11.8%). However, a high proportion of the sample indicated that sleepiness impacted them *a few days week* during postpartum week 12 (64.7%) and week 18 (47.1%). Overall, Figure 1 shows a trend of mothers being less frequently impacted as the postpartum period progresses, for both fatigue and sleepiness. Although at 18 weeks postpartum a high proportion (82.4%) of the sample still indicated that sleepiness impacted them **at least** once a week.

Mothers' driving in the postpartum period

There was one participant who did not drive during all three assessment weeks. During postpartum weeks 6, 12 and 18 there were 191, 196 and then 231 driving journeys undertaken

respectively. Approximately 90.0% of the journeys were undertaken between 6am and 6pm during each assessment period.

In order to compare self-reported sleepiness when driving, scores on the KSS were collapsed into either low or high sleepiness. Scores ranging from one to four were categorised as low levels of sleepiness, which reflect normal alertness levels during the daytime (Åkerstedt et al., 2008). Scores ranging from five to nine were categorised as high sleepiness, which reflects the exponential increase in crash risk with increasing levels of sleepiness. Åkerstedt et al. (2008) deemed that a KSS score ranging from one to four corresponded to an odds ratio for an injury crash marginally above zero; whereas an individual with a KSS sleepiness score ranging from five to nine corresponded to an odds ratio for an injury crash from four to 25 respectively.

The number and percentage of all driving journeys by low or high KSS score for each assessment period is displayed in Table 2. Of the 191 journeys undertaken during postpartum week 6, 100 journeys (52.4%) had a high KSS. The proportion of high KSS rated journeys reduced in the subsequent weeks; 92 episodes (46.9%) out of 196 during week 12, and 82 episodes (35.5%) out of 231 during week 18. However, of concern is that across the three time points of the study, 44.3% of the driving journeys were undertaken when the participant had a high KSS score.

Table 2. Number and percentage of driving episodes by low or high KSS score at week 6, week 12, and week 18 postpartum

	No. of driving episodes (<i>percentage</i>) Low KSS	No. of driving episodes (<i>percentage</i>) High KSS	Total No. of driving episodes (<i>percentage</i>)
Week 6	91 (47.6%)	100 (52.4%)	191 (100.0%)
Week 12	104 (53.1%)	92 (46.9%)	196 (100.0%)
Week 18	149 (64.5%)	82 (35.5%)	231 (100.0%)
Total	344 (55.7%)	274 (44.3%)	618 (100.0%)

Comparison of all driving journeys by low or high KSS score by time of day for each assessment period is displayed in Table 3. The small number of journeys undertaken between midnight and 6am corresponded with a high self-reported level of sleepiness. Further, a greater

number of journeys between 6pm and midnight reflected high rather than low KSS scores during postpartum weeks 12 and 18. The percentage of high KSS driving journeys occurring during the day, between 6am and 6pm, decreased from week 6 to week 12 and further from week 12 to week 18 postpartum.

Table 3. Number and percentage of driving episodes by time of day and KSS score at week 6, week 12, and week 18 postpartum

Time Range	Week 6		Week 12		Week 18	
	No. of driving episodes (percentage)		No. of driving episodes (percentage)		No. of driving episodes (percentage)	
	Low KSS	High KSS	Low KSS	High KSS	Low KSS	High KSS
00:00 – 05:59	0 (0.0%)	4 (2.1%)	0 (0.0%)	1 (0.5%)	0 (0.0%)	0 (0.0%)
06:00 – 11:59	49 (25.7%)	43 (22.5%)	49 (25.0%)	34 (17.3%)	78 (33.8%)	38 (16.5%)
12:00 – 17:59	38 (19.9%)	49 (25.7%)	47 (24.0%)	42 (21.4%)	66 (28.6%)	33 (14.3%)
18:00 – 23:59	4 (2.1%)	4 (2.1%)	8 (4.1%)	15 (7.7%)	5 (2.2%)	11 (4.8%)

Discussion

This research investigated mothers' fatigue and sleepiness in the first 18 weeks postpartum, as well as their sleep and driving behaviour. As sleepy driving is a serious issue that contributes to road crashes (Åkerstedt, 2000), it is important to help mothers avoid driving whilst fatigued or sleepy. This research shows that a high proportion of these mothers felt that fatigue impacted them frequently early in the postpartum period but less so over time. However, sleepiness affected a large proportion during the entire period assessed. It was also found that there was a concerning proportion of times when the mothers drove when they were experiencing high levels of sleepiness.

The number of journeys undertaken by the sample throughout this study demonstrates the high reliance on driving in Australian society; however there was wide variation. The high variability does demonstrate that there were mothers who made it through this period with driving small amounts. Most driving journeys in this study were undertaken during the day, and a small number were between midnight and 6am. It was encouraging to find that minimal journeys were undertaken during these late night and early morning hours, as this is the period of a large reduction in alertness (Van Dongen, Bender, & Dinges, 2012). The reduced alertness at this time of day was highlighted by the notably higher sleepiness rated driving journeys than low sleepiness driving journeys. The findings also indicate that over half of driving episodes were undertaken with high sleepiness levels during postpartum week 6, gradually reducing in the subsequent assessment weeks. This is in line with the mothers' general self-reported descriptions of sleepiness across the assessment period. Driving with these high levels of sleepiness increases safety risk, and thus the percentage of journeys with high sleepiness ratings in this study highlights a valuable intervention point. As some mothers limited driving during this period, it may be possible for awareness campaigns to be developed in order to inform mothers' decisions of whether to drive or not when their safety risk could be elevated.

The most prevalent educational information for mothers regarding postpartum sleep usually encourages mothers to try to catch up on sleep whenever they can (Mindell & Owens, 2003); in essence to make up for lack of sleep. However, our study found that on average the amount of sleep the mothers obtained was close to the average amount of sleep obtained by adults (Carskadon & Dement, 2011), which is in line with some previous research (e.g. Swain et al., 1997). There were a small number of mothers who reported a lack of sleep, and it is imperative to acknowledge individual differences when discussing sleep. It was also interesting to note that the amount mothers were sleeping remained similar across the three time periods; that is, the amount of sleep the mothers' obtained did not significantly increase or decrease.

Inadequate sleep, rather than simply lack of sleep, appears to be a better description of sleep in the postpartum period for some mothers. All mothers taking on the feeding role will have disrupted or fragmented sleep early in the postpartum period due to infants' short sleep/wake and feeding cycles (Stewart, 2006). During week 6 postpartum there were night awakenings recorded for every mother in

the sample. This in line with the developmental abilities of infants this age demonstrating a lack of ability to sleep through the night (Henderson et al., 2010). Highly disrupted sleep is analogous to short sleep periods. Thus, we extrapolated the longest sleep periods experienced by the mothers during each assessment week as an indication of sleep consolidation. We found that the mean longest sleep period significantly increased between weeks 6 and 12 postpartum, suggesting that the mothers' sleep was becoming more consolidated as the postpartum period progressed. There were notable individual differences in sleep consolidation and disruption observed in this study. Thus, unfortunately there appears to be no one description of mothers' sleep in the postpartum period. Therefore the provision of accurate information about the range of potential sleep experiences during the postpartum (such as common sleep disruption and lack of sleep consolidation) needs to be conveyed to mothers, rather than the simple suggestion to rest when the baby rests.

Limitations

The main limitation of the study was the use of self-report assessment of the participants' sleep and driving behaviour. However, sleep-wake diaries are commonly used to measure sleep in general populations as well as in the postpartum period specifically (e.g. Gress et al., 2010; Swain et al., 1997). To gain a more accurate assessment of mothers' sleep in this period further research should utilise materials to objectively assess their sleep, such as actigraphy. Also, variation in sleepiness levels throughout driving journeys (particularly long journeys) were not captured as only one KSS rating was given to each journey. Additionally, the scope of this study only included measuring the sleep factors that have been suggested to have an impact of mothers' sleepiness levels during this period. While these factors are closely linked to mothers' sleepiness levels, we acknowledge that there are a number of other factors that may contribute. Finally, although the sample size was adequate for the purposes of the planned statistical analyses performed in this study, we recognise that a larger sample size would have allowed for additional hypothesis testing (i.e. predictive hypotheses).

Conclusion

A myriad of literature has demonstrated that performance on safety-sensitive tasks, such as driving, are impaired when a person is sleepy. In the postpartum period many mothers report feelings of fatigue, particularly in the early weeks, or sleepiness, which appears to be more enduring. Lack of

optimal sleep is experienced by the majority of mothers in this period. This aspect can be targeted through educative means in order to attempt to improve sleep quality for postpartum women. In order to successfully formulate education programs to inform mothers about both postpartum sleep and sleepy driving during the postpartum period, it is necessary to firstly identify mothers' current level of accurate knowledge within these two areas. It will then be important to identify their thought processes and beliefs regarding the importance of their sleep as well as their driving, and also importantly their motivations for driving. For instance, we suggest that a twofold approach could be beneficial in educating mothers about reducing the potential increased risk of driving during this period. This would firstly involve the provision of information about sleep during the postpartum period, particularly the ways in which it may be less than optimal, and how to optimise it. Secondly it would involve providing information about performance impairments when driving whilst fatigued or sleepy, and the benefits of avoiding this potentially risky behaviour, particularly during times of day associated with increased crash risk. Following this path of enquiry is a potential avenue for further study.

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