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# Fatigue among heavy vehicle drivers: the impact of shift-start times and time of day

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## Abstract

To examine the relationship between heavy vehicle driver fatigue, time of day and shift-start times, data from an automatic driver monitoring system (Guardian, Seeing Machines) was assessed for over 140,000 shifts across four different operator companies. Results revealed that of the 2290 fatigue events detected, 63% occurred during the night time (between 6pm – 6am). Higher rates of fatigue events were also observed for shifts that started in the afternoon (12pm – 6pm) and evening (6pm – 12am) compared to those starting in the morning (6am – 12pm). Furthermore, shifts that started in the afternoon and evening were associated with earlier onset of fatigue. These results are consistent with the deleterious circadian influence on alertness at night and demonstrate the potential for using alertness monitoring to evaluate the impact of shift schedules on fatigue. Adjusting schedules based on such objective alertness data has the potential to mitigate the impact of fatigue.

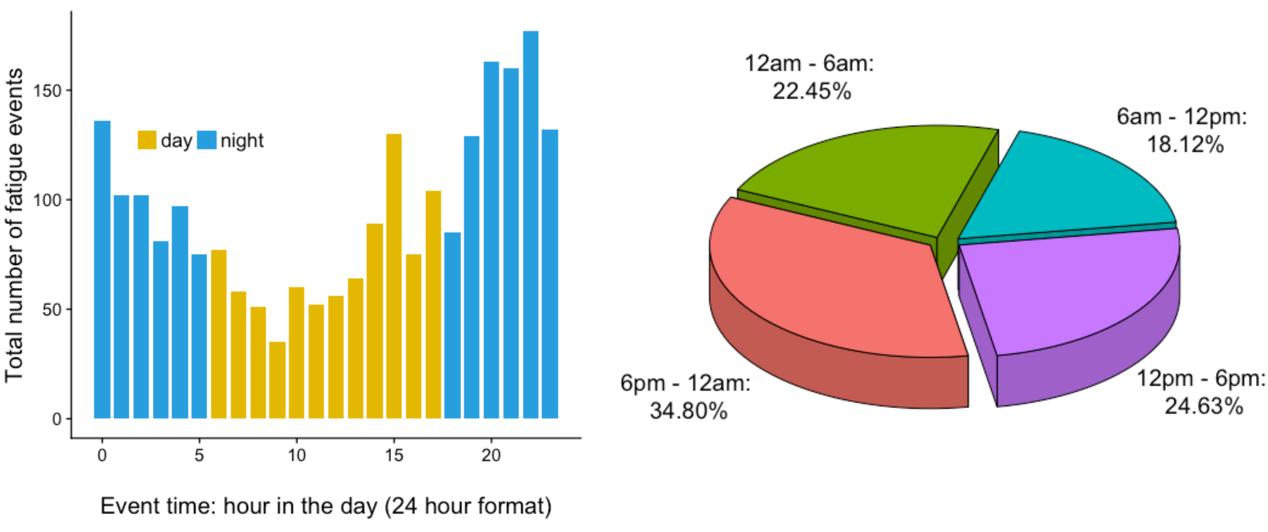
# 1 Introduction

Heavy vehicle drivers often work long shifts with varying start-times. The combination of extended wakefulness and disruption to the natural sleep-wake cycle puts such drivers at a greater risk of experiencing fatigue. Given that driver fatigue contributes to up 30% of all fatal road accidents (National Traffic Safety Committee, 2013), outlining the key factors associated with the prevalence of fatigue among heavy vehicle drivers is a critical step towards the development of mitigating strategies. The increasing availability of advanced driver monitoring technologies that detect driver drowsiness provides an opportunity to examine the overall influence of shift schedules and time of day upon the occurrence of fatigue.

# 2 Method

This study employed a retrospective approach whereby data were sourced from operators that utilise the Guardian driver monitoring system (DMS). The Guardian DMS is a video-based system that monitors drivers across entire shifts and automatically defines fatigue events as drowsiness-related eye closure activity lasting longer than 1.5 seconds (Fitzharris *et al.*, 2017). To facilitate data sourcing, Seeing Machines invited their Australia-based clients to participate in the study. Four companies signed consent forms allowing researchers to obtain their data from the Guardian systems installed in their vehicles. Across the four operators, data from a total of 142,642 shifts were included for analysis.

**Figure 1. Fatigue events by time of day (left) and proportion of fatigue events by start-time (right)**



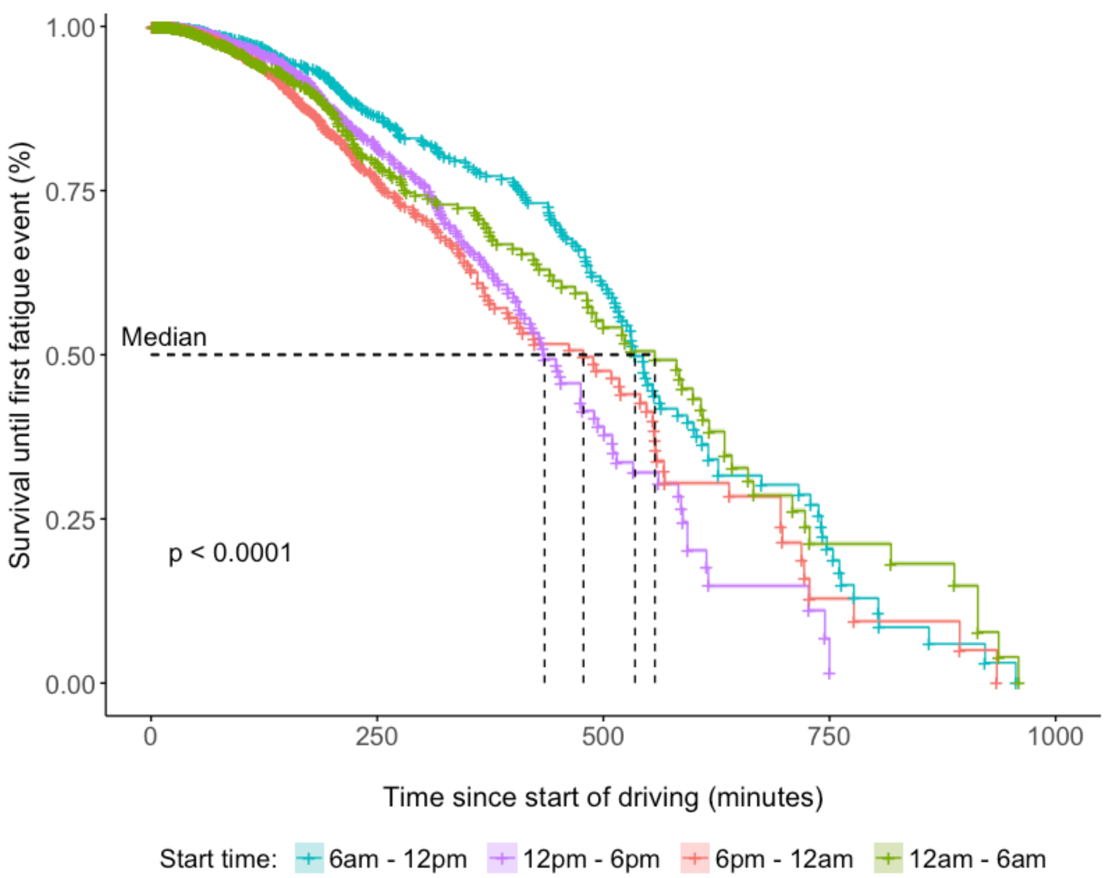

# 3 Results

Overall, 2290 fatigue events were detected, 63% of which occurred at night. Fatigue event occurrence was 38% more likely during the night compared to day time (odds ratio: 1.38, 95% CI: 1.19 – 1.42, $p < 0.001$). Figure 1 (left) depicts the distribution of fatigue events by time of day.

The impact of shift-start times was assessed across quarterly groups of 6:01am – 12:00pm, 12:01pm – 6:00pm, 6:01pm – 12:00am, and 12:01am – 6:00am start times. The lowest proportion of fatigue events occurred within shifts that started between 6am – 12pm. Compared to this time, the rate of fatigue events significantly increased for shifts that started between 12pm – 6pm (rate ratio = 19, 95% CI = 14 – 36, $p = 0.009$) and those starting between 6pm – 12am (rate ratio = 28, 95% CI = 13 – 46, $p < 0.001$). Overall proportion of fatigue events by start times is depicted in Figure 1 (right).

Survival analysis indicated that the earliest onset of fatigue occurred when shifts started between 12pm – 6pm (hazard ratio = 1.49, 95% CI = 1.47 – 1.50), where the average time elapsed from start of shift until the first fatigue event was 435 minutes. This was followed by start time of 6pm – 12am with an average time of 478 minutes until first fatigue event, 535 minutes for 6am – 12pm start, and 557 minutes for 12am – 6am start times. The relative likelihood of a fatigue event (hazard ratio) increased by 50% for the 6pm – 12am start, by 49% for 12pm – 6pm start and by 10% for 12am – 6am start times compared to 6am – 12pm start time. Figure 2 depicts these results as a Kaplan-Meier survival curve until the first fatigue event in a shift.

**Figure 2. Kaplan-Meier survival curve until first fatigue event in a shift.**



# 4 Discussion

The results presented in this report give clear indication that heavy vehicle drivers are more likely to experience fatigue during night shifts (see Figure 1, left), and that earlier start times are associated with later onset of fatigue events (see Figure 2).This is consistent with the circadian influence on alertness whereby the body maintains wakefulness during the day whilst requiring rest at night (Monk *et al.*, 1997), and previous research that has demonstrated an increase in road crash risk between the hours of 2 – 5am (Connor *et al.*, 2002). Hence, alertness monitoring data could be used to improve heavy vehicle driver schedules in order to reduce fatigue. To further illustrate this possibility, the next phase of the present study will examine the extent to which rest breaks and shift duration influence the occurrence of fatigue events.

**Acknowledgments**

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