A systems approach to reduce drowsy driving among night-shift nurses

Final Report

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Executive summary

Drowsy driving among nurses is a significant problem and is attributable to over 90% of all crashes involving shift work nurses. Many attempts have been made to reduce fatigue among nurses, but most have focused on improving outcomes during the shift rather than the post-shift commute. Two promising approaches to reducing post-shift drowsy driving are training and technology. Technological solutions have not been well studied in the healthcare domain, despite evidence of their success in other domains such as transportation logistics and oil and gas extraction. The primary barrier to implementation of training and technological solutions is nurse acceptance of the interventions. The goal of this project was to address these limitations by developing a training and technology system, DD-RN, implementing the system at a single hospital, and evaluating the system using a comprehensive set of driving safety and subjective metrics.

The project goals were accomplished through a series of three studies: an interview study to understand prevalence of drowsy driving and preferences for training and technology, a naturalistic driving study to understand objective and subjective changes attributable to the intervention, and a second interview study to highlight barriers to broad implementation of the DD-RN system. All studies were conducted at Houston Methodist with night-shift nurses. Interviews were conducted immediately before or immediately following the nurses’ shift. The naturalistic driving study was conducted over a 7 month period with the interventions occurring after the 2nd month of data collection. Data collected over the 7 months included nightly sleep logs, subjective ratings of drowsiness during the drive, shift information, and continuous driving data. The interventions included a training session conducted by nurses modified from the NIOSH training for shift-work nurses and the Vuemate driver state detection system (a dashboard mounted camera-based device).

The initial interviews highlighted that drowsy driving was prevalent among night-shift nurses at Houston Methodist and that nurses responded to this drowsiness with a variety of ineffective methods including cellular phone conversations, music, and opening the car windows. The findings also showed that nurses were unfamiliar with, but open to training and technological interventions for drowsy driving. Further nurses preferred practical training on methods to reduce their drowsiness and technological systems that could be used without significant modifications to their routines. Based on these preferences, the existing NIOSH training was modified to focus on practical solutions and fit within the nurses preferred time (1 hour) and the Vuemate driver state monitoring system was selected as the technological component of the DD-RN.

The results of the naturalistic driving study showed that following the training intervention, nurses did not significantly increase their amount of daily sleep or time in bed, however, nurses in the education group did report higher quality sleep. Nurses also did not make significant changes to their shift schedules or consecutive shifts. Despite the lack of changes, nurses who received the training reported feeling more alert during their post work commutes and lower percentages of the drive where they were drowsy. Nurses had a variety of responses to the warnings from the device but in 18 cases reported that it woke them up or caused them to open their eyes, and in 2 other cases it prompted nurses to take a nap. Overall these results suggest a positive impact. Future work will continue the analysis to show the impacts of the device and training on driving safety.
Background

Nurse fatigue is a worldwide problem contributing to health decline, patient care errors, and sickness absences (Blouin, Smith-Miller, Harden, & Li, 2016; Rhéaume & Mullen, 2018; Sagherian, Clinton, Abu-Saad Huijer, & Geiger-Brown, 2017; Smith-Miller, Shaw-Kokot, Curro, & Jones, 2014). The effects of nurse fatigue often extend beyond the walls of healthcare facilities, where fatigue leads to alarming rates of drowsy driving (Claire C Caruso et al., 2017; Scott et al., 2007). Research suggests that up to 79% of night-shift nurses have experienced drowsy driving at least once (Scott et al., 2007) and that 95% of crashes and driving incidents involving night-shift nurses can be attributed to drowsy driving (Gold et al., 1992; Novak & Auvil-Novak, 1996). Barring substantial interventions, the number of drowsy driving crashes among night-shift nurses will continue to grow due to projected expansions in the healthcare sector (Folkard & Tucker, 2003; L. Smith, Folkard, Tucker, & Macdonald, 1998). The number of nursing jobs in the United States is expected to grow 15% over the next 10 years, the majority of which consist of 12-hour shift in a hospital (Bureau of Labor Statistics, 2018; Rogers, Hwang, Scott, Aiken, & Dinges, 2004). The severity and scope of the drowsy driving problem has led regulatory agencies to call for novel countermeasures to prevent drowsy driving crashes and reduce the frequency of drowsy driving in healthcare (Claire C Caruso et al., 2017; Higgins et al., 2017).

The majority of current drowsy driving countermeasures for nurses focus on addressing broad work-shift fatigue and consist of a single intervention (Fallis, McMillan, & Edwards, 2011; J. Geiger-Brown et al., 2016; Zion & Shochat, 2019). These interventions include napping, education, work planning, peer care, and practicing healthy habits outside of the workplace (Berger & Hobbs, 2006; C. C. Caruso, 2014; Hughes & Rogers, 2004; Scott et al., 2007; Smith-Miller et al., 2014). Of these approaches, napping has received the most attention and has been shown to significantly reduce subjectively experienced fatigue in the latter portions of shifts (Fallis et al., 2011; Jeanne Geiger-Brown et al., 2016; S. S. Smith, Kilby, Jorgensen, & Douglas, 2007; Zion & Shochat, 2019). However, the implementation of naps during the shift often faces significant organizational and occupational culture barriers (Jeanne Geiger-Brown et al., 2016; Smith-Coggins et al., 2006; Steege & Rainbow, 2017). In particular, nurses’ perceptions of the feasibility and acceptability of napping play a significant role in nap utilization (Fallis et al., 2011). While there is some evidence that the benefits of napping extend to the drive home, the objective impact on driving safety is unclear (Jeanne Geiger-Brown et al., 2016; Scott, Hofmeister, Rogness, & Rogers, 2010a).

Beyond napping, training interventions have also received significant attention in recent years (C. C. Caruso, Geiger-Brown, Takahashi, Trinkoff, & Nakata, 2015). Training interventions typically introduce nurses to fatigue and drowsiness, discuss the potential consequences of working and driving while fatigued or drowsy, and strategies to reduce or prevent those consequences. Like napping interventions, the success of training programs depends on nurses’ perceptions, cultural factors, and implementation effectiveness (Scott, Hofmeister, Rogness, & Rogers, 2010b). Unlike napping interventions, the success of training programs also relies on nurses’ ability and willingness to make lifestyle changes outside of the workplace (e.g., going to bed immediately on arriving home, taking a rest break during their commute home).

Other drowsy driving countermeasures have been documented; albeit in non-nursing domains. These include: caffeine, interactive games, bright light exposures, thermal stimuli (i.e. air conditioning), listening to music, talking, taking a break from driving, exercising, and drowsiness mitigation.
technologies (Gaspar et al., 2017; Horne, 1988; Horne & Reyner, 1996; Reyner & Horne, 1997; Taillard et al., 2012a; Takayama & Nass, 2008). Of these interventions, only caffeine and bright light exposure have been shown to be effective in multiple studies (Reyner & Horne, 1997, 2000, 2002; Sletten et al., 2017; Taillard et al., 2012b; Weisgerber, Nikol, & Mistlberger, 2017). Furthermore, there is strong scientific evidence that listening to music and thermal stimuli are ineffective (Reyner & Horne, 1998; Schwarz et al., 2012). Among the remaining mitigation techniques drowsiness mitigation technologies have shown promise in reducing drowsy driving crashes in other shift-work contexts. For example, studies in the long haul truck driving and oil and gas extraction industries have shown considerable reductions in drowsy driving crashes associated with the use of mitigation technologies (Heinzmann, Tate, & Scott, 2008; Mabry, Glenn, & Scott, 2019). While the success of mitigation technology in these domains shows promise for reducing drowsy driving crashes in nurses, adoption of such technology in the nursing community may face significant organizational and personal barriers (Lee, 2004).

The overarching goal of our research is to mitigate drowsy driving among night shift nurses using effective and evidence-based methods including technological interventions. Successful implementation of new technologies is dependent on cultural factors and perceptions of the nursing community (De Veer, Fleuren, Bakkema, & Francke, 2011). Therefore, there is a critical need to further understand previous experiences with drowsy driving, their impact on nurses, as well as their perceptions of available countermeasures, needs, and expectations for novel intervention programs.

Research Objectives

We proposed to address the issue of drowsy driving in nurses through a four phase approach consisting of:

1. Prevalence analysis of drowsy driving among nurses.
2. User-centered design of drowsy driving reduction for nurses (DD-RN) system.
3. Verification and validation testing through a randomized controlled trial evaluation of the DD-RN system comparing the DD-RN with a training program and controls.
4. Identification of gaps and opportunities for broad implementation including regulatory compliance and plan for long-term user adoption.

Phases 1 and 2 were conducted through an interview analysis with 30 nurses and an internal design process. Phase 3 was conducted through an on road naturalistic driving study consisting of daily sleep and driving performance logs and real-time naturalistic driving data collection. Phase 4 consisted of an additional round of interviews with 45 nurses at the conclusion of the Phase 3 study. At the time of this submission all data collection has been completed, however, data analysis on Phases 3 and 4 are ongoing.
Methods

Interviews to assess prevalence and preferences

Participants
Thirty night-shift nurses were recruited using voluntary sampling; no nurses refused to participate or dropped out of the study. After completing the informed consent process, demographic information was collected for all participants. All of the nurses interviewed were frontline nurses, working 12-hour night shifts. While the standard working week for the nurses consisted of three shifts in a “two days on-one day off-one day on” pattern, the exact weekly schedule varied across the nurses. Nurses worked different days of the week and varied amounts of consecutive shifts. Both male and female nurses were included, representing a range of ages and ethnicities. These factors are shown alongside national averages in Table 1. While the sample was approximately aligned with the age distribution at the national level, certain ethnicities (e.g., Asian and Black) and males are overrepresented in this sample. Table 2 provides additional details on the practice areas and work experience level of the participating nurses.

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Nation (Data USA, 2018)</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age (SD; range)</td>
<td>43.7</td>
<td>36.1 (10.89; 22-64)</td>
</tr>
<tr>
<td>Gender</td>
<td>F: 90%; M: 10%</td>
<td>F: 67%; M: 33%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>White 76.3% Black 10.8% Asian 9.3% Multiple 1.7% Other 1.4%</td>
<td>16.67% 26.67% 50% 3.33% 3.33%</td>
</tr>
</tbody>
</table>

Table 1 Sample of nurse participants compared to nurse population in United States

<table>
<thead>
<tr>
<th>Factor</th>
<th>Levels</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice area</td>
<td>Intensive/Critical Care (ICU/CCU) 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medical-Surgical (Med/Surg) 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neurology/Orthopedic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Neuro/Ortho) 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catheterization Lab 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intermediate Care Unit (IMU) 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cardiac 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nursery 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labor and Delivery 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 1</td>
<td></td>
</tr>
<tr>
<td>Work Experience</td>
<td>&lt;1 year 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-2 years 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-5 years 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-10 years 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11-20 years 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20+ years 6</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Practice areas and work experience of the participating nurses

Data Collection
Data collection took place in the hospital following a 12-hour night shift (7:00 PM - 7:00 AM). The timing of interviews (after the night shift) was preferred by the nurses and was determined in
consultation with the nurse administrators. Each interview, restricted to the interviewer and participant, began with a brief introduction to the study, consent documentation, and obtaining nurses’ permission to audio-record the interview. A semi-structured interview guide, driven by the identified research gaps, was used covering four main topics: (1) perceptions of drowsy driving among night shift nurses, (2) current practices and methods to mitigate drowsiness during the shift and drowsy driving, (3) preferences and expectations for training on drowsiness management, and, (4) preferences and expectations for in-vehicle technological mitigations. Under each main topic, several probing questions were included to facilitate collection of detailed information. The complete set of questions is provided in Appendix A. Not every question was asked during each interview due to time constraints and no repeat interviews were carried out. All interviews were audio-recorded. Each interview session was 20-30 minutes in duration. Daily debriefs were used to assess saturation.

**Data Analyses**
The transcribed interview sessions were analyzed by the coders using thematic analysis. The thematic analysis approach consists of an iterative process of coding and consolidation, ultimately leading to themes of the transcribed data (Braun & Clarke, 2006; Guest, MacQueen, & Namey, 2012). Initial codes were developed from the interview guide and responses were coded independently by the two coders. During the coding process new codes were created by both coders to accommodate responses that did not align with existing codes. After initial coding, an inductive coding phase was conducted to identify and code patterns and similarities in responses. Finally, a thematic coding process was used to bridge themes and concepts among the previously identified codes. In each phase of the coding process the coders completed the step independently, discussed the results to resolve differences, and reached agreement on the final results. While stylistic differences (e.g., applying different amounts of codes to an interchange) existed in the initial coding process, no substantial interpretative differences occurred throughout the process. All analysis was completed in MAXQDA Analytics Pro Version 12 software (VERBI Software, 2018).

**Naturalistic driving study**

**Participants**
Initially 300 nurses expressed interest in participating in the study however only 87 decided to enroll. Of these 87 participants, there were 57 controls, 13 education recipients, 17 device recipients. This imbalance was due primarily to nurse availability as many nurses were unable to participate in the educational program and the hospital declined to support the program through offering of certification hours.

**Data collection**
Data collection began in March 2019 and continued through October 31st 2019. Each nurse was enrolled for a maximum of 5 months with at least 1 month pre-intervention and 3 months post-intervention. Nurses were divided into three groups: Controls, Education, and Education and Technology (referred to as Technology in this report). Nurses in the Education group received an abbreviated version of the NIOSH training for shift work nurses (designed as an outcome of the previous study phase). Nurses in the technology group received an additional device—the Vuemate drowsy driving detection system (shown in Figure 1).
Throughout data collection nurses were asked to complete daily surveys indicating their sleep duration, total awakenings, factors that disturbed their sleep, the number of shifts they had worked that week, and the number of consecutive shifts they had worked. In addition, the surveys asked nurses to rate how they felt on their drive home on a 5 point Likert scale, and the percentage of their post-work commute during which they felt drowsy. In conjunction with this survey, nurses were provided with an OBD-Link MX+ device paired with the OBDLink Software to record and automatically upload post-work commute driving data. Driving data collected included Speed, 3 axis acceleration, and GPS data at 2 Hz.

![Image of the Vuemate driver state monitor installed on a participant's dashboard.](image)

**Data analysis**

Data analysis on the naturalistic driving study is ongoing however initial analyses of the driving and sleep survey data have been performed using basic correlation and visualization analysis. To date, nurses have responded to 2,551 surveys and have completed 1,525 drives. The results presented in this report focus on the 2,551 surveys.

**Post-study interviews**

Post study interviews were conducted with 45 of the naturalistic driving study participants. Interviews followed a semi-structured protocol to address concerns with the study, experiences with the education and technological intervention, and lifestyle changes the nurses made as a result of participating in the study. Subsequent grounded theory analyses are planned for this data but they have not been conducted at the time of the submission of this report.
Results and findings

Prevalence and preference findings
Table 3 summarizes the themes and subthemes identified by the thematic analysis of the prevalence and preference interviews. The definition of each theme and supporting quotes are presented in the subsequent sections. Nurses are referred to with participant numbers to ensure confidentiality while maintaining individuality.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Subthemes</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drowsy driving experience</td>
<td>Anecdotes</td>
<td>Anecdotes, personal or from others, concerning drowsy driving experiences</td>
</tr>
<tr>
<td></td>
<td>Post-work dip</td>
<td>A profound decrease in alertness reported immediately following the shift</td>
</tr>
<tr>
<td></td>
<td>Emergent drowsiness</td>
<td>Feelings of drowsiness that emerge during the commute, typically related to monotonous driving</td>
</tr>
<tr>
<td></td>
<td>Continuing to drive</td>
<td>Driving home after the shift even when nurses were aware of their drowsiness and fatigue</td>
</tr>
<tr>
<td>Existing countermeasures</td>
<td>Use of ineffective countermeasures</td>
<td>The reported use of countermeasures that have no supporting scientific evidence of effectiveness</td>
</tr>
<tr>
<td></td>
<td>Multiple countermeasures</td>
<td>The reported use of multiple countermeasures to deter sleep onset while driving</td>
</tr>
<tr>
<td></td>
<td>Interactive countermeasures</td>
<td>The reported use of interactive drowsiness countermeasures such as talking on the phone.</td>
</tr>
<tr>
<td>Social influences</td>
<td>Shared anecdotes</td>
<td>Shared stories or anecdotes of drowsy driving and crashes among the nurses</td>
</tr>
<tr>
<td></td>
<td>Shared countermeasures</td>
<td>Countermeasures for drowsy driving mitigation that are shared among nurses</td>
</tr>
<tr>
<td>Barriers</td>
<td>Nature of work</td>
<td>The elements of the nurses’ work environment and practices that contribute to their post-work drowsiness and are a barrier for engaging in effective countermeasures (e.g., naps)</td>
</tr>
<tr>
<td></td>
<td>Commuting options</td>
<td>The options (or lack thereof) for nurses to commute home after the shift</td>
</tr>
<tr>
<td></td>
<td>Family duties</td>
<td>The roles and responsibilities outside of work that are a barrier to making significant lifestyle changes to prevent or reduce drowsiness</td>
</tr>
<tr>
<td>Educational program perspectives</td>
<td>Uncertainty</td>
<td>The fact that many nurses responded with uncertainty when asked what they needed or expected from drowsy driving mitigation training</td>
</tr>
<tr>
<td></td>
<td>Practicality</td>
<td>The preference of nurses to have the course content and format be practical</td>
</tr>
<tr>
<td>Drowsy driving mitigation technology perspectives</td>
<td>Feedback</td>
<td>Nurses’ perceptions of the types of feedback from a technology</td>
</tr>
<tr>
<td></td>
<td>Specific requirements</td>
<td>Specific requirements of potential drowsy driving mitigation technology mentioned by nurses</td>
</tr>
<tr>
<td></td>
<td>Concerns</td>
<td>Issues related to privacy and effectiveness of the technology mentioned by the nurses</td>
</tr>
</tbody>
</table>

Table 3 Themes and subthemes and the subtheme definitions

Drowsy driving experience
All of the nurses interviewed reported experiencing drowsiness while driving at least once, however, the specific nature of their experience varied. The majority of nurses (18/30) reported experiencing drowsiness at least once per week, with the remaining nurses experiencing drowsiness after every shift. Nurses noted that drowsiness was typically only an issue during the post-work commute, although one nurse mentioned experiencing drowsiness during both commutes. Drowsiness was most often reported following the first shift after time off, or the last shift of the week. Beyond these broad differences,
nurses specifically differed in their recollections of anecdotes, their willingness to continue driving after feeling drowsy, and the occurrence of drowsiness in the form of a post-work dip or emergence during their post-work commute.

Anecdotes
All of the nurses recalled first or second hand experiences of drowsy driving. Most nurses used prior crashes, involving themselves or their colleagues, to describe the problem of drowsy driving. Crashes were perceived as a significant but rare event, with the majority of nurses reporting a single adverse event over their careers.

“One time I drove home… [I am] going [into] the garage so in my mind I'm already home. So, I close my eyes. I didn't notice I closed my eyes. And then I bumped inside the garage and all the things, the cabinets, the plastic cabinets... It just went 'whoosh’” – P026 (F, 48, Med/Surg)

“I know somebody that … actually had total collision. … You know hit … a parked vehicle because you know just getting off work. I don’t know how far or where it happened but I just heard that … she crashed.” – P024 (M, 45, Med/Surg)

“Well firsthand experience I've fallen asleep. I've actually had totaled my car driving home.” – P012 (M, 64, Nursery)

While crashes were the most frequently cited example of the problem of drowsy driving, several nurses also reported feeling sleepy or struggling to stay awake during their commute (15/30) and falling asleep behind the wheel (6/30). These experiences were strongly related to, and referenced alongside of, the duration of the nurse’s commute. Nurses who reported falling asleep behind the wheel typically did so at a traffic signal or near their home. Both sleepiness and falling asleep behind the wheel were a more frequent experience compared to crashes.

“Even if you sleep well after a 12-hour shift … it’s always hard for you to stay awake on your drive home especially if you have a long commute.” – P001 (F, 31, L&D)

“From my experience I have fallen asleep at a light. It wasn’t a busy street so when I woke up everybody else was gone so I was by myself at the light” – P003 (F, 34, Cath Lab)

“You know sometimes, the last time actually, and many times before that, I make it all the way home and I don't even make it inside. I sleep in my car in front of my house.” – P014 (F, 33, ICU/CCU)

Post-work dip
Nurses generally reported a feeling of alertness during the shift driven by a consistent but manageable workload with the exception of a circadian nadir during the “lunch” break (between 2 and 4 AM). After the workday, many nurses reported experiencing an abrupt “post-work dip” in energy characterized by physical and mental exhaustion or a loss of adrenaline. Nurses who experienced this post-work dip suggested that it left them ill-prepared to commute home. The dip appeared to be qualitatively different from the circadian nadir. During the nadir nurses used terms such as sleepy to describe their experience whereas nurses characterized the post-work dip as a whole-body exhaustion.
“If you have patients that are coding all night, and you are on your feet nonstop—your adrenaline going—and by the time [you] stop and you are sitting in the garage for forty-five minutes the adrenaline drains down and you are just exhausted.” – P016 (F, 40, ICU/CCU)

“That’s when drowsiness really hits, you say when you clock out and you are ready to go that’s when you feel everything, you wonder like how did I make it through the night.” – P006 (F, 30, ICU/CCU)

“I think it’s just being on your feet, running all night, and you’re just at a higher level, so you kind of sort of crash after work.” – P002 (M, 28, ICU/CCU)

**Emergent drowsiness**

Many nurses who did not report a post-work dip instead reported that their feelings of drowsiness emerged during their commute. This emergent drowsiness was most often attributed to the comfortable environment of nurse’s vehicles or minimal roadway demands. Several nurses reported that their drowsiness peaked while they were stopped at traffic signals, and that they often fell fully asleep while stopped. At least two nurses directly connected their emergent drowsiness to prolonged periods of highway driving. Like the experiences of drowsiness, this emergent drowsiness was related to the length of the nurse’s commutes, with longer commutes leading to more emergent drowsiness.

“you really don’t feel anything... you hardly ever really feel exhausted at work but then once you drive and get comfortable...change the setting kinda becomes a problem.” – P002 (M, 28, ICU/CCU)

“Right now, I’m not, but when I’m already driving that is the time I feel sleepy...” – P026 (F, 48, Med/Surg)

“I have to take smaller roads and so it is a lot of the sitting at the stoplights and that’s when it really starts to, you know, start to blink a little longer... It start[s] to feel sleepier when I sit.” – P004 (F, 30, ICU/CCU)

**Continuing to drive**

Despite the recollections of experiences of drowsy driving and its consequences, many of the nurses reported that they continued to drive after feeling drowsy. This continuation was driven by a variety of factors including a personal motivation to return home (12/30), safety and fear of stopping (3/30), and awaiting personal responsibilities (2/30). Nurses who attributed their continuation to personal motivation appeared to feel that they could overcome their drowsiness with personal effort. In contrast, nurses who attributed their continuation to safety reasons or awaiting personal responsibilities, felt that they had no other options.

“You just think you can make it.” – P015 (M, 26, ICU/CCU)

“I have a fear of sleeping in my car. That motivates to keep going and get to my bed.” – P005 (F, 27, ICU/CCU)

“My wife always [tells] me ‘oh [you just] need to pull over into a gas station or something’ but I’m not comfortable doing that.” –P012 (M, 64, Nursery)
“Well, when that happens, I usually just think about my kids. I don't want them to lose their mom. So that keeps me kind of going.” – P008 (F, 48, ICU/CCU)

Existing countermeasures
All of the nurses were aware of and reported the use of countermeasures to address their drowsiness on the roadway. Nurses either viewed countermeasures as a part of their post-work routine, or as a reaction to emergent drowsiness. Some nurses had a preferred countermeasure that they regularly relied on, while others employed a series of countermeasures as needed. Further, many nurses mentioned trying and subsequently abandoning methods that they deemed to be ineffective. There was a substantial divergence between the nurses reported use of countermeasures and those that have scientific support.

Use of ineffective countermeasures
The list of countermeasures and the number of nurses who engaged in each countermeasure are presented in Table 4. Effective countermeasures (i.e. countermeasures supported by scientific evidence) are highlighted in grey. The table shows that most of the nurses reported depending on ineffective countermeasures. Further, many of the most common countermeasures (e.g., listening to music, talking on the phone, opening the window) require minimal effort and no changes to the nurse’s routine. It is notable that several nurses mentioned napping. Nurses who napped typically did so off of the hospital campus because naps were not permitted during the shift and nurses incurred additional parking fees for staying more than an hour after their shift. Because of these barriers and nurses’ preferences for minimal disruptions to their routines, naps were typically discussed as a “last resort.”
<table>
<thead>
<tr>
<th>Countermeasures</th>
<th>When Engaged</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening to music</td>
<td>During drive</td>
<td>16</td>
</tr>
<tr>
<td>Talking on the phone</td>
<td>During drive</td>
<td>16</td>
</tr>
<tr>
<td>Snacking/Eating</td>
<td>During drive</td>
<td>13</td>
</tr>
<tr>
<td>Opening the window</td>
<td>During drive</td>
<td>10</td>
</tr>
<tr>
<td>Drinking water</td>
<td>During drive</td>
<td>7</td>
</tr>
<tr>
<td>Napping</td>
<td>Pre-drive</td>
<td>7</td>
</tr>
<tr>
<td>Stopping</td>
<td>During drive</td>
<td>6</td>
</tr>
<tr>
<td>Physical pain</td>
<td>During drive</td>
<td>6</td>
</tr>
<tr>
<td>Coffee</td>
<td>Pre-drive/ During drive</td>
<td>3</td>
</tr>
<tr>
<td>Chewing gum</td>
<td>During drive</td>
<td>3</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>During drive</td>
<td>3</td>
</tr>
<tr>
<td>Exercise</td>
<td>Pre-drive</td>
<td>2</td>
</tr>
<tr>
<td>Deep breathing</td>
<td>During drive</td>
<td>1</td>
</tr>
<tr>
<td>Moving to a new home</td>
<td>Pre-drive</td>
<td>1</td>
</tr>
<tr>
<td>Caffeinated drinks</td>
<td>Pre-drive/ During drive</td>
<td>1</td>
</tr>
<tr>
<td>Medical stimulants</td>
<td>Pre-drive</td>
<td>1</td>
</tr>
<tr>
<td>Washing one’s face</td>
<td>Pre-drive</td>
<td>1</td>
</tr>
<tr>
<td>Singing</td>
<td>During drive</td>
<td>1</td>
</tr>
<tr>
<td>Light manipulation</td>
<td>Pre-drive/ During drive</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4 Countermeasures nurses reported using and the frequency of their report. Techniques with empirical evidence of effectiveness are highlighted.

**Multiple countermeasures**

Nearly all of the nurses discussed the use of multiple countermeasures to prevent their drowsiness. In addition, several nurses (12/30) mentioned using multiple countermeasures in sequence that escalate in perceived effectiveness. The sequence typically started with loud music, opening the windows, or turning on the car’s air conditioning and escalated to making a phone call or a taking nap.

“I roll my windows down, turn music all the way up, I pack my snacks in my backpack...some chips, some candy or something. If I’m really tired, I’ll call my mom or call one of my coworkers and we’ll talk on my way home. Just something to keep me up.” – P002 (M, 28, ICU/CCU)

**Interactive countermeasures**

The use of interactive countermeasures such as snacking (13/30) or talking on the phone (16/30) was frequent across the nurses. Nurses generally felt that these methods were effective, often engaging in them after other methods were no longer perceived to be effective. In general, nurses felt that these tasks acted as a distraction from their feelings of drowsiness. Nurses who reported snacking suggested that they eat items such as crackers or potato chips, which require reaching into a box or a bag, rather than foods that are easier to consume while driving. Nurses who reported talking on the phone generally called family members (especially spouses), friends, or co-workers.
“I call my husband, that helps a lot. On my way to work I call my husband, because he is working days so we’re just kind of catching up and that always works for me.” – P029 (F, 43, Med/Surg)

“If my friend is awake I’ll … call a friend. So, I’ll have something to distract myself, to keep me awake.” – P028 (M, 33, ICU/CCU)

“Munching on some chips, some kind of snack that lasts the whole ride will keep me wide awake … It’s the only thing that works.” – P015 (M, 26, ICU/CCU)

Social influences
The nurses’ social network at work had a strong influence on the sharing of both experiences and countermeasures. Many of the nurses had heard of, or shared anecdotes of other nurses who had experienced drowsy driving. Nurses were also readily able to recall countermeasures used by their peers. There was a strong sense among the nurses that drowsy driving was a common shared experience, many nurses even referenced “we” or “us” when discussing the problem, countermeasures, or work experiences.

Shared anecdotes
While a portion of the interview protocol asked nurses specifically about their colleagues’ experiences and behavior, it is notable that several participants relayed anecdotes about colleagues prior to those questions. In these recollections, crashes were the most common incident discussed, but nurses also recalled stories of colleagues falling asleep behind the wheel. These experiences were readily recalled by nearly all of the nurses, and nurses often mentioned stories that were heard second- or third-hand. It was evident from these discussions that drowsy driving was an impactful topic among the nurses.

“I know somebody that… actually had total collision. I mean…[they] hit a parked vehicle because … [they were] just getting off work. I don’t know how far or where it happened but I just heard that…she crashed.” – P024 (M, 45, Med/Surg)

“I’ve talked to a couple of friends who have had issues with … waking up and falling asleep at the light or waking up and not remembering … how they got where they were.” – P002 (M, 28, ICU/CCU)

Notably, not all of the anecdotes were personally relayed from the nurse who experienced a consequence but rather, the nurses reported spreading these stories among themselves.

Shared techniques
In addition to sharing anecdotal evidence of crashes or incidents, nurses also shared their preferred countermeasures. Nurses differed in their responses to hearing of new countermeasures. Several nurses suggested that they tried a countermeasure they heard about, but established that it did not work for them and now no longer used it. Others continued to use countermeasures shared by other nurses after finding them to be effective. Still others stated that they did not use a shared countermeasure and would not try it. Listening to music, rolling the windows down, and coffee were the most common
countermeasures that nurses reported trying based on their colleagues’ suggestions and subsequently abandoning. Coffee was the most commonly cited countermeasure that nurses did not use and did not try. Nurses justified this decision based on the fact that they were not a coffee drinker or did not like the effects of caffeine. Eating ice chips was an example of a countermeasure with perceived effectiveness that was passed on and used by several nurses.

“People say ‘roll the windows down, ... turn the music up.’ When I had my accident, I had the music up, I remembered actually listening to a song, and saying to myself ‘oh I like this song’. Seconds later I was out and crashed into a pole. Thank God I wasn’t going as fast.” – P012 (M, 64, Nursery)

“[One of my friends] plays music loud ..., but If I play music I love, I’ll fall asleep.” – P013 (F, 54, ICU/CCU)

“Sometimes I bring ice chips home with me and I chew on them... One of the other night shift nurses told me... That’s what they did to keep awake.” – P009 (F, 23, Med/Surg)

“Somebody just told me recently... to chew ice. I'd never heard of that one before.” – P012 (M, 64, Nursery)

Barriers
Many nurses commented on barriers to avoiding drowsy driving including the demanding nature of their work, the lack of commuting options and responsibilities at home. These barriers provide a context to understand why few nurses reported engaging in pre-drive mitigation techniques, and why most nurses continued to drive after feeling drowsy.

Nature of the work
Evidence from interviews, and prior research, suggests that workload and long duration of work are major contributors to drowsiness. In addition, nurses mentioned the effects of multiple shifts and, in some cases, consecutive shifts. Other work- and organizational-related factors mentioned as a contributor to drowsiness were: high workload (physical and mental; 11/30), low workload (12/30), lack of breaks (7/30), poor coworker performance (2/30), and post-work training (1/30). Environmental factors such as poor lighting conditions (1/30) and cold temperatures (1/30) were also noted by some nurses.

“Taking a break feels like a burden, like if you leave, you going to have so much to get caught up with when you come back.” – P006 (F, 30, ICU/CCU)

“We don’t get downtime or you know we will have our lunch break that is usually cut short, you know! There is just not a break.” – P027 (F, 38, ICU/CCU)

“It’s just the lights [that] just aren’t as bright or they’ve gone out for whatever reason if ... it’s a slower night and I'm working in that section I will notice I'll get sleepier.” – P014 (F, 33, ICU/CCU)
“[Trainings] start at 8 o’clock go to … 9:30 so that means that’s … almost a 14-hour day and then we’re hitting the roads … I know of my coworkers had gotten into an accident after one of those … trainings.” – P004 (F, 30, ICU/CCU)

Commuting options
A few of the nurses (3/30) mentioned the lack of available and practical alternatives in returning home. The nurses mentioned they would use such alternatives; however, they claimed such opportunities do not currently exist. Notably, one nurse reported that they decided to move closer to campus to reduce their commute and drowsy driving effects. Others noted that even if they planned to commute by car they were constrained in planning their commute due to medical center policies.

“Not all of us have that option [referring to designated drivers]. Nobody can drive us like that all the time” – P008 (F, 48, ICU/CCU)

“Most of them have a long commute and if they wait longer the traffic is worse and it takes them longer to get home. [It] puts them more at risk.” – P016 (F, 40, ICU/CCU)

“If we decide to take a nap in our car in the parking garage we have to pay for parking so we get penalized for that.” – P016 (F, 40, ICU/CCU)

Family duties
A few nurses (5/30) mentioned the tasks at home that prevent them from getting adequate sleep or necessitate them to return home such as caring for children, caring for an elderly relative, pet care, and chores around the house.

“It’s worse on the weekdays… because I have to do some mommy duties” – P030 (F, 44, ICU/CCU)

“I have a pretty good role where I can sleep during the whole day but I know some night nurses that have families… then nobody can get 8 hours or 6 [hours of sleep] per night or per day. I know a lot of people struggle with it” – P028 (M, 33, ICU/CCU)

Educational program perspectives
Only one of the nurses reported receiving prior training regarding drowsy driving, which was part of a punitive driver education course. The other nurses suggested that they never received training and many commented that the dangers of shift work were simply not discussed during training. This effect did not appear to depend on when a nurse received their education or the level of highest education they achieved, as nurses from all levels of experience and education reported a training gap. Despite this training gap, several nurses were able to provide perspectives on their needs for a program. These needs, guided by the interview protocol, covered both course content and educational methods.

“I just finished my master’s program but we never talked about, we never really talked about anything regarding nurses and their experience with work shift disorder” – P007 (F, 29, Cardiac)

Uncertainty
None of the nurses were aware of currently available education or training programs for drowsy driving. In addition, many nurses (9/30) were unsure of the content that would help them prevent or reduce
their drowsy driving or their preferred format. While most of the interviewed nurses did not hold staff training roles, they did have extensive experience with other trainings on emergent issues in the nursing profession. It was apparent from this uncertainty that nurses were unaware of the role of training in reducing their drowsy driving.

**Practicality**

Of the nurses who were able to provide feedback, most thought an education program should include specific training on effective drowsy driving countermeasures. Other commonly mentioned content included time management skills, drowsy driving prevention both before and during the commute, general health advice, and sleep hygiene. The nurses mentioned a variety of preferred formats including in-person (15/30), online (11/30), interactive (7/30), and readings (5/30). Some nurses (4/30) were opposed to an online course because they believed they would not feel the need to fully engage with the program. Many nurses preferred short courses (commonly expected to be under an hour) so that they could return home earlier, however this request may have been related to hospital policy in which trainings were scheduled after the shift.

“I think that it would really need to be if it’s geared toward drowsy driving for people who work night shift. It needs to be geared toward realistic techniques that people who work nights can use, because pulling over on the side of the road … getting out and taking a walk isn’t really realistic when you are talking about the commute from … the medical center to … where my house is. It’s freeway the whole way” – P021 (M, 46, ICU/CCU)

**Drowsy driving mitigation technology perspectives**

None of the nurses had previously used technological interventions for drowsy driving. However, nurses were generally enthusiastic about using technology to solve the problem of drowsy driving. This contrasted somewhat with their more muted feelings about drowsy driving training. Many of the nurses emphasized the need for a usable technology that did not require excessive setup or cost. However, several nurses did not have clear expectations or desires for a drowsy driving technology, and a few had concerns with its effectiveness and privacy.

**Mitigation technology feedback**

Of the topics discussed regarding mitigation technology, nurses provided the most detail regarding the feedback they wanted to receive from a drowsy driving mitigation technology. This feedback primarily centered on modality (audio, tactile, or visual). Most nurses (24/30) indicated audio feedback would be an acceptable method to alert the driver. Among the audio alerts, nurses stated they would like a loud sound (14/29), music (4/29) or human voice (15/30) to alert them when they are drowsy. Fewer nurses responded positively to visual feedback (9/15). Nurses who did not like visual feedback suggested that it would be distracting or insufficient to awaken them. Many nurses (15/19) responded positively to tactile feedback while a few nurses (4/30) thought it would not be viable because it might be mistaken for vehicle problems.

“If you heard someone speaking to you instead of a beep that might be more effective.” – P028 (M, 33, ICU/CCU)
Specific requirements
Beyond feedback methods, several nurses provided specific ideas on a technology that could help them mitigate drowsy driving. These included lane keeping assistance, automation, eye tracking and alerting, and driver readiness technology (e.g., a breathalyzer analog for drowsy driving). Further, some stated an app on their phone or a wearable device would be their preferred technological mitigation because they thought it would be able to monitor them, detect drowsiness, and then alert them.

“something that would track your car maybe going off the tracks and do a similar thing and to make a noise or something, [because] that’s how it starts for me, that’s where I kind of catch myself so that’s good thing I can think of that might top that” – P015 (M, 26, ICU/CCU)

“It would be kind of nice if they would monitor you almost like a Fitbit. If it saw that you were getting tired; if you could somehow program it kind of give you a vibration to kind of remind you” – P016 (F, 40, ICU/CCU)

Concerns
While the majority of nurses (27/30) felt technology would be acceptable, a few (3/30) raised concerns with its efficacy and privacy. One nurse mentioned alarm fatigue, suggesting that an auditory alert might be ignored by nurses finishing the shift. Others mentioned privacy concerns, specifically with technology that recorded and retained video of their face while driving. However, most (10/30) thought a monitoring technology was acceptable if it did not save images.

“I mean it depends if somebody’s ... viewing it live or its just ... an app ... where you know it’s only monitored by [the] app; it’s not monitored by real person.” – P019 (M, 28, Med/Surg)

“The only bad thing about nurses is that we hear beeps constantly with our monitors and patients. So it almost becomes white noise. So, a beep for a nurse would not be as stimulating as a beep for the average joe ... In theory, a beep would be great. But for a nurse it would just be another beep in our life.” – P016 (F, 40, ICU/CCU)

“I'm scared of that, I don't want any device anymore we have so many devices.” – P013 (F, 54, ICU/CCU)

Naturalistic driving study findings

Subjective driving experience
Nurses assessed their post-work commute drowsiness on 2 items. First, nurses reported they would describe their alertness on the drive home on a 5 point Likert scale (5: Excellent and 1: Poor). Second, nurses indicated the percentage of their post work commute that they felt drowsy. The results of the responses to these measures are shown in Figure 2 and 3. The results show that the Education group reported substantially higher alertness and lower percentages of the drive they spent drowsy. The Technology group showed no change in alertness and some decrease in percentage of the drive they spent drowsy. Notably the variance was larger on both measures for the technology group post intervention.
Figure 2 Box plots indicating the nurses self-reported alertness during their post work commute. Scores were provided on a 5 point Likert scale with 5 being Excellent and 1 being Poor.

Figure 3 Box plots indicating the percentage of post-work commutes nurses indicated feeling drowsy.

Further insight into the increased variance in the percentage of drive spent drowsy for the Technology group can be gained by investigating individual responses. Figure 4 shows the change in mean pre and post intervention drowsiness percentages. Negative scores indicate improvement (less drowsiness) and positive scores indicate increased drowsiness. The plot shows that experiences following the intervention were bimodal—participants either reported a substantial reduction in drowsiness or a substantial increase in drowsiness. One explanation for this may be that the device increased awareness of drowsiness among nurses.
Drowsy driving detection device warnings

Nurses reported receiving a total of 656 warnings from the drowsy driving device throughout the study. Interestingly only 6 of the 17 nurses who received the device reported receiving warnings. Among these nurses each nurse received between 3 and 14 warnings per week while using the device. These nurses also account for the majority of nurses who reported experiencing increased drowsiness following the installation of the device which further supports the hypothesis that the device makes the nurses more aware of their drowsiness.

Perceptions of warning accuracy varied widely among the nurses who received warnings. Nurses reported as low as 12% accuracy and as high as 60%, with an overall mean of 36%. The summary of reported accuracies is shown in Table 5. Nurses actions following the warning—depicted in Figure 5 reflect these accuracies. The most common response to receiving a warning was to redirect one’s attention to the roadway followed by listening to music or cold air (two ineffective countermeasures that were advised against during the education). Beyond these actions the next most common response was to open one’s eyes or wake up. Two nurses reported stopping driving and taking a nap. It is notable that these results in part align with the frequency of nurses’ mitigation engagements (shown in Table 4).
Table 5 Participant IDs and reported warning accuracy, and the total mean accuracy.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Mean warning accuracy</th>
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<tr>
<td>4</td>
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<td>197</td>
<td>12 %</td>
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<td>All</td>
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Figure 5 Nurses actions following a warning from the device.

Sleep hygiene
Beyond driving metrics, nurses were also asked about their sleep behaviors through multiple items including the quality of rest and their hours of sleep. The results of these items are shown in Figure 6 and Figure 7. The results show that the median post intervention quality of rest was higher for the Education group than the pre intervention median, however there is a large variance in the responses. There appears to be no differences in the quality of rest reported by the Technology group. Figure 7 suggests that there were no substantial changes in the hours of sleep across both groups before and after the intervention. This finding is consistent with the known limitations on education programs which suggests that nurses (and other shift workers) struggle to make lifestyle changes that would enable the nurses to achieve more sleep. The nominal improvement in the quality of rest for the nurses in the Education group may explain the pathway by which nurses had improved drowsiness on their post-work commutes, i.e. they had higher quality rest which led them to be less drowsy.
Discussion

Prevalence and preferences

The findings of the prevalence and preferences analysis confirm the results of prior studies (e.g., Caruso and Hitchcock, 2010; Dorrian et al., 2008; Lee and Lipscomb, 2003; Scott et al., 2010b) which document high prevalence of drowsy driving among night shift nurses. However, the findings highlighted that the drowsiness nurses experience while driving may be more severe than shift-fatigue due to the
post-work dip and emergent drowsiness during the ride. It is notable that most nurses who mentioned experiencing the post-work dip or emergent drowsiness, related the experience with transition from high to low workload; or task offloading/underloading. Thus, while it is well established that circadian factors, workload, and shift duration lead to sleep-related fatigue following the shift (Åkerstedt, 1998; Rhéaume and Mullen, 2018; Smith-Coggins et al., 2006; Smith-Miller et al., 2014), our findings highlight that task underload may also have a significant effect on drowsy driving. It is critical to pay attention to the design of context-specific interventions as “one-size-fits-all” mitigations and those that reduce sleep-related fatigue (i.e. naps) may be insufficient to address task underload-related fatigue (May and Baldwin, 2009).

The evidence of task-related fatigue is highlighted by nurses’ choice of drowsy driving countermeasures. Many of the commonly referenced techniques, e.g., tuning the radio, talking on the phone, eating, drinking, involve engagement in a secondary task while driving. This suggests that nurses seek to increase their workload during their post-work commute to combat task-underload fatigue. However, this may result in distraction to the driving task, whose negative effects particularly for using mobile devices, have been well-documented (Caird et al., 2018). Beyond the relationship with task-related fatigue, it is notable that few of the nurses used effective countermeasures such as caffeine and naps. The seven nurses that did engage in napping typically did so outside of the hospital. The rationale for the decision to take naps off of hospital property may be motivated by several factors including hospital policies and perception of management (Edwards et al., 2013; Fallis et al., 2011). Beyond these factors, our findings suggest that nurses view napping as a “last resort” and only decide to nap after other methods fail.

A final significant finding from nurses’ discussions of mitigations is the connection to the nurses’ social network. Our findings highlight that nurses freely share and are aware of countermeasures that other nurses use. While this indicates an opportunity for efficient propagation of effective methods among nurses, it is notable that many nurses reported that they did not use countermeasures employed by their colleagues. This finding highlights a potential additional barrier for implementing new countermeasures. One method for overcoming this barrier is through the use of nurse champions—earlier adopters and community leaders—who can leverage social connections to facilitate the adoption of technology (White, 2011).

Our findings highlighted that several important barriers exist from several dimensions including nurses’ work, family, and organization. These reports align with prior work which has shown that nurses have significant concerns with work-life balance (Yildirim and Aycan, 2008) and struggle to find adequate time to sleep (Kurumatani et al., 1994). While prior work has indicated that these factors may lead to broad work-life dissatisfaction (Williams, 2008), our findings here suggest that these barriers also have a direct impact on drowsy driving. While it is challenging for hospitals to provide oversight and mitigation for family barriers, our findings suggest that organizational changes such as providing safe and reliable commute options, accommodation, or designated napping locations, in addition to specific training on work-life balance may be well received by nurses and should be considered for educational programs.

The Education theme highlighted that most of the nurses interviewed were unfamiliar with educational programs for drowsy driving, that they had considerable uncertainty about their educational
needs, and that they preferred short, practical training sessions. These findings align with previous research which suggests that nurses prefer education programs less than one hour in duration, offered by an engaging instructor or via online modules, and programs that are interactive (Tedesco-Schneck, 2013). It is notable that currently available training for shift-work (e.g., Caruso et al., 2015), does not comply with these preferences due to its length and online nature. The findings here suggest that such training may be more effective if offered as a series of short sessions and presented by an engaging instructor, particularly a nurse that the other nurses are familiar with such as a nurse champion. The content of the education, driven by nurse suggestions, should incorporate effective techniques that help nurses overcome underload fatigue, sleep-related fatigue, and the barriers they encounter in their personal and work life. In particular, the findings here also suggest a need to emphasize the use of effective countermeasures and correspondingly to combat the frequent use of ineffective countermeasures that were broadly employed by nurses and accompanied with anecdotal support. Finally, the uncertainty surrounding education suggests that nurses may lack an adequate mental model of the relationship between their habits, behavior, and drowsy driving consequences. This uncertainty suggests a need for educational methods that establish and support the development of an accurate mental model.

While nurses in this study had not been exposed to drowsy driving detection technologies, many nurses reported already using technology such as the radio, podcasts and conversations on their cellphone as techniques for mitigating drowsiness. These interventions share common themes of being minimally disruptive, and requiring minimal post-shift planning and time. It is notable that these themes align with many broadly available drowsiness mitigation technologies that have already been employed in shift-work dominant industries (Retzer et al., 2013). Despite this connection, it is important to acknowledge that a few nurses mentioned concerns with the potential efficacy and invasions of privacy associated with camera-based mitigation technologies. In particular, the concerns of privacy invasions may limit the adoption and acceptance of certain fatigue monitoring systems such as fleet management software which record and save videos of the driver. These concerns when combined with the uncertainty among nurses regarding their needs and preferences for a drowsy driving mitigation technology emphasize the need for a structured program for drowsy driving technology introduction among nurses including proactive investigation of issues related to readiness, acceptance, and implementation of such technologies.

**Naturalistic driving study findings**

The findings of the naturalistic driving study provide support for the use of both training and technology to reduce drowsy driving among shift work nurses. Nurses who received the Education generally reported lower levels of post-work drowsiness, likely brought on by an increase in their quality of sleep. Nurses in the technology group who received warnings were likely more aware of their drowsiness and in at least some cases were woken up or had their attention redirected as a result of the device warning. Additional work is needed to assess if these responses had a significant impact on driving safety. Following this analysis, more firm recommendations may be made regarding the use of drowsy driving technology to prevent drowsy driving crashes among night shift nurses.
Future work

The findings of this study support the need for a broader analysis of technological and training mitigations for drowsy driving. Work is underway to develop a proposal for a second round of randomized controlled trials including a second pilot study at another hospital. Four other hospitals have expressed interest in becoming involved in the second round of randomized controlled trials. In these second round experiments the focus will be on increasing engagement among the nurses and improving the data collection platform to ensure improved data reliability.

References


