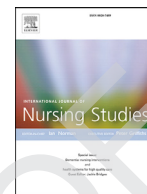


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Night-shift nurses and drowsy driving: A qualitative study

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ABSTRACT

Background: Drowsy driving following the night shift is persistent among nurses resulting in elevated rates of vehicle crashes and crash-related injuries and deaths. While considerable effort has been dedicated to the development of countermeasures, implementation of these countermeasures in nursing has lagged behind other shift work oriented industries. Developing effective countermeasures for drowsy driving in nurses requires a thorough characterization of nurse's perceptions of drowsy driving and potential mitigations.

Objective: The objective of this research was to elicit night shift nurses' perceptions of drowsy driving, countermeasures, and educational and technological interventions.

Design: Perceptions were elicited through a semi-structured interview protocol. The protocol design was driven by previously identified research gaps. Questions focused on four topics: perceptions of drowsy driving, current practices and methods to mitigate drowsiness during the shift and commute, preferences and expectations for training on drowsiness management, and, preferences and expectations for technological mitigations.

Setting: The data collection took place at a large urban hospital in Texas, USA.

Participants: Thirty night-shift nurses were recruited with voluntary sampling. No nurses declined to participate after initially consenting. The participants were male and female nurses who currently worked a 12 hour night shift. The nurses had between 1 and more than 20 years of experience and worked in a variety of units.

Method: The interview recordings were transcribed by the research team and entered into a qualitative data analysis software. Transcripts were analyzed by two independent coders with a grounded theory approach to identify common themes and subthemes across participants.

Findings: Feelings of drowsiness typically manifested immediately following the shift or during the post work commute. Nurses responded to drowsiness by engaging in multiple ineffective countermeasures (e.g., listening to music) and effective countermeasures (e.g., naps) were used sparingly. Experiences and mitigation methods traversed through the nurses' social network although they did not always alter behavior. Nurses were uncertain but enthusiastic about educational and technological interventions preferring practical training and auditory interactive alerts.

Conclusions: The findings suggest a strong need for real time drowsiness interventions during or immediately prior to nurses' post work commutes. Nurses' enthusiasm for training and technology to prevent drowsy driving suggests high levels of readiness and acceptance for such interventions. Future work should focus on the development and implementation of practical training and technological interventions for drowsy driving in nurses.

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1 What is known about the topic?

- 2 • Drowsy driving is a pervasive problem for night shift nurses im-
3 pacting at least 79% of all night-shift nurses.

- 4 • Interventions, such as naps, training, and caffeine, have been
5 implemented and have subjectively improved drowsy driving
6 rates but they are not suitable for all nursing units.
7 • Technology to mitigate drowsy driving has been successful in
8 other industries that rely on shift work but it has not been
9 widely used in healthcare.

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10 What this paper adds?

- 11 • The findings show that nurses experience peak drowsiness immediately following the shift or during low demand portions of their commutes, suggesting the need for interventions immediately before or during the drive home.
- 12
- 13
- 14
- 15 • The findings show that nurses regularly engage in ineffective mitigation techniques often believing that they are effective.
- 16
- 17 • Comments from the nurses indicate that they are enthusiastic about technology and training to reduce their drowsy driving.
- 18

19 1. Introduction

20 Nurse fatigue is a worldwide problem contributing to health decline, patient care errors, and sickness absences (Blouin et al., 2016; Rhéaume and Mullen, 2018; Sagherian et al., 2017; Smith-Miller et al., 2014). The effects of nurse fatigue often extend beyond the walls of healthcare facilities, where fatigue leads to alarming rates of drowsy driving (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 and 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 and Tucker, 2003; Smith et al., 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 et al., 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 (Caruso et al., 2017; Higgins et al., 2017).

42 The majority of current drowsy driving countermeasures for nurses focus on addressing broad work-shift fatigue and consist of a single intervention (Fallís et al., 2011; Geiger-Brown et al., 2016; Zion and Shochat, 2019). These interventions include napping, education, work planning, peer care, and practicing healthy habits outside of the workplace (Berger and Hobbs, 2006; Caruso, 2014; Hughes and 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 (Fallís et al., 2011; Geiger-Brown et al., 2016; Smith et al., 2007; Zion and Shochat, 2019). However, the implementation of naps during the shift often faces significant organizational and occupational culture barriers (Geiger-Brown et al., 2016; Smith-Coggins et al., 2006; Steege and Rainbow, 2017). In particular, nurses' perceptions of the feasibility and acceptability of napping play a significant role in nap utilization (Fallís 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 (Geiger-Brown et al., 2016; Scott et al., 2010a).

62 Beyond napping, training interventions have also received significant attention in recent years (Caruso et al., 2015). Training interventions typically introduce nurses to fatigue and drowsiness, discuss the potential consequences of working and driving while fatigued or drowsy, and provide 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 et al., 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 and Reyner, 1996; Reyner and Horne, 1997; Taillard et al., 2012; Takayama and Nass, 2008). Of these interventions, only caffeine and bright light exposure have been shown to be effective in multiple studies (Reyner and Horne, 2002, 2000, 1997; Sletten et al., 2017; Taillard et al., 2012; Weisgerber et al., 2017). Furthermore, there is strong scientific evidence that listening to music and thermal stimuli are ineffective (Reyner and 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 et al., 2008; Mabry et al., 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 et al., 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. Qualitative and participatory methods such as interviews, which have been well established in the medical community may provide insights into experiences and inform preferences and expectations for future interventions (Burnard, 1991; Graneheim and Lundman, 2004; Lee, 2004). The goal of this study was to elicit night shift nurses' perceptions of drowsy driving, current countermeasures, and novel educational and technological interventions for drowsiness.

2. Methods

Semi-structured interviews were conducted with nurses at a large urban hospital in Texas. All interviews were conducted on-site and in person between September 7th and 17th, 2018. The study protocol was approved by the hospital's Institutional Review Board (IRB) prior to the start of data collection. Participants were recruited through mass email and paper flyers posted across the hospital campus. Participants received a \$25 gift card as compensation.

2.1. 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

Table 1

Sample of nurse participants compared to nurse population in United States.

Demographic Variable	Nation (Data USA, 2018)	Participants
Mean Age (SD; range)	43.7	36.1 (10.89; 22-64)
Gender	F: 90%; M: 10%	F: 67%; M: 33%
Ethnicity	White	76.3%
	Black	10.8%
	Asian	9.3%
	Multiple	1.7%
	Other	1.4%

Table 2

Practice areas and work experience of the participating nurses.

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

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.

2.2. Research Team

Two of the authors, a graduate student (A1) and PhD-level scientist (A2), and a post-doctoral researcher (A4) interviewed the nurses—with whom they did not have any previous relationships—and took notes throughout the interviews. All of the interviewees are males with prior training and experience in qualitative research methods. A1 and another PhD level scientist (A3) performed the interview coding.

2.3. 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.

2.4. Data Analyses

The transcribed interview sessions were analyzed by the coders using thematic analysis (Braun & Clarke, 2006; Guest, MacQueen, & Namey, 2012). Similar to grounded theory, analysis was conducted in three phases: initial coding, focused coding and thematic coding. However, unlike grounded theory no theory was constructed. Initial codes were created and defined (by A1) from the interview guide. For example, the question "Are there any techniques you use to stay awake while driving?" became the code 'Countermeasures'. Responses to the previous question, and parts of the text that were related to the question, were placed in the 'Countermeasures' code; this process was completed for all transcripts and codes in the initial coding phase. Focused coding, which occurred iteratively with the initial coding phase, consisted of creating new codes for responses that did not fit into the initial codes, as well as creating sub codes under the existing codes. At this phase existing codes were also reorganized based on identified patterns and similarities. An example of focused coding for the 'Countermeasures' code is creating sub codes for the different countermeasures participants used: 'Caffeine', 'Open windows', etc. Finally, a thematic coding process was used to bridge themes and concepts among the previously identified codes and consolidate some to form more analytic themes.

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).

3. Findings

Table 3 summarizes the themes and subthemes identified by the thematic analysis and the frequency of each subtheme. 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.

3.1. 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.

3.1.1. 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

Table 3

Themes, subthemes, subtheme code frequencies, and the subtheme definitions.

Theme	Subthemes	Frequency	Definition
Drowsy driving experience	Anecdotes	23	Anecdotes, personal or from others, concerning drowsy driving experiences
	Post-work dip	12	A profound decrease in alertness reported immediately following the shift
	Emergent drowsiness	5	Feelings of drowsiness that emerge during the commute, typically related to monotonous driving
	Continuing to drive	33	Driving home after the shift even when nurses were aware of their drowsiness and fatigue
Existing countermeasures	Use of ineffective countermeasures	59	The reported use of countermeasures that have no supporting scientific evidence of effectiveness
	Multiple countermeasures	22	The reported use of multiple countermeasures to deter sleep onset while driving
	Interactive countermeasures	38	The reported use of interactive drowsiness countermeasures such as talking on the phone.
Social influences	Shared anecdotes	10	Shared stories or anecdotes of drowsy driving and crashes among the nurses
	Shared countermeasures	56	Countermeasures for drowsy driving mitigation that are shared among nurses
Barriers	Nature of work	30	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)
	Commuting options	4	The options (or lack thereof) for nurses to commute home after the shift
	Family duties	5	The roles and responsibilities outside of work that are a barrier to making significant lifestyle changes to prevent or reduce drowsiness
Educational program perspectives	Uncertainty	15	The fact that many nurses responded with uncertainty when asked what they needed or expected from drowsy driving mitigation training
	Practicality	47	The preference of nurses to have the course content and format be practical
Drowsy driving mitigation technology perspectives	Feedback	123	Nurses' perceptions of the types of feedback from a technology
	Specific requirements	38	Specific requirements of potential drowsy driving mitigation technology mentioned by nurses
	Concerns	21	Issues related to privacy and effectiveness of the technology mentioned by the nurses

225 the majority of nurses reporting a single adverse event over their
226 careers.

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

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

236 "Well firsthand experience I've fallen asleep. I've actually had to
237 taled my car driving home." – P012 (M, 64, Nursery)

238 While crashes were the most frequently cited example of the
239 problem of drowsy driving, several nurses also reported feeling
240 sleepy or struggling to stay awake during their commute (15/30)
241 and falling asleep behind the wheel (6/30). These experiences were
242 strongly related to, and referenced alongside of, the duration of the
243 nurses commute. Nurses who reported falling asleep behind the
244 wheel typically did so at a traffic signal or near their home. Both
245 sleepiness and falling asleep behind the wheel were a more fre-
246 quent experience compared to crashes.

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

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

"You know sometimes, the last time actually, and many times be- 253
fore that, I make it all the way home and I don't even make it 254
inside. I sleep in my car in front of my house." – P014 (F, 33, 255
ICU/CCU) 256

3.1.2. Post-work dip 257

Nurses generally reported a feeling of alertness during the shift 258
driven by a consistent but manageable workload with the excep- 259
tion of a circadian nadir during the "lunch" break (between 2 and 260
4 AM). After the workday, many nurses reported experiencing an 261
abrupt "post-work dip" in energy characterized by physical and 262
mental exhaustion or a loss of adrenaline. Nurses who experienced 263
this post-work dip suggested that it left them ill-prepared to com- 264
mute home. The dip appeared to be qualitatively different from 265
the circadian nadir. During the nadir nurses used terms such as 266
sleepy to describe their experience whereas nurses characterized 267
the post-work dip as a whole-body exhaustion. 268

"If you have patients that are coding all night, and you are on 269
your feet nonstop—your adrenaline going—and by the time [you] 270
stop and you are sitting in the garage for forty-five minutes the 271
adrenaline drains down and you are just exhausted." – P016 (F, 272
40, ICU/CCU) 273

"That's when drows[iness] really hits, you say when you clock out 274
and you are ready to go that's when you feel everything, you won- 275
der like how did I make it through the night." – P006 (F, 30, 276
ICU/CCU) 277

"I think it's just being on your feet, running all night, and you're 278
just at a higher level, so you kind of sort of crash after work." – 279
P002 (M, 28, ICU/CCU) 280

281 3.1.3. Emergent drowsiness

282 Many nurses who did not report a post-work dip instead re-
 283 ported that their feelings of drowsiness emerged during their com-
 284 mune. This emergent drowsiness was most often attributed to the
 285 comfortable environment of nurses vehicles or minimal roadway
 286 demands. Several nurses reported that their drowsiness peaked
 287 while they were stopped at traffic signals, and that they often fell
 288 fully asleep while stopped. At least two nurses directly connected
 289 their emergent drowsiness to prolonged periods of highway driv-
 290 ing. Like the experiences of drowsiness, this emergent drowsiness
 291 was related to the length of the nurses commutes, with longer
 292 commutes leading to more emergent drowsiness.

293 *"you really don't feel anything... you hardly ever really feel ex-*
 294 *hausted at work but then once you drive and get comfort-*
 295 *able...change the setting kinda becomes a problem."* – P002 (M,
 296 28, ICU/CCU)

297 *"Right now I'm not, but when I'm already driving that is the time*
 298 *I feel sleepy..."* – P026 (F, 48, Med/Surg)

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

303 3.1.4. Continuing to drive

304 Despite the recollections of experiences of drowsy driving and
 305 its consequences, many of the nurses reported that they contin-
 306 ued to drive after feeling drowsy. This continuation was driven by
 307 a variety of factors including a personal motivation to return home
 308 (12/30), safety and fear of stopping (3/30), and awaiting personal
 309 responsibilities (2/30). Nurses who attributed their continuation
 310 to personal motivation appeared to feel that they could overcome
 311 their drowsiness with personal effort. In contrast, nurses who at-
 312 tributed their continuation to safety reasons or awaiting personal
 313 responsibilities, felt that they had no other options.

314 *"You just think you can make it."* – P015 (M, 26, ICU/CCU)

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

317 *"My wife always [tells] me 'oh [you just] need to pull over into*
 318 *a gas station or something' but I'm not comfortable doing that."*
 319 –P012 (M, 64, Nursery)

320 *"Well, when that happens, I usually just think about my kids. I*
 321 *don't want them to lose their mom. So that keeps me kind of go-*
 322 *ing."* – P008 (F, 48, ICU/CCU)

323 3.2. Existing countermeasures

324 All of the nurses were aware of and reported the use of coun-
 325 termeasures to address their drowsiness on the roadway. Nurses
 326 either viewed countermeasures as a part of their post-work rou-
 327 tine, or as a reaction to emergent drowsiness. Some nurses had
 328 a preferred countermeasure that they regularly relied on, while
 329 others employed a series of countermeasures as needed. Fur-
 330 ther, many nurses mentioned trying and subsequently abandoning
 331 methods that they deemed to be ineffective. There was a substan-
 332 tial divergence between the nurses reported use of countermea-
 333 sures and those that have scientific support.

334 3.2.1. Use of ineffective countermeasures

335 The list of countermeasures and the number of nurses who en-
 336 gaged in each countermeasure are presented in Table 4. Effective
 337 countermeasures (i.e. countermeasures supported by scientific evi-
 338 dence) are highlighted in grey. The table shows that most of the

Table 4

Countermeasures nurses reported using and the frequency of their report. Tech-
 niques with empirical evidence of effectiveness are highlighted.

Countermeasures	When Engaged	Frequency
Listening to music	During drive	16
Talking on the phone	During drive	16
Snacking/Eating	During drive	13
Opening the window	During drive	10
Drinking water	During drive	7
Napping	Pre-drive/ During drive	7
Stopping	During drive	6
Physical pain	During drive	6
Coffee	Pre-drive/ During drive	3
Chewing gum	During drive	3
Air conditioning	During drive	3
Exercise	Pre-drive	2
Deep breathing	During drive	1
Moving to a new home	Pre-drive	1
Caffeinated drinks	Pre-drive/ During drive	1
Medical stimulants	Pre-drive	1
Washing one's face	Pre-drive	1
Singing	During drive	1
Light manipulation	Pre-drive/ During drive	1

nurses reported depending on ineffective countermeasures. Fur- 339
 340 ther, many of the most common countermeasures (e.g., listening
 341 to music, talking on the phone, opening the window) require min-
 342 imal effort and no changes to the nurse's routine. It is notable that
 343 several nurses mentioned napping. Nurses who napped typically
 344 did so off of the hospital campus because naps were not permit-
 345 ted during the shift and nurses incurred additional parking fees for
 346 staying more than an hour after their shift. Because of these bar-
 347 riers and nurses preferences for minimal disruptions to their rou-
 348 tines, naps were typically discussed as a "last resort."

349 3.2.2. Multiple countermeasures

350 Nearly all of the nurses discussed the use of multiple counter-
 351 measures to prevent their drowsiness. In addition, several nurses
 352 (12/30) mentioned using multiple countermeasures in sequence
 353 that escalate in perceived effectiveness. The sequence typically
 354 started with loud music, opening the windows, or turning on the
 355 car's air conditioning and escalated to making a phone call or a
 356 taking nap.

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

362 3.2.3. Interactive countermeasures

363 The use of interactive countermeasures such as snacking (13/30)
 364 or talking on the phone (16/30) was frequent across the nurses.
 365 Nurses generally felt that these methods were effective, often en-
 366 gaging in them after other methods were no longer perceived to be
 367 effective. In general, nurses felt that these tasks acted as a distrac-
 368 tion from their feelings of drowsiness. Nurses who reported snack-
 369 ing suggested that they eat items such as crackers or potato chips,
 370 which require reaching into a box or a bag, rather than foods that
 371 are easier to consume while driving. Nurses who reported talking
 372 on the phone generally called family members (especially spouses),
 373 friends, or co-workers.

374 *"I call my husband, that helps a lot. On my way to work I call my*
 375 *husband, because he is working days so we're just kind of catching*
 376 *up and that always works for me."* – P029 (F, 43, Med/Surg)

377 *"If my friend is awake I'll ... call a friend. So I'll have something to*
 378 *distract myself, to keep me awake."* – P028 (M, 33, ICU/CCU)

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

382 3.4. Social influences

383 The nurses social network at work had a strong influence on
384 the sharing of both experiences and countermeasures. Many of the
385 nurses had heard of, or shared anecdotes of other nurses who had
386 experienced drowsy driving. Nurses were also readily able to re-
387 call countermeasures used by their peers. There was a strong sense
388 among the nurses that drowsy driving was a common shared expe-
389 rience, many nurses even referenced “we” or “us” when discussing
390 the problem, countermeasures, or work experiences.

391 3.4.1. Shared anecdotes

392 While a portion of the interview protocol asked nurses specifi-
393 cally about their colleagues' experiences and behavior, it is notable
394 that several participants relayed anecdotes about colleagues prior
395 to those questions. In these recollections, crashes were the most
396 common incident discussed, but nurses also recalled stories of col-
397 leagues falling asleep behind the wheel. These experiences were
398 readily recalled by nearly all of the nurses, and nurses often men-
399 tioned stories that were heard second- or third-hand. It was evi-
400 dent from these discussions that drowsy driving was an impactful
401 topic among the nurses.

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

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

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

413 3.4.2. Shared techniques

414 In addition to sharing anecdotal evidence of crashes or inci-
415 dents, nurses also shared their preferred countermeasures. Nurses
416 differed in their responses to hearing of new countermeasures.
417 Several nurses suggested that they tried a countermeasure they
418 heard about, but established that it did not work for them and
419 now no longer used it. Others continued to use countermeasures
420 shared by other nurses after finding them to be effective. Still
421 others stated that they did not use a shared countermeasure and
422 would not try it. Listening to music, rolling the windows down,
423 and coffee were the most common countermeasures that nurses
424 reported trying based on their colleagues' suggestion and subse-
425 quently abandoning. Coffee was the most commonly cited counter-
426 measure that nurses did not use and did not try. Nurses justified
427 this decision based on the fact that they were not a coffee drinker
428 or did not like the effects of caffeine. Eating ice chips was an ex-
429 ample of a countermeasure with perceived effectiveness that was
430 passed on and used by several nurses.

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

“[One of my friends] plays music loud ..., but if I play music I love, 436
I'll fall asleep.” – P013 (F, 54, ICU/CCU) 437

“Sometimes I bring ice chips home with me and I chew on them... 438
One of the other night shift nurses told me... That's what they did 439
to keep awake.” – P009 (F, 23, Med/Surg) 440

“Somebody just told me recently... to chew ice. I'd never heard of 441
that one before.” – P012 (M, 64, Nursery) 442

443 3.5. Barriers

Many nurses commented on barriers to avoiding drowsy driving 444
including the demanding nature of their work, the lack of com- 445
muting options and responsibilities at home. These barriers pro- 446
vide a context to understand why few nurses reported engaging in 447
pre-drive mitigation techniques, and why most nurses continued 448
to drive after feeling drowsy. 449

450 3.5.1. Nature of the work

Evidence from interviews, and prior research, suggests that 451
workload and long duration of work are major contributors to 452
drowsiness. In addition, nurses mentioned the effects of mul- 453
tiple shifts and, in some cases, consecutive shifts. Other task- 454
and organizational-related factors mentioned as a contributor to 455
drowsiness were: high workload (physical and mental; 11/30), low 456
workload (12/30), lack of breaks (7/30), poor coworker perfor- 457
mance (2/30), and post-work training (1/30). Environmental fac- 458
tors such as poor lighting conditions (1/30) and cold temperatures 459
(1/30) were also noted by some nurses. 460

“It's just the lights [that] just aren't as bright or they've gone out 461
for whatever reason if ... it's a slower night and I'm working in 462
that section I will notice I'll get sleepier.” – P014 (F, 33, ICU/CCU) 463

“[Trainings] start at 8 o'clock go to ... 9:30 so that means that's ... 464
almost a 14-hour day and then we're hitting the roads ... I know 465
of my coworkers had gotten into an accident after one of those ... 466
trainings.” – P004 (F, 30, ICU/CCU) 467

468 3.5.2. Commuting options

A few of the nurses (3/30) mentioned the lack of available 469
and practical alternatives in returning home. The nurses mentioned 470
they would use such alternatives; however, they claimed such op- 471
portunities do not currently exist. Notably, one nurse reported that 472
they decided to move closer to campus to reduce their commute 473
and drowsy driving effects. Others noted that even if they planned 474
to commute by car they were constrained in planning their com- 475
mute due to medical center policies.. 476

“Not all of us have that option [referring to designated drivers]. 477
Nobody can drive us like that all the time” – P008 (F, 48, 478
ICU/CCU) 479

“Most of them have a long commute and if they wait longer the 480
traffic is worse and it takes them longer to get home. [It] puts them 481
more at risk.” – P016 (F, 40, ICU/CCU) 482

“If we decide to take a nap in our car in the parking garage we 483
have to pay for parking so we get penalized for that.” – P016 (F, 484
40, ICU/CCU) 485

486 3.5.3. Family duties

A few nurses (5/30) mentioned the tasks at home that prevent 487
them from getting adequate sleep or necessitate them to return 488
home such as caring for children, caring for an elderly relative, pet 489
care, and chores around the house. 490

“It's worse on the weekdays... because I have to do some mommy 491
duties” – P030 (F, 44, ICU/CCU) 492

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

497 3.6. Educational program perspectives

498 Only one of the nurses reported receiving prior training regard-
499 ing drowsy driving, which was part of a punitive driver educa-
500 tion course. The other nurses suggested that they never received
501 training and many commented that the dangers of shift work were
502 simply not discussed during training. This effect did not appear to
503 depend on when a nurse received their education or the level of
504 highest education they achieved, as nurses from all levels of ex-
505 perience and education reported a training gap. Despite this train-
506 ing gap, several nurses were able to provide perspectives on their
507 needs for a program. These needs, guided by the interview proto-
508 col, covered both course content and educational methods.

509 "I just finished my master's program but we never talked about,
510 we never really talked about anything regarding nurses and their
511 experience with work shift disorder" – P007 (F, 29, Cardiac)

512 3.6.1. Uncertainty

513 None of the nurses were aware of currently available education
514 or training programs for drowsy driving. In addition, many nurses
515 (9/30) were unsure of the content that would help them prevent or
516 reduce their drowsy driving or their preferred format. While most
517 of the interviewed nurses did not hold staff training roles, they did
518 have extensive experience with other trainings on emergent issues
519 in the nursing profession. It was apparent from this uncertainty
520 that nurses were unaware of the role of training in reducing their
521 drowsy driving.

522 3.6.2. Practicality

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

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

544 3.7. Drowsy driving mitigation technology perspectives

545 None of the nurses had previously used technological inter-
546 ventions for drowsy driving. However, nurses were generally en-
547 thusiastic about using technology to solve the problem of drowsy
548 driving. This contrasted somewhat with their more muted feelings
549 about drowsy driving training. Many of the nurses emphasized the

need for a usable technology that did not require excessive setup 550
or cost. However, several nurses did not have clear expectations or 551
desires for a drowsy driving technology, and a few had concerns 552
with its effectiveness and privacy. 553

554 3.7.1. Mitigation technology feedback

555 Of the topics discussed regarding mitigation technology, nurses
556 provided the most detail regarding the feedback they wanted to
557 receive from a drowsy driving mitigation technology. This feed-
558 back primarily centered on modality (audio, tactile, or visual). Most
559 nurses (24/30) indicated audio feedback would be an acceptable
560 method to alert the driver. Among the audio alerts, nurses stated
561 they would like a loud sound (14/29), music (4/29) or human voice
562 (15/30) to alert them when they are drowsy. Fewer nurses re-
563 sponded positively to visual feedback (9/15). Nurses who did not
564 like visual feedback suggested that it would be distracting or insuf-
565 ficient to awaken them. Many nurses (15/19) responded positively
566 to tactile feedback while a few nurses (4/30) thought it would not
567 be viable because it might be mistaken for vehicle problems.

568 "If you heard someone speaking to you instead of a beep that
569 might be more effective." – P028 (M, 33, ICU/CCU)

570 3.7.2. Specific requirements

571 Beyond feedback methods, several nurses provided specific
572 ideas on a technology that could help them mitigate drowsy driv-
573 ing. These included lane keeping assistance, automation, eye track-
574 ing and alerting, and driver readiness technology (e.g., a breathal-
575 yzer analog for drowsy driving). Further, some stated an app on
576 their phone or a wearable device would be their preferred techno-
577 logical mitigation because they thought it would be able to moni-
578 tor them, detect drowsiness, and then alert them.

579 "something that would track your car maybe going off the tracks
580 and do a similar thing and to make a noise or something, [be-
581 cause] that's how it starts for me, that's where I kind of catch my-
582 self so that's good thing I can think of that might top that" – P015
583 (M, 26, ICU/CCU)

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

588 3.7.3. Concerns

589 While the majority of nurses (27/30) felt technology would be
590 acceptable, a few (3/30) raised concerns with its efficacy and pri-
591 vacy. One nurse mentioned alarm fatigue, suggesting that an au-
592 ditory alert might be ignored by nurses finishing the shift. Oth-
593 ers mentioned privacy concerns, specifically with technology that
594 recorded and retained video of their face while driving. However,
595 most (10/30) thought a monitoring technology was acceptable if it
596 did not save images.

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

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

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

607 4. DISCUSSION

608 This study sought to characterize the experience of night-shift
609 nurses' drowsy driving, use of countermeasures, and perspectives
610 on educational and technological approaches through interviews
611 with thirty night-shift nurses in a large representative health sys-
612 tem. The themes identified by this study illustrate that drowsy
613 driving is a common experience among night-shift nurses, that
614 most nurses currently respond to the problem through a combi-
615 nation of ineffective countermeasures, that both experiences and
616 countermeasures are shared socially among nurses, that nurses
617 work and lifestyles create significant barriers to addressing drowsy
618 driving, and that nurses are open to technological and educational
619 interventions but have had little exposure to such methods.

620 The findings of the study confirm the results of prior studies
621 (e.g., Caruso and Hitchcock, 2010; Dorrian et al., 2008; Lee and Lip-
622 scomb, 2003; Scott et al., 2010b) which document high prevalence
623 of drowsy driving among night shift nurses. However, the findings
624 highlighted that the drowsiness nurses experience while driving
625 may be more severe than shift-fatigue due to the post-work dip
626 and emergent drowsiness during the ride. It is notable that most
627 nurses who mentioned experiencing the post-work dip or emer-
628 gent drowsiness, related the experience with transition from high
629 to low workload; or task offloading/underloading. Thus, while it is
630 well established that circadian factors, workload, and shift duration
631 lead to sleep-related fatigue following the shift (Åkerstedt, 1998;
632 Rhéaume and Mullen, 2018; Smith-Coggins et al., 2006; Smith-
633 Miller et al., 2014), our findings highlight that task underload may
634 also have a significant effect on drowsy driving. It is critical to pay
635 attention to the design of context-specific interventions as "one-
636 size-fits-all" mitigations and those that reduce sleep-related fatigue
637 (i.e. naps) may be insufficient to address task underload-related fa-
638 tigue (May and Baldwin, 2009).

639 The evidence of task-related fatigue is highlighted by nurses'
640 choice of drowsy driving countermeasures. Many of the commonly
641 referenced techniques, e.g., tuning the radio, talking on the phone,
642 eating, drinking, involve engagement in a secondary task while
643 driving. This suggests that nurses seek to increase their workload
644 during their post-work commute to combat task-underload fatigue.
645 However, this may result in distraction to the driving task, whose
646 negative effects particularly for using mobile devices, have been
647 well-documented (Caird et al., 2018). Beyond the relationship with
648 task-related fatigue, it is notable that few of the nurses used effec-
649 tive countermeasures such as caffeine and naps. The seven nurses
650 that did engage in napping typically did so outside of the hospital.
651 The rationale for the decision to take naps off of hospital prop-
652 erty may be motivated by several factors including hospital policies
653 and perception of management (Edwards et al., 2013; Fallis et al.,
654 2011). Beyond these factors, our findings suggest that nurses view
655 napping as a "last resort" and only decide to nap after other meth-
656 ods fail.

657 A final significant finding from nurses' discussions of mitiga-
658 tions is the connection to the nurses' social network. Our findings
659 highlight that nurses freely share and are aware of countermea-
660 sures that other nurses use. While this indicates an opportunity
661 for efficient propagation of effective methods among nurses, it is
662 notable that many nurses reported that they did not use coun-
663 termeasures employed by their colleagues. This finding highlights
664 a potential additional barrier for implementing new countermea-
665 sures. 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 tech-
nology (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 bal-
ance (Yildirim and Aycan, 2008) and struggle to find adequate
time to sleep (Kurumatani et al., 1994). While prior work has indi-
cated 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 bal-
ance may be well received by nurses and should be considered for
educational programs.

The Education theme highlighted that most of the nurses in-
terviewed were unfamiliar with educational programs for drowsy
driving, that they had considerable uncertainty about their educa-
tional needs, and that they preferred short, practical training ses-
sions. These findings align with previous research which suggests
that nurses prefer education programs less than one hour in du-
ration, offered by an engaging instructor or via online modules,
and programs that are interactive (Tedesco-Schneck, 2013). It is no-
table 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 train-
ing 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 in-
corporate effective techniques that help nurses overcome under-
load 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 counter-
measures and correspondingly to combat the frequent use of in-
effective 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 develop-
ment of an accurate mental model.

While nurses in this study have 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

730 including proactive investigation of issues related to readiness,
731 acceptance, and implementation of such technologies.

732 4.1. Limitations and future work

733 Despite the promising findings of the study, the study is lim-
734 ited by several factors including the participant sample and inter-
735 view methodology. The use of a single sample from one hospi-
736 tal may introduce bias associated with policies or practices at the
737 hospital or within the specialties of the nurses. The bias may be
738 further accentuated by the volunteer sampling methodology and
739 recruitment materials which indicated that the study focused on
740 drowsy driving. These methods may have facilitated participation
741 by nurses who felt strongly about drowsy driving. Beyond these
742 factors, the timing of the interviews—after the night-shift—may
743 have influenced the nurses' abilities to recall experiences or pro-
744 vide adequate feedback on education and technology. Finally, sim-
745 ilar to other qualitative data analysis methods, our coding may be
746 subject to individual biases. Despite these limitations, the consid-
747 erable connection between our findings and that of prior broader
748 studies suggests at least some validity in the novel findings. Future
749 work should address these limitations through a broader, multi-
750 hospital sample and mixed methods such as surveys and focus
751 groups. In addition, the findings here suggest a future need to as-
752 sess the effectiveness of current training and technological meth-
753 ods for drowsy driving crash prevention.

754 5. Conclusions

755 Interviews were conducted with night-shift nurses in a large
756 hospital in Texas to understand drowsy driving perceptions, mit-
757 igation methods used, and nurses' preferences for educational and
758 technological interventions. Our findings suggest that drowsy driv-
759 ing is perceived to be pervasive among the night-shift nurses.
760 Nurses claimed to use a variety of methods to mitigate drowsy
761 driving; however, most of these methods are not evidence-based
762 and some have shown to be ineffective. While nurses exhibit a
763 high degree of readiness for educational and in-vehicle technologi-
764 cal interventions, such interventions are rarely used in healthcare
765 settings and are timely. Work is in progress to address these is-
766 sues through the design and evaluation of several nurse-centered
767 interventions.

768 Conflicts of Interest

769 None.

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Appendices

Appendix A. Questions for the semi-structured interview

- Prevalence of Drowsy Driving
 - Is drowsy driving a problem among nurses in general?
 - How/Why?
 - How often do YOU experience sleepiness or drowsiness while driving?
 - How many days of the week do you experience drowsy driving?
 - When do you experience more drowsiness while driving - To Home or to Work?
 - If happens: Why do you continue to drive when you feel drowsy?
 - Are there any techniques you use to stay awake while driving?
 - How often do other nurses experience sleepiness or drowsiness while driving?
 - If happens: Why do they continue to drive when they feel drowsy?
 - Are there any techniques other nurses use to stay awake while driving?
 - How does your work as a nurse contribute to your drowsiness?
 - Do you ever experience drowsiness while you are working?
 - Do other nurses experience drowsiness while they are working?
 - Education Programs
 - What are some of the past educational tools or trainings that you've used for drowsy driving?
 - What was the format of the training?
 - What does an ideal training or course for drowsy driving look like?
 - What specific content should be covered?
 - What is the most appropriate format for such training?
 - How long would the ideal training or course be?
 - Technology
 - If there was some sort of technological device to help you stay awake while driving what would it look like?
 - What type of feedback do you expect from a technology that can detect drowsiness?
 - Do you find it acceptable to have an auditory warning (such as a beep) to notify you about drowsy driving or alert you?
 - What about video monitoring to detect eye closure?
 - This technology does not infringe upon your privacy as it does not store any data.
- Is there anything else you would like to share?

CRediT authorship contribution statement

Alec Smith: Methodology, Formal analysis, Investigation, Data curation, Writing - original draft. **Anthony D. McDonald:** Conceptualization, Formal analysis, Data curation, Writing - original draft, Supervision, Project administration, Funding acquisition. **Farzan Sasangohar:** Conceptualization, Methodology, Investigation, Writing - original draft, Supervision, Funding acquisition.

References

- Åkerstedt, T., 1998. Shift work and disturbed sleep/wakefulness. *Sleep Med. Rev.* 2, 117–128. [https://doi.org/10.1016/S1087-0792\(98\)90004-1](https://doi.org/10.1016/S1087-0792(98)90004-1).
- Berger, A., Hobbs, B., 2006. Impact of shift work on the health and safety of nurses and patients. *Clin. J. Oncol. Nurs.* 10, 465–471.
- Blouin, A.S., Smith-Miller, C.A., Harden, J., Li, Y., 2016. Caregiver fatigue implications for patient and staff safety, part 1. *J. Nurs. Adm.* 46, 329–335. <https://doi.org/10.1097/NNA.0000000000000353>.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. <https://doi.org/10.1191/1478088706qp0630a>.
- Bureau of Labor Statistics, 2018. Registered Nurses [WWW Document]. URL <https://www.bls.gov/ooh/healthcare/registered-nurses.htm> (accessed 11.15.18).
- Burnard, P., 1991. A method of analysing interview transcripts in qualitative research. *Nurse Educ. Today* 11, 461–466. [https://doi.org/10.1016/0260-6917\(91\)90009-Y](https://doi.org/10.1016/0260-6917(91)90009-Y).
- Caird, J.K., Simmons, S.M., Wiley, K., Johnston, K.A., Horrey, W.J., 2018. Does Talking on a Cell Phone, With a Passenger, or Dialing Affect Driving Performance? An Updated Systematic Review and Meta-Analysis of Experimental Studies. *Hum. Factors* 60, 101–133. <https://doi.org/10.1177/0018720817748145>.
- Caruso, C.C., 2014. Negative impacts of shiftwork and long work hours. *Rehabil. Nurs.* 39, 16–25. <https://doi.org/10.1002/rnj.107>.
- Caruso, C.C., Baldwin, C.M., Berger, A., Chasens, E.R., Landis, C., Redeker, N.S., Scott, L.D., Trinkoff, A., 2017. Position statement: Reducing fatigue associated with sleep deficiency and work hours in nurses. *Nurs. Outlook* 65, 766–768. <https://doi.org/10.1016/j.outlook.2017.10.011>.
- Caruso, C.C., Geiger-Brown, J., Takahashi, M., Trinkoff, A., Nakata, A., 2015. NIOSH training for nurses on shift work and long work hours.
- Caruso, C.C., Hitchcock, E.M., 2010. Strategies for nurses to prevent sleep-related injuries and errors. *Rehabil. Nurs.* 35, 192–197. <https://doi.org/10.1002/j.2048-7940.2010.tb00047.x>.
- De Veer, A.J.E., Fleuren, M.A.H., Bekkema, N., Francke, A.L., 2011. Successful implementation of new technologies in nursing care: A questionnaire survey of nurse-users. *BMC Med. Inform. Decis. Mak.* 11. <https://doi.org/10.1186/1472-6947-11-67>.
- Dorrian, J., Tolley, C., Lamond, N., van den Heuvel, C., Pincombe, J., Rogers, A.E., Drew, D., 2008. Sleep and errors in a group of Australian hospital nurses at work and during the commute. *Appl. Ergon.* 39, 605–613. <https://doi.org/10.1016/j.apergo.2008.01.012>.
- Edwards, M.P., McMillan, D.E., Fallis, W.M., 2013. Napping during breaks on night shift: Critical care nurse managers' perceptions. *Dynamics* 24, 30–35.
- Fallis, W.M., McMillan, D.E., Edwards, M.P., 2011. Napping during night shift: Practices, preferences, and perceptions of critical care and emergency department nurses. *Crit. Care Nurse* 31. <https://doi.org/10.4037/ccn2011710>.
- Folkard, S., Tucker, P., 2003. Shift work, safety and productivity. *Occup. Med. (Chic. Ill.)* 53, 95–101. <https://doi.org/10.1093/occmed/kqg047>.
- Gaspar, J.G., Brown, T.L., Schwarz, C.W., Lee, J.D., Kang, J., Higgins, J.S., 2017. Evaluating driver drowsiness countermeasures. *Traffic Inj. Prev* 18, S58–S63. <https://doi.org/10.1080/15389588.2017.1303140>.
- Geiger-Brown, J., Sagherian, K., Zhu, S., Wieroniey, M.A., Blair, L., Warren, J., Hinds, P.S., Szeles, R., 2016. Napping on the night shift: A two-hospital implementation project. *Am. J. Nurs.* 116, 26–33. <https://doi.org/10.1097/01.NAJ.0000482953.88608.80>.
- Gold, D.R., Rogacz, S., Bock, N., Tosteson, T.D., Baum, T.M., Speizer, F.E., Czeisler, C.A., 1992. Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. *Am. J. Public Health* 82, 1011–1014. <https://doi.org/10.2105/AJPH.82.7.1011>.
- Graneheim, U.H., Lundman, B., 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ. Today* 24, 105–112. <https://doi.org/10.1016/j.nedt.2003.10.001>.
- Guest, G., MacQueen, K.M., Namey, E.E., 2012. Applied thematic analysis. Sage Publications.
- Heinzmann, J., Tate, D.R.D., Scott, R., 2008. Using technology to eliminate drowsy driving. in: SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production. Society of Petroleum Engineers. <https://doi.org/10.2118/111942-MS>.
- Higgins, J.S., Michael, J., Austin, R., Åkerstedt, T., Van Dongen, H.P.A., Watson, N., Czeisler, C.A., Pack, A.I., Rosekind, M.R., 2017. Asleep at the wheel-The road to addressing drowsy driving. *Sleep* 40, 1–9. <https://doi.org/10.1093/sleep/zsx001>.
- Horne, J., 1988. Why we sleep: The functions of sleep in humans and other mammals. Oxford medical publications, New York, New York, USA.
- Horne, J., Reyner, L., 1996. Counteracting driver sleepiness: Effects of napping, caffeine, and placebo. *Psychophysiology* 33, 306–309. <https://doi.org/10.1111/j.1469-8986.1996.tb00428.x>.
- Hughes, R., Rogers, A.E., 2004. Are You Tired?: Sleep deprivation compromises nurses' health. *Am. J. Nurs.* 104, 36–38.
- Kurumatani, N., Koda, S., Nakagiri, S., Hisashige, A., Sakai, K., Saito, Y., Aoyama, H., Dejima, M., Moriyama, T., 1994. The effects of frequently rotating shiftwork on sleep and the family life of hospital nurses. *Ergonomics* 37, 995–1007. <https://doi.org/10.1080/00140139408963713>.
- Lee, K.A., Lipscomb, J., 2003. Sleep among shiftworkers—a priority for clinical practice and research in occupational health nursing. *Am. Assoc. Occup. Heal. Nurses J.* 51, 418–420.
- Lee, T.T., 2004. Nurses' adoption of technology: Application of Rogers' innovation-diffusion model. *Appl. Nurs. Res.* 17, 231–238. <https://doi.org/10.1016/j.apnr.2004.09.001>.
- Mabry, J.E., Laurel, T., Jeffrey, G., Hickman, S., 2019. Commercial motor vehicle operator fatigue detection technology catalog and review.
- May, J.F., Baldwin, C.L., 2009. Driver fatigue: The importance of identifying causal factors of fatigue when considering detection and countermeasure technologies. *Transp. Res. Part F Traffic Psychol. Behav.* 12, 218–224. <https://doi.org/10.1016/j.trf.2008.11.005>.
- Novak, R.D., Auvil-Novak, S.E., 1996. Focus group evaluation of night nurse shiftwork difficulties and coping strategies. *Chronobiol. Int.* 13, 457–463. <https://doi.org/10.3109/07420529609020916>.
- Retzer, K., Hill, R., Burton, J., 2013. A review of the literature: Motor vehicle safety initiatives in the oil and gas extraction industry. Society of Petroleum Engineers - SPE Americas E and P Health, Safety, Security, and Environmental Conference 2013, pp. 83–95.
- Reyner, L., Horne, J., 2002. Efficacy of a "functional energy drink" in counteracting driver sleepiness. *Physiol. Behav.* 75, 331–335. [https://doi.org/10.1016/S0031-9384\(01\)00669-2](https://doi.org/10.1016/S0031-9384(01)00669-2).
- Reyner, L., Horne, J., 2000. Early morning driver sleepiness: Effectiveness of 200 mg caffeine. *Psychophysiology* 37, 251–256. <https://doi.org/10.1111/1469-8986.3720251>.
- Reyner, L., Horne, J., 1998. Evaluation of 'in-car' countermeasures to sleepiness: Cold air and radio. *Sleep* 21, 46–51. <https://doi.org/10.1093/sleep/21.1.46>.
- Reyner, L., Horne, J., 1997. Suppression of sleepiness in drivers: Combination of caffeine with a short nap. *Psychophysiology* 34, 721–725. <https://doi.org/10.1111/j.1469-8986.1997.tb02148.x>.
- Rh eume, A., Mullen, J., 2018. The impact of long work hours and shift work on cognitive errors in nurses. *J. Nurs. Manag.* 26, 26–32. <https://doi.org/10.1111/jonm.12513>.
- Rogers, A.E., Hwang, W.T., Scott, L.D., Aiken, L.H., Dinges, D.F., 2004. The working hours of hospital staff nurses and patient safety. *Health Aff* 23, 202–212. <https://doi.org/10.1377/hlthaff.23.4.202>.
- Sagherian, K., Clinton, M.E., Abu-Saad Huijter, H., Geiger-Brown, J., 2017. Fatigue, work schedules, and perceived performance in bedside care nurses. *Work. Heal. Saf.* 65, 304–312. <https://doi.org/10.1177/2165079916665398>.
- Schwarz, J.F.A., Ingre, M., Fors, C., Anund, A., Kecklund, G., Taillard, J., Philip, P., Åkerstedt, T., 2012. In-car countermeasures open window and music revisited on the real road: Popular but hardly effective against driver sleepiness. *J. Sleep Res.* 21, 595–599. <https://doi.org/10.1111/j.1365-2869.2012.01009.x>.
- Scott, L.D., Hofmeister, N., Rogness, N., Rogers, A.E., 2010a. An interventional approach for patient and nurse safety: a fatigue countermeasures feasibility study. *Nurs. Res.* 59, 250–258. <https://doi.org/10.1097/NNR.0b013e3181de9116>.
- Scott, L.D., Hofmeister, N., Rogness, N., Rogers, A.E., 2010b. Implementing a fatigue countermeasures program for nurses: A focus group analysis. *J. Nurs. Adm.* 40, 233–240. <https://doi.org/10.1097/NNA.0b013e3181da4078>.
- Scott, L.D., Hwang, W.T., Rogers, A.E., Nysse, T., Dean, G.E., Dinges, D.F., 2007. The relationship between nurse work schedules, sleep duration, and drowsy driving. *Sleep* 30, 1801–1807. <https://doi.org/10.1093/sleep/30.12.1801>.
- Sletten, T.L., Ftouni, S., Nicholas, C.L., Magee, M., Grunstein, R.R., Ferguson, S., Kenaway, D.J., O'Brien, D., Lockley, S.W., Rajaratnam, S.M.W., 2017. Randomised controlled trial of the efficacy of a blue-enriched light intervention to improve alertness and performance in night shift workers. *Occup. Environ. Med.* 74, 792–801. <https://doi.org/10.1136/oemed-2016-103818>.
- Smith-Coggins, R., Howard, S.K., Mac, D.T., Wang, C., Kwan, S., Rosekind, M.R., Sowb, Y., Balise, R., Levis, J., Gaba, D.M., 2006. Improving alertness and performance in emergency department physicians and nurses: The use of planned naps. *Ann. Emerg. Med.* 48, 596–604.e3. <https://doi.org/10.1016/j.annemergmed.2006.02.005>.
- Smith-Miller, C.A., Shaw-Kokot, J., Curro, B., Jones, C.B., 2014. An integrative review: Fatigue among nurses in acute care settings. *J. Nurs. Adm.* <https://doi.org/10.1097/NNA.0000000000000104>.
- Smith, L., Folkard, S., Tucker, P., Macdonald, I., 1998. Work shift duration: A review comparing eight hour and 12 hour shift systems. *Occup. Environ. Med.* 55, 217–229. <https://doi.org/10.1136/oem.55.4.217>.
- Smith, S.S., Kilby, S., Jorgensen, G., Douglas, J.A., 2007. Napping and nightshift work: Effects of a short nap on psychomotor vigilance and subjective sleepiness in health workers. *Sleep Biol. Rhythms* 5, 117–125. <https://doi.org/10.1111/j.1479-8425.2007.00261.x>.
- Steege, L.M., Rainbow, J.G., 2017. Fatigue in hospital nurses – 'Supernurse' culture is a barrier to addressing problems: a qualitative interview study. *Int. J. Nurs. Stud.* 67, 20–28. <https://doi.org/10.1016/j.ijnurstu.2016.11.014>.
- Taillard, J., Capelli, A., Sagaspe, P., Anund, A., Åkerstedt, T., Philip, P., 2012. In-Car nocturnal blue light exposure improves motorway driving: A randomized controlled trial. *PLoS One* 7. <https://doi.org/10.1371/journal.pone.0046750>.
- Takayama, L., Nass, C., 2008. Assessing the effectiveness of interactive media in improving drowsy driver safety. *Hum. Factors* 50, 772–781. <https://doi.org/10.1518/001872008X312341>.
- Tedesco-Schneck, M., 2013. Active learning as a path to critical thinking: Are competencies a roadblock? *Nurse Educ. Pract.* 13, 58–60. <https://doi.org/10.1016/j.nepr.2012.07.007>.
- VERBI Software, 2018. MAXQDA 12 [computer software].

- 948 Weisgerber, D.M., Nikol, M., Mistlberger, R.E., 2017. Driving home from the night
949 shift: a bright light intervention study. *Sleep Med* 30, 171–179. [https://doi.org/](https://doi.org/10.1016/j.sleep.2016.09.010)
950 [10.1016/j.sleep.2016.09.010](https://doi.org/10.1016/j.sleep.2016.09.010).
- 951 White, C.L., 2011. Nurse champions: A key role in bridging the gap between research
952 and practice. <https://doi.org/10.1016/j.jen.2011.04.009>
- 953 Williams, C., 2008. Work-life balance of shift workers.
- Yildirim, D., Aycan, Z., 2008. Nurses' work demands and work-family conflict: A
questionnaire survey. *Int. J. Nurs. Stud.* 45, 1366–1378. [https://doi.org/10.1016/](https://doi.org/10.1016/j.ijnurstu.2007.10.010)
[j.ijnurstu.2007.10.010](https://doi.org/10.1016/j.ijnurstu.2007.10.010).
- Zion, N., Shochat, T., 2019. Let them sleep: The effects of a scheduled nap during the
night shift on sleepiness and cognition in hospital nurses. *J. Adv. Nurs.* <https://doi.org/10.1111/jan.14031>.