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Drowsy and Dangerous? Fatigue in Paramedics: An Overview

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LITERATURE REVIEW

DROWSY AND DANGEROUS? FATIGUE IN PARAMEDICS: AN OVERVIEW

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Abstract

Background

Fatigue is a complex phenomenon that has effects on physical characteristics, cognition, behaviours, and physical and mental health. Paramedicine crosses the boundaries of many high-risk industries, namely medicine, transport and aviation. The effects of fatigue on paramedics thus need to be explored and considered in order to begin to identify appropriate interventions and management strategies.

Aim

The aim of this article was to provide an overview of fatigue in paramedics and its potential effects on various areas of practice and provider health, and to outline potential solutions to assess and manage the risk of fatigue in paramedics as suggested by the literature.

Methods

We conducted unstructured, non-systematic searches of the literature in order to inform an overview of the literature. An overview is a summary of the literature that attempts to survey the literature and describe its characteristics. We thematically structured the review under the following headings: defining occupational activity and health status; clinical performance and patient safety; shift length and time at work; effects on paramedic health; effects on driving abilities; fatigue risk management; and, fatigue proofing.

Discussion

Fatigue should be considered in the context of overall paramedic health status and paramedic occupational activity. The nature of paramedic shift work, and the associated occupational activity place paramedics at increased risk from fatigue. Shift work may also contribute to sleep disorders among paramedics. Fatigue is associated with increased errors and adverse events, increased chronic disease and injury rates, depression and anxiety, and impaired driving ability.

Conclusion

The issue of fatigue in paramedicine is complex and has serious consequences for patients and paramedics. Paramedic services and paramedics need to work collaboratively to identify and action appropriate measures to reduce the effects of fatigue on the wellbeing of the workforce and mitigate its effects on clinical performance and safety.

Keywords: fatigue; paramedic; EMS; mental health; physical health; sleep

Introduction

Fatigue is a complex phenomenon that is not particularly well defined in the literature. Often simplified to sleepiness, or tiredness, it is a complex interplay of physical, psychological, socioeconomic, and environmental factors that affect both mind and body. (1) Some argue that fatigue, and the physiological impairment that can result, are separate, distinct and need to be clearly distinguished from one another. Causative factors in fatigue are the length of continuous work spells and daily duty periods, time available for rest and continuous sleep, and the arrangement of duty, rest, and sleep periods within each 24-h cycle.(1) In addition, the underlying health status of the paramedic is an important factor in the development of fatigue including sleep quality, diet, stress levels, and mental health.

Fatigue is an entirely subjective, personal experience (2), and can manifest itself differently from one person to another. One individual may not feel fatigued but may demonstrate impaired functioning. Alternatively, another individual may demonstrate adequate performance, but may experience extreme tiredness or discomfort.(1) Paramedicine is a high risk, high reliability work environment that places significant demands on the paramedic with potential for harm to patients and the workers. Paramedic practice also crosses the boundaries of several high risk industries including medicine, and transport. As such the effects of fatigue on paramedics need to be explored in order to begin to identify appropriate interventions and management strategies.

Aim

The aim of this article was to provide an overview of fatigue in paramedics and its potential effects on several identified areas of practice and provider health, and to outline potential solutions to assess and manage the risk of fatigue in paramedics as suggested in the literature.

Methods

We conducted unstructured, non-systematic searches various electronic databases (MEDLINE, CINAHL, EMBASE, Google Scholar) using combinations of keywords and subject headings where appropriate including paramedic, Emergency Medical Services (EMS), fatigue, driving, 'mental health', obesity, 'patient safety'. An overview is a summary of the literature that attempts to survey the literature and describe its characteristics, and aim to *"provide a broad and often comprehensive summation of a topic area and, as such, have value for those coming to a subject for the first time"* (3). It is not intended to be exhaustive in its identification of the literature. We structured the overview thematically under the following headings: defining occupational activity and health status; clinical performance and patient safety; shift length and time at work; effects on paramedic health; effects on driving abilities; fatigue risk management; and, finally fatigue proofing.

Defining paramedic occupational activity & health status

When considering fatigue in paramedics, it is first important to define paramedic occupational activity, and the health status of paramedics. Paramedics are noted to adapt or fit the delivery of care into their work context: the unpredictable out-of-hospital environment, which makes them relatively unique in the world of healthcare.(4) While paramedic work can be very unpredictable, the following demands could be expected in carrying out the occupational tasks: standing/walking, sitting, lifting and carrying, bending, crouching/kneeling, climbing, reaching, pushing/pulling and handling/grasping (5), in a work environment that can follow a rotating schedule. These demands and their effect on the development of fatigue have not been well quantified in the literature. What has been well reported is that paramedics have high injury rates compared to other occupations (6,7), with resultant rates of sick time and worker's compensation claims that are significant.(8,9) Additionally, paramedics have markers of poor health status such as elevated Body Mass Index (BMI) (10–13), cardiovascular disease with a high prevalence of hypertension (14–16), and low rates of exercise.(11)

Physiological response to paramedic occupational tasks has also not been well studied. In one of the first studies of the cardiorespiratory physiological demands of

paramedics Gamble et al. (1991) monitored heart rate in 8 paramedics in Northern Ireland over a total of 21 shifts. The data showed periods of high activity that included CPR and carrying patients that resulted in heart rates above anaerobic threshold for periods of up to 11 minutes.(17) As well as the physical demands, other occupational stressors can elicit heart rate responses. Karlsson et al. (2009) noted that paramedics exhibited significant increases in heart rate not related to physical exertion of an emergency call and postulated that this was due to other occupational stressors (for instance responding to a report of an ill child).(18) Similarly, level of care influenced heart rate response. Paramedics were observed to have significantly higher heart rate changes (in beats per minute) on the intensive care unit as opposed to the patient transport unit (30 ± 17 bpm versus 7 ± 8 bpm respectively, $p< 0.001$).(19) The implication for paramedics, especially those whose health status is low, is that they may be more prone to fatigue with increased heart rate response due to physical or occupational stressors.

Clinical performance and patient safety

By taking cues from other industries, it is demonstrable how fatigue is directly related to performance in shift work.(20–23) A growing body of evidence suggests that fatigue in paramedics can potentially have an inverse relationship with performance. It is estimated that between 10% and 55% of EMS clinicians suffer from severe mental and/or physical fatigue.(24–27) Increased levels of fatigue are associated with compromise in cognitive function (28,29), impaired task performance (30); increased error and accident rates, and ultimately reduced safety.(31) Patterson et al. demonstrated that paramedics who were fatigued (OR 2.3, 95% CI 1.5, 3.3) or reported poor sleep quality (OR 1.5, 95%CI 1.0, 2.1) were more likely to report an error or adverse event in practice.(25) In addition, they demonstrated that the odds of committing an error or adverse event, or of engaging in safety-compromising behaviours were 2.2 (95% CI 1.4, 3.3) times greater and 3.6 (95% CI 1.5, 8.3) times greater, respectively, among the fatigued EMS clinicians than the non-fatigued.(32) Donnelly et al. concluded that injury or exposure ($p=<0.02$), safety compromising behaviours ($p=<0.01$) and medication errors ($p=0.01$) are all significantly related to fatigue.(33)

Nurses also suffer from the effects of fatigue. Those who reported an error or near miss obtained significantly less sleep than nurses who did not report an error or near miss.(34) Compared with day shifts, risks of injury or error are 28% higher for night shifts. When compared with 8-hour shifts, 12-hour shifts increased risk of injury or error by 28%.(35) Working overtime, whether at the end of a regularly scheduled shift (even an 8-hour shift) or working more than 40 hours in a week, is associated with an increase in the risk of an error.(36,37) Accident rates increased during extended periods of work: they rose after 9 hours, doubled after 12 consecutive hours, and tripled by 16 consecutive hours of work.(38,39)

Effects on paramedic health

Fatigue experienced by paramedics and other healthcare professionals is associated with an increased risk of depression and anxiety.(40) Paramedics have previously scored in the above normal ranges for depression (36.1%), anxiety (24.6%), and stress (39.3%).(41) The risk appeared similar among shift working paramedics in both rural and metropolitan areas.(41) Sofianopoulos et al. (2011) concluded that 26.7% of paramedics studied in relation to fatigue had a mild likelihood of depression, 10% had a moderate likelihood, and 1.7% had a severe likelihood.(42) Fatigue is also associated with burnout and lack of support from management.(32) Given recent evidence suggesting that paramedics and EMS personnel are more susceptible to suicidal ideation than other first responders (43,44), this potential link between fatigue and paramedic mental health is concerning.

Shift work, and working extended shifts (> 8 hours) have adverse effects on worker health, including increased risk of chronic disease, obesity, and risk of injury or accident.(45) Paramedics may have a higher prevalence of sleep disorders than other healthcare professionals (46), and left untreated, those problems could increase morbidity and mortality and potentially impair professional performance. An often overlooked area is the difference between sleep opportunity and actual sleep or rest. Shift workers suffer

from many different sleep pathologies, and aspects of their job lead to sleep periods that are not restful or restorative. A majority (68%) of Australian paramedics studied reported poor sleep quality.(42) Paramedics may identify as being fatigued even when the period of "rest time" between shifts is considered adequate. There is convincing evidence that sleep duration is linked to metabolism and the regulation of appetite, and decreased sleep times may contribute to increased obesity rates. The link between sleep and maintenance of a healthy weight is well documented and there is a demonstrated association between sleep loss and an increased risk of obesity and type 2 diabetes.(47,48)

Effects on driving abilities

Fatigue is considered to be the largest identifiable and preventable cause of accidents in transport operations (between 15 to 20% of all accidents), surpassing that of alcohol or drug related incidents in all modes of transportation.(49) Official statistics often underestimate this contribution, and as such, fatigue is insufficiently recognized and reported as a cause of road accidents.(1) Fatigue, and sleep deprivation can cause impairment similar to that caused by alcohol intake.(50,51) The effects of fatigue on driving stem largely from prolonged and irregular working hours, such as alternating day and night shift patterns familiar to many paramedics, rather than simply from time spent at the wheel. Alertness, vigilance, concentration, judgment, mood and performance are all significantly affected by fatigue (42,52–54), and drivers are encouraged to avoid driving after sleep restriction, even on relatively short trips especially if they feel sleepy.(55) A 2009 study in Japan suggested that a modified night shift (which ensured time for paramedics to take long, restful power naps) alleviated subjective fatigue, and improved physiological function which are often adversely affected by night workload.(56)

Fatigue risk management in paramedic services

High risk professions that require high reliability in decision making and performance are therefore subject to risk as a result of physical and cognitive fatigue. Traditional approaches to fatigue management have mainly attempted to limit shift length and promote adequate rest between shifts. This approach may have inadequate impact, especially for workers on night shift and in professions such as emergency services where periods of effort and cognitive load are often unpredictable and have a high potential for sustained periods. Many high risk, high reliability professions have adopted Safety Management Systems (SMS).(57) Paramedicine crosses the boundaries of many of these industries: medicine, transport and aviation. It therefore stands to reason that a paramedic service should have a robust SMS that incorporates fatigue management as a key principle in the reduction of risk, prevention of errors, and enhancement of patient and paramedic safety. Paramedicine faces some unique challenges in this regard in that paramedic services are often designed to respond to emergencies, and perform interfacility transfers. This crossing of boundaries may present challenges when looking to the evidence in other sectors.

The Threat Error Management (TEM) model developed for aviation Crew Resource Management (CRM) provides a model that focuses on individual, team and organizational interventions to reduce threats and hazards.(58) The TEM model approaches threat and error management as a partnership and joint responsibility between workers and an organization. The mainstay of this approach is the requirement for a just culture and collaborative safety model. Organizations that are able to implement such a model are considered to have mature SMS programs. Based on the work of Dawson and McCulloch (57), a Fatigue Risk Management System (FRMS) applies four defensive layers to an SMS program.

1. Sleep Opportunity, shift work patterns, strategic rostering and fatigue modelling tools;
2. Sleep logging: opportunity and actual;
3. Symptoms checklist, self-report behaviour scales, physiological monitoring;
4. Fatigue proofing strategies, SMS error and near miss reporting.

Despite all of these layers of defence built into an FRMS there is still high potential of error or accident resulting from fatigue. A collaborative culture of safety, and just

culture, needs to be present to continually improve the mitigation of these risks following an event. Organizations with a reliance on a prescriptive policy and compliance through punitive means may struggle to build an effective SMS approach which depends on a trusting and open reporting culture.(59) Steps in building such a system include revisiting workplace policies and guidelines using a just culture approach. Incorporating human factors and an end-user design process has been shown to build a positive work culture with greater trust when designing for patient and worker safety.

Fatigue Proofing

Even with the implementation of robust FRMS using lessons learned from other industries, overall fatigue risk management still requires individual action and cultural buy in. The effects of fatigue on performance may be downplayed or individuals may consider that fatigue does not impact them.(60) This culture likely exists within paramedic services. Even with FRMS designed to reduce the risk of fatigued individuals in the workplace, it is very likely that this will still occur. Organizations therefore also need to build in fatigue-proofing systems, which act as risk-reduction behaviours when fatigued individuals are still in the workplace.(61,62) Often fatigue-proofing happens informally and naturally.(61,63) There are a number of common fatigue proofing strategies previously discussed in this article including: caffeine, napping, and exercise.

These strategies are also outlined in national fatigue guidelines developed in the US (62), along with their associated outcome measures.(64) Less commonly discussed fatigue proofing strategies can be divided into task related and behaviour related adaptations.(65) Task related adaptations include task slowing, delegation, cross-checking, and task rotation between individuals. The primary behavioural adaptation involves increasing the amount of verbalisation of steps during the performance of complex tasks. Fatigue proofing tends to develop organically within organizations, but can have significant impacts on avoidance of fatigue related errors.(65) Logging of opportunity versus actual sleep can yield valuable data. Paramedic services can also identify high risk areas for fatigue related errors through incident review and staff focus groups. These can then be used as targets for fatigue proofing strategies, and services can work with staff to improve and enhance the informally developed fatigue proofing strategies as a component of the FRMS.

Recommendations

Further research is urgently required in relation to fatigue in paramedics. In particular, this review has highlighted the need for research on paramedic health status as the foundation for future research into fatigue and its impact on paramedics. The safety impact of shift length and pattern raises questions – if medication errors occur, when do they happen? Are they related to extended shift patterns, time of day/night? Are there other factors to consider such as paramedics activities on rest days, or working multiple jobs? Does the reliance on “on-call” staff in rural and remote areas contribute to fatigue in these workers?

Fatigue management should be incorporated into paramedic education in order to prepare new entrants for entry to practice, and practicing paramedics should also be offered education and resources. The best method to achieve this requires further investigation. Further, the implementation of robust SMS and FRMS approaches within paramedic services warrants research and dissemination.

Limitations

This overview is subject to a number of limitations. We did not conduct reproducible, structured searches in our search for literature. As this was an overview designed to provide a broad and comprehensive summation, we agreed that structured searches limited to fatigue in paramedicine would not have enabled us to explore related issues that were relevant from other industries. As such, we may not have identified all relevant literature. We did not conduct a quality assessment on any of the identified literature.

Conclusion

Fatigue is a complex, multi-faceted issue within paramedic practice, and paramedic services. It is both caused by, and a symptom of other system issues such as shift length,

case complexity, and workload, in combination with individual health status, stress levels, lifestyle, and mental health. Fatigue risk management is a shared responsibility of both the paramedics and the organisation and it needs to be considered an integral part of the organisational culture. Without the support of management, paramedics may feel disenfranchised and undervalued. This support should focus on strategies to mitigate the increased risk of burnout, job dissatisfaction, and absences that are associated with fatigue in healthcare providers.(66) Building positive work cultures leads to an environment that can mitigate fatigue risk in the paramedic work environment. As this trust is built and matured; the system can engage staff in discussion that identifies cultural safety nets that can be formalized and areas identified for improvement, further building towards an environment of self-reporting and self-identification of hazards, risks and proactive prevention through cooperation. Paramedics need to be supported when they make risk assessments regarding their fatigue levels. Fatigue management can include changes to shift patterns, restriction of overtime after night shifts including shorter duration of shifts, scheduled breaks, education and resources on fatigue management, and monitoring of fatigue levels. In addition, it can incorporate lifestyle changes, access to occupational health services, input from sleep specialists, and a myriad of other strategies that can be considered by services willing to invest in the wellbeing of paramedics and patients.

References

1. Brown ID. Driver Fatigue. Hum Factors [Internet]. 1994 Jun 23;36(2):298–314. Available from: https://doi.org/10.1177/001872089403600210
2. Bartley SH, Chute E. Fatigue and impairment in man. [Internet]. Fatigue and impairment in man. New York, NY, US: McGraw-Hill Book Company; 1947. ix, 429-ix, 429. Available from: https://doi.org/10.1037/11772-000
3. Grant MJ, Booth A. A typology of reviews: An analysis of 14 review types and associated methodologies. Health Info Libr J [Internet]. 2009;26(2):91–108. Available from: https://doi.org/10.1111/j.1471-1842.2009.00848.x
4. Bell RC. The Ambulance: A History [Internet]. McFarland & Company; 2009. Available from: https://books.google.ca/books?id=-YtlthqHmHsC
5. Bureau of Labor Statistics. Occupational Outlook Handbook, EMTs and Paramedics. [Internet]. 2018 [cited 2019 Feb 8]. Available from: https://www.bls.gov/ooh/healthcare/emts-and-paramedics.htm#tab-3
6. Maguire BJ, Smith S. Injuries and Fatalities among Emergency Medical Technicians and Paramedics in the United States. Prehosp Disaster Med [Internet]. 2013 Aug 9;28(04):376–82. Available from: https://doi.org/10.1017/S1049023X13003555
7. Maguire BJ, O'Meara PF, Brightwell RF, O'Neill BJ, Fitzgerald GJ. Occupational injury risk among Australian paramedics: an analysis of national data. Med J Aust [Internet]. 2014 May 5;200(8):477–80. Available from: https://doi.org/10.5694/mja13.10941
8. Gray S, Collie A. Worker's compensation claims among nurses and ambulance officers in Australia, 2008/09-2013/14. [Internet]. Melbourne; 2016. Available from: https://www.iscrr.com.au/__data/assets/pdf_file/0004/487552/workers-compensation-claims-among-nurses-and-ambulance-officers-in-Australia-20082014.pdf
9. Goodwin I. Report on Health. Report on Health 2017. Sydney; 2017.
10. Buzga M, Jirak Z, Buzgova R. State of physical health and fitness of paramedics in Czech republic. Wulfenia. 2015;22(3).
11. MacQuarrie AJ, Robertson C, Micalos P, Crane J, High R, Drinkwater E, et al. Fit for duty: The health status of New South Wales Paramedics. Irish J Paramed [Internet]. 2018;3(2). Available from: https://doi.org/10.32378/ijp.v3i2.109
12. Studnek JR, Bentley M, Mac Crawford J, Fernandez AR. An Assessment of Key Health Indicators among Emergency Medical Services Professionals. Prehospital Emerg Care [Internet]. 2010 Jan 30;14(1):14–20. Available from: https://doi.org/10.3109/10903120903144957
13. Hegg Deloye S. Work-related and Dietary Factors Associated with Weight Gain over the Period of Employment in Paramedics. Occup Med Heal Aff [Internet].

2014;02(04). Available from: https://doi.org/10.4172/2329-6879.1000173
14. Boreham CA, Gamble RP, Wallace WF, Cran GW, Stevens AB. The health status of an ambulance service. Occup Med [Internet]. 1994;44(3):137–40. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7919297
15. Kales SN, Tsismenakis AJ, Zhang C, Soteriades ES. Blood Pressure in Firefighters, Police Officers, and Other Emergency Responders. Am J Hypertens [Internet]. 2009 Jan 1;22(1):11–20. Available from: https://doi.org/10.1038/ajh.2008.296
16. Hegg-Deloye S, Brassard P, Prairie J, Larouche D, Jauvin N, Poirier P, et al. Prevalence of risk factors for cardiovascular disease in paramedics. Int Arch Occup Environ Health [Internet]. 2015 Oct 6;88(7):973–80. Available from: https://doi.org/10.1007/s00420-015-1028-z
17. Gamble RP, Stevens AB, McBrien H, Black A, Cran GW, Boreham CAG. Physical-Fitness and Occupational Demands of the Belfast Ambulance Service. Br J Ind Med. 1991;48(9):592–6.
18. Karlsson K, Niemelä P, Jonsson A. Heart Rate as a Marker of Stress in Ambulance Personnel: A Pilot Study of the Body's Response to the Ambulance Alarm. Prehosp Disaster Med [Internet]. 2011 Feb 25;26(01):21–6. Available from: https://doi.org/10.1017/S1049023X10000129
19. Backe EM, Kaul G, Klussmann A, Liebers F, Thim C, Massbeck P, et al. Assessment of salivary cortisol as stress marker in ambulance service personnel: comparison between shifts working on mobile intensive care unit and patient transport ambulance. Int Arch Occup Environ Health [Internet]. 2009 Oct;82(9):1057–64. Available from: https://doi.org/10.1007/s00420-009-0428-3
20. Caruso C, Hitchcock R. Russo. J. Schimt, J. ED, Anonymous. Overtime and Extended Work Shifts: Recent findings on illness, injuries and health behaviours. Natl Inst Occup Saf Heal [Internet]. 2004; Available from: https://doi.org/10.1109/IEMBS.2009.5333242
21. Ashish jha, Duncan B, Bates D. Fatigue, Sleepiness, and Medical Errors. In: Making health care safer: a critical …. 2001.
22. West CP, Tan AD, Habermann TM, Sloan JA, Shanafelt TD. Association of resident fatigue and distress with perceived medical errors. JAMA - J Am Med Assoc [Internet]. 2009; Available from: https://doi.org/10.1001/jama.2009.1389
23. Monaco K, Williams E. Assessing the Determinants of Safety in the Trucking Industry. J Transp Stat. 2000;3(1):69–79.
24. van der Ploeg E. Acute and chronic job stressors among ambulance personnel: predictors of health symptoms. Occup Environ Med [Internet]. 2003;60(>90001):40i–46. Available from: http://oem.bmj.com/cgi/doi/10.1136/oem.60.suppl_1.i40
25. Patterson PD, Weaver MD, Frank RC, Warner CW, Martin-Gill C, Guyette FX, et al. Association Between Poor Sleep, Fatigue, and Safety Outcomes in Emergency Medical Services Providers. Prehospital Emerg Care [Internet]. 2012 Jan 5;16(1):86–97. Available from: https://doi.org/10.3109/10903127.2011.616261
26. Patterson PD, Suffoletto BP, Kupas DF, Weaver MD, Hostler D. Sleep Quality and Fatigue Among Prehospital Providers. Prehospital Emerg Care [Internet]. 2010 Jun 3;14(2):187–93. Available from: https://doi.org/10.3109/10903120903524971
27. Donnelly E, Bradford P, Hedges C, Davis M, Socha D, Morasutti P. Fatigue, shiftwork, and safety outcomes in Canadian paramedics. Prehospital Emerg Care. 2017;21(1):119.
28. Harrison Y, Horne JA. The impact of sleep deprivation on decision making: a review. J Exp Psychol Appl [Internet]. 2000 Sep;6(3):236–49. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11014055
29. Lim J, Wu W, Wang J, Detre JA, Dinges DF. Perfusion Study of the Time-On-Task Effect. Neuroimage. 2010;49(4):3426–35.
30. Gillberg M, Kecklund G, Åkerstedt T. Sleepiness and performance of professional drivers in a truck simulator - Comparisons between day and night driving. J Sleep Res. 1996;5(1):12–5.

31. Williamson A, Lombardi DA, Folkard S, Stutts J, Courtney TK, Connor JL. The link between fatigue and safety. Accid Anal Prev [Internet]. 2011;43(2):498–515. Available from: http://dx.doi.org/10.1016/j.aap.2009.11.011
32. Patterson PD, Weaver MD, Hostler D, Guyette FX, Callaway CW, Yealy DM. The Shift Length, Fatigue, and Safety Conundrum in EMS. Prehospital Emerg Care [Internet]. 2012; Available from: https://doi.org/10.3109/10903127.2012.704491
33. Donnelly E, Bradford P, Hedges C, Davis M, Socha D, Winter E. Stress and safety in EMS: How work-related stresses and fatigue relate to safety outcomes. Prehospital Emerg Care. 2016;20(1):159.
34. Fletcher A, Dawson D. A quantitative model of work-related fatigue: Empirical evaluations. Ergonomics [Internet]. 2001;44(5):475–88. Available from: https://doi.org/10.1080/00140130119824
35. Folkard S, Lombardi DA. Modeling the impact of the components of long work hours on injuries and "accidents." Am J Ind Med [Internet]. 2006;49(11):953–63. Available from: https://doi.org/10.1002/ajim.20307
36. Scott LD, Rogers AE, Hwang W-T, Zhang Y. Effects of critical care nurses' work hours on vigilance and patients' safety. Am J Crit care [Internet]. 2006 Jan;15(1):30–7. Available from: https://doi.org/10.4037/ajcc2012607
37. Rogers AE, Hwang WT, Scott LD, Aiken LH, Dinges DF. The working hours of hospital staff nurses and patient safety. Health Aff. 2004;23(4):202–12.
38. Hanecke K, Tiedemann S. Original articles Accident risk as a function of hour at work and time of day as determined from accident data and exposure models for the German working population. 2011;28(6):43–8. Available from: https://doi.org/10.1073/pnas.1524845114
39. Folkard S, Tucker P. Shift work, safety and productivity. Occup Med (Chic Ill). 2003;53(2):95–101.
40. Courtney JA, Francis AJP, Paxton SJ. Caring for the country: Fatigue, sleep and mental health in Australian rural paramedic shiftworkers. J Community Health. 2013;
41. Courtney JA, Francis AJP, Paxton SJ. Caring for the Carers: Fatigue, Sleep, and Mental Health in Australian Paramedic Shiftworkers. Aust New Zeal J Organ Psychol [Internet]. 2010; Available from: https://doi.org/10.1375/ajop.3.1.32
42. Sofianopoulos S, Williams B, Archer F, Thompson B. The exploration of physical fatigue, sleep and depression in paramedics: a pilot study. J Emerg Prim Heal Care [Internet]. 2011;9(1):Article 990435. Available from: https://doi.org/10.1017/CBO9781107415324.004
43. Carleton RN, Dobson KS, Keane TM, Afifi TO, Turner S, Taillieu T, et al. Suicidal Ideation, Plans, and Attempts Among Public Safety Personnel in Canada. Can Psychol [Internet]. 2018;59(3):220–31. Available from: http://proxy1.calsouthern.edu/login?url=https://search.proquest.com/docview/2108802706?accountid=35183
44. Vigil NH, Grant AR, Perez O, Blust RN, Chikani V, Vadeboncoeur TF, et al. Death by Suicide—The EMS Profession Compared to the General Public. Prehospital Emerg Care [Internet]. 2018 Sep 14;0(0):1–6. Available from: http://dx.doi.org/10.1080/10903127.2018.1514090
45. Caruso CC. Negative Impacts of Shiftwork and Long Work Hours. Rehabil Nurs [Internet]. 2014 Jan;39(1):16–25. Available from: https://doi.org/10.1002/rnj.107
46. Dianne L Elliot and Kerry s keuhl. Effects of Sleep Deprivation on Fire Fighters and EMS Responders. Int Assoc Fire Chiefs [Internet]. 2007;1–104. Available from: https://aams.org/toolbox/IAFC - Effects of Sleep Deprivation Report.pdf
47. Pannain S, Beccuti G, Van Cauter E. The connection between sleep loss, obesity, and type 2 diabetes. In: Sleep Loss and Obesity: Intersecting Epidemics [Internet]. 2012. Available from: https://doi.org/10.1007/978-1-4614-3492-4_10
48. Beccuti G, Pannain S. Sleep and obesity [Internet]. Current Opinion in Clinical Nutrition and Metabolic Care. 2011. Available from: https://doi.org/10.1097/MCO.0b013e3283479109
49. Akerstedt T. Consensus statement: fatigue and accidents in transport operations. J Sleep Res [Internet]. 2000;9(4):395. Available from: https://doi.org/10.1046/

j.1365-2869.2000.00228.x
50. Williamson AM, Feyer A. Moderate sleep deprivation produces impairments in cognitive and motor perfor ... Heal (San Fr. 2000;649–55.
51. Haraldsson P-O, Åkerstedt T. Sleep disturbances - Greater traffic hazard than alcohol. Causes, risks and treatment. Lakartidningen [Internet]. 2001; Available from: https://doi.org/10.1109/ICMLC.2008.4620583
52. Dinges DF. An overview of sleepiness and accidents. J Sleep Res [Internet]. 1995 Dec;4:4–14. Available from: https://doi.org/10.1111/j.1365-2869.1995.tb00220.x
53. Kribbs NB, Dinges D. Vigilance decrement and sleepiness. In: Sleep onset: Normal and abnormal processes [Internet]. 1994. Available from: https://doi.org/10.1037/10166-000
54. Haraldsson PO, Carenfelt C, Laurell H, Tornros J. Driving vigilance simulator test. Acta Otolaryngol [Internet]. 1990; Available from: https://doi.org/10.3109/00016489009122528
55. Philip P, Sagaspe P, Moore N, Taillard J, Charles A, Guilleminault C, et al. Fatigue, sleep restriction and driving performance. Accid Anal Prev [Internet]. 2005;37(3):473–8. Available from: https://doi.org/10.1016/j.aap.2004.07.007
56. Takeyama H, Itani T, Tachi N, Sakamura O, Murata K, Inoue T, et al. Effects of a modified ambulance night shift system on fatigue and physiological function among ambulance paramedics. J Occup Health [Internet]. 2009;51(3):204–9. Available from: https://doi.org/10.1539/joh.L7040
57. Dawson D, McCulloch K. Managing fatigue: It's about sleep [Internet]. Sleep Medicine Reviews. 2005. Available from: https://doi.org/10.1016/j.smrv.2005.03.002
58. Helmreich RL, Klinect JR, Wilhelm JA. Models of threat, error and response in flight operations. Tenth Int Symp Aviat Psychol. 1999;677–82.
59. Reason J. Human Factors Aspects of Safety Management Systems. In: Proceedings of the 15th Annual FAA/TC/CAA Maintenance Human Factors Symposium. London; 2001.
60. Steege LM, Rainbow JG. Fatigue in hospital nurses — 'Supernurse' culture is a barrier to addressing problems: A qualitative interview study. Int J Nurs Stud. 2017;
61. Dawson D, Chapman J, Thomas MJW. Fatigue-proofing: A new approach to reducing fatigue-related risk using the principles of error management [Internet]. Sleep Medicine Reviews. 2012. Available from: https://doi.org/10.1016/j.smrv.2011.05.004
62. Patterson PD, Higgins JS, Van Dongen HPA, Buysse DJ, Thackery RW, Kupas DF, et al. Evidence-Based Guidelines for Fatigue Risk Management in Emergency Medical Services. Prehospital Emerg Care [Internet]. 2018;22(S1):89–101. Available from: https://doi.org/10.1080/10903127.2017.1376137
63. Dawson D, Mayger K, Thomas MJW, Thompson K. Fatigue risk management by volunteer fire-fighters: Use of informal strategies to augment formal policy. Accid Anal Prev [Internet]. 2015; Available from: https://doi.org/10.1016/j.aap.2015.06.008
64. Martin-Gill C, Higgins JS, Van Dongen HPA, Buysse DJ, Thackery RW, Kupas DF, et al. Proposed Performance Measures and Strategies for Implementation of the Fatigue Risk Management Guidelines for Emergency Medical Services. Prehospital Emerg Care [Internet]. 2018;22(S1):102–9. Available from: https://doi.org/10.1080/10903127.2017.1381791
65. Dawson D, Cleggett C, Thompson K, Thomas MJW. Fatigue proofing: The role of protective behaviours in mediating fatigue-related risk in a defence aviation environment. Accid Anal Prev [Internet]. 2017; Available from: https://doi.org/10.1016/j.aap.2015.10.011
66. Mathew JJ, Joseph M, Britto M, Joseph B. Shift work disorder and its related factors among health-care workers in a tertiary care hospital in Bangalore, India. Pakistan J Med Sci [Internet]. 2018; Available from: https://doi.org/10.12669/pjms.345.16026