

Managing Truck Drivers' Fatigue: A Critical Review of the Literature and Recommended Remedies

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Abstract—In recent years, much attention has been given to truck drivers' fatigue management. Long working hours negatively influence truck drivers' physiology, health, and safety. However, there is little empirical research in the heavy vehicle transport sector in Australia to identify the influence of working hours' management on drivers' fatigue and consequently, on the risk of crashes and injuries. There is no national legislation regulating the number of hours or kilometres travelled by truck drivers. Consequently, it is almost impossible to define a standard number of hours or kilometres for truck drivers in a safety management system. This paper reviews the existing studies concerning safe system interventions such as tachographs in relation to fatigue caused by long working hours. This paper also reviews the literature to identify the influence of frequency of rest breaks on the reduction of work-related road transport accidents involving trucks. A framework is presented to manage truck drivers' fatigue, which may result in the reduction of injuries and fatalities involving heavy vehicles.

Keywords—Fatigue, time management, trucks, traffic safety.

I. INTRODUCTION

THE results of risk assessment and workplace accident analysis suggest that fatigue is a contributing factor for accidents, injuries and deaths in a wide range of workplace accidents [1]. Tired employees in all settings including transport operations such as road, aviation, rail and maritime, as well as other occupational settings, are less likely to produce safe performance, and the likelihood of unsafe performance or action increases notably when irregular/long hours of work are involved [1]. Within the transport industry, fatigue is known to be a workplace/work-related hazard and appears to be a reason for the large number of workplace-related road transport incidents, especially those involving heavy vehicles [2].

In research on sleep and fatigue in transportation industries, different fatal transportation industry accidents were analysed and it was concluded that there was one common root cause of these accidents: sleepiness-related fatigue, to which working hours was the greatest contributor [3]-[5]. In Australia, as in other countries around the world, fatigue has been identified as a casual factor in heavy vehicle and road transport accidents and working time makes a direct contribution to increased fatigue among drivers [3]. Driver fatigue has been identified as a contributing factor in 25% of road transport accidents across Australia and more than 30% of fatigued drivers break the road rules [4].

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According to a recent study conducted by the Monash University Accident Research Centre (MUARC) intoxication and/or fatigue and diverted attention or distraction represent major road safety problems [2].

TABLE I
MUARC STUDY OF 340 CASUALTY CRASHES IN VIC AND NSW 2000-2011 [2]

Crash Casualty	Importance (%)
Intoxication	13.5
Fell asleep	11.8
Fatigued	10.9
Failed to look	3.2
Passenger interaction	3.2
Felt ill	2.6
Blacked out	2.6
Feeling stressed	1.8
Looked but failed to see	1.5
Animal or insect in vehicle	1.4
Using a mobile phone	0.9
Changing CD/cassette/radio	0.9
Adjusting vehicle systems	0.9
Looking at vehicle systems	0.9
Searching for object	0.3

Although fatigue is unavoidable, management methods exist to eliminate/reduce this public hazard. A systematic approach to haulage road safety is required to ensure that the safety of drivers and all other road users is maintained. In order to facilitate and inform such an approach, it is necessary to have some understanding of the existing knowledge, and the determination of areas requiring future research would facilitate a systematic approach to filling existing knowledge gaps.

II. HUMAN FATIGUE AUTHENTICITY

In the nineteenth century discovery of the laws of thermodynamics in physics led to the study of human activity and compared the human body to an industrial machine [4]. Scientists could measure the elements that would facilitate harmony between an industrial machine and the human body to increase the performance of labour, and the discovery revealed that the process of decline, dissolution and exhaustion in the human body is inevitable when fatigue occurs. According to this study, fatigue is the endemic disorder of energy conservation and the entropy in human motor and is the characteristic sign of the external limits of the human body and mind [5].

The management of truck driver fatigue is one of the most important safety issues in the prevention of road transport

incidents and accidents. In nations like Australia, truck crashes in the long-distance road freight industry are often attributed to fatigue resulting from long driving hours [6]. Truck drivers rank between fourth and eighth among the most prone to accidental deaths on highways [6]. The Australian Transport Safety Bureau's 1996 data reported 34 deaths involving truck drivers in road crashes [7]. This matter has attracted interest, since road transport has been an extremely competitive industry for the past 20 years, with a large number of operators responding to the pressures of commercial activity. Commercial activities include strategies to promote cost-saving through increased subcontracting, contingent work, and pay systems to encourage or reward employees, such as providing bonuses or penalties. Competition, on the other hand, is influenced by factors such as the increase in supermarket chains, improved business logistics, and the use of information technology, which has paved the way for easier vehicle use and tracking [8]. However, competition and commercial practices have attracted critical attention since they contribute to risky work practices. In a survey conducted among truck drivers, it was found that fatigue due to hours of work (along with other hazardous behaviors like speeding and drug use) is due to several factors, including delays in loading and unloading, lack of security related to trip-based pay, and unaccounted non-driving tasks in scheduling [9]. The focus of the present study is to evaluate the impact of truck drivers' fatigue on workplace incidents and accidents. Based on evidence gathered from this research, the objective is to provide helpful information for the development of safety measures relevant to the prevention of injuries and fatalities in heavy road transport.

III. TRUCK DRIVERS' FATIGUE

Fatigue involves great danger to any driver and this becomes more severe, for top-heavy vehicles carrying hazardous materials. Even the slightest error in rolling motion or turning can possibly put the lives of people in peril, not only that of the driver but also the unsuspecting public. This is because exhaustion causes poor decision-making, delayed reaction time, and reduced concentration [10]. Unlike average drivers, truck drivers have greater road exposure due to the many more kilometers that they travel. This is a very important consideration, since the number of people killed or seriously injured per 100 million kilometers travelled determines the risk in relation to exposure. The longer the distance and hours of driving, the greater the possibility for drivers to experience fatigue, which is one of the main causes of road accidents [11]. Studies show that fatigue-related road crashes are three times more likely to occur especially when it includes poor sleep quality. This is why heavy vehicle drivers must constantly undergo assessment in terms of their fitness status. Chest problems and other issues involving abdominal organs may worsen driver fatigue [12].

Government departments are doing everything in their capacity, such as the regulation of drivers' hours, in order to ensure that their strength and energy are restored after driving long distances. For instance, the Australian Work Health and

Safety Strategy 2012-2022 along with different advocates of the motor carrier industry and highway safety interest groups have been pushing for the prevention of driver fatigue, which is considered a crucial public policy transportation issue. They are also encouraging other sectors, such as those belonging to the scientific community, to aid their research in order to strengthen evidence that driver fatigue is indeed one of the leading causes of highway injuries and deaths [13]. Even private researchers like the Zaragoza Logistic Center stress the importance of complying with the rules for taking the amount of rest required by the Australian Heavy Vehicle Driver Fatigue Law [14]. However, regulations tend to have limitations, such as the difficulty of monitoring the number of hours driven due to the falsification of logbooks. In addition, regulations may not be applicable to other countries, since the regulated driving hours do not operate in unison with the human body clock, thus leading to more fatigue [11]. There is also the issue that there is little empirical research in countries like Australia that demonstrates how the management of truck drivers' working hours influences fatigue that leads to vehicular accidents.

According to Anderson [12], fatigue management is a very complex task, especially when the aim is to ensure public road safety. The reason for this is that there are many factors to be considered and understood at the same time. Fatigue management mostly serves as helpful suggestions but not as imposing regulations. Fatigue management is an on-going debate that needs further study.

IV. EFFECTS OF LONG WORKING HOURS ON THE PHYSIOLOGY, HEALTH AND SAFETY OF TRUCK DRIVERS

The Australian Government is among those who immediately took action in prioritizing truck safety through public education campaigns and surveys of opinion. This demonstrates public awareness of fatigue as a road safety issue. However, these measures have yet to be proven effective in reducing the number of truck-related traffic incidents [11]. Based on studies in relation to the effective management of workplaces, long hours of work have negative effects on a person's mental health, can be physically and emotionally strenuous, and may result in heart disease. In a study including 300 Australian long-distance truck drivers, half of the respondents revealed they suffered from chronic back injury or hearing loss or worse, committed suicide due to the amount of stress [15], [16]. It also causes male infertility, as being in a seated position for long hours leads to abnormalities in sperm counts resulting from the unhealthy temperature of the scrotum [17]. To make matters worse, some individuals cope with stress by resorting to unhealthy behaviors such as smoking, alcoholism, and poor diet. Another negative effect of long working hours is lack of concentration, which may lead to errors and accidents on the highway [18]. Furthermore, drivers often experience occupational violence which exposes them to physical assault resulting from long hours of driving.

According to Mayhew and Quinlan [9], at least three types of violence are experienced by truck drivers due to long

driving hours. The first is verbal abuse and violence from other motorists, which is very common due to road rage in heavy traffic, especially along areas of red traffic lights or road junctions where traffic flows slowly. There are also abuse and threats from staff at freight forwarding or loading yards, as well as from customers when deliveries arrive late or during disagreements over the price of deliveries. In interviews, drivers reported having missiles thrown at them or being shot. Therefore, further investigation is required in order to understand the extent and degree of occupational violence resulting from long hours of driving. In addition, issues involving aggression at loading yards and from customers, which originate from problems such as economic and time pressures, must also be resolved [9].

V. FRAMEWORK FOR THE MANAGEMENT OF TRUCK DRIVERS' FATIGUE

There are different models for understanding the appropriate management of truck driver's fatigue as a means to reduce injuries and fatalities involving heavy vehicles. One of is the Truck Driver Fatigue Model [19], which focuses on determining several factors related to scheduling and scheduling-related elements, carrier safety practices and policies affecting driver fatigue, and the bases of driver fatigue. This model has three important categories: truck driving environments, economic pressures, and carrier support for driving safety.

A. Truck Driving Environments

This category discusses the role of three elements in truck driving environments. The first is regular time which is used as the basis for forming routine schedules for drivers and is often not in accordance with the circadian rhythm or daily cycle of activity commonly observed among working individuals. A person's circadian rhythm provides helpful information in determining the risk of accidents within the body's 24-hour cycle.

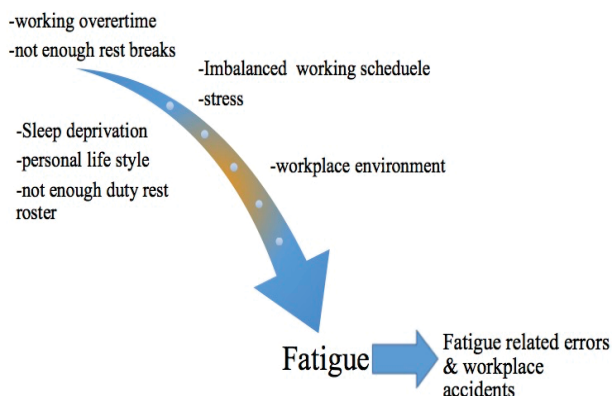


Fig. 1 Factors affecting driver's fatigue

The risk of vehicular accidents among truck drivers tends to double between 12 midnight and 6 o'clock in the morning [20]. The long working hours of truck drivers include a great deal of physical exertion and mental concentration, especially

when driving under poor road and weather conditions. Stress-inducing factors also include heavy cargoes, noise, extreme temperatures, and mechanical vibrations, which are detrimental to one's physical health [21]. Therefore, it is imperative to develop a regular driving schedule where the elements for consideration include the percentage of time on normal driving hours, careful arrangement of driving within a 24-hour period, the quality of uneven driving work, and maximum hours of driving in a week. Next to regularity of time is quality of rest, which is concerned with the location and at what time drivers are able to have long and continuing sleep. The third element is the trip control measure, which indicates the driver's ability to plan ahead for incoming trips and how successfully they are able to execute the trip plan later [19]. 24 In understanding the totality of their surrounding conditions, it would be easier for drivers to anticipate possible difficulties and deal with them reasonably.

B. Economic Pressures

The discussion on economic pressures identifies issues involved in scheduling which have intensified due to the popularity of just-in-time production processes and increased customer demands. Drivers have no choice but to keep up with the trend, despite the reality that most of the time they may already be drained of energy and effectiveness in their job. The pressure becomes even worse with the employers' financial and non-financial incentive strategies, as well as penalties which are used to entice the drivers to work harder and employers warning them of the consequences when they are unable to meet the targeted loads and trips. Drivers must be made aware of the disadvantages of being overwhelmed by these pressures. They must realize the importance of quality sleep and time spent relaxing with friends [14].

C. Carrier Support for Driving Safety

Crum and Morrow [14], stressed the responsibility of both the driver and carrier businesses in the management of driver fatigue and therefore the prevention of road crashes and injuries. First and foremost, drivers must exercise judgment if they are already overly fatigued and therefore must stop driving. On the other hand, carrier management must consider the consequences of driver fatigue and must establish work cultures, incentive systems, and training opportunities that will help resolve the issue. Activities that lead to the improvement of truck driving skills include special on-road dynamics, which is concerned with the ability to recognize other road users, compromise on road rules, and anticipate other users with regard to on-road decisions [22]. Companies must make driver safety their top priority, instead of profitability. They must also be open to suggestions from drivers on how to strengthen safety on the job [14]. Furthermore, carrier management must also make the customers (both shippers and receivers) understand the dangers of driver fatigue in order to encourage sensitivity and prevent them from creating unreasonable demands.

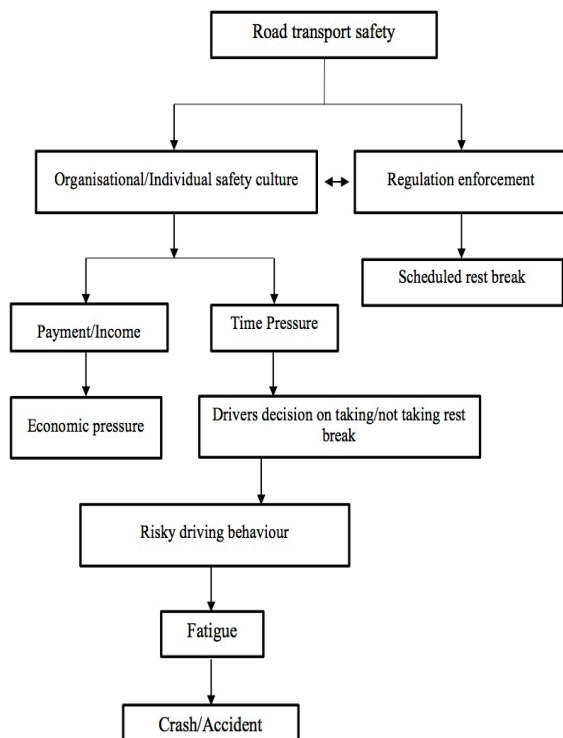


Fig. 2 Relationships between elements contributing to driver fatigue and the likelihood of accidents

VI. SAFE SYSTEM INTERVENTIONS TO SOLVE FATIGUE ISSUES CAUSED BY LONG WORKING HOURS

Many safe system interventions have been applied in order to address the issue of fatigue caused by long working hours. One of them is the use of tachographs, which were created for the purpose of controlling the working hours, rest hours, and vehicle speeds of truck drivers [23]. Invented in 1940 by the

Sangamo Electric Company, the tachograph is also used to measure the frequency and duration of stops which are recorded on wax charts [24]. The tachograph is a very reliable device since it is also capable of monitoring law-breaking activities like unlicensed toxic waste dumping as well as fuel theft. Unfortunately, this is the same reason why individuals tamper with the instrument, such as drivers who falsify the information to show that they have driven less distance [25]. Cheating with tachographs in such a manner is one indication of economic pressure where truck drivers are exerting efforts to earn more but are prevented by regulating bodies due to road accident risks once drivers become fatigued. For instance, drivers may claim that they were on their day off but were still in fact working [26].

VII. INFLUENCE OF FREQUENT REST BREAKS ON WORK-RELATED ROAD ACCIDENT INVOLVING TRUCKS

The practice of frequent rest breaks among truck drivers is very important for their driving performance. It prevents any impairment on the job which may lead to possible risks of increased road accidents. In Australia, regulations allow for a maximum of 12 hours of driving within a 24-hour period. This includes a 30-minute break after 5.5 hours of driving. This is a common regulation, but may be subject to changes depending on the country's territories [27]. Fortunately, some areas provide facilities for drivers, called roadside rest areas, in order to facilitate the safety of motorists by encouraging truck drivers to have sufficient rest. They also include other facilities such as drinking water, toilets, tables and benches and telephones. The public has agreed on the effectiveness of rest areas in promoting motorist safety due to reduction in fatigue and other driving issues [28].

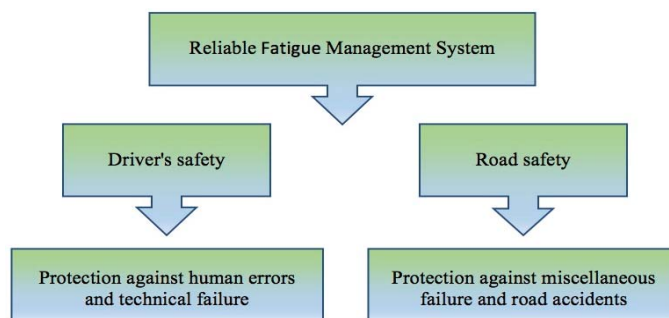


Fig. 3 Fatigue management and transport safety

There is not enough evidence to prove this claim, due to the lack of measure but the short-term lowering of accidents becomes probable once drivers relax, have a nap, a cup of coffee, or do some stretching exercises [29]. However, due to the increased demand for parking, drivers experience shortages and limited stays in the aforementioned facilities [29]. As a result, some settle for taking short breaks on roadway access ramps and shoulders, which can be dangerous

because it may prevent vehicles from accelerating safely into the traffic from their parked position. Another reason is that some vehicles might accidentally move aimlessly into the shoulder area and hit parked vehicles. In such cases, government agencies and private sectors are trying to formulate cost-effective solutions to address the issue [29].

A systems approach to road safety is now on the agenda of leading road safety countries. This includes transportation

system design, in which the roads, vehicles and speeds need to accommodate human errors to reduce the severity of injury outcomes [30].

VIII. CONCLUSION

Truck drivers will only be able to appreciate the essence of driving safely if the firms they are working for are also concerned with the implementation of safety management practices [30]-[33]. The issue of managing truck drivers' fatigue through the analysis of long driving hours involves several interconnected elements that are yet to be revealed and understood, such as economic pressures. Uncovering those elements will pave the way for strong regulations that will ensure compliance and public road safety in the future.

REFERENCES

- [1] ILO (international Labour Office Geneva), (2005), The issue of Fatigue and Working time in the road transport sector.
- [2] Akhtar, M., & Bouwer Utne, I. (2014). Common patterns in aggregated accident analysis charts from human fatigue-related groundings and collisions at sea. *Maritime Policy & Management*, 42(2), 186-206. <http://dx.doi.org/10.1080/03088839.2014.926032>
- [3] Williamson, A., Lombardi, D., Folkard, S., Stutts, J., Courtney, T., & Connor, J. (2011). The link between fatigue and safety. *Accident Analysis & Prevention*, 43(2), 498-515.
- [4] Rabinbach, A. (1990). *The human motor*. New York: Basic Books.
- [5] Dawson, D., Chapman, J., & Thomas, M. (2012). Fatigue-proofing: A new approach to reducing fatigue-related risk using the principles of error management. *Sleep Medicine Reviews*, 16(2), 167-175. <http://dx.doi.org/10.1016/j.smrv.2011.05.004>
- [6] James, P. (2006). *Health and Safety at Work and Its Relevance to Employment Relations Research*. Bingley, United Kingdom: Emerald Group Publishing.
- [7] Laird, P. & Bachels, M. (2001). *Back on Track: Rethinking Transport Policy in Australia and New Zealand*. Sydney, Australia: UNSW Press.
- [8] Tovey, M. (2013). *Design for Transport: A User-Centred Approach to Vehicle Design and Travel*. Surrey, England: Gower Publishing, Ltd.
- [9] Mayhew, C., & Quinlan, M. (2006). Economic pressure, multi-tiered subcontracting and occupational health and safety in Australian long-haul trucking. *Employee Relations*, 28(3), 212-229.
- [10] Pape, D. (2012). *Role of Human Factors in Preventing Cargo Tank Truck Rollovers*. Washington, DC: Transportation Research Board.
- [11] OECD. (2002). *Safety on Roads What's the Vision?: What's the Vision?*. Danvers, MA: OECD Publishing.
- [12] Anderson, M. (2013). *Contemporary Ergonomics and Human Factors 2013: Proceedings of the International Conference on Ergonomics & Human Factors 2013*, Cambridge, UK, 15-18 April 2013. New York, NY: Taylor & Francis.
- [13] De Smet, A. (2008). *Transportation Accident Analysis and Prevention*. New York, NY: Nova Publishers.
- [14] Crum, M. R., & Morrow, P. C. (2002). The influence of carrier scheduling practices on truck driver fatigue. *Transportation Journal*, 42, 20-41.
- [15] Acton, A. (2013). *Issues in Computer Science and Theory: 2013 Edition*. Atlanta, GA: Scholarly Editions.
- [16] Boyd, C. (2004). *Human Resource Management and Occupational Health and Safety*. New York, NY: Routledge.
- [17] Du Plessis, S., Agarwal, A. & Sabanegh, E. Jr. (2014). *Male Infertility: A Complete Guide to Lifestyle and Environmental Factors*. New York, NY: Springer.
- [18] Pfeffer, J. (2013). *What Were They Thinking?: Unconventional Wisdom About Management*. Boston, MA: Harvard Business Press.
- [19] Morrow, P. C., & Crum, M. R. (2004). Antecedents of fatigue, close calls, and crashes among commercial motor-vehicle drivers. *Journal of Safety Research*, 35(1), 59-69.
- [20] Kjellen, U. (2002). *Prevention of Accidents Through Experience Feedback*. New York, NY: CRC Press.
- [21] Langan-Fox, J. & Cooper, C. (2011). *Handbook of Stress in the Occupations*. Northampton, MA: Edward Elgar Publishing.
- [22] Porter, B. (2011). *Handbook of Traffic Psychology*. Waltham, MA: Academic Press.
- [23] Lemke, Paar, & Wolf. (2006). *Embedded Security in Cars: Securing Current and Future Automotive IT Applications*. New York, NY: Springer Science & Business Media.
- [24] Hamilton, S. (2008). *Trucking Country: The Road to America's Wal-Mart Economy*. Princeton, NJ: Princeton University Press.
- [25] Verster, J., Pandi-Perumal, S., Ramaekers, J., & De Gier, J. (2009). *Drugs, Driving and Traffic Safety*. Germany: Springer Science & Business Media.
- [26] Amundsen, A. H., & Sagberg, F. (2003). Hours of service regulations and the risk of fatigue-and sleep-related road accidents. A literature review Report, 659.
- [27] Stutts, J. (2000). *Sleep Deprivation Countermeasures for Motorist Safety*. Washington, DC: Transportation Research Board.
- [28] Trombly, J. (2003). *Dealing with Truck Parking Demands*. Washington, DC: Transportation Research Board.
- [29] Arboleda, A., Morrow, P. C., Crum, M. R., & Shelley, M. C. (2003). Management practices as antecedents of safety culture within the trucking industry: similarities and differences by hierarchical level. *Journal of Safety Research*, 34(2), 189-197.
- [30] Anderson, R. (2010). *Security Engineering: A Guide to Building Dependable Distributed Systems*. Hoboken, NJ: John Wiley & Sons.
- [31] Arnold, P., Hartley, L., Corry, A., Hochstadt, D., Penna, F., & Feyer, A. (1997). Hours of work, and perceptions of fatigue among truck drivers. *Accident Analysis & Prevention*, 29(4), 471-477. [http://dx.doi.org/10.1016/s0001-4575\(97\)00026-2](http://dx.doi.org/10.1016/s0001-4575(97)00026-2)
- [32] Asvin Goel, Claudia Archetti, Martin Savelsbergh, (2012), *Truck driver scheduling in Australia* *Computers & Operations Research* 39 (5), 1122-1132. (2012).
- [33] Safe Work Australia, 2012, *Australian Work Health and Safety Strategy 2012-2022*.