

The Wait Advisor – A Mobile App that Examines the Factors which Influence Truck Driver Fatigue

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1. Introduction

Fatigue and fatigue-related symptoms in the trucking industry is a major concern for all stakeholders involved in the transport of freight by road with Haworth et al. (1989) estimating that fatigue contributed to a large percentage of accidents involving a truck. The major issue with fatigue and fatigue-related studies is that very little is known into what causes or influences a truck driver to experience fatigue. Whilst a truck driver may experience fatigue will likely experience reductions in performance that may include reduced response or reaction times, deficits in attention and make poor or inappropriate decisions that may increase the number of truck accidents that occur on the road (Dawson et al., 2018; Dawson and Reid, 1997; Sadeghniaat-Haghighi and Yazdi, 2015).

The common approach to significantly reduce the likelihood that a truck driver will experience fatigue-related symptoms is by restricting the total hours of service a truck driver is permitted to undertake work activities in a set period (Goel and Vidal, 2013). Whilst the maximum number of hours of service may differ in most countries (see Federal Motor Carrier Safety Administration, National Heavy Vehicle Regulator, Driver and Vehicle Licensing Agency), the hours of service includes all work-related activities a truck driver may reasonably undertake to include, driving, loading and unloading of vehicles and general administration tasks (Marcus and Rosekind, 2017; Sparrow et al., 2016; Smith, 2016).

However, the major issue is that whilst fatigue is recognised as the largest identifiable and preventable cause of all truck accidents and is typically associated disruptions to the circadian rhythm and its influence on sleep disorders, chronic anxiety and depression (Marcus and Rosekind, 2017; Gao and Jia, 2017; Ji et al., 2004). That may be associated with as extended driving hours, a lack of sleep, driving while drowsy. being overtired, the absence of an elevated Blood alcohol concentration disruptions to the circadian rhythm, inadequate or erratic sleep patterns and pathological sleepiness (Arnold et al., 1997). This means that to identify what may have caused the fatigue-related episode, the investigation can limit itself to driver behaviour, because many car and truck drivers will drive for extended periods (Zhang et al., 2016; Potter et al., 2016) and not to system-wide factors as very little known about the factors that may contribute to or cause a truck driver to experience fatigue.

2. Fatigue Surveillance

To understand the requirements to develop a beneficial fatigue surveillance program, it must be acknowledged that urbanisation, changes to contemporary work patterns, the demand for goods and services to be transported by road and the global shortage of truck drivers, will increase the truck driver experiencing stress and other health complaints that may induce fatigue symptoms (Mooren et al., 2014; Costello and Suarez, 2015). Indicating that the surveillance technique should be able to address all types of fatigue and demonstrate how these may influence the truck driver's actions and behaviours that may indicate the onset of a fatigue-related episode (Smith, 2016).

While one such program is underpinned by education programs which are designed to reinforce the importance of sleep and the adverse effects of sleep loss and sleep disorders have on a truck drivers health and wellbeing (NHVR, 2018; Goel and Vidal, 2013; Mahajan et al., 2019). These education programs do not consider the other types of fatigue that can be experienced by truck drivers or the influence these different types of fatigue may not be directly linked with sleep patterns or be validated through current fatigue management strategies (Sadeghniaat-Haghighi and Yazdi, 2015); even though they might influence a fatigue-related serious or fatal accident.

2.1. Cognitive Fatigue

While sleep loss is substantial, truck drivers who typically experience cognitive fatigue when the workload is insufficient or there is an inability to sustain mental effort, as there is likely to be a decline in executive attention performance that results in a reduction in an individual's ability to perform required functions (Holtzer et al., 2010). Truck drivers who continually experience severe cognitive fatigue increase the risk of being involved in a serious or fatal accident and may be at risk of anxiety, burnout or lack of sleep (Van Cutsem et al., 2017). The primary issue with truck drivers who experience cognitive fatigue is that it will negatively influence the truck drivers ability to sustain concentration, being attentive in driving tasks and less able to carry out high-level information processing (Chaudhuri and Behan, 2000; McMorris et al., 2018; Guillemin et al., 2018).

Truck drivers who experience cognitive fatigue may fail to observe a situation appropriately or be unable to drive to the prevailing conditions as they have decreased decision-making abilities and will apply poor judgement to a given situation (Häkkinen and Summala, 2001).

However, in the event of an accident, these areas may be associated with driver error, because it may not be possible to effectively measure the impact of cognitive fatigue on driving, when considering the normal actions found in truck driving will cause fluctuations in the cognitive load and truck drivers may experience cognitive fatigue on multiple occasions during a standard workday (Mehler et al., 2009).

2.2. Muscle Fatigue

Gandevia (2001) describes muscle fatigue as a decrease in maximal force or power production in response to contractile activity, originating in different levels of the motor pathway. Muscle fatigue is typically categorised as peripheral fatigue in terms of the changes at or distal to the neuromuscular junction and central fatigue originates at the central nervous system which contributes to the decline in force, compromising performance of activities that require a large muscle mass (Taylor et al., 2016; Bigland-Ritchie et al., 1978). Whilst muscle fatigue is a phenomenon that limits athletic performance and other strenuous or prolonged activity commonly associated with athletes. Truck drivers will frequently experience muscle weakness, exhaustion and adversely influence the physiological functions of the musculoskeletal system, caused by failure in the musculoskeletal tissue, that may influence slower reaction times, and increase the risk of various pathological conditions that may include neurological, muscular and cardiovascular disorders (Gallagher and Schall, 2017).

Apostolopoulos et al. (2016) suggests that driving for extended periods of time, combined with the stress associated with strenuous loading and unloading of various freight types, will increase the amount of force required in any given task. Indicating that as the task complexity increases during the numerous functions a truck driver may undertake, suggesting that that most of the issues that may cause or contribute to fatigue will appear less complex than they are and truck drivers will frequently experience muscle fatigue (Delaney et al., 2019).

3. Fatigue Monitoring Systems

The risk of fatigue and fatigue-related truck accidents has witnessed an increase in fatigue monitoring technology-based systems (Ji et al., 2004). While many of these systems packaged with driver assistance technologies to act as a co-driver, others are designed to be independent monitor the driver's alertness, fitness-for-duty testing and alertness promotion. Heitmann et al. (2001) however, found that these technologies show promise, no single assessment is either sensitive or reliable enough to confirm the presence of driver fatigue.

Indicating that the system which is designed to monitor the onset of fatigue-related symptoms will only identify changes in driver behaviour and not the factors that may induce fatigue (Tsimhoni and Reed, 2007), as the multi-sensor approach applied in these systems may present numerous difficulties in the data interpretation.

This means that the system may not have been designed to allow for the fact that over half of the time a driver spends behind the wheel, is taken up with physical or behavioural distractions (Sullman, 2012). In addition, these systems are designed to focus on one element of the road transport system and do not consider the numerous hostile traffic systems that are found (Delaney, 2018; Locke and Romis, 2007) and where this systems are located in the remainder of the road transport system, the supply chain ecosystem or the numerous other complex and complicated systems that will completely reconfigure themselves to suit the environment (Horberry et al., 2014; Santos et al., 2010; Poli, 2013; Melnyk et al., 2010).

4. Monitoring Fatigue

To develop a fatigue monitoring device that assists trucking companies to identify the factors that may cause or contribute to fatigue, the Wait Advisor App intends to identify how the system induces fatigue in truck drivers. These events may include failures in the road transport system that is influenced by disruptions to the road traffic system, road works, traffic accident or other event or delays which occur during loading or unloading of freight or failures within the supply chain ecosystem. Truck drivers using the App, will report the location and duration of the delay, which will be catalogued and analysed to present a detailed synopsis to all trucking companies, government agencies and other parties in the supply chain for the purposes of developing strategies that can improve the efficiencies in the transportation of freight across the supply chain and significantly reduce the episodes of driver fatigue and the number of accidents that are caused by fatigue.

4.1. Technical Specifications

In its current form, the Wait Advisor App is available for use on all Android and IOS mobile or cell phones. The device requires the GPS functionality and data connectivity of the phone to be active as this will allow the data on waiting and/or delays will be captured and stored. The functionality of the Wait Advisor allows for it to be embedded in existing onboard devices or used as a stand-alone Arduino-based device that can be plugged into other on-board diagnostic devices. Where trucking companies apply on-board navigation tools and

telematics for vehicle movement monitoring, data sharing arrangements can be agreed upon. Data visualisation includes a multi-layered heat map of delay information, with other insights produced that will allow fleet allocators to identify routes where delays are common and alter scheduling to ensure delays at load/unload points can be minimised.

4.1.1. Data Collection

The data collected on the delays experienced by the truck driver will only occur when the App is manually activated by the truck driver, using GPS the App will record the location and time of the activation, as soon as the truck driver has resumed activities (e.g. driving, loading/unloading) the driver manually deactivates the App, however, the app will automatically deactivate at speed (40 km/h or 25 mph). As soon as deactivation has occurred, the App will record GPS location and time, calculate the duration of the delay and transmitted to a secure cloud-based server for detailed analysis. Confidentiality and security of the data collected (within the limits of the law) will be guaranteed, all data will be aggregated and any personal details that may identify the truck driver will be removed

5. Benefits to the Trucking Industry

With the increasing body of literature supports fatigue and fatigue-related events may influence a truck drivers' prevalence of being involved in a serious and/or fatal accident, causing loss of life, damage to infrastructure or the environment. Similarly, there is a large percentage of academic and grey literature which suggests that delays or excessive waiting times will increase the risk of a truck driver experience fatigue. The benefits the Wait Advisor presents is by actionable insights which allows the trucking industry to reduce fatigue-related events and better plan transport routes. Key stakeholders in the Supply Chain ecosystem who are essential in the supply of products and material can integrate the data into their manufacturing and scheduling procedures, all levels government can use the data in their traffic management processes and inform expenditure needs for specific infrastructure projects. Future plans for the Wait Advisor include developing advanced alert systems to inform the truck driver of the delays that might be encountered on a specific route to further optimise their driving schedules.

6. Conclusion

Unless a cohesive understanding of causes of fatigue is reached, the consequences of a fatigue-related truck accident will negatively influence the company that consigns or receives

the freight, all road users and the wider community, as well as the truck driver and the transport operator will continue to be a significant concern (Zhang et al., 2016). Whilst significant improvements have been witnessed in the reduction of fatigue-related episodes associated with lack of sleep, there is a gap in understanding how fatigue is influenced by delays that occur during a truck drivers' normal tasks. The Wait Advisor App analyses these delays to provide trucking companies, government agencies and stakeholders involved in the supply with a better understanding into where these delays occur and how practical solutions can be developed to reduce the risk of the delay and improve the general health and well being of the truck driver and significantly influence the number of fatigue-related compensation claims or serious and/or fatal accidents.

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