**Literature review draft: Determinants of Truck Drivers’ Critical Events**

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This paper proposes to review relevant literature on key factors associated with truck drivers’ safety critical events, and determinants of these key factors.

**1. Outcome - truck drivers’ safety critical events and their significance**

As online shopping such as Amazon and eBay becomes more and more popular in our age, transportation incidents are becoming widely recognized as a public safety issue. As estimated by the World Health Organization (WHO) in January 2017, road injuries were the 10th cause of death globally in 2015, with approximately 1.34 million people died from road injuries, which were approximately 2.3% of the total number of deaths globally in 2015[1]. In the United States of America, the number of motor-vehicle related deaths in 2016 was 40,200 in total, rising up 6% compared with the number in 2015 [2]. It is to be noted that the death numbers have been keeping an increase rate of 6% for two consecutive years since 2014, probably because of the continued dropping of gasoline prices and a better economy [2]. The total economic cost of traffic accidents and injuries are approximately 242 billion USD each year [3]. In addition, when the quality of life is taken into account, the summed total amounts to a shocking number of over 830 billion USD [3].

Safety critical events of drivers are typically known as the crashes between automobiles or between automobiles and human beings. However, these crashes are just the tip of the iceberg. As defined by Dingus et al., safety critical events of drivers include three categories [4]:

1. Crash: situations in which there is physical contact between the subject vehicle and another vehicle, fixed object, human beings, or animals.
2. Near-crash: situations requiring a rapid, severe, evasive maneuver to avoid a crash.
3. Incident: situations requiring an evasive maneuvers occurring at less magnitude than a near crash.

**2. Risk factors of truck drivers’ safety critical events**

Truck drivers’ safety critical events are caused by various factors, typically including exogenous and endogenous factors. Exogenous factors are ambient related causes, i.e. ice, snow, and fog, while endogenous factors are driver-related causes, i.e. distracted driving, over-speed, and drunk driving. Although both of the two categories of reasons are to blame, it is estimated that driver-related causes are the leading causes for over 70% of injury-inducing crashes [5 - 7]. The following two parts will explain different levels of risk factors for truck drivers’ safety critical events in the mode of the ecological model, namely the individual level (driver-related risk factors) and the institutional level (ambient-related risk factors).

**2.1 Driver-related risk factors of truck drivers’ safety critical events.**

Among all driver-related safety critical events, fatigue has become the most pressing problem of traffic accidents. It is estimated by National Sleep Foundation that approximately 32% of drivers in U.S drive with fatigue over twice a month [8]. Another statistic provided by American Automobile Association Foundation for Traffic Safety in 2010 said that 16.5% of fatal traffic accidents and 12.5% of collisions related to injuries in U.S were associated with driving with fatigue [9]. Drowsy driving is an especially common practice in less-developed countries because of cost control and tight schedule. Surveys of commercial and public road transportation companies in less-developed countries showed that employers were frequently forcing their employees to drive for longer hours and keep working even when they were exhausted [6, 10, 11]. High proportions of drowsy driving have been found in Brazilian (22%) [12], Argentinean (44%) [13], Pakistani (54%) [14], and Thai (75%) [15] truck or bus drivers. The mechanism of fatigue leading to safety critical events is that a driver’s capability to stay alert to ambient traffic and pedestrians will be largely impaired. The reaction time is subsequently prolonged in that situation [16]. It is estimated that 17 hours of continuous working lead to a deterioration of driving performance equivalent to a blood alcohol level of 0.05% [17]. What makes the outcomes worse is that fatigue driving is more likely to happen on expressways and major highways where the speed limit is over 55 miles per hour [18]. This is especially concerning because fatigue driving safety critical events are more likely to result in serious injuries and fatalities, compared with non-fatigue driving safety critical events.

Another driver-related risk factor of driving safety critical events is drivers’ age. In many developing countries, to meet the huge demand services and supply chain management, it is very common to extend the retirement age or reemploy retired workers [19]. Aging drivers increase the chance of the safety critical events in three aspects: impaired eyesight, prolonged reaction time to exogenous stimuli, and vulnerability to fatigue [20]. Aged drivers are associated with eyesight diseases or functionality impairment, such as cataracts, narrowed peripheral vision and decreasing visual acuity [20]. In addition, working for truck companies often means irregular shifts and taking the night schedules, which disrupt the circadian time-keeping systems, especially for the aged workers [21].

Aged drivers may find it much more difficult to adjust for the sleep-wake cycle to keep pace with the schedule required by the employer company. Therefore, this disruption of the circadian systems, in turn, increases the chances to feel sleepy or fatigue for workers. It is indicated by research that the “critical age” of shiftwork intolerance is about 45 to 50 years, at which sleep disorder, persisting fatigue and digestive problems become the most obvious [20]. Young drivers are much better in the sense of physical health and resistance to fatigue compared with aged drivers, however, they are more vulnerable regarding the experience of driving. A study conducted by Clarke suggested that young drivers (17 – 19 years old), especially males, have significantly more accidents than other drivers during the hours of darkness, on rural curves, and rear-end shunts compared with male drivers aged 20 -25 years [22]. The reasons for these young driver accidents were not fully explained, but could largely be attributed to inexperience.

One more risk factor that could explain driving safety critical events is drivers’ gender. Gender has been suggested to be related with outcomes in medical treatment, education, sports and other fields, and there is no exception for truck drivers’ safety. In the first place, women are more likely to suffer from fatigue compared with men. A study found that women in general have 1.4 times higher chance of complaining of fatigue than men [23]. However, females are found to have longer sleeping hours than their male counterparts of the same race [24]. In that study, it was found that the mean sleep hours for white females was 6.7 hours compared with 6.1 hours for white males, and 5.9 hours for black female compared with 5.1 hours for black males even after adjusting for socioeconomic status, lifestyle and sleep apnea [24]. Gender differences are huge in terms of working conditions. Females had significantly fewer working hours per week, with 47 hours versus 52 hours per week [25]. In general, women tend to work fewer hours within a week but are more prone to feel fatigue and have a higher risk of traffic incidences.

**2.2 Ambient-related risk factors of truck drivers’ safety critical events**

In this section, we mainly concentrate on two ambient-related risk factors of drivers’ critical events, ambient weather and safety climate of the employer company.

Weather has both direct and indirect effects on drivers’ safety critical events. On one hand, the increase of ambient temperature places risks on drivers’ occupational safety, and possibly leads to cognition loss, heat stroke, and impairment of wakefulness. Evidence showed that the risk of mistakes and safety critical events increase in hot weather [26, 27]. Leard and Roth found that for a day with temperature above 80◦F there is a 9.5% increase in fatality rates compared with a day at 50-60◦F [28]. A literature review found that 11 out of 13 studies indicated an increase in unintentional injuries associated with high temperatures [29]. On the other hand, real-time extreme weather conditions such as heavy rain, fog, storm, and snow can either impair the driver’s visual capability or reduce the safety of driving on the road [30 - 32]. It is to noted that the cumulative time of driving in such extreme weather conditions could increase the chances of safety critical events. Studies that explore the association between precipitation and driving safety critical events consistently find a negative relationship. The positive linear relationship between precipitation and traffic accidents can be observed in both driver accidents and pedestrian accidents [31, 33]. Abdel-Aty et al. used detector and sensor data to successfully predict more than 70% of accidents with low visibility conditions [34]. The common problem for the literature exploring the relationship between ambient weather and safety driving critical events is the failure to include the cumulative effect of weather conditions. Instead, they all use an indicator variable to represent whether extreme weather happened during the trip or not, which could lead to potential bias in prediction models.

Another institutional level risk factor associated with safety driving critical events is safety climate within the employer company. Safety climate is the shared employee beliefs of how safety management is operationalized in their place of work [35]. It is an endogenous factor that characterizes the extent to which the employer organization values safety behavior. The mechanism underlying the link between employee safety climate and driving critical events is that a good driving climate can encourage safety driving behavior, while a negative safety driving climate deteriorates this safety driving motivation [36]. Safety driving climate normally involves conscientious obedience to rules and regulations formulated by the company. Since the safety driving climate questionnaire typically includes multiple safety climate dimensions, relevant literature uses structural equation models and factor analysis to bridge the link between different dimensions of safety climate and driving safety critical events. Andrew et al. used exploratory factor analysis to find the relationship between six safety climate dimensions and four aspects of work-related driving. The study found that safety climate factors were best able to predict self-reported distraction than other patterns of driving behaviors [37]. Another study by Huang et al. used path analysis and social exchange theory to find the relationship between safety climate and employees’ job satisfaction, engagement and turnover rate. That study also found positive relations between safety climate and three outcomes. The problem for this safety climate risk factor is measurement. Since safety climate is a tacit agreement among employees within one company, it cannot be measured and recorded directly with a number. Therefore, a number of questionnaires have been developed to measure safety climate, most of which were based on the work of Zohar [39]. The validity and reliability of different questionnaires are hard to verify.

**4. summary**

This literature review aims to explore relevant literature on the relationship between different categories of risk factors and truck drivers’ safety driving critical events, on the basis of an ecological model. The review begins with the definition of safety driving critical events and their significance in the contemporary context. Then, I discuss several individual level risk factors of safety driving critical events, including fatigue, age, and gender. In the third section, I discussed two ambient-related risk factor of critical events, ambient weather and safety driving climate within the employer company. I also argue that cumulative time of driving in extreme weather can be a better predictor of critical events, instead of the indicator variable used in existing literature, and the reliability and validity of safety driving climate questionnaires need to be verified in existing literature.

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