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BEHIND THE WHEEL: UNDERSTANDING THE RISKS FOR TRUCK DRIVERS IN THE ERA OF THE INTERNET OF THINGS AND ADVANCEMENTS IN AUTONOMOUS VEHICLES

Summary. Freight transportation is a crucial part of the global economy, but it encounters several complex challenges, with truck drivers at the centre of these issues. These professionals, responsible for transporting goods over long distances, often work in challenging conditions, exposing them to a range of risks, including physical, psychological, and chemical hazards. These risks make the profession less appealing to younger drivers, leading to an ageing workforce and worsening the driver shortage crisis in the road transport sector. This article aims to identify the various risks faced by truck drivers and examine their negative impacts on several critical aspects, including company image, service quality, financial implications, and road safety. Additionally, the article explores the transformative impact of the Internet of Things (IoT) and autonomous vehicles (AV) on the truck driving profession.

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1. INTRODUCTION

Heavy vehicle drivers operate in a high-risk work environment characterized by elevated rates of fatalities and injuries [1]. Compared to workers in other industries, they are more frequently in need of surgical procedures [2]. Research indicates that truck drivers often struggle with being overweight, poor overall health, and various medical conditions [3]. These health problems exacerbate the acute shortage of qualified and experienced drivers in the commercial transport and logistics sector [4], a situation further worsened by an ageing workforce with an average age of 45 years [5].

This shortage results in a scarcity of competent and experienced drivers available to handle essential deliveries and transports. This could have significant repercussions on the transport sector, affecting both transport companies and the entire logistics chain. Indeed, this unavailability will hinder companies from finding drivers to carry out scheduled deliveries, leading to delays in the delivery of goods. These delays can disrupt production schedules, customer delivery timelines, and, consequently, tarnish the company's image.

The poor working conditions of truck drivers are often highlighted, as they expose these workers to a multitude of risks, which we will detail further.

2. IDENTIFYING THE CAUSES OF HEAVY GOODS VEHICLE DRIVER UNAVAILABILITY

2.1. Physical Risks

The profession of heavy goods vehicle (HGV) driver involves significant physical risks that necessitate special attention to ensure the safety and well-being of the drivers. These risks include musculoskeletal disorders affecting the musculoskeletal system, cardiovascular diseases such as heart attacks, and digestive issues like gastritis. These conditions are common among HGV drivers and can lead to occupational disability. Additionally, slips, trips, falls from heights, road accidents, and accidents on loading docks contribute to many injuries among these professionals.

2.1.1. Musculoskeletal disorders

Musculoskeletal disorders are a leading cause of absenteeism and work stoppages. In 2019, 117.54 thousand deaths and 322.75 million cases of incidents related to musculoskeletal disorders were recorded [6]. These conditions encompass various forms of discomfort and disabling injuries that irreversibly affect the musculoskeletal system, including muscles, tendons, bones, cartilage, ligaments, and nerves [7].

The musculoskeletal disorders are common among truck drivers; back, neck, leg and sciatica pain caused by herniated discs, as well as joint pain in the shoulders, knees and ankles, numbness in the legs, are often linked to prolonged sitting, vehicle vibrations and incorrect seat or control position adjustments, steering wheel or pedals [8]. Inadequate seat or vehicle suspension, road conditions and speed bumps can also primarily harm the spine. Vibrations

causing vibrations and jolts felt in the cabin can lead to spinal disorders, particularly at the dorsolumbar and lumbosacral junctions [9]. Manual handling efforts during loading and unloading operations (slinging and securing loads, etc.) must also be considered.

This risk may increase as truck drivers' years of experience and time in the seat increase [10]. Other factors linked to individual characteristics contribute to the development of musculoskeletal disorders in truck drivers. These include age, obesity, smoking, alcohol consumption and physical activity [11].

2.1.2. Falls

Fall-related workplace accidents are caused by falls on the same level, from a height, or from loose packages or objects. Falls from the truck cab are frequent, due to numbness of the lower limbs and/or slipperiness of the step or road surface, as are falls from height from the access ladder onto tanks, skips or specific equipment [12]. The most common injuries are strains, sprains, contusions, skin wounds and haemorrhages, as well as fractures of the lower or upper limbs. Poorly secured or defective parcel wedging and lashing, a poorly distributed and balanced load, unsecured objects can result in a fall or projection in the event of sudden braking, as well as trauma when the load being handled tips over, such as crushing of limbs, foot and hand entrapment, bruising and haematomas [13].

2.1.3. Road accidents

Road accidents involving HGVs are a major concern for road safety. The consequences of these accidents can be serious, resulting in injuries and sometimes even loss of life. According to the Federal Motor Carrier Safety Administration, in 2020, 125780 trucks were involved in road accidents, 4842 of which were fatal [14]. Indeed, driving HGVs is inherently dangerous due to the high kinetic energy involved, which can lead to more serious accidents than those involving light vehicles [15]. These accidents can be caused by a number of factors, such as the condition of the vehicle, driving errors by the driver or others, road conditions and adverse weather conditions. Factors that impair alertness and diminish concentration and attention, as well as demands for efficiency and punctuality, can add to the constraints of road traffic, thus generating stressful situations causing accidents in most cases [16].

2.1.4. Risks associated with handling aids and lifting accessories

The use of mechanical handling aids and lifting accessories can reduce physical effort and make handling easier, but it does entail risks such as overexertion injuries, pinched fingers and hands, crushed toes, loads falling onto feet or legs, or pinched or lacerated hands and arms when the sling is tensioned. These incidents can be caused by inadequate training, equipment failure, overloading and incorrect lifting techniques.

2.1.5. Gastrointestinal diseases

Gastrointestinal diseases are diseases that affect the digestive system responsible for ingestion, propulsion, digestion (chemical and mechanical), absorption and elimination of food [17]. These diseases cost millions of dollars a year in the United States alone, causing one hundred thousand deaths and healthcare costs [18]. The most common gastrointestinal diseases include [19]: inflammatory bowel disease, irritable bowel syndrome and gastric reflux.

It is essential to consider the impact of the working environment on the emergence and management of gastrointestinal diseases, even though they are linked to dietary factors and general living conditions. Several factors associated with the work environment may contribute to the development of gastrointestinal disease in truck drivers. Travel and staggered meal schedules lead to poor food hygiene, which can be the cause of numerous digestive disorders such as gastritis, colopathy, dyspepsia and ulcers [20].

2.1.6. Cardiovascular disease

Cardiovascular disease is a major threat to public health, and can lead to serious health problems, including heart attacks, strokes, and death. According to data from the World Health Organization (WHO), they are responsible for around a third (33%) of deaths worldwide [21].

Several factors may increase the risk of developing cardiovascular disease in truck drivers. It is often attributed to a combination of personal habits and work-related factors, such as dietary choices, lack of physical activity and prolonged periods of sitting [22]. High blood pressure, hyperglycemia and hyperlipidemia are common among truck drivers and may increase the risk of heart attack. This may be due to a sedentary lifestyle at work that leads to overweight, also stress caused by traffic and safety conditions, or the work rhythm (variable hours, night work, etc.), disrupts diet and thus increases the risk of cardiovascular disease in truck drivers.

2.2. Psychological risks

Professional truck drivers work under demanding conditions that can disrupt their social and family lives and increase the risk of psychological distress. Mental health issues such as depression, loneliness, sleep problems, anxiety, and substance use are common among drivers [23]. While these psychiatric disorders have little effect on driver absenteeism rates, they do significantly increase the risk of accidents or near-misses [24].

Truck drivers often work irregular hours [25]. Most of the time, they are required to spend long periods away from home and family, with sleep quality and duration frequently reduced [26]. These sleep disorders can be especially problematic for HGV drivers. They can affect their physical health and risk their ability to drive safely. Sleep deprivation can also increase the risk of developing mental disorders, such as depression and anxiety [27].

HGV drivers face a multitude of work pressures and demands. Work stressors reported among professional drivers include pressure to deliver the order on time, unfavourable driving conditions and traffic [28]. This stress at work has adverse consequences for drivers' mental and psychological health [29], significantly reduces driving skills and consequently increases the risk of accidents [30].

Low family income is also among the known risk factors for depression [31]. As for driver pay, it is often perceived to be much lower for comparable work, leading to additional financial stress for drivers who find themselves unable to provide adequately for their families [32]. In most parts of the world, transport companies pay drivers based on kilometres driven or percentage of revenue charged for transporting goods [33] which further incentivizes drivers to work overtime, consequently, it affects their safety performance and significantly increases the risk of accidents [34].

Social isolation can be a significant problem for HGV drivers, who spend many hours alone on the road and are often estranged from family and friends [35]. Indeed, HGV drivers can experience isolation due to their irregular schedules and their distance from home and their social network. These unpredictable work schedules were frequently associated with depressive

symptoms [36]. Social isolation can have serious repercussions on their well-being and behaviour. It can lead them to adopt risky behaviours such as driving at excessive speed, overeating, consuming alcohol and psychotropic drugs, and engaging in inappropriate individual behaviour.

In addition to isolation, truck drivers face increased risks from violence, including theft of goods from parking lots and stowaways. These situations can be very stressful and worrying for those road professionals.

In addition, the constant noise of urban traffic can also affect their well-being at work and their safety. Noise can disrupt their concentration, making them more nervous and aggressive, which in turn can influence their behaviour on the road.

The combination of all these factors can leave truck drivers in a state of permanent stress. Their demanding work rhythm, the pressure of road traffic and the challenges of personal safety can lead to psychological disorders such as anxiety, depression, dependence on alcohol or tranquillizers, as well as neurotic disorders such as driving phobia. Sleep disorders can also be common among these high-stress professionals. It is therefore essential to consider the specific psychological challenges and risks faced by truck drivers. Raising awareness of these issues and putting in place support and prevention measures are crucial to preserving their mental well-being and safety on the roads.

2.3. Chemical risks

Heavy goods vehicle drivers working in polluted environments or transporting hazardous chemicals face significant health risks. Prolonged exposure to exhaust fumes and air pollution can have adverse effects on their respiratory and cardiovascular systems. Studies have shown that fine particles and pollutants in exhaust gasses can penetrate deep into the respiratory tract, leading to respiratory problems such as asthma, chronic bronchitis and chronic obstructive pulmonary disease [37].

In addition to the risks associated with exhaust fumes, truck drivers are also exposed to polycyclic aromatic hydrocarbons (PAHs), which are chemicals found in exhaust fumes and some chemicals used in transportation. PAHs are classified as carcinogenic to humans by the WHO's International Agency for Research on Cancer (IARC). Prolonged exposure to these substances can increase the risk of developing serious diseases, including respiratory, skin and other cancers [38].

HGV drivers who are responsible for transporting hazardous materials face increased risks. One of the most obvious dangers is the possibility of leaks or spills during the loading, unloading, or transit of substances, which can expose drivers and the environment to toxic, corrosive, or flammable substances. Such accidents can not only result in significant material damage but also endanger the health and safety of drivers and people in the vicinity [39]. In addition, some transported materials can react violently in the event of collision, impact, or adverse environmental conditions, potentially leading to devastating explosions [40].

Heavy truck drivers responsible for transporting powdery materials face specific health risks due to the dust from these mineral particles. When powdery materials are handled or transported, fine particles can be released into the air, creating a potentially dust-laden atmosphere. These airborne mineral particles can be inhaled by the drivers, entering their respiratory tracts. Regular inhalation of these dust particles can cause respiratory tract irritation, manifesting as symptoms like frequent sneezing, a sensation of a blocked or runny nose, and breathing discomfort. Drivers who are prone to allergies may be more sensitive to mineral dust, which can trigger allergic reactions such as allergic rhinitis [41]. Prolonged exposure to these

mineral dust particles can also lead to inflammation of the nasal mucosa and respiratory tract, worsening respiratory symptoms and disrupting the drivers' overall well-being.

3. IMPACT OF DRIVER UNAVAILABILITY

An efficient distribution supply chain thrives on its ability to respond seamlessly to customer demands. However, unexpected disruptions can throw a wrench into this delicate balance. Driver unavailability poses a significant challenge, potentially leading to delays and disruptions throughout the entire chain.

When a driver is unexpectedly unavailable, finding a suitable replacement quickly can be difficult. This will lead to a disruption in the company's activity and cause disturbances throughout the entire supply chain. These impacts are felt on four levels:

- Financial impacts: the financial consequences mainly concern the generation of additional costs, lower revenues or receipts, poor customer relations and loss of market share in the face of competition.
- Impact on the company's image: When drivers are unavailable at crucial moments, it creates a domino effect. Deliveries and transportation services get delayed, which chips away at a company's reputation for reliability and punctuality. Customers who experience missed deadlines due to driver shortages lose trust in the company. This can snowball into a damaged reputation, hurting relationships with customers and impacting competitiveness, stakeholder loyalty, media perception, and even the company's ability to operate [42]. A strong reputation directly influences customer service evaluations [43]. Conversely, a positive company image reinforces customer expectations and builds confidence in the services offered [44].
- Impact on service quality: service quality plays a crucial role in the success of the logistics transport sector. According to research by Restuputri, Indriani, and Masudin, service quality comprises three variables: personnel service quality, operational service quality, and technical service quality [45]. Their study results indicate that personnel service quality and technical service quality significantly impact customer satisfaction. They also found that customer satisfaction and trust positively influence customer loyalty. The unavailability of drivers at the required times can cause delivery delays, posing a major challenge for logistics transport companies. Delays can disrupt the agreed schedules with customers, leading to a perceived decline in service quality. This situation can cause customer dissatisfaction and even frustration, calling into question the company's ability to meet its commitments.
- Impact on road safety: when there is a shortage of qualified drivers, transport companies often face increased workloads and longer driving hours for existing drivers. This situation exposes them to high levels of fatigue, which can compromise their ability to drive safely and responsibly [46]. Fatigue can lead to decreased alertness, slower reaction times, and impaired decision-making abilities, thus increasing the risk of accidents on the road. Another effect of the driver shortage is that some companies may be forced to hire less experienced or less-qualified drivers to fill vacant positions. These novice drivers may lack the expertise needed to handle difficult road situations, increasing the risk of dangerous incidents. Their lack of experience may lead to risky behaviours or inappropriate decisions in complex driving circumstances.

4. CONTRIBUTION OF AI AND IOT TO TRUCK DRIVERS WORK

AI is radically transforming many economic sectors, and distribution logistics is no exception. With the advent of AI and IoT technologies, the lives of heavy truck drivers will undergo significant changes, altering their daily activities and work environment. Indeed, thanks to IoT, trucks could be equipped with sensors and advanced navigation systems that enable drivers to choose the most efficient routes based on real-time traffic conditions. This could reduce wait times, delays, and the stress associated with navigation [47].

Connected sensors in trucks could also monitor mechanical performance in real-time and automatically report potential issues. This would allow drivers to take preventive measures to avoid costly breakdowns, thus enhancing their safety and efficiency [48]. Additionally, connected trucks could be equipped with technologies that improve driver comfort while on the road. This could include entertainment systems, advanced communication tools, and ergonomic adjustments, making long journeys more bearable [49].

IoT could help accurately track drivers' driving and rest hours, ensuring compliance with road safety regulations and driver well-being. This could also mitigate issues related to driver fatigue. With connected truck technology, communication between drivers and warehouses could be facilitated, allowing for more efficient coordination during loading and unloading. This could reduce wait times and improve overall supply chain management [50].

Another technological advancement generating significant interest is autonomous vehicles (AVs). They are viewed as a promising solution to the driver shortage, even though there will still be a constant need for drivers to carry out specific tasks. Possible developments within the industry could attract new workers but would require adaptations for older workers to acclimate to the use of new technologies.

An autonomous vehicle (AV) is equipped with advanced AI technologies, sensors, and navigation systems that allow it to operate without direct human intervention [51]. AV technology is based on six levels of automation [52]:

- Level 0 “No Driving Automation”: The vehicle is not equipped with automated driving functions or assistance systems. The driver is fully responsible for all aspects of driving.
- Level 1 ”Driver Assistance”: The vehicle has basic driver assistance systems, such as cruise control or lane-keeping assistance. These systems provide limited automated functions but require the driver to be fully engaged and in control of the situation.
- Level 2 “Partial Driving Automation”: The vehicle is equipped with advanced driver assistance systems that can control both steering and acceleration/deceleration. However, the driver must remain attentive and be ready to take control of the vehicle at any time.
- Level 3 “Conditional Driving Automation”: The vehicle can handle most driving tasks under certain conditions. The driver can relinquish control and engage in non-driving activities, but must be ready to take over when the system requests.
- Level 4 “High Driving Automation”: The vehicle can operate autonomously in most driving scenarios without human intervention. However, human oversight may be necessary in certain conditions or situations.
- Level 5 “Full Driving Automation”: The vehicle is entirely autonomous and requires no human attention. It can operate in all conditions and perform all driving tasks without human intervention. However, a human driver is still necessary to handle challenging situations, such as congested roads, despite the presence of automated features.

The trucking industry may be the first to widely adopt self-driving trucks for two reasons. First, AVs could help alleviate the trucker shortage, although human drivers would still be necessary for certain situations. Second, AVs could make roads safer by reducing the frequency and severity of accidents [53]. Furthermore, autonomous vehicles will lower fuel expenses by 5 to 10% and reduce driver wages and benefits costs, increasing profit margins for road transport companies [54, 55].

The integration of AVs is expected by 2030, with the process occurring in several progressive stages [56]. Initially, truck platooning on highways will be implemented, where only the lead truck is driven by a human driver. In a later stage, trucks will be fully autonomous on highways, but a driver will be needed for loading and unloading at specific relay points. Finally, in the third stage, trucks will acquire the capability to travel autonomously on the entire highway network without human intervention.

AVs have the potential to revolutionize the trucking industry by improving safety and reducing insurance costs [57]. Additionally, enhanced road safety would be a significant attraction for younger drivers [58]. AVs could play a crucial role in improving the efficiency of the road transport sector by operating continuously without needing breaks or rest. Moreover, they could optimize routes to reduce both travel times and fuel consumption [59].

AVs could help address the chronic driver shortage in the trucking industry [60]. Their adoption is expected to lead to profound changes in the driving workforce. Truck drivers are likely to see their jobs disappear due to automation. Some drivers may choose to transition to alternative careers in the transport sector, such as vehicle maintenance, while ageing workers might be forced to retire early [61].

According to Gittleman and Monaco, even with level 4 AVs, drivers will not be entirely replaced [62]. They will still be needed for tasks beyond driving itself, or to manage platoons of AVs in heavy traffic situations [63]. Significant workforce changes will not happen in the immediate future (2-5 years) and will likely only occur once level 4 and 5 AV technology is fully adopted [57].

5. CONCLUSION

Road transport plays a crucial role in the global economy by ensuring the secure, efficient, and sustainable movement of people and goods. Heavy truck drivers are central to this industry, as they are responsible for delivering goods in a timely and condition-compliant manner.

In addition to driving the vehicle, heavy truck drivers are also responsible for maintaining the truck, supervising the loading of goods, and, in some cases, unloading them. They ensure the proper execution of deliveries and take care of the transported goods.

In this article, we have identified the risks that contribute to heavy truck drivers' unavailability. We then conducted a causal analysis to highlight the various cause-and-effect relationships leading to this unavailability, aiming to anticipate risks and issues during the planning phase and to develop appropriate solutions.

We also examined the impact of IoT and AV on the daily work of drivers. These technologies undoubtedly herald a new era in road transport. However, the transition to a future where they become ubiquitous will not happen overnight. It will require careful planning, continuous adaptability, and an openness to innovation. Heavy truck drivers, the industry, and society as a whole all play crucial roles in shaping this outlook and fully exploiting its potential.

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