TRANSPORT PROBLEMS 2025 Volume 20 Issue 3
PROBLEMY TRANSPORTU DOI: 10.20858/tp.2025.20.3.07

Keywords: truck driver; hazard identification; risk assessment; road transport; logistics; occupational safety management

Michał PAŁĘGA[1], Mariusz SALWIN[2]*, Tomasz CHMIELEWSKI[3], Dariusz MASŁOWSKI[4]

PROFESSIONAL DRIVER OCCUPATIONAL RISK ASSESSMENT: CHALLENGES AND THREATS TO THE DEVELOPMENT OF ROAD TRANSPORT

Summary. This article aims to assess the occupational risks faced by truck drivers in the context of road transport development, using the Five Steps risk assessment method, which is consistent with international standards (ISO 12100, ISO 31000, ILO). The authors conducted a study to assess 23 occupational hazards faced by truck drivers. Furthermore, the authors identified the economic consequences of road accidents (employee absenteeism, compensation, and logistical losses). The highest risk levels were estimated for road collisions, fires, electrocutions, and factors related to driver stress and fatigue. These results are confirmed by statistics published by EU-OSHA and OSHA, confirming the accuracy of the risk analysis. The risk analysis demonstrates the need to implement specific preventive measures. The goal of this article is to fill a research gap in the assessment of occupational risk among truck drivers and to propose effective preventive measures, which constitute the basis for developing new occupational safety standards in the analyzed profession. It should be emphasized that risk assessment also allows for the identification of significant implications for shaping industry policy, which can contribute to reducing the risk of road accidents and improving driver safety, which is crucial for the efficiency and sustainable development of road transport.

1. INTRODUCTION

Ensuring safe and hygienic working conditions for a professional driver (truck driver) is of great importance for the development of road transport [1, 2], which is one of the pillars of the modern economy, enabling the efficient flow of goods and people on a local, national, and international scale. At the same time, the road transport sector poses numerous risks, both for drivers and for other road users [3, 4]. Examples include improper working conditions, fatigue, stress, and time pressure, which can lead to road accidents, which, in turn, cause material losses and threaten human life and health [5, 6].

The safety of a truck driver should be considered not only from an individual perspective but also from a social and economic perspective [7, 8]. The growing number of accidents involving truck drivers has significant social and economic implications. They can be related to, among others, hospitalization of injured people, repair of damaged vehicles, and losses resulting from delivery delays. Additionally, it is worth noting that the constant improvement of working conditions for truck drivers leads to

[1] Częstochowa University of Technology; 19 Armii Krajowej Av., 42-201 Częstochowa, Poland; e-mail: michal.palega@pcz.pl; orcid.org/0000-0002-2779-431X
[2] Warsaw University of Technology; 85 Narbutta, 02-524 Warsaw, Poland; e-mail: mariusz.salwin@pw.edu.pl; orcid.org/0000-0001-9325-8796
[3] Warsaw University of Technology; 85 Narbutta, 02-524 Warsaw, Poland; e-mail: tomasz.chmielewski@pw.edu.pl; orcid.org/0000-0003-0002-8751
[4] Opole University of Technology; 76 Prószkowska, 45-267 Opole, Poland; e-mail: d.maslowski@po.edu.pl; orcid.org/0000-0002-3964-540X
* Corresponding author. E-mail: mariusz.salwin@onet.pl

increased efficiency and decreased turnover in this profession, which is also crucial for addressing the deficit of qualified employees in the transport industry [9, 10].

In addition, reducing the number of road accidents translates to timely deliveries. It is essential to remember that every road incident causes delays that can have serious consequences for logistics companies and their customers. This is particularly important in the face of the modern economy based on the just-in-time principle. The precise management of delivery times often determines the competitiveness of economic entities [11, 12]. For this reason, it is essential to prioritize increasing truck drivers' safety and ensuring the continuity of the supply chain. The key elements of the strategy to improve the efficiency of road transport include, among others, investing in training, modern driver assistance systems, and optimizing the working time of truck drivers [13, 14].

This paper is motivated by the growing importance of road transport in the economy and the increasing number of road accidents involving professional drivers. Fatigue, excessive speed, improper workplace ergonomics, and insufficient training are just some of the leading causes of road accidents, which directly impact the health and lives of employees in this industry sector. In addition, it is worth noting that the dynamic development of technology in road transport creates both new opportunities and challenges in the field of driver safety. Globalization and the constantly growing requirements in terms of logistics necessitate action to improve driver safety [15, 16].

Accident prevention also affects the efficiency and stability of the entire transport sector. Implementing effective occupational risk management strategies and promoting best practices in the field of safety are also dictated by the growing awareness of the importance of workplace ergonomics and the impact of psychophysical load on drivers' health. It should be noted that various types of work-related ailments, such as chronic back pain, vision problems, or sleep disorders, can significantly impact driving safety [17, 18].

This paper analyzes the importance of professional driver safety in the context of road transport's functioning and development. In particular, the authors focused on identifying and assessing occupational hazards occurring in the work environment of truck drivers.

The quantitative Five Steps method was used to assess the level of occupational risk. In addition, based on the results of the conducted research, possible technical and organizational actions were indicated that can contribute to improving work safety and reducing road accidents [19].

The implementation of the above research objective also requires answers to the research questions below:

1. What occupational hazards occur in the work environment of a professional driver, and how do they affect the overall level of occupational risk?
2. How is the occupational risk assessment process carried out using the Five Steps method?
3. What protective measures and preventive actions should be implemented to limit the impact of risk factors on the safety of truck drivers?
4. How can the proposed protective measures and preventive actions reduce the number of accidents and the health and life of truck drivers?

According to the authors of the paper, the results of the conducted analysis of the occupational risk to truck drivers should be considered in light of current statistical data on road safety in Poland and other European Union countries. Data published by the Central Statistical Office indicate that 21,519 road accidents were recorded in Poland in 2024, representing a 3% increase compared to 2023. In these accidents, 1,896 people died (a 0.2% increase), and 24,782 were injured. Furthermore, the number of road collisions also increased compared to the previous year, reaching 390,580 in 2024.

Based on the data, the fatality rate remains stable, but it is one of the highest road fatality rates in the European Union, at 52 deaths per million inhabitants, compared to 44 in the European Union. By comparison, 19,800 people died on European Union roads in 2024, a decrease of approximately 3% compared to 2023. The highest fatality rates per million inhabitants were recorded in Latvia (59), Portugal (60), Bulgaria (74), and Romania (77). Above-average rates were recorded in France (50%), Poland (52%), and Italy (53%). Above-average rates were recorded in Spain (38%), Slovenia (39%), Lithuania (42%), Finland, and Belgium (43% each). The lowest fatality rate per million inhabitants was recorded in Sweden (20). Slightly higher rates were also recorded in Malta (21%), Denmark (24%), Ireland (27%), and Germany (31%). These countries have very high road safety. Poland, with a rate of

52 fatalities per million inhabitants, exceeds the EU average, indicating a relatively moderate level of road safety.

Data on the participation of heavy goods vehicles in road accidents are particularly worrying. According to an analysis by the European Road Safety Observatory, trucks are involved in approximately 14% of all fatal accidents in the EU, resulting in over 3,000 fatalities annually. In Poland, truck drivers were responsible for 7.8% of road accidents in 2023 [20–22]. The latest data for 2024 has not yet been published.

2. CHARACTERISTICS OF THE PROFESSION OF A TRUCK DRIVER

A truck driver drives vehicles, except buses, with a permissible total weight exceeding 3.5 tonnes, with or without trailers, intended for public road transport. The driver checks the technical condition of the vehicle, prepares it for driving, and operates the truck in accordance with road traffic regulations and their qualifications (driving license category C or C1, C+E, or C1+E), transporting loads on designated routes in domestic and international transport. The driver performs service, maintenance, and minor repairs on trucks as part of their responsibilities [3, 23]. They take care of his safety and that of other road users, observing breaks and working hours while driving, per the regulations on drivers' working hours and the "Road Traffic Law". The driver keeps driving records related to transport tasks, secures the vehicle against theft, unauthorized use, and accidental starting, and protects the entrusted load from damage, destruction, or loss. When participating in road traffic, drivers are obliged to provide first aid to victims of road accidents [24].

A truck driver can work in domestic and international municipal and long-distance transport companies. It is possible to work in this profession on one's own account. One can be employed in positions related to transport, such as a truck driver or a traffic dispatcher. Speaking a foreign language is helpful in performing this profession, especially in international transport [12, 25].

The work environment in this profession is characterized by high and very complex occupational risk. Hence, identifying and assessing threats requires a systematic approach, e.g., using the Five Steps method [15, 18].

The basic scope of professional activities, which includes, among others, driving a vehicle, technical preparation of the vehicle for driving, supervising cargo, and interacting with customers, may pose specific threats (Table 1).

Table 1

Scope of work of a truck driver and division of potential hazards

Scope of work	Potential hazard
Getting in and out of the vehicle, moving around the warehouse	Hitting fixed objects, moving machinery, and other vehicles
Driving a vehicle in road traffic	Collision, road accident, microclimate, dust, and lighting
Working at night and in various weather conditions	Lighting and stress
Vehicle maintenance and minor repairs	Contact with hot water and other media, electric current, and chemicals
Loading/unloading and securing goods	Fall, contact with sharp edges, catching, crushing, overload of the musculoskeletal system, microclimate, fire, explosion, chemicals, and dust
Fixed seat, vibrations, and noise	Overload of the musculoskeletal system, noise, general and local vibrations, and forced body position
Cooperation with customers and contractors	Aggression, viruses and bacteria, and stress

Truck drivers should have developed sensorimotor skills (including vision, reflexes, and coordination), physical endurance, and resilience to stress. This is extremely important from the point of view of occupational safety and prevention of road accidents [10, 26].

3. RESEARCH METHODOLOGY

The Five Steps method is one of the popular and practical methods used to quantitatively assess occupational risk. The risk level is calculated using the following formula [27]:

$$R = P \, x \, F \, x \, S \, x \, I, \tag{1}$$

where:
P – probability of occurrence of a hazardous event,
F – exposure to the hazard,
S – severity of the consequences of the event,
I – number of people exposed to the hazard.

The numerical value assigned to each parameter is determined based on criteria detailed in Table 2, which contains point scales and corresponding qualitative descriptions, enabling a uniform and transparent assessment of the parameters. After assigning appropriate values to all four parameters, the risk value R is calculated as their product. The resulting result is then interpreted according to the adopted scale, allowing for the determination of the risk level and the implementation of appropriate preventive or corrective actions.

Table 2

Characteristics of the value of the probability of hazard occurrence, characteristics of the value of exposure to hazard, characteristics of the value of the magnitude of consequences, characteristic values of the number of people exposed to the hazard, values, and characteristics of risk levels R [27]

Probability Level (P)	**Description**
0.033	Almost impossible
1	Very unlikely, but possible
1.5	Unlikely, but could happen
2	Possible, but unusual
5	Equal chance
8	Likely
10	Happens
15	Certain
Hazard Exposure Level (F)	**Description**
0.5	Once a year
1	Once a month
1.5	Once a week
2.5	Once a day
4	Every hour
6	Constantly
Effect Magnitude Level (S)	**Description**
0.1	Scratches, bruises
0.5	Lashes, mild injuries
2	Minor illness, simple fractures
4	Serious fractures, serious illness
6	Loss of one limb, loss of an eye, permanent hearing loss
10	Loss of two limbs, loss of an eye
15	Death
Value of the number of people exposed to the hazard (I)	**Description**
1	1–2 people
2	3–7 people
4	8–15 people
12	16–50 people
Risk Level (R)	**Description**
$0.5 \leq R$	Negligible risk
$5 < R \geq 50$	Low but significant risk
$50 < R \geq 500$	High risk
$500 < R$	Unacceptable risk

Data acquisition is a critical stage in the risk analysis process, as it enables a precise determination of hazards and an assessment of the risk associated with the profession of driving. These data should

come from many different sources, as this ensures the results' reliability and considers all aspects of work [11, 28]. Below are the basic sources of data collection used by the authors to conduct the occupational risk assessment in the present work.

First, the authors conducted numerous interviews with managers of transport companies, drivers, and occupational health and safety specialists. Direct interviews were conducted to obtain information on the daily tasks and challenges faced by truck drivers [29, 30]. This was necessary to identify potential hazards that do not always seem obvious and to discern employees' opinions on risk perception.

In addition, an analysis of documents and internal reports of transport companies was carried out. These included:

- reports of road accidents and incidents,
- data on drivers' working time,
- vehicle technical reports,
- data from GPS systems.

These sources of information were supplemented by the analysis of statistical data published by external institutions, such as the Central Statistical Office in Poland, Eurostat, and other transport industry organizations. First of all, they are concerned about the number of road accidents that may affect the occupational risk of drivers.

4. IDENTIFICATION OF OCCUPATIONAL HAZARDS AND RISK ASSESSMENT OF A TRUCK DRIVER

A detailed identification of occupational hazards for a truck driver and a description of the causes and effects of their occurrence are presented in Table 3. The truck driver's occupational risk assessment card is presented in Table 4.

Table 3

Identification of occupational hazards in the work environment of a truck driver

No	Hazard	Causes	Effects
1.	Falling on the same level	Wet, slippery, or icy surfaces and lack of due care when entering/exiting the cab, inappropriate work footwear, spilled liquids and oils, tripping over protruding elements (tools, cables)	Contusions, sprains, dislocations of limbs, lumps, bruises, cuts, temporary absence, loss of concentration, and reduced sense of security
2.	Falling to a lower level	Falling from a trailer or loading platform, improper use of ladders and platforms, lack of protection when covering with tarpaulins, and a lack of due care	Fractured limbs, head injuries, spine injuries, internal organs, hospitalization, long-term rehabilitation, and possible total incapacity to work in the profession
3.	Hitting fixed objects	Narrow passages and accesses, careless movement around the warehouse or transport base, and a lack of proper lighting	Contusions, lacerations, lumps and bruises, and a short-term decrease in work efficiency
4.	Contact with sharp edges (cuts)	Exposed metal elements, tools, poorly secured load, no gloves, and a lack of due care	Cuts, cuts and lacerations, need for first aid, and limited mobility of the limb (hand, fingers)
5.	Hitting falling objects	Improper securing of cargo, falling objects when opening the trailer, and vibrations causing the cargo to move	Crushing of limbs, neck and head injuries, concussion, fractures, cuts, wounds, and risk of permanent injuries
6.	Moving machinery and other vehicles	Failure to observe pedestrian and machine traffic zones, driving too fast in parking lots, lack of due caution in loading areas, and limited visibility of the driver by operators of other machines (so-called blind spots)	Fractures, dislocations, cuts, hitting, injuries to internal organs, and risk of death

No	Hazard	Causes	Effects
7.	Collision, road accident	Driver fatigue and drowsiness, lack of due caution and distraction (e.g., when using a mobile phone), excessive speed inappropriate for road and weather conditions, limited visibility, vehicle breakdown, incorrect behaviour of other road users, failure to maintain an appropriate distance from other vehicles, incorrect manoeuvres, improper securing of cargo	Fractures of limbs, head and spine injuries, injuries to internal organs, concussion, paralysis, amputations, long-term hospitalization and rehabilitation, stress (PTSD), anxiety, and death
8.	Catching or crushing	Operation of moving equipment (e.g., trolleys, forklifts, conveyor belts, pallet jacks), operation of trailer mechanisms (latches, lifts), dangerous zones between vehicles, and moving cargo	Crushing, dislocations, fractures, cuts, injuries to internal organs, loss of limbs (amputation), and psychological trauma (trauma)
9.	Overloading the musculoskeletal system	Carrying heavy loads, prolonged sitting position, and incorrect seat adjustment	Musculoskeletal system diseases, degenerations, posture defects, and back, joint, and neck pain
10.	Contact with hot water and other media	Touching hot engine or exhaust system parts, cooling system faults, contact with steam during failures, and failure to use work gloves	Burns, pain, scars, possible infections, need for first aid, need for hospitalization, and the possibility of long-term sick leave
11.	Electric current	Faulty electrical installation, improper operation of electrical devices, and damaged extension cords or tools	Shock, electric shock, loss of consciousness, heart rhythm disturbances, and the possibility of death
12.	Microclimate	High or low temperature in the cabin, loading materials that emit heat or moisture, and steamed-up windows	Overheating, stroke, hypothermia, frostbite, respiratory diseases, loss of concentration, and deterioration of general health
13.	Fire, explosion	Electrical short circuit, starting a fire (e.g., while smoking cigarettes, improper securing of flammable materials, faulty fuel or gas systems	Serious burns, damage to the respiratory tract, disability, and the possibility of death,
14.	Aggression of people and animals	Robbery, conflicts with other road users, and intrusions of wild animals in rest areas	Bumps, bruises, contusions, fractures, wounds, bites, stress (PTSD), and anxiety
15.	Chemical substances	Fuel fumes, engine exhaust fumes, oils, brake fluids, transport of hazardous materials (ADR), and cleaning agents	Irritation of the skin, eyes, respiratory tract, poisoning, allergies, respiratory and digestive system diseases, and a need for specialist treatment
16.	Dust	Road dust generated when driving on an unpaved surface, loading or unloading bulk materials, and failure to use protective masks in a dusty environment	Allergies, headaches, burning eyes, irritation, itching, chronic cough, shortness of breath, respiratory system diseases, and decreased physical performance
17.	Viruses and bacteria	Contact with sick people, difficult hygiene, and prolonged stays in a closed room (e.g., in a cabin)	Infectious diseases (flu, pneumonia), fungal skin diseases, and digestive system diseases
18.	Noise	Noise emitted by vehicles in road traffic, noise at loading and unloading points, and the loud use of the radio	Hearing organ damage, nuisance at work, distraction, headaches, stress, fatigue, and the possibility of causing an accident
19.	Local and general vibration	Vibrations transmitted through the steering wheel and pedals, driving on	Numbness of limbs (arms, legs), vibration syndrome, and musculoskeletal system diseases

No	Hazard	Causes	Effects
		uneven terrain, and using a seat without suspension	
20.	Lighting	Insufficient lighting when driving after dark, the blinding effect of another vehicle's lights, and failure of cabin lighting or headlights	Eye fatigue, visual acuity disorders, fatigue, risk of collision or accident, and decreased work efficiency
21.	Stress	Transporting valuable cargo, responsibility, working under time pressure, long working hours, lack of sleep, conflicts with other people (e.g., forwarders, customers), and unexpected problems on the road (traffic jams, roadworks)	Sleep disorders, decreased concentration, digestive system ailments and diseases, hypertension, heart disease, neurosis, depression, and addictions
22.	Forced body position	Long-term driving, incorrectly adjusted seat, and a lack of ergonomics during loading and unloading	Spine, neck, leg pain, musculoskeletal system diseases, fatigue, and posture defects
23.	Hazards related to ventilation and air conditioning	Inefficient ventilation or air conditioning, inadequate air exchange, mold growth in the ventilation system, unpleasant or harmful odor	Cold, sore throat, allergies, eye irritation, discomfort, and drowsiness

Table 4

Truck Driver Occupational Risk Assessment Card

No	Hazard	Probability	Exposure	Magnitude of effects	Number of people exposed	Risk
1.	Falling on the same level	P = 2	F = 2.5	S = 0.5	I = 1	R = 2.5
		Possible, but unusual	Once a day	Mild injuries	1–2 people	Negligible
2.	Falling to a lower level	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness, minor fractures	1–2 people	Low but significant
3.	Hitting fixed objects	P = 2	F = 2.5	S = 0.5	I = 1	R = 2.5
		Possible, but unusual	Once a day	Mild injuries	1–2 people	Negligible
4.	Contact with sharp edges (cuts)	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness, minor fractures	1–2 people	Low but significant
5.	Hitting falling objects	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Serious illness	1–2 people	Low but significant
6.	Moving machinery and other vehicles	P = 2	F = 2.5	S = 15	I = 1	R = 45
		Possible, but unusual	Once a day	Death	1–2 people	Low but significant
7.	Collision, road accident	P = 2	F = 2.5	S = 15	I = 4	300
		Possible, but unusual	Once a day	Death	8–15 people	High

No	Hazard	Probability	Exposure	Magnitude of effects	Number of people exposed	Risk
8.	Catching or crushing	P = 2	F = 2.5	S = 6	I = 1	R = 30
		Possible, but unusual	Once a day	Loss of one limb	1–2 people	Low but significant
9.	Overloading the musculoskeletal system	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
10.	Contact with hot water and other media	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
11.	Electric current	P = 2	F = 2.5	S = 15	I = 1	R = 75
		Possible, but unusual	Once a day	Death	1–2 people	High
12.	Microclimate	P = 2	F = 2.5	S = 2	I = 1	10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
13.	Fire, explosion	P = 2	F = 2.5	S = 15	I = 1	R = 300
		Possible, but unusual	Once a day	Death	1–2 people	High
14.	Aggression of people and animals	P = 2	F = 2.5	S = 4	I = 4	R = 20
		Possible, but unusual	Once a day	Serious illness	8–15 people	Low but significant
15.	Chemical substances	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Serious illness	1–2 people	Low but significant
16.	Dust	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
17.	Viruses and bacteria	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
18.	Noise	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Serious illness	1–2 people	Low but significant
19.	Local and general vibration	P = 2	F = 2.5	S = 2	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
20.	Lighting	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Serious illness	1–2 people	Low, but significant
21.	Stress	P = 2	F = 2.5	S = 2	I = 1	R = 20
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant
22.	Forced body position	P = 2	F = 2.5	S = 4	I = 1	R = 20
		Possible, but unusual	Once a day	Serious illness	1–2 people	Low but significant

No	Hazard	Probability	Exposure	Magnitude of effects	Number of people exposed	Risk
23.	Hazards related to ventilation and air conditioning	P = 2	F = 2.5	S = 4	I = 1	R = 10
		Possible, but unusual	Once a day	Mild illness	1–2 people	Low but significant

When assessing occupational risk, the same level of probability of hazard occurrence was assumed—"possible, but unusual" (P = 2) and the same frequency of exposure - "once a day" (F = 2.5) for all assessed occupational hazards. This results primarily from the specificity of a professional driver's work and the nature of the environment in which they perform their professional tasks. A probability level of P = 2 means that the hazard may occur on any working day, but there is no certainty that it will occur (statistically, it does not happen every day). However, taking into account the dynamic nature of the driver's work, adopting such a level of probability is fully justified and allows for maintaining the consistency of the assessment. In turn, the exposure level was defined as "once a day" (F = 2.5) because a truck driver has daily contact with situations that may potentially lead to a hazard [31, 32].

The occupational risk assessment included 23 potential threats. Based on the obtained risk index (R) values, the threats were classified into three groups: negligible, low but significant, and high.

The hazard posing the greatest risk to a truck driver's work is a collision or road accident, which had the highest risk index (R = 300). This is a possible but rare event that can cause tragic consequences, including a threat to the lives of many people (8–15 employees). The same level of risk (R = 300) was also estimated for the hazard associated with fire or explosion, which is associated with transporting hazardous materials and technical failures. Electric shock is the third most severe hazard, with a high risk level (R = 75). This hazard is associated with using electrical installations during vehicle operation or loading infrastructure. Most of the hazards that were assessed are characterized by low but significant risk. In the work of a truck driver, special attention should be paid to the following risk factors:

- moving machines and other vehicles (R = 45),
- being caught or crushed (R = 30),
- contact with sharp edges, chemicals, noise, stress, lighting, and hot media (R = 20),
- dust, microclimate, vibrations, overload of the musculoskeletal system, and forced body position (R = 10).

It should be emphasized that the risk values of these threats are relatively low. However, their constant exposure in the work environment may harm the human body and lead to chronic health problems. Therefore, employers are obligated to implement adequate preventive measures to improve the ergonomic conditions of the workplace and, in particular, provide regeneration breaks, use personal protective equipment, ensure adequate air conditioning and ventilation, and offer psychological support [33]. The lowest risk index (R = 2.5) was estimated for two hazards that were classified as negligible: falling at the same level and hitting stationary objects. Both threats were assessed as possible but rare, with mild effects and a limited number of people exposed. This risk was considered very low; however, it requires basic safety measures, such as wearing appropriate work footwear, maintaining proper organization of the space, and keeping the work environment orderly.

An essential element is the implementation of appropriate corrective and preventive actions. In the case of a truck driver, basic personal protective equipment includes [34]:

- protective clothing and work footwear (e.g., reflective vests, jackets, and safety footwear);
- work gloves;
- protective earplugs and earmuffs;
- safety glasses;
- safety helmets.

All personal protective equipment should be based on the characteristics of the driver's work environment, and employees should comply with the obligation to use it.

Implementing effective preventive programs [35, 36] is also important for work safety and should focus on reducing the risk of occupational diseases, accidents, and driver fatigue. Such programs include:

- health and sports programs for drivers (e.g., regular cardiology, neurological, vision tests, sports packages, and massages);
- training in ergonomics and health prevention (e.g., training in the correct body posture while driving, and performing relaxation exercises);
- stress management programs and psychological support (e.g., learning how to cope with stress, techniques for communicating with customers, and crisis management).

Possible changes in the work organization system should include:

- rotations and changes in route planning (avoiding long-term performance of monotonous tasks, avoiding excessive workload on one driver, introducing days off from work, and reducing the number of hours behind the wheel);
- increasing the number of breaks and rests (increasing breaks for rest, regeneration, meals, and sleep);
- shift work (driver rotation, ensuring even distribution of mental and physical workload).

Modern tools and technologies are also worth implementing to manage risk in a truck driver's work effectively. In particular, they support monitoring driver fatigue, managing working time, and assessing vehicle condition. These include [37, 38]:

- driver fatigue recorders – modern systems monitoring the driver's fatigue state, based on recognizing changes in their behavior (e.g., systems detecting head drop, changes in driving style, and reactions to the environment). Such systems can warn the driver about the need for a break and help avoid dangerous situations;
- work time management applications – mobile applications that allow drivers to track work and rest times per applicable regulations;
- fleet monitoring systems (telematics) – modern telematics systems can be used to collect data on speed, fuel consumption, driving style, and monitor the technical condition of vehicles. They allow for the quick detection of technical faults,
- cameras that monitor driver behavior – systems that monitor driver behavior in real time can detect fatigue and respond to threats such as sudden loss of concentration, improper driving, or exceeding the permitted speed.

The effectiveness of the proposed preventive measures for truck drivers' occupational safety requires a comprehensive and systematic approach. Several important aspects of their effective implementation and potential barriers that may hinder this process should be highlighted. It is important to build a unified system based on formal and informal requirements (occupational safety culture). This requires the involvement of top management, training staff, and the drivers themselves. The systematic monitoring of working conditions and responding to any emerging changes and threats should also be considered.

In practice, the most important barriers to effective safety system implementation include financial constraints, which can hinder investments in modern technologies or the implementation of health programs. These problems are particularly prevalent among small local transport companies. Furthermore, the pressure of time and the timely completion of transport orders can lead to drivers neglecting or overlooking occupational safety practices. Furthermore, a very low level of acceptance of various preventive measures and activities can be observed among drivers. Employees often perceive preventive checkups, rest breaks, and training as unnecessary and hindering their work. This is primarily due to low awareness of potential threats and a persistent organizational culture.

Additionally, high staff turnover and inadequate supervision of on-the-road employees can exacerbate driver misconduct. Furthermore, the lack of proper adaptation of occupational health and safety regulations and procedures to drivers' actual working conditions and the specific nature of the transport industry is also worth mentioning, as it can further exacerbate difficulties in their practical application. The presented barriers indicate a real need for transport companies to undertake educational, organizational, and technical measures that will create a coherent system of protection that will effectively reduce occupational risks for drivers and ensure improved working conditions. Additionally,

high staff turnover and inadequate supervision of on-the-road employees can exacerbate driver misconduct.

In the context of road transport development and industry policy, the results of the driver occupational risk assessment indicate several important implications for a systematic approach to driver occupational risk management.

Due to the high risk of hazards such as road accidents and fires, it is essential to implement appropriate legal regulations and standards regarding the use of modern preventive technologies and work organization. Examples include the mandatory installation of advanced driver assistance systems, vehicle condition monitoring, and strict emergency procedures.

Attention should also be paid to the hazards related to drivers' physical and psychosocial work environments. Research findings show that these hazards are relatively low-level, but they are also significant from the perspective of occupational safety and require long-term preventative measures and support from employers and occupational safety supervisors. In this regard, industry policy should focus on implementing and developing health and ergonomics programs, which will reduce the risk of occupational illnesses and increase overall safety, work efficiency, and driver satisfaction.

From a legislative perspective, there is a need to tighten regulations regarding drivers' working and rest times, employee turnover, and mandatory safety and stress management training. These measures can positively impact the number of road accidents.

Furthermore, given the development of the transport industry, sustainable development issues should also be addressed. The technical and organizational solutions proposed in this article, in addition to improving driver safety, also impact the quality of services provided, as well as the competitiveness and image of transport companies.

In summary, the results of the occupational risk assessment for truck drivers indicate the need for comprehensive changes in industry policy. The authors believe these changes should address legal regulations, investments in new technologies, and preventive measures. Only such an approach can address the challenges of modern road transport and ensure continuous improvement in occupational safety.

5. CONCLUSIONS

Many different mechanical, ergonomic, and psychosocial occupational hazards were identified in the work environment of a truck driver. The risk analysis identified 23 significant hazards that could have varying impacts on employee safety, including death, serious injuries, or mass incidents (e.g., collisions, fires, and electric shocks). It should be noted that the results of the occupational risk assessment for truck drivers presented in this study are reflected in statistics provided by the European Agency for Health and Safety at Work (EU-OSHA) and the Occupational Safety and Health Administration (OSHA), USA, regarding road transport accidents. Thus, the authors confirmed the accuracy of the conducted risk assessment.

Occupational hazards common in the work environment of truck drivers, such as road accidents, injuries, stress, and various musculoskeletal ailments, have serious health and economic consequences. Transport companies incur costs related to employee absenteeism and their treatment, disability benefits, and the costs of recruiting and hiring new employees (e.g., training and medical examinations). Road accidents cause additional economic losses related to damage to the vehicle or the cargo being transported. Furthermore, they can result in the payment of contractual penalties and compensation to customers for late order completion. Globally, these situations increase the costs of the national healthcare and social security systems, ultimately leading to a decline in productivity across the transport industry.

The Five Steps method was used in this research, as dictated by the universality and transparency of its application in work environments. Also, this method considers many risk variables, including probability, exposure, effect, and the number of exposed people.

It should also be emphasized that the selected Five Steps methodology is justified by the international standards ISO 12100 and ISO 31000, as well as the guidelines of the International Labor Organization

(ILO). Furthermore, the risk assessment framework, which takes into account factors such as the probability of hazard occurrence, exposure, the severity of consequences, and the number of people exposed, is consistent with the assumptions of the Health and Safety Executive (HSE, UK) and practices presented in the literature on occupational health and safety.

The conducted diagnosis of occupational risk among truck drivers indicates the need for significant implications for shaping appropriate industry policy. Identifying the most serious risk factors should form the basis for developing consistent guidelines for businesses and institutions supervising the transport industry. Among the most important implications for transport policy is the urgent need to develop standards for working and rest time, regular preventive health checkups, and fleet ergonomic modernization. It is also essential to emphasize the importance of developing health programs that consider drivers' mental health and stress management. Furthermore, building a systemic approach to occupational risk management, which includes the continuous and systematic improvement of working conditions, will contribute to increased efficiency and stability within the road transport industry.

The effective reduction of the impact of risk factors requires implementing specific organizational and technical actions. The basis for this is the use of personal protective equipment, including protective clothing and footwear, gloves, earplugs, glasses, and helmets. Then, preventive measures such as health examinations, ergonomic training, and psychological support should be indicated. Organizational changes based on the rationalization of the work schedule, task rotation, and increasing the number of breaks also play an important role in accident prevention. In addition, implementing modern technological tools, such as fatigue monitoring systems, work time management applications, telematics systems, and on-board cameras, will also positively impact truck drivers' safety.

The current results fill the gap regarding the lack of comprehensive, up-to-date risk assessment tools in road transport. In addition, the study provided the basis for building integrated systems to manage the safety of drivers' work. A critical task is to develop new standards for occupational risk assessment and practical guidelines for mitigating the impact of risk factors, specifically targeting the transport industry, given the growing digitalization and automation of logistics processes.

References

1. Jacyna-Gołda, I. & Shmygol, N. & Sembiyeva, L. & et al. Modeling sustainable development of transport logistics under climate change, ecosystem dynamics, and digitalization. *Applied Sciences*. 2025. Vol. 15. No. 7593. DOI: 10.3390/app15137593.
2. Jacyna-Gołda, I. & Shmygol, N. & Gavkalova, N. & et al. Sustainable development of intermodal freight transportation – Through the integration of logistics flows in Ukraine and Poland. *Sustainability*. 2023. Vol. 16. No. 267. DOI: 10.3390/su16010267.
3. Budzyński, A. & Sładkowski, A. Machine learning in road freight transport management. In: Sładkowski, A. (ed.) *Using Artificial Intelligence to Solve Transportation Problems*. Springer, Cham. 2024. P. 485-565. DOI: 10.1007/978-3-031-69487-5_9.
4. Osintsev, N. & Tsyganov, A. & Rakhmangulov, A. & et al. Multi-criteria assessment of piggyback systems in sustainable supply chains. In: Sładkowski, A. (ed.) *Modern Trends and Research in Intermodal Transportation*. Springer, Cham. 2022. P. 451-559. DOI: 10.1007/978-3-030-87120-8_10.
5. Grabarek, I. & Bęczkowska, S. Analysis of factors determining ergonomic conditions of driver's workplace and safety in transport of dangerous goods. *Archives of Transport*. 2012. Vol. 24. P. 297-306.
6. HM Treasury. *The Orange Book: Management of Risk – Principles and Concepts*. UK. 2004.
7. Antoniou, C. & Balakrishna, R. & Koutsopoulos, H.N. A synthesis of emerging data collection technologies and their impact on traffic management applications. *European Transport Research Review*. 2011. Vol. 3. P. 139-148. DOI: 10.1007/s12544-011-0058-1.
8. Topolšek, D. & Babić, D. & Fiolić, M. The effect of road safety education on the relationship between driver's errors, violations and accidents: Slovenian case study. *European Transport Research Review*. 2019. Vol. 11. No. 18. DOI: 10.1186/s12544-019-0351-y.

9. Pałęga, M.Ł. & Rydz, D. & Salwin, M. & et al. Occupational safety management and human reliability testing during the operation of a plastic injection molding machine. *Eksploatacja i Niezawodność – Maintenance and Reliability*. 2024. Vol. 26(4). No. 192112. DOI: 10.17531/ein/192112.
10. Masłowski, D. & Salwin, M. & Pałęga, M. & et al. The significance of changes in fuel prices in the context of the operations of transport enterprises in Poland and Europe. *Transport Problems*. 2024. Vol. 19. No. 3. P. 169-182. DOI: 10.20858/tp.2023.19.3.14.
11. Romanowska-Słomka, I. & Słomka, A. *Ocena ryzyka zawodowego*. Tarbonus. 2010. [In Polish: *Occupational risk assessment*].
12. Providing state-supported financial incentives and benefits for vehicle insurance policies using telematics. In: *Strengthening European Mobility Policy*. Springer, Cham. 2024. P. 87-99. DOI: 10.1007/978-3-031-67936-0_7.
13. Jacyna, M. & Szczepański, E. & Lewczuk, K. & et al. Noise pollution from transport. In: *International Encyclopedia of Transportation*. Elsevier. 2021. P. 277-284. DOI: 10.1016/B978-0-08-102671-7.10723-7.
14. Domański, J. Competitiveness of nongovernmental organizations in developing countries: Evidence from Poland. *Nonprofit and Voluntary Sector Quarterly*. 2012. Vol. 41. P. 100-119. DOI: 10.1177/0899764010395947.
15. Sałaciński, T. & Chrzanowski, J. & Chmielewski, T. Statistical process control using control charts with variable parameters. *Processes*. 2023. Vol. 11. No. 2744. DOI: 10.3390/pr11092744.
16. Yang, H. & Zhao, X. & Luan, S. et al. Examining causal factors of traffic instability using traffic flow and driving behavior data. *International Journal of Transportation Science and Technology*. 2025. DOI: 10.1016/j.ijtst.2025.01.009.
17. Jacyna-Gołda, I. & Kłodawski, M. & Lewczuk, K. et al. Elements of perfect order rate research in logistics chains. *Archives of Transport*. 2019. Vol. 49. P. 25–35. DOI: 10.5604/01.3001.0013.2771.
18. Lewczuk, K. & Żuchowicz, P. Virtual reality application for the safety improvement of intralogistics systems. *Sustainability*. 2024. Vol. 16. No. 6024. DOI: 10.3390/su16146024.
19. HSE. *Five steps to risk assessment*. Sudbury. 2006.
20. Police Headquarters. *Road accidents in Poland in 2024 – annual report*. Warsaw. 2024.
21. Central Statistical Office. *Road accidents in Poland in 2024*. Warsaw. 2024.
22. Atasayar, H. & Fleischer, M. & Donabauer, M. *Annual statistical report on road safety in the EU, 2024*. European Road Safety Observatory, European Commission. Brussels. 2024.
23. Oikonomou, M.G. & Sekadakis, M. & Ziakopoulos, A. et al. Integrated traffic simulation developer suite for shared automated mobility. In: *Lecture Notes in Mobility*. Springer, Cham. 2025. P. 215-231. DOI: 10.1007/978-3-031-71793-2_13.
24. Szczucka-Lasota, B. & Węgrzyn, T. & Jurek, A. et al. Monitoring fuel quality in the transport industry. *Scientific Papers of Silesian University of Technology*. *Organization and Management Series*. 2024. No. 191. P. 541-549. DOI: 10.29119/1641-3466.2024.191.34.
25. Salwin, M. & Nehring, K. & Jacyna-Gołda, I. & Kraslawski, A. Product-service system design – an example of the logistics industry. *Archives of Transport*. 2022. Vol. 63. P. 159-180. DOI: 10.5604/01.3001.0016.0820.
26. Masłowski, D. Telematics solutions for traffic management of public transport vehicles. In: Mikulski, J. (ed.) *Research and the Future of Telematics*. Springer, Cham. 2020. P. 138-151. DOI: 10.1007/978-3-030-59270-7_11.
27. Pałęga, M. Application of the Job Safety Analysis (JSA) method to assessment occupational risk at the workplace of the laser cutter operator. *Management and Production Engineering Review*. 2021. Vol. 12(3). P. 40-50. DOI: 10.24425/mper.2021.138529.
28. Polukarov, O.I. & Prakhovnik, N.A. & Polukarov, Y.O. et al. Assessment of occupational risks: New approaches, improvement, and methodology. *International Journal of Advanced and Applied Sciences*. 2021. Vol. 8. P. 79-86. DOI: 10.21833/ijaas.2021.11.011.

29. Grodzicka, A. & Plewa, F. & Krause, M. & et al. Selection of employees for performing work activities in currently used ventilation systems in hard coal mining. *Energies*. 2022. Vol. 15. No. 408. DOI: 10.3390/en15020408.
30. Nævestad, T.-O. & Laiou, A. & Yannis, G. Safety culture among car drivers and motorcycle riders in Norway and Greece. *Frontiers in Sustainable Cities*. 2020. Vol. 2. DOI: 10.3389/frsc.2020.00023.
31. Darby, P. & Murray, W. & Raeside, R. Applying online fleet driver assessment to help identify, target and reduce occupational road safety risks. *Safety Science*. 2009. Vol. 47. P. 436-442. DOI: 10.1016/j.ssci.2008.05.004.
32. Priolo, G. & Vignoli, M. & Nielsen, K. Risk perception and safety behaviors in high-risk workers: A systematic literature review. *Safety Science*. 2025. Vol. 186. No. 106811. DOI: 10.1016/j.ssci.2025.106811.
33. Jakobsen, M.D. & Seeberg, K.G.V. & Møller, M. & et al. Influence of occupational risk factors for road traffic crashes among professional drivers: Systematic review. *Transport Reviews*. 2023. Vol. 43. P. 533-563. DOI: 10.1080/01441647.2022.2132314.
34. Guibert, N. & Martin, J.-L. & Gadegbeku, B. & et al. The risk of road traffic crashes for occupational drivers: A responsibility study with comparison to the general population. *Work*. 2024. Vol. 77. P. 511-522. DOI: 10.3233/WOR-220578.
35. Mudiyanselage, S.E. & Nguyen, P.H.D. & Rajabi, M.S. & et al. Automated workers' ergonomic risk assessment in manual material handling using sEMG wearable sensors and machine learning. *Electronics*. 2021. Vol. 10. No. 2558. DOI: 10.3390/electronics10202558.
36. Nguyen, P.-T. & Nguyen, T.-A.-T. Application of SLP and LEAN method in designing the layout of auto parts manufacturing factory. In: *2023 8th International Scientific Conference on Applying New Technology in Green Buildings (ATiGB)*. IEEE. 2023. P. 1-7. DOI: 10.1109/ATiGB59969.2023.10364437.
37. Fasanmade, A. & Al-Bayatti, A.H. & Morden, J.N. et al. Context-aware quantitative risk assessment machine learning model for drivers distraction. *arXiv preprint*. 2024. DOI: 10.48550/ARXIV.2402.13421.
38. Karimi, S. & Ardalan, Z. & Poursabzi, O. et al. Toward a safe supply chain: Incorporating accident, physical, psychosocial and mental overload risks into supply chain network. *Environment, Development and Sustainability*. 2023. Vol. 25. P. 5579-5595. DOI: 10.1007/s10668-022-02281-y.

Received 05.06.2024; accepted in revised form 19.08.2025