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systematic review

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Influence of occupational risk factors for road traffic crashes among professional drivers: systematic review

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ABSTRACT

This systematic review focuses on factors associated with occupational road crashes among professional drivers of commercial vehicles, e.g. trucks, buses and taxis. PubMed, MEDLINE and Google Scholar were searched, and quality assessment followed guidelines developed by the British Sociological Association medical sociological group. Sixty-six cross-sectional studies and one cohort study were included, of which 18, 45 and 3 studies were categorised as high-, moderate- and low-quality studies, respectively. Twenty-seven significant risk factors for road crashes were divided into six domains: (1) organisational, (2) individual driver characteristics, (3) qualifications, (4) driver conditions, (5) driving behaviour, and (6) external. The most frequently investigated factors were age (individual driver characteristics domain), sleepiness and substance use (driver conditions), driving duration and time of driving (organisational). More recently studied risk factors were management support (organisational), years of experience (qualifications), health parameters (driver conditions), vehicle speed and distracting activities, e.g. use of phone or navigation tools while driving (driving behaviour). The review identified overall risk factor domains and occupation-specific risk factors suitable for targeting and prioritising organisational preventive safety efforts. To obtain a more in-depth understanding of the antecedents of road crashes, future prospective studies are encouraged that evaluate preventive strategies for occupational road crashes.

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Sleepiness; inattention; shift-work; workers; occupational driver; road crash(es)

1. Introduction

The European Road Safety Observatory estimates that approximately 40–60% of all occupational accidents with a fatal outcome are road crashes (European Commission: ERSO, 2012). In addition, injury severity is generally higher for van and truck crashes compared to crashes involving a person's car (Chen et al., 2020). In Denmark, for example, injury

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crashes with a van are twice as likely to be fatal (12%) compared to injury crashes with cars (6%) (Havarikommissionen for Vejtrafikulykker, 2021). The increased use of independent home delivery vans and taxi services (e.g. Uber, Lyft, Curb), means that crashes involving them will be an area of heightened concern. Road crashes are thus a key element in occupational casualties and the associated impact on families, employers, employees and societies (European Commission: ERSO, 2012). To combat this problem, increased knowledge about factors associated with occupational road traffic crashes is needed to develop and implement effective preventive organisational strategies and legislations targeted at professional drivers.

More than a decade ago, Robb et al. (2008) conducted a literature review of epidemiological studies on risk factors for occupational road traffic crashes and injuries and found, despite lack of quality and convincing study evidence, that behavioural or driver condition factors such as sleepiness and fatigue where the most researched risk factors and were consistently associated with road crashes. These driver condition risk factors correspond well with the identified risk factors for road crashes among the general driving population (Gottlieb et al., 2018); however, several other risk factors such as substance use (e.g. alcohol, drugs, medicine), time and speed of driving and telephone use have also been frequently explored during the last decade (Bioulac et al., 2017). Due to the highly different working conditions across the professional motor vehicle road driving occupations (i.e. taxi, bus and truck drivers), an identification and comparison of occupation-related risk factors is needed for developing suitable organisational preventive safety efforts within each specific driver occupation.

According to The European Organizational Health and Safety Agency (OSHA Europe, 2021), employers are responsible for the safety of their drivers and should prioritise occupational road safety by assessing the risks on the road and implement a road traffic safety policy in the organisation. Nonetheless, for an organisation, it may seem like an everlasting challenge to implement effective safety strategies against the myriad of risk factors associated with road crashes (Baikejuli et al., 2022). Increased organisational focus on safety and regulations appears to improve individual driver employee safety (Öz et al., 2010, 2013). Thus, creating a healthy organisational safety culture is an important foundation for driver safety – yet it is an increasing challenge with the new ways of organising work, such as digital platform economies. Strong international, national and company policies, regulations and enforcement on, e.g. driving hours and rest periods (European Commission ERSO, 2006), as well as road and vehicle design and innovation, also play an important role. Thus, a deeper understanding of the antecedents of road crashes among professional drivers in a more organisational context seems evident for designing effective preventive interventions to reduce occupational fatalities and serious injuries.

Much progress has been made over the last decade in IT-communication and vehicle technology, as well as legislation for professional drivers and their vehicles (e.g. collision avoidance systems, navigation and planning tools, use of cameras and additional mirrors, GPS surveillance and black-box recordings, active driver monitoring, electric and autonomous vehicles) (European Road Safety Observatory, 2016). The present study, therefore, aims to extend and build on the work of Robb et al. (2008) to create an overview of the most frequently investigated risk factors significantly associated with occupational road traffic crashes among professional drivers. The results will highlight factors suitable for organisational preventive efforts, as well as factors needing additional attention during driver

education. This can then support the development of targeted measures and prioritised strategies that can be used by, e.g. policy makers, researchers and occupational health and safety managers to prevent occupational road traffic crashes among professional drivers.

2. Methods

2.1. Protocol registration

This review has been registered in the international prospective register of systematic reviews (PROSPERO) number CRD: 42019120062.

2.2. Eligibility/inclusion criteria

We identified studies that examined risk factors for road traffic crashes among professional drivers of commercial vehicles, e.g. trucks, buses and taxis. Only studies focusing on factors associated with crashes in the context of professional drivers were included. The eligibility criteria addressed in this systematic review were based on the PICOS framework (Table 1; PICOS – Population, Intervention, Comparison, Outcome, Study design), and study selection was restricted to scientific peer review literature published in English. There were no specific criteria for the timeframe for this review, however, the included studies were published in the period from 1987 to May 2021, where our study search ended.

2.3. Outcome measures

The primary outcome of the systematic review were risk factors for road traffic crashes (including road injuries and road accidents) among professional drivers. Professional drivers' were defined as workers that drive as a main part of their work i.e. professional transport (delivering goods and people), but not commuters. We did not differentiate between whether the drivers had a primary "causal" or "active" role in the crashes (the driver caused the accident), or whether they had a secondary or tertiary passive role where the crashes occurred as a result of another or several crashes.

2.4. Data sources and search terms

We searched the PubMed (including the database MEDLINE) and Google Scholar databases with a search strategy that combined three main components/criteria: (1) drivers AND (2) risk factors AND (3) crashes/injuries/accidents.

Table 1. Overview of the PICOS framework used for the systematic literature review search regarding occupational risk factors for road traffic crashes among professional drivers.

P	Population	Adult individuals (≥18 years) who worked as a professional driver (e.g. driving cars, trucks, taxis or buses as the main part of their job)
I	Intervention/ Exposures	Occupational risk factors for road traffic crashes
C	Comparator	Both with or without a comparison group
O	Outcome	Road crashes
S	Study design	All types of study designs were included

2.5. Study selection

EndNote X9 was used to collect potential studies, of which we included all identified PubMed studies, whereas only the first 200 top-ranking Google Scholar articles were included (ranked by Google's own algorithms, which especially put high weight on citation counts and words included in a document's title) (Pega et al., 2017). The references were exported to the software program Covidence. Title and abstract screening were then assessed independently by two reviewers (authors 1 and 2) for compliance with the PICOS criteria shown in Table 1. Any disagreements were discussed with a third member of the team (author 5). Full-text papers of relevant title/abstract screening were then screened in a similar manner. Studies that adhered to the eligibility criteria were included in the systematic review. A PRISMA flow diagram was generated to summarise the process of the study selection (Figure 1; PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

2.6. Data collection and extraction

Data were extracted on general characteristics: (1) reference, (2) publication year, (3) country, (4) population including specific occupational drivers, (5) age, (6) gender, (7) follow-up, (8) study design and (9) type of outcome measure.

2.7. Quality assessment

Two members of the review (authors 1 and 2) team independently assessed the quality of all full-text findings. Disagreement was resolved by a third member of the team (author 5). For the methodological appraisal of the cross-sectional studies, we used the quality assessment developed by the British Sociological Association (BSA) Medical Sociology Group (2018), based on the included study's design in this systematic review. The BSA quality assessment was based on seven questions using either a yes or no answer: (1) appropriate research design, (2) recruitment strategy, (3) response rate, (4) sample representativeness, (5) objective or reliable measures, (6) power calculation/ justification of numbers, and (7) appropriate statistical analysis. The number of quality indicators met out of seven were rated as 1–2 low quality, 3–5 moderate, and 6–7 high quality. For the quality assessment of the single cohort study, we used the Newcastle-Ottawa scale (Stang, 2010). The Newcastle-Ottawa scale provides up to nine stars in three domains (selection, comparability and outcome/exposure) which are converted into good/high, fair/moderate and poor/low study quality as follows: High quality: 3–4 stars in selection domain, and 1–2 stars in comparability domain, and 2–3 stars in outcome/exposure domain. Moderate quality: 2 stars in the selection domain, and 1–2 stars in the comparability domain, and 2–3 stars in the outcome/exposure domain. Low quality: 0–1 star in selection domain, or 0 stars in the comparability domain, or 0 or 1 stars in outcome/exposure domain.

2.8. Study characteristics and quality

The database search generated 5058 records (4858 from PubMed and 200 from Google Scholar), of which 405 were duplicates (Figure 1). Accordingly, 4653 records were

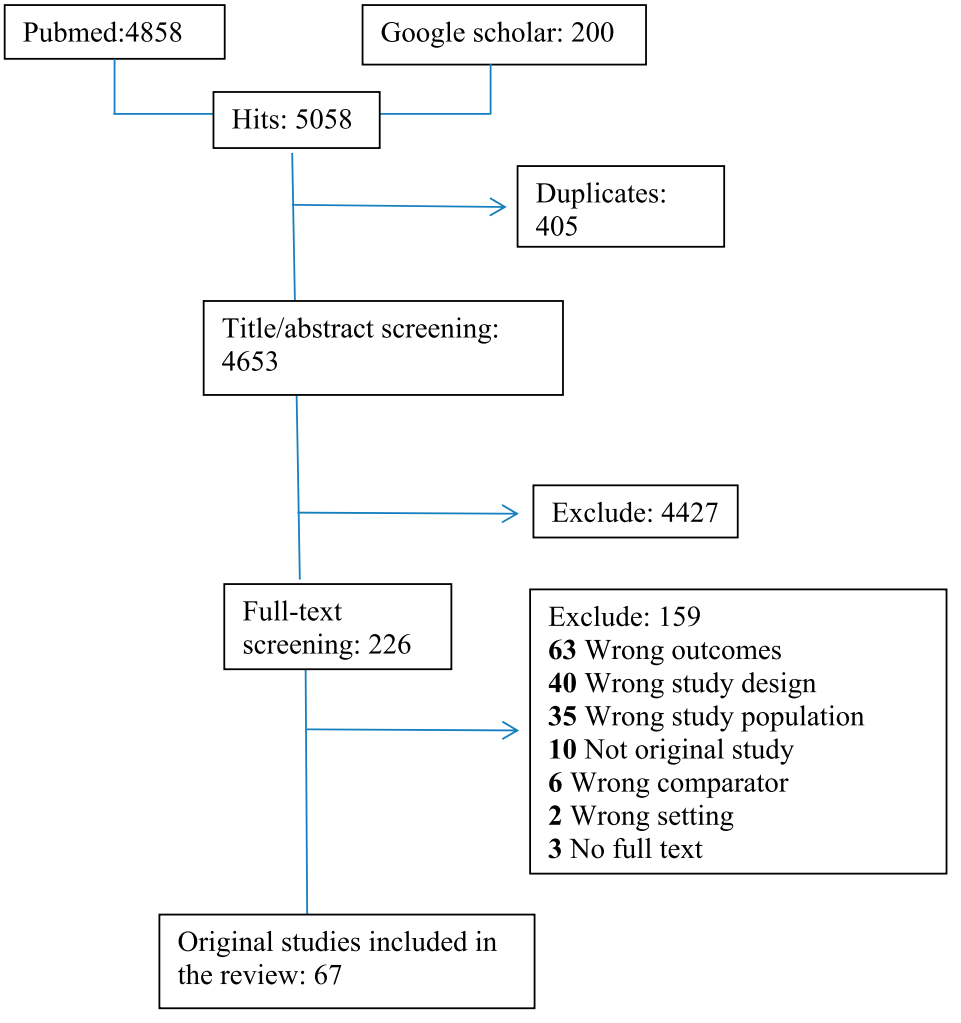

Figure 1. Flow of study selection.

screened for title/abstract, of which the vast majority of records did not live up to the inclusion chritera and were therefore excluded (4428). The remaining 225 articles/records were full text screened for eligibility and 158 were excluded due to the following incongruous factors: wrong outcome, not original study, wrong population, wrong setting and no full text available. Thus, a total of 67 articles published from 1987 to 2021 fulfilled the inclusion criteria and were included in this review.

Of the 67 studies eligible for the review, only one cohort study was found, whereas the remaining were cross-sectional studies published in English. The studies took place all over the world (3 from Africa, 4 from South America, 5 from Oceania, 12 from Europe, 13 from North America, and 30 from Asia) and included truck-, bus, taxi, company, professional and commercial drivers. The number of study participants ranged from 16 to 30,491. The main outcome of each study – number of road traffic crashes – were in the majority of studies assessed using questionnaires,

whereas 20, 12 and 1 study used database registers, interviews and videos recordings, respectively (see Table 2).

Three studies were categorised as low, 46 as moderate and 18 as high quality.

2.9. Summary measures and synthesis of results

When conducting the evidence synthesis for the current review, we chose to employ a narrative and a vote-counting approach, as statistical comparison across all studies was not possible (Verbeek et al., 2012). The narrative approach was used simply to describe the results, whereas the voting approach was used for estimating the consistency of the findings i.e. summing up the numbers of medium to high-quality studies with statistically significant outcomes and those without a significant outcome. If the number of statistically significant studies was larger than the non-significant ones, it was concluded that there was evidence for an association between the risk factor (exposure) and road crashes (primary outcome).

3. Results and discussion

3.1. Risk factor categories

The 67 studies identified 27 risk factors significantly associated with road crashes among professional drivers. We clustered the risk factors into six main categories using a semantic approach. Each category included risk factors related to similar characteristics or conditions of the driver or the environment and was labelled accordingly, indicating aspects and areas for organisations and policy makers to address in future preventive measures (Figure 2). The six categories are: (1) Organisational factors relating to managerial processes within the organisation, i.e. how to manage professional drivers, income policies, etc.; (2) Individual driver characteristics relating to person-specific attributes such as age, sex, body composition, etc.; (3) Qualification factors associated with the drivers level of education, experience and driver license type; (4) Driver condition factors relating to driver health and health impairing behaviour; (5) Driving behaviour relating to general precautions and safety or harzardious behaviour while driving; and finally (6) External factors such as those not directly related to the driver or organisation, i.e. area and road type condition, freight type, season/weather conditions, etc.

For comparison and identification of occupation-specific risk factors, all risk factor tables (Tables 2–8) are sorted by type of occupation. Thus, individual studies may appear in several tables if the study investigated multiple risk factors.

3.2. Organisational factors

Thirty-one studies included organisational risk factors (see Table 3), in which several risk factors specific to the organisational domain could be addressed in organisational preventive efforts. Risk factors such as duration behind the wheel and night shift or late working hours were significantly associated with an increased risk of road crashes in half of the studies, and among all types of occupations. However, other less "driving specific" risk factors were also identified, including sufficient job security, i.e.: Support from

Table 2. Systematic literature review of road traffic crashes among professional drivers – description of included studies.

Studies ($N = 67$)	Participants (type of occupation, N, Country)	Outcome measures (how were accidents measured?)	Risk factor measures (how was the risk factor measured?)	Quality of the study
Pokorny et al. (1987)	Bus accidents, $N = 1251$, Netherlands	Database (bus accidents from 1976 to 1980)	Database (company records)	Moderate
Feng et al. (2016)	Bus drivers, $N = 1380$, U.S.A.	Database (Buses Involved in Fatal Accidents (BIFA))	Database (BIFA)	High
Tasbakan et al. (2018)	Bus drivers, $N = 1400$, Turkey	Questionnaire (lifetime history)	Questionnaire	Moderate
Dorn and af Wahlberg (2008)	Bus drivers, $N = 12,244$, U.K.	Database (U.K. bus company crash database)	Questionnaire	High
Celikhisar and Ilkhan (2020)	Bus drivers, $N = 162$, Turkey	Database (official municipality records)	Clinical evaluation, polysomnography, questionnaire	Moderate
Wu et al. (2019)	Bus drivers, $N = 200$, China	Interview (one-month history)	Interview	Moderate
Miyama et al. (2020)	Bus drivers, $N = 301$, Japan	Questionnaire (one-month history)	Questionnaire	Moderate
La et al. (2013b)	Bus drivers, $N = 365$, Vietnam	Interview (three-year history)	Interview	Moderate
Hamed et al. (1998)	Bus drivers, $N = 438$, Jordan	Interview (lifetime history)	Interview	Moderate
Gomez-Ortiz et al. (2018)	Bus drivers, $N = 524$, Colombia	Questionnaire (three-year history)	Questionnaire	Moderate
Vennelle et al. (2010)	Bus drivers, $N = 677$, Scotland	Questionnaire (five-year history)	Questionnaire	Moderate
Wang et al. (2021)	Bus drivers, $N = 725$, China	Database (NA) and survey (one-year history)	Questionnaire	Moderate
Kim and Chung (2019)	MT (bus and taxi), $N = 223$, South Korea	Database (Korea Expressway Corporation database, crashes from 2009 to 2014)	Questionnaire	Moderate
Tzamalouka et al. (2005)	MT (bus and truck), $N = 317$, Greece	Interview (one-year history)	Interview	Moderate
Kwon et al. (2019)	MT (bus, construction, taxi and trucks), $N = 161$, South Korea	Questionnaire	Questionnaire	Moderate
Chen et al. (2014)	MT (delivery services drivers and truck drivers), $N = 5568$, U.S.A.	Database (BLS Census of Fatal Occupational Injuries)	Database	High
Mir et al. (2012)	MT (large passenger vehicles and trucks), $N = 857$, Pakistan	Questionnaire (five-year history)	Questionnaire	High
Mir et al. (2013)	MT (large passenger vehicles and trucks), $N = 857$, Pakistan	Questionnaire (five-year history)	Questionnaire	High
Mehdizadeh et al. (2019)	MT (taxi and truck), $N = 785$, Iran	Questionnaire	Questionnaire	High
Boufous and Williamson (2009)	MT, $N = 145,302$, Australia	Database (Workers' Compensation Scheme Statistics (WCSS) and The Traffic Accident Database System (TADS))	Database (TADS)	High
Howard et al. (2004)	MT, $N = 2503$, Australia	Questionnaire (three-year history)	Questionnaire	Moderate
Ebrahimi et al. (2015)	MT, $N = 556$, Iran	Questionnaire (five-year history)	Questionnaire	Moderate
Malka et al. (2018)	MT, $N = 572$, Israel	Interview	Interview	Moderate
Ezeibe et al. (2019)	MT, $N = 720$, Nigeria	Group interview	Field observation	Low

(*Continued*)

Table 2. Continued.

Studies ($N = 67$)	Participants (type of occupation, N, Country)	Outcome measures (how were accidents measured?)	Risk factor measures (how was the risk factor measured?)	Quality of the study
Amra et al. (2012)	MT, $N = 931$, Iran	Questionnaire (lifetime history)	Questionnaire	High
Zhang et al. (2017)	Other (farmers), $N = 1422$, China	Questionnaire	Questionnaire	Moderate
Barger et al. (2015)	Other (firefighters), $N = 6933$, U.S.	Questionnaire	Questionnaire	Moderate
Harland et al. (2016)	Other (fleet service drivers), $N = 229$, U.S.A.	Naturalistic driving videos	Naturalistic driving videos	High
Chu (2016)	Other (police drivers), $N = 473$, Taiwan	Database (national police accident reports, four-year history)	Database	High
Ozer et al. (2014)	Other (public transport drivers), $N = 320$, Turkey	Questionnaire (lifetime history)	Questionnaire	High
Sebastian and Vaghela (2021)	Other (public transport drivers), $N = 4094$, India	Questionnaire (three-year history)	Questionnaire	High
Sumer (2003)	Other, $N = 295$, Turkey	Questionnaire (three-year history)	Questionnaire	Moderate
Salminen et al. (2005)	Other, $N = 720$, Finland	Questionnaire (one-year history)	Questionnaire	Moderate
Zuzewicz et al. (2010)	Other, $N = 30{,}491$	Database (Central Statistical Office Accidents database, six-year history)	Database (Central Statistical Office Accidents database, six-year history)	Moderate
La et al. (2013a)	Taxi drivers, $N = 1214$, Vietnam	Interview (lifetime history)	Interview	Moderate
Baba et al. (2019)	Taxi drivers, $N = 1739$, Japan	Questionnaire	Questionnaire	Moderate
Allahyari et al. (2008)	Taxi drivers, $N = 160$, Iran	Questionnaire (three-year history)	Questionnaire	Moderate
Peng et al. (2020)	Taxi drivers, $N = 2391$, China	Interview and questionnaire (two-year history)	Interview and questionnaire	High
Wang et al. (2019)	Taxi drivers, $N = 2391$, China	Interview and questionnaire (two-year history)	Interview and questionnaire	Moderate
Dalziel and Job (1997)	Taxi drivers, $N = 42$, Australia	Questionnaire (two-year history)	Questionnaire	Low
Lam (2004)	Taxi drivers, $N = 7923$, Australia	Database (Traffic Accident Database System(TADS))	Database (TADS)	High
Asefa et al. (2015)	Taxi drivers, $N = 712$, Ethiopia	Questionnaire (three-year history)	Questionnaire	Moderate
Wang et al. (2015)	Taxi drivers, $N = 726$, China	Database (Xi'an Traffic Police Department official database)	Database (Xi'an Traffic Police Department official database)	Moderate
Chu (2012)	Truck drivers (gravel trucks), $N = 1825$, Taiwan	Data base (National police accident reports (four-year history))	Database (National police accident reports (four-year history))	High
Adams-Guppy et al. (2003)	Truck drivers (heavy goods vehicles), $N = 640$, U.K.	Questionnaire (lifetime history)	Questionnaire	High
Campbell (1991)	Truck drivers (large trucks), $N \leq 25{,}000$, U.S.	Database (University of Michigan Transportation Research Institute (UMTRI))	Database (University of Michigan Transportation Research Institute (UMTRI))	Moderate
Adejugbagbe et al. (2015)	Truck drivers (long-distance), $N = 592$, Nigeria	Interview (lifetime and one-year history)	Interview	Moderate
Lemke et al. (2016)	Truck drivers (long-haul truckers), $N = 260$, U.S.A.	Survey data	Survey	Moderate
Stoohs et al. (1994)	Truck drivers (long-haul truckers), $N = 90$, U.S.A.	Database (NA) and questionnaire (five-year history)	Questionnaire	Moderate

(*Continued*)

Table 2. Continued.

Studies ($N = 67$)	Participants (type of occupation, N, Country)	Outcome measures (how were accidents measured?)	Risk factor measures (how was the risk factor measured?)	Quality of the study
Pérez-Chada et al. (2005)	Truck drivers (long-haul), $N = 738$, Argentina	Questionnaire (lifetime history)	Questionnaire	Moderate
Swedler et al. (2015)	Truck drivers (multiple types), $N = 446$, U.S.A.	Questionnaire	Questionnaire	Moderate
Sabbagh-Ehrlich et al. (2005)	Truck drivers (Port trucks), $N = 160$, Israel	Interview (lifetime history)	Interview	Moderate
Laberge-Nadeau et al. (2000)	Truck drivers, $N =$ 3593 (driver years), Canada	Database (four-year history, public insurer for automobile injuries) # Cohort	Database and Questionnaire	High
Morrow et al. (2004)	Truck drivers, $N = 116$, U.S.A.	Database (Motor Carrier Safety Status Measurement System Database: Safestat)	Database (Safestat)	Moderate
Gander et al. (2006)	Truck drivers, $N = 130$, New Zealand	Questionnaire (lifetime history)	Questionnaire	Moderate
Hong et al. (2019)	Truck drivers, $N =$ 15,011, South Korea	Database (Korea Expressway Corporation (KEC) crash database, 2012–2016)	Database (Korea Expressway Corporation (KEC) crash database, 2012–2016)	Moderate
Staplin and Gish (2005)	Truck drivers, $N =$ 25,609, U.S.A.	Database (Motor Carrier Management Information System: MCMIS)	Database (MCMIS)	Moderate
Souza et al. (2005)	Truck drivers, $N = 260$, Brazil	Questionnaire (five-year history)	Questionnaire	Low
Garbarino et al. (2016a)	Truck drivers, $N = 283$, Italy	Questionnaire	Clinical evaluation, interview, questionnaire, polysomnography	Moderate
Alahmari et al. (2019)	Truck drivers, $N = 338$, Saudi Arabia	Questionnaire (six-month history)	Questionnaire	Moderate
Oliveira et al. (2016)	Truck drivers, $N = 535$, Brazil	Interview (lifetime history)	Interview	Moderate
Hamido et al. (2021)	Truck drivers, $N = 554$, Japan	Database (drivers records, three-year history)	Database (drivers records)	Moderate
Catarino et al. (2014)	Truck drivers, $N = 714$, Portugal	Interview and questionnaire (five-year history)	Interview and Questionnaire	Moderate
Ronna et al. (2016)	Truck drivers, $N = 797$, U.S.A.	Questionnaire	Questionnaire	High
Thiese et al. (2015)	Truck drivers, $N = 797$, U.S.A.	Questionnaire (lifetime history)	Questionnaire	Moderate
Garbarino et al. (2016b)	Truck Drivers, $N = 949$, Italy	Questionnaire	Clinical evaluation, interview and questionnaire	Moderate
Garbarino et al. (2017)	Truck Drivers, $N = 949$, Italy	Questionnaire	Clinical evaluation, interview and questionnaire	Moderate

Note: Sorted by occupational type. MT = multiple types of drivers (truck, taxi, bus and/or other).

management, proper systems or support from management for reporting poor health, and perceived level of income sufficiency to support their family were important organisational factors among bus and taxi drivers that may improve driver safety. Specifically, Gomez-Ortiz et al. (2018) showed that a lack of supervisor support increased the risk of crashes among bus drivers, while Staplin and Gish (2005) found that an increased job change rate increased the risk of road crashes among truck drivers. Conversely, La et al. (2013a, 2013b) found that a perceived sufficiency of income was associated with a decreased risk of crash among bus and taxi drivers. Also having difficulties or feeling reluctant towards reporting poor health conditions was a risk factor related to management support, which was only found among transport drivers (bus and taxi) (Baba et al.,

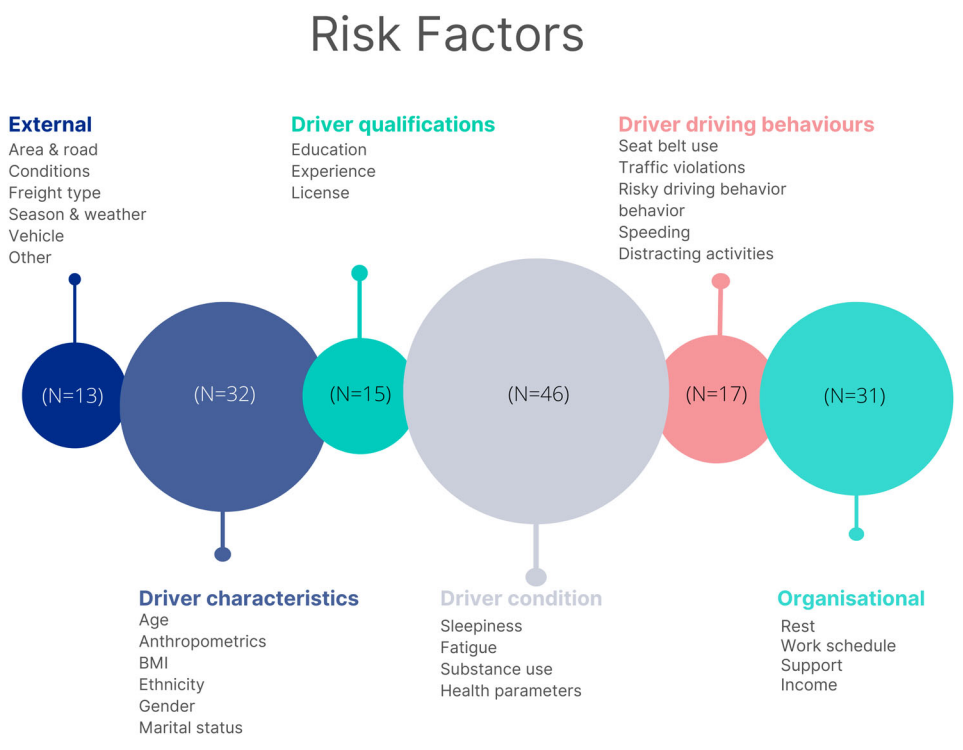

Figure 2. Framework for categorising risk factors for road crashes among professional drivers. *n* = number of studies.

2019; Miyama et al., 2020). Baba et al. (2019) found that, compared to finding it easy, finding it difficult to report poor health increased the odds of being involved in a crash or near-miss incidence by 2.29 times among Japanese taxi drivers. Moreover, feeling organisational justice, i.e. perception of fairness in the organisation, was also found to be a risk factor for road crashes among bus and taxi drivers, which relates to job satisfaction and management support (Kim & Chung, 2019). Altogether, ensuring sufficient management support by creating a feeling of justice and trust towards the management and overall working conditions seems crucial for driver safety and should be prioritised, particularly among transport drivers of buses and taxis.

In congruence with Robb and co-workers literature review from 2008, the current review found multiple methodologically sound studies demonstrating significant risk factors for work-related road crashes (Robb et al., 2008). Factors such as, e.g. the influence of substance use, health parameters, driver experience and time of driving has been extensively investigated since the work of Robb et al., yet, the most prominently researched significant risk factors among professional drivers still relates to sleep, fatigue and time behind the wheel. Moreover, compared to Robb et al., the higher number of included studies in this review promotes the possibility of comparing risk factors across occupational types.

Although laboratory studies have shown that, e.g. taking a nap is an effective countermeasure against driver fatigue (Hashemi Nazari et al., 2017), taking a break from driving (e.g. 15–30 minute rest period when needed) was not a highly investigated organisational

Table 3. Risk factors for road traffic crashes among professional drivers in the organisational domain.

Participants (author) ($n = 31$)	Rest ($n = 6$)	Shift work ($n = 6$)	Working time ($n = 14$)	Support and income ($n = 8$)	Other ($n = 14$)
Bus drivers (Gomez-Ortiz et al., 2018)				Lack of supervisor support ↑	
Bus drivers (Hamed et al., 1998)	No effect (regular rest times)				No effect (time of day)
Bus drivers (La et al., 2013b)				Perceived sufficiency of income ↓	
Bus drivers (Miyama et al., 2020)			Long working hours, inadequate time spent with family ↑		Difficulty reporting poor health ↑
Bus drivers (Pokorny et al. 1987)		No effect			
Bus drivers (Wang et al., 2021)					Low safety climate level ↑
Bus drivers (Wu et al., 2019)			Working ≥14 hours/day ↑	Performance-based salary ↑	Restrictive work requirements ↑
MT (bus and taxi drivers) (Kim & Chung, 2019)					Low organisational justice ↑
MT (bus and truck drivers) (Tzamalouka et al., 2005)			Non-driving working hours ↑		
MT (Ebrahimi et al., 2015)		No effect (rotational work)	No effect (hours/day)		No effect (driving route)
MT (Howard et al. 2004)		Night shift ↓	No effect (hours/week)		
MT (Malka et al., 2018)					Dual priority work task ↑
MT (taxi and truck drivers) (Mehdizadeh et al., 2019)				Higher income ↓	
Other (farmers) (Zhang et al., 2017)				Dissatisfaction with income ↑	
Other (police drivers) (Chu 2016)		No effect			

(*Continued*)

Table 3. Continued.

Participants (author) ($n = 31$)	Rest ($n = 6$)	Shift work ($n = 6$)	Working time ($n = 14$)	Support and income ($n = 8$)	Other ($n = 14$)
Other (Salminen et al., 2005)	Freedom to choose timing of breaks ↓				
Other (Zuzewicz et al., 2010)					Night time (23.00–6.59 o'clock) ↑
Taxi drivers (Asefa et al., 2015)				No effect (salary)	
Taxi drivers (Baba et al., 2019)	Irregular breaks ↑		Insufficient vacation ↑		No effect (company size) Difficulty reporting poor health ↑
Taxi drivers (La et al., 2013a)		Part time ↑		Perceived sufficiency of income ↓	
Taxi drivers (Peng et al., 2020)			More working hours ↑	Financial burden, dissatisfaction with income ↑	
Truck drivers (Catarino et al. 2014)			Supplementary hours ↑		
Truck drivers (Garbarino et al. 2016b)	Rest breaks ↓				
Truck drivers (Laberge-Nadeau et al., 2000)					Higher working radius and distance driven ↑
Truck drivers (Lemke et al. 2016)			No effect (working > daily hour limit)		
Truck drivers (Morrow et al. 2004)	No effect (difficulty finding rest places)		Increased time spent loading ↑		No effect (schedule regularity)
Truck drivers (Oliveira et al., 2016)			Working >12 hours/day ↑		No effect (hired/self-employed)
Truck drivers (Sabbagh-Ehrlich et al. 2005)	Difficulty finding parking when tired ↑		No effect (workday < legal hours)		
Truck drivers (Souza et al. 2005)			No effect (hours/day)		
Truck drivers (Staplin & Gish, 2005)					Job change ↑

Truck drivers (Thiese et al., 2015)		Night shift ↓	No effect (long vs. short haul)		No effect (Unloading/loading)
Summary	[4/6] Rest breaks (1) and freedom to choose timing of breaks (1) ↓ Irregular breaks (1), difficulty finding parking when tired (1) ↑	[3/6] Night shift (2) ↓ Part time (1) ↑	[8/14] Long working hours (5), increased time spent loading (1), non-driving working hours (1), insufficient vacation (1) or time spent with family (1) ↑	[7/8] Higher income (1), sufficient income (2) ↓ Financial burden (1), dissatisfaction with income (2), performance-based salary (1), lack of supervisor support (1) ↑	[10/14] Difficulty reporting poor health (2), night time (1), low safety climate level (1), restrictive work requirements (1), low organisational justice (1), higher working radius and distance driven (1), dual priority work tasks (1), job change (1) ↑

Note: ↑ and ↓ means increased and decreased risk, respectively. Sorted by occupational type. MT = multiple types of drivers (truck, taxi, bus and/or other).

Table 4. Risk factors for road traffic crashes among professional drivers in the individual driver characteristics domain.

Participants (author) (n = 32)	Age (n = 30)	Anthropometrics (n = 5)	BMI (n = 9)	Ethnicity (n = 2)	Gender (n = 9)	Marital status (n = 7)
Bus drivers (Celikhisar & Ilkhan, 2020)	No effect	Higher neck circumference ↑	No effect			
Bus drivers (Dorn & af Wahlberg 2008)	U-shaped effect of age					
Bus drivers (Feng et al. 2016)	U-shaped effect of age				Male ↑	
Bus drivers (Hamed et al., 1998)	Old age ↑					
Bus drivers (La et al., 2013b)	No effect					No effect
Bus drivers (Miyama et al., 2020)	No effect				No effect	No effect
Bus drivers (Tasbakan et al. 2018)	Old age ↑					
Bus drivers (Wang et al., 2021)					No effect	Unmarried ↑ (univariate)
MT (Amra et al. 2012)	No effect	Higher neck circumference ↑	No effect			
MT (Boufous & Williamson 2009)	Old age ↑				Male ↑	
MT (bus and truck drivers) (Tzamalouka et al., 2005)	No effect					
MT (Ebrahimi et al., 2015)	No effect		No effect			
MT (Howard et al. 2004)	Old age ↓				No effect	
MT (taxi and truck drivers) (Mehdizadeh et al., 2019)	No effect					
MT (truck drivers, delivery services drivers) (Chen et al. 2014)	Old age ↑			No effect	Male ↑	
Other (police drivers) (Chu 2016)	Young age ↑					
Other (public transport drivers) (Sebastian & Vaghela 2021)	No effect	No effect	No effect			
Other (Salminen et al., 2005)	Young age ↑					
Taxi drivers (Baba et al., 2019)	Old age ↓		No effect		No effect	No effect
Taxi drivers (La et al., 2013a)	Old age ↓					No effect
Taxi drivers (Lam 2004)	No effect				Female ↑	
Taxi drivers (Wang et al., 2019)	Old age ↑					
Truck drivers (Alahmari et al., 2019)	Young/Old ↓					
Truck drivers (Campbell 1991)	No effect					
Truck drivers (Catarino et al. 2014)	No effect	No effect	BMI ≤35 ↑			
Truck drivers (Garbarino et al. 2016b)	No effect					
Truck drivers (Hamido et al., 2021)	No effect					
Truck drivers (long-distance) (Adejugbagbe et al., 2015)	Young age ↑			No effect		No effect

(*Continued*)

Table 4. Continued.

Participants (author) (n = 32)	Age (n = 30)	Anthropometrics (n = 5)	BMI (n = 9)	Ethnicity (n = 2)	Gender (n = 9)	Marital status (n = 7)
Truck drivers (Oliveira et al., 2016)	No effect					No effect
Truck drivers (Souza et al. 2005)	Young age ↑		No effect			
Truck drivers (Stoohs et al. 1994)			Higher BMI ↑			
Truck drivers (Thiese et al., 2015)	Old age ↑	No effect	No effect		Male ↑	
Summary	[16/30] Old age (4), Young (1) ↓ Old (6), young (4) ↑ U-shaped effect (2)	[2/5] Higher neck circumference (2) ↑	[2/9] Higher BMI (2) ↑	[0/2] No effect	[5/9] Male (4), female (1) ↑	[1/7] Unmarried (1) ↑

Note: Sorted by occupational type. MT = multiple types of drivers (truck, taxi, bus and/or other).
^Stated significant in the text but p-values not reported. ↑ = Increase risk, ↓ = Decrease risk.

risk factor. Two of the six studies featuring taking a break or freedom to take brakes from driving, identified it to be a significant protective action against road crashes (Salminen et al., 2005; Garbarino et al. 2016b). The safety implications of taking regular breaks should definitely not be neglected, as these may improve alertness and reduce driver sleepiness (Hashemi Nazari et al., 2017). Yet, the efficacy of such strategies should be tested in larger longitudinal studies.

Another interesting yet rarely investigated finding from the organisational domain was the influence of non-driving time or waiting time. Tzamalouka et al. (2005) showed that the probability of involvement in road crashes increased with the number of non-driving working hours among Greek truck and bus drivers. As non-driving work is comprised of e.g. waiting time, customer interaction and delivery handling of packages (loading, unloading and carrying), these activities may increase the pressure to meet specific delivery deadlines and therefore compromise safety. Hence, increased organisational focus on optimised route planning is essential to reduce such incidences and, thereby, improve driver safety. Along these lines, the dual priority of both road safety and customer service versus single priority of road safety was also shown to increase the risk of road crashes and could arguably be decreased by rearranging driving schedules (Malka et al., 2018).

3.3. Individual driver characteristics

Thirty-two studies were grouped into the individual driver characteristic domain (Table 4). More than half of the studies (56%), which included age in the analyses, showed a higher crash risk for young and older drivers compared with middle-aged drivers across all driving occupations, and therefore an indication of a U-shaped risk factor curve (Dorn & Af Wahlberg, 2008; Feng et al. 2016). Accordingly, the risk of being involved in road crashes was higher for young, novice drivers and for older drivers, compared with middle-aged drivers. In younger drivers, this phenomenon may be due to several characteristics, such as having less experience (Ryan et al., 1998), underdeveloped perception skills (Lee et al., 2008), and an underestimation of risks (Weinstein, 1980), which may

Table 5. Risk factors for road traffic crashes among professional drivers in the qualification factor domain.

Participants (author) ($n = 15$)	Education ($n = 6$)	Experience ($n = 14$)	License ($n = 2$)
Bus drivers (Dorn & af Wahlberg 2008)		More experience ↓ (effect weakens with time)	
Bus drivers (Hamed et al., 1998)		More experience ↓	
Bus drivers (La et al., 2013b)	No effect		
Bus drivers (Wang et al., 2021)	No effect		
MT (Amra et al. 2012)	No effect		
MT (Boufous & Williamson 2009)			No effect
MT (Ebrahimi et al., 2015)		More experience ↑	
MT (taxi and truck drivers) (Mehdizadeh et al., 2019)		More experience (only taxi drivers) ↑	
Other (Salminen et al., 2005)		Less experience ↑	
Other (truck and bus drivers) (Tzamalouka et al., 2005)		No effect	
Taxi drivers (Asefa et al., 2015)	No effect (first aid training)		
Taxi drivers (Baba et al., 2019)		No effect	
Taxi drivers (La et al., 2013a)	No effect	No effect	Higher license level ↑
Taxi drivers (Wang et al., 2015)		More experience ↓^	
Truck drivers (Alahmari et al., 2019)		6–10 years' experience ↑	
Truck drivers (long-distance) (Adejugbagbe et al., 2015)	No education ↑	No effect	
Truck drivers (Oliveira et al., 2016)		More experience ↓	
Truck drivers (Swedler et al. 2015)		No effect	
Truck drivers (Thiese et al., 2015)		No effect (in adjusted model)	
Summary	[1/6] No education (1) ↑	[8/14] More experience (4) ↓ More experience (2), less experience (1), 6–10 years' experience (1) ↑	[1/2] Higher license level ↑

Note: Sorted by occupational type. MT = multiple types of drivers.
^Stated significant in the text but *p*-values not reported. ↑ = Increase risk, ↓ = Decrease risk.

contribute to young drivers being more prone to high-risk behaviours, such as using drugs and alcohol (Scott-Parker et al., 2015), speeding (Hasselberg & Laflamme, 2009), and driving violations and errors (Lucidi et al., 2010). Conversely, physical factors such as reaction speed (Keskinen et al., 1998; Savolainen et al., 2011), hearing (Green et al., 2013) and size of the visual field (Huisingh et al., 2015) as well as cognitive processing (Owsley et al., 2011) seem to decrease in elderly drivers (e.g. drivers above 60 years of age). On the other hand, previous research has implied that the U-shaped risk factor curve may be skewed or non-existent due to mileage bias (Langford et al., 2006). Hence, the associations found in the studies of Dorn and Af Wahlberg (2008) and Feng et al. (2016) should be interpreted with caution, as these were not adjusted for mileage. Nonetheless, potential organisational preventive efforts should keep an additional focus on young (and elderly) employees, providing frequent checks of their mental and physical health status, and with leaders and co-workers to ensure a positive safety culture.

Four out of nine studies found that gender, of which specifically being male, was a risk factor for road crashes. However, one study (Lam 2004) found that female taxi drivers in Australia had nearly a 2.5 times higher risk of road crashes than their male counterparts (OR = 2.30 [95% CI = 1.45–3.65]). Neck circumference, BMI (Body Masss Index based on height and weight) and ethnicity were also associated with road crashes; however, these were only recognised as significant risk factors in about one-third of the identified

Table 6. Risk factors for road traffic crashes among professional drivers in the driver condition domain.

Participants (author) ($n = 46$)	Sleep ($n = 25$)	Fatigue ($n = 15$)	Substance use ($n = 21$)	Health parameters ($n = 22$)
Bus drivers (Celikhisar & Ilkhan, 2020)			No effect (alcohol, smoking)	Obstructive sleep apnea (OSA) severity ↑
Bus drivers (Gomez-Ortiz et al., 2018)				Hypertension ↑
Bus drivers (La et al., 2013b)	No effect	No effect	No effect (alcohol, smoking)	
Bus drivers (Miyama et al., 2020)	Inadequate sleep ↑		No effect (smoking)	Driving when feeling sick ↑
Bus drivers (Tasbakan et al. 2018)	Sleepiness ↑			
Bus drivers (Vennelle et al. 2010)	Sleepiness ↑			
Bus drivers (Wang et al., 2021)				Insomnia ↑
MT (Amra et al. 2012)	Sleepiness ↑		No effect (smoking)	High-risk Berlin Questionnaire ↑
MT (bus and truck drivers) (Tzamalouka et al., 2005)	Decreased sleep duration ↑	No effect	No effect (alcohol, smoking)	
MT (bus, construction, taxi and truck drivers) (Kwon et al., 2019)	Sleepiness, bad sleep quality ↑	Fatigue ↑		Poor mental health ↑
MT (Ebrahimi et al., 2015)	Sleepiness ↑		No effect (smoking)	
MT (Howard et al. 2004)	Sleepiness ↑		Narcotic analgesic, antihistamines ↑	No effect (Multivariable Apnea Prediction)
MT (large passenger vehicle and truck drivers) (Mir et al. 2012)			Alcohol, marijuana ↑	
MT (large passenger vehicle and truck drivers) (Mir et al. 2013)			Alcohol ↑	
Other (farmers) (Zhang et al., 2017)		Fatigue ↑	Drunk driving ↑	Sleep disorder, illness, chronic disease, stress, poor vision or hearing ↑
Other (firefighters) (Barger et al. 2015)				Sleeping disorder ↑
Other (fleet service drivers) (Harland et al., 2016)			No effect (smoking)	
Other (public transport drivers) (Ozer et al. 2014)	Sleepiness ↑			
Other (public transport drivers)	Sleepiness, snoring ↑		No effect (smoking) Alcoholism ↑	No effect (diabetes, hypertension) OSA severity ↑

(*Continued*)

Table 6. Continued.

Participants (author) ($n = 46$)	Sleep ($n = 25$)	Fatigue ($n = 15$)	Substance use ($n = 21$)	Health parameters ($n = 22$)
(Sebastian & Vaghela 2021)				
Taxi drivers (Allahyari et al. 2008)				No effect (Cognitive Failure Questionnaire)
Taxi drivers (Asefa et al., 2015)			Alcohol ↑	
Taxi drivers (Baba et al., 2019)				Chronic disease ↑
Taxi drivers (Dalziel & Job 1997)		No effect		
Taxi drivers (La et al., 2013a)	No effect	No effect	No effect (alcohol, smoking)	
Taxi drivers (Peng et al., 2020)	Sleep problems ↑	Fatigue ↑		
Taxi drivers (Wang et al., 2015)		No effect		
Taxi drivers (Wang et al., 2019)	Sleep problems ↑	Fatigue ↑		
Truck drivers (Adams-Guppy et al. 2003)		No effect		
Truck drivers (Alahmari et al., 2019)	Bad sleep quality ↑			
Truck drivers (Catarino et al. 2014)	Sleepiness ↑	Fatigue, "feeling not up to par" ↑	Alcohol, antidepressants ↑	Depression, hypertension, gastroesophageal reflux disease (GERD) symptoms ↑
Truck drivers (Chu 2012)			No effect (drunk driving)	
Truck drivers (Gander et al. 2006)		No effect		
Truck drivers (Garbarino et al. 2016a)				Sleeping disorder severity ↑
Truck drivers (Garbarino et al. 2016b)	Sleepiness ↑		No effect (smoking)	Sleep disorder ↑
Truck drivers (Garbarino et al. 2017)				Sleep disorder ↑
Truck drivers (Laberge-Nadeau et al., 2000)				Uncomplicated diabetes (no insulin) ↑
Truck drivers (Lemke et al. 2016)	Decreased sleep duration ↑			
Truck drivers (long-distance) (Adejugbagbe et al., 2015)			Alcohol ↑	
Truck drivers (Morrow et al. 2004)	No effect	No effect		
Truck drivers (Oliveira et al., 2016)	No effect		No effect (alcohol, illicit drugs)	No effect (stress, psychiatric diagnosis)
	Sleepiness ↑			

(*Continued*)

Table 6. Continued.

Participants (author) ($n = 46$)	Sleep ($n = 25$)	Fatigue ($n = 15$)	Substance use ($n = 21$)	Health parameters ($n = 22$)
Truck drivers (Pérez-Chada et al. 2005)				No effect (insufficient sleep syndrome)
Truck drivers (Ronna et al. 2016)				Risk for cardiovascular disease (CVD) ↑
Truck drivers (Sabbagh-Ehrlich et al. 2005)	Sleepiness ↑	No effect		
Truck drivers (Souza et al. 2005)	No effect		No effect (alcohol, psychostimulants)	Excessive Daytime Sleepiness (EDS) ↑
Truck drivers (Stoohs et al. 1994)	Sleepiness ↑			
Truck drivers (Thiese et al., 2015)	No effect	Feeling exhausted after work ↑	No effect (alcohol use)	Increased pulse pressure ↑ No effect (heart disease, low-back pain)
Summary	[19/25] Sleepiness (13), bad sleep quality (2), inadequate sleep (1), decreased sleep duration (2), sleep problems (2), snoring (1) ↑	[6/15] Fatigue (6), "feeling not up to par" (1), exhausted after work (1) ↑	[8/21] Alcohol (6), drunk driving (1), marijuana (1), antidepressants (1), narcotic analgesic (1), antihistamines (1) ↑	[18/22] Sleep disorder (5), sleep disorder severity (3), risk for OSA (1), excessive daytime sleepiness (1), chronic disease (2), illness (2), hypertension (2), increased pulse pressure (1) GERD (1), depression (1), poor mental health (1), uncomplicated diabetes (1), risk for CVD (1), poor vision and/or hearing (1) ↑

Note: Sorted by occupational type. MT = multiple types of drivers.
^Stated significant in the text but *p*-values not reported. ↑ = Increase risk, ↓ = Decrease risk.

studies. Finally, being unmarried was found, only in a univariate model, to be a significant risk factor for road crashes in one out of seven studies (Wang et al., 2021).

3.4. Qualification factors

Fifteen studies were grouped as qualification factors (Table 5). Most of these investigations included "years of driving experience" as a factor, yet only 4 out of 14 studies identified a significant protective association between years of driving experience and a reduced occurrence of road crashes (Dorn & Af Wahlberg, 2008; Hamed et al., 1998; Oliveira et al., 2016; Salminen et al., 2005; Wang et al., 2015). Accordingly, Oliveira et al. (2016) only found more experience to be a protective factor when adjusting for emotional stress, psychiatric disorders, substance abuse, sleep quality and excessive daytime sleepiness. In fact, Ebrahimi et al. (2015) found that number of years of experience increased the risk of crashes among multiple types of Iranian professional drivers. This implies that increased experience may also lead to reduced caution while driving in some drivers. Along these lines, La et al. (2013a) showed that having a higher level driving license was associated with an increased risk for road crashes, even when accounting for individual driving exposure. The authors

Table 7. Risk factors for road traffic crashes among professional drivers in the driving behaviour domain.

Participants (author) (n = 17)	Seat belt use (n = 6)	Traffic violations and risky driving behaviour (n = 12)	Speeding (n = 8)	Distracting activities (n = 8)
Bus drivers (La et al., 2013b)	No effect	No effect		No effect (phone use)
Bus drivers (Wang et al., 2021)		Previous traffic violation ↑	Speeding ↑	
MT (Boufous & Williamson 2009)			Speedy driving ↑	
MT (large passenger vehicles and truck drivers) (Mir et al. 2013)	Seat belt use ↓			
MT (taxi and truck drivers) (Mehdizadeh et al., 2019)		Previous traffic violation, aggressive driving ↑		
Other (farmers) (Zhang et al., 2017)		Driving while ill or drunk ↑		Phone use ↑
Other (police drivers) (Chu 2016)		No effect	Lower speed limit during emergency response ↑	No effect (distracted driving)
Other (Sumer 2003)		No effect		
Other drivers (fleet service drivers) Harland et al., 2016				Phone use ↑
Taxi drivers (Asefa et al., 2015)	No effect	Previous traffic violation ↑	Speedy driving ↑	Phone use ↑ Listening to mass media ↓
Taxi drivers (La et al., 2013a)	Seat belt use ↓	Previous traffic violation ↑		No effect (phone use)
Taxi drivers (Peng et al., 2020)		Reckless driving ↑	Speeding ↑	
Taxi drivers (Wang et al., 2015)	No effect	No effect	No effect	No effect (phone use)
Taxi drivers (Wang et al., 2019)			Speeding ↑	
Truck drivers (Oliveira et al., 2016)	No effect	Previous traffic violation/ticket ↑	No effect	
Truck drivers (Swedler et al. 2015)		No effect		
Truck drivers (Thiese et al., 2015)				Phone use ↑
Summary	[2/6] Seat belt use (2) ↓	[7/12] Previous traffic violation (5), reckless and aggressive driving (2), driving while ill or drunk (1) ↑	[6/8] Speedy driving (2), speeding (3), lower speed limit during emergency response (1) ↑	[4/8] Listening to mass media (1) ↓ Phone use (4) ↑

Note: Sorted by occupational type. MT = multiple types of drivers.
^Stated significant in the text but p-values not reported. ↑ = Increase risk, ↓ = Decrease risk.

argued that this may be related to the fact that the drivers who held a level C license and above were previously employed as truck drivers and may be over confident and take more risks. In addition, working part-time doubled the risk of road crashes. Notably, only one study out of six, which focused on Nigerian long-distance drivers, found that no education (e.g. no public school attendance or only non-formal education) was a significant risk factor for road crashes (OR = 2.7, 95% CI = 1.5–4.6) (Adejugbagbe et al., 2015). Altogether, providing additional safety management training, e.g. for workers with little experience or

Table 8. Risk factors for road traffic crashes among professional drivers in the external factors domain.

Participants (author) ($n = 13$)	Area and road condition ($n = 10$)	Freight type ($n = 3$)	Season/weather ($n = 6$)	Vehicle factors ($n = 2$)	Other ($n = 2$)
Bus drivers (Hamed et al., 1998)	No effect (suburb, rural, urban area)^		No effect (weather)		
Bus drivers (La et al., 2013b)					Migrate from other province ↑
MT (bus and truck drivers) (Tzamalouka et al., 2005)		Fruit/vegetables and livestock ↑			No effect (church attendance)
MT (Ezeibe et al., 2019)	Traffic sign deficit ↑				
MT (Howard et al. 2004)	Interstate/country driving ↓				
MT (large passenger vehicles and truck drivers) (Mir et al. 2013)	Poor road conditions ↑			Brake/tire failures ↑	
Taxi drivers (Asefa et al., 2015)	Wet roadway ↑			Faulty taxi ↑	
Taxi drivers (Lam 2004)	No effect (special road feature)		No effect (weather)		
Taxi drivers (Wang et al., 2015)	Wet pavement ↑		Adverse weather and bad visibility ↑		
Truck drivers (Chu 2012)	Signalised rural area ↓	No effect (overload/ improper load)	No effect (weather)		
Truck drivers (Hong et al., 2019)	High traffic volume ↑		Snow, rain ↑		
Truck drivers (long-distance) (Adejugbagbe et al., 2015)	Narrow roads, bad portions of tarred roads ↑		First quarter of year ↑		Saturday ↑
Truck drivers (Thiese et al., 2015)		No effect (loading/ unloading of trucks)			
Summary	[8/10] Interstate/country driving (1), signalised rural area (1) ↓ Poor road conditions (2), wet roads (2), high traffic volume (1), narrow roads (1) traffic sign deficit (1) ↑	[1/3] Fruit, vegetables and livestock (1) ↑	[3/6] First quarter of year (1), adverse weather (1), bad visibility (1), snow (1), rain (1) ↑	[2/2] Faulty vehicle (2) ↑	[1/2] Migrate from other province (1), Saturday (1) ↑

Note: Sorted by occupational type. MT = multiple types of drivers.

previous driving experience in other professions, that addresses risky or over confident driving behaviour, should be prioritised in organisational preventive efforts.

3.5. Driver condition factors

The driver condition domain was highly investigated with a total of 46 studies identifying traditional risk factors such as poor sleep and fatigue, substance use or misuse of e.g.

alcohol and drugs, and impaired health parameters such as sleeping disorders, hypertension and cognitive impairment across all occupations (Table 6). Six out of 15 studies found that being fatigued while driving was a significant risk factor. More than three-quarters of the studies on health parameters, e.g. sleeping disorders, chronic diseases, hypertension etc., as well as almost half of the studies on the influence/misuse of different types of psychoactive substances such as alcohol, antidepressants, etc., identified significant risk factors within these categories. While addressing these behavioural and health-specific risk factors, it seems intuitive to focus on organisational health promotion programs. However, this is quite a challenge for the company, as professional drivers are on the road for most of their work day, which makes it difficult to conduct health-promoting activities. Nevertheless, considering the substantial company costs of employee involvement in crashes, this may strengthen the incentive for prioritising effective strategies (European Transport Safety Council, 2003). Likewise. providing healthy meals and snacks to bring on the road may be a solution for improving driver health and safety, in order to e.g. stabilise blood glucose levels throughout the day, and thereby minimise the often accompanied drop in attention and driving performance during the day (Ahmed, 2010). In regards to having poor blood glucose control, the only longitudinal study included in this review showed that being diabetic, without using insulin, increased the risk of road traffic crashes by 1.76 times (Laberge-Nadeau et al., 2000). Hence, caution should be taken with food with a high glycemic load, as the insulin response may cause subsequent drowsiness. Thus, recommendations that are easy to understand for the drivers – e.g. examples of types of meals that are preferred and types to be avoided – may be a way forward.. On the other hand, in spite of government legislation and company policies on drug and alcohol use, it may be regarded as unethical for a company to interfere with most of the driver condition risk factors, as they often relate to activities in the driver's unpaid, spare time. Although a manager may encourage a driver to get more sleep, they cannot force them to do so, as this relates to individual privacy and/or the medical condition of the driver, etc. However, scheduling working hours according to the driver's chronotype or analysing the driving schedule to ensure that the drivers are not fatiguing may be one solution for improving their alertness behind the wheel (Correa et al., 2014; Del Rio-Bermudez et al., 2014), as well as educating the workers in the signs and consequences of being drowsy, i.e. through Fatigue Risk Management (Michon, 1985). As there is solid evidence from laboratory studies that self-administered countermeasures such as napping, caffeine, bright light exposure, melatonin supplementation and use of sleep medication reduces fatigue while driving (Pallesen et al., 2010), such countermeasures could be scheduled or promoted by the organisation for drivers with specific sleep-related problems. Moreover, organisations should consider recent developments in vehicle implementation of real-time technologies for directly identifying physiological factors associated with fatigue or inattention, such as single channel electroencephalographic (EEG) frequency band activity, eye movement variables and heart rate variability (see Fernández et al., 2016; Sahayadhas et al., 2012; Shi et al., 2017) when pursuing future countermeasures for road traffic crashes among professional drivers.

3.6. Driving behaviour

We included 17 studies in the driving behaviour domain (Table 7). More than half of the studies found that the speed of the vehicle and history of traffic violation were

significantly associated with road crashes within each occupational type. Distracting activities, in particular phone use, seem to be an emerging risk factor that was frequently found to be significantly related to road crashes (Asefa et al., 2015; Harland et al., 2016; Thiese et al., 2015; Zhang et al., 2017).

A 2018 systematic review concluded that both conversations on a handheld and hands-free phone resulted in performance costs when compared with baseline driving for reaction time, stimulus detection, and collisions (Caird et al., 2018). The authors attributed the decline in performance to a lack of attention caused by the additional cognitive load associated with conversation while driving. Thus, regardless of whether the phone was handheld or not, or the driver took part in any other sort of communication or logistical route planning while driving, such distracting behaviours seem to compromise road safety. Hence, minimising communication and interaction with devices while driving should be encouraged and ascertained by the company by means of proper scheduling and communication, before initiating the delivery or route. Although studies involving part-time drivers were not included in this study, a recent study involving gig economy drivers from Uber or Deliveroo showed that these drivers, besides experiencing fatigue, were particularly distracted by their phones and also felt pressure to violate traffic regulations due to time pressure (Christie & Ward, 2019). As a result, this unregulated area of work is contributing to road safety risks for the drivers themselves and to others. Phone use amongst drivers might thus be reduced through technical surveillance equipment for detecting and alerting the driver while phone or media handling, as well as via policies such as fines.

The cost-benefits of preventive initiatives targeting individual risk factors should furthermore be evaluated in future studies. In an economic evaluation of traffic safety measures for transport companies, Rienstra et al. (2000) found that the cost–benefit of crash prevention is more profitable for larger companies. In general, strategies that influence the behaviour of drivers (e.g. through company policies targeting the use of navigation systems or phones while driving) require lower investments and fewer organisational efforts and thus are perceived as the most attractive by the transport companies (Rienstra et al., 2000). From a government and policy perspective, the implementation of voluntary safety training for bus and truck drivers has been associated with a cost–benefit ratio of 2.2 and 9.5 when implementing roadside inspections of trucks in Norway. Implementing such initiatives at a company level may likely lead to similar economic benefits (Elvik, 2003).

3.7. External factors

Thirteen studies were identified that investigated external risk factors (Table 8). Two-thirds of the studies found that the type of area (i.e. urban or rural) and road conditions (i.e. wet road) were associated with road crashes. Along these lines, season-specific and weather conditions were identified as significant risk factors among some truck drivers (Adejugbagbe et al., 2015; Hong et al., 2019), whereas taxi- and bus drivers were less affected by weather conditions (Hamed et al., 1998; Lam 2004). In addition, vehicle factors such as vehicle type and brake failure were found to be significant risk factors for road crashes. Although this primarily relates to truck drivers, only one, rather old study (Tzamalouka et al., 2005) out of three studies, showed that freight type, e.g.

transportation of fruit, vegetables livestock, was associated with road crashes. However, more current research indicates that although the circulation of longer and heavier vehicles, i.e. megatrucks, may improve productivity, it may also introduce new risk factors. In a recent study by Castillo-Manzano et al. (2021), fewer crashes, but higher fatality rates were observed in the European countries where megatrucks circulate (Castillo-Manzano et al., 2021). To combat this emerging problem, there is a need to develop specific organisational strategies, e.g. with increased safety training for megatruck drivers in parallel with the country's road and safety policy to diminish the higher risk of fatal road crashes as a result of circulating megatrucks.

4. Limitations

Several limitations/methodological issues should be considered when interpreting the findings of the current review. Although the literature search identified multiple studies of moderate to a high quality that collectively pointed in one direction for several risk factors, we almost exclusively found cross-sectional studies and only one cohort longitudinal study. Thus, in spite of many high-quality studies, we were unable to pinpoint any causal effects of being exposed to the risk factors at hand, as they did not compare the data in a longitudinal design, nor use actual control groups. Randomised controlled trials investigating the influence of specific risk factors are neither feasible nor ethical. On the other hand, a well-designed longitudinal observational study, e.g. in job groups characterised by occupational driving, should be feasible to perform. Due to the weak study designs, this review could not comply with the complete recommendations for systematic reviews and meta-analysis. For that reason, it was only possible to conduct a quality assessment approach that adhered to a cross-sectional design (cohort design in one study). Furthermore, a more narrative and vote-counting approach was used to interpret the results, e.g. by estimating the overall validity and significance of each risk factor by the consistency of the associated studies. However, this clearly has its shortcomings and should be interpreted with caution. Another weakness in our findings was that the majority of the risk factors and number of road crashes were assessed by questionnaires and interviews, which may be influenced by recall bias (Coughlin, 1990). The validity of each finding could be improved by objectively measuring the risk factor. Future research should aim at objectively identifying the most prominent risk factors, e.g. amount and type of sleep, fatigue or distracting activities, to attain a more precise estimate of how, when and at what level the risk factor is critical for the safety of the driver. Furthermore, assessing a more detailed and precise estimate of the influence of each risk factor will strengthen and ease the design and implementation of future driver safety preventive strategies. Future safety research should look into the extensive literature on factors impacting injury severity as a result of crashes among professional drivers.

Crashes result from a complex interplay between different factors and behaviours (Baikejuli et al., 2022). Various classifications have been applied to provide an overview of crash factors, including a distinction between performance and behavioural or motivational factors (Shinar, 2017). However, additional in-depth studies are needed to entirely understand the mechanisms contributing to occupational road traffic crashes. We, therefore, chose to cluster the identified risk factors according to person and environment

characteristics. This classification does not pinpoint the specific content included in future preventive measures. However, it is helpful for organisations to develop preventative measures, as it identifies aspects and areas to be aware of to increase safety. Finally, this review highlighted differences in risk factors between different types of occupations – whenever such interesting findings were observed. However, these comparisons should be interpreted with caution, due to the sometimes low number of studies within each risk factor category.

5. Conclusion

The review investigated risk factors associated with occupational road traffic crashes among professional drivers and found 64 moderate and high-quality studies, identifying a total of 27 significant risk factors related to road crashes. Throughout the last 30 years of road safety research, the most abundant and consistently significant associations with road crashes were observed for driver sleepiness, substance use, age, duration and time (of day) of driving. However, more recent risk factors, of which some were only investigated within certain driver occupations, were related to distracting activities such as the use of phone or navigation tools while driving, health parameters, driver experience, vehicle speed and management support. Although this paper provides an overview of the most frequently investigated risk factors for road crashes, it should be noted that the review primarily identified cross-sectional studies. Thus, more prospective and longitudinal studies are needed to create an in-depth understanding of the antecedents of road crashes to support future organisational strategies for improved driver safety among professional drivers.

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