

Review

# Work-Related Driving of Heavy Goods Vehicles: Factors That Influence Road Safety and the Development of a Framework for Safety Training

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**Abstract:** Road traffic accidents are a major health concern all over the world. Each year, 1.3 million people die in fatal road traffic accidents. Fatal and serious heavy goods vehicle (HGV) crashes are over-represented in many countries. This paper is a contribution to the road safety literature and has two aims. First, the study seeks to identify important factors in managing road safety for work-related driving of HGVs. Second, the study proposes an overall framework for how safety training could be executed and its overall content. Methods used were a literature review and a case study. The results show that important factors for management of road safety could be arranged at different levels: governmental level, third-party level, organizational level and driver level. Most important is that a systematic approach to road traffic safety for HGVs is essential. Every party is jointly responsible for road traffic safety, and parties must communicate and work together to increase road traffic safety for work-related driving of HGVs. By developing a safety training program for all parties in the system, the study proposes a method for increased communication, collaboration and cooperation between parties.

**Keywords:** road traffic safety; heavy goods vehicles; driver training; system approach



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## 1. Introduction

Road traffic accidents are a major health concern all over the world. Each year, 1.3 million people die in fatal road traffic accidents [1]. Another 20–30 million people sustain non-fatal injuries annually [2]. Fatal and serious heavy goods vehicle (HGV) crashes are over-represented in many countries [3]. Due to HGVs' great size and weight, accidents involving these vehicles are often fatal. In Norway, road transport organizations employ a large number of professionals whose main work is on the roads. HGV drivers account for the largest proportion (40%) of drivers in work who are involved in accidents and sustain injuries [4]. In Norway, specific interventions and measures directed particularly at work-related driving of HGVs are implemented. If new interventions and measures are not put in place, however, reducing HGV accidents and consequently achieving Norway's road safety target presents a challenge [5].

Even though there is a large body of research on the causes of HGV crashes, there is little research to evaluate the strategies that might be effective for preventing these crashes [3]. As a consequence, new research focuses increasingly on a systematic approach to reducing accidents involving HGVs. This means that accidents that do occur are not solely the driver's responsibility [5]. A crash caused by fatigue, for example, might not solely be the driver's fault, but could also be due to the supervisor's lack of involvement in route planning, or the type of compensation method used to align performance objectives with drivers' payment. Supervisors' level of involvement may also be restricted due to their own workload, company policies or pressure from higher up in the organization [6]. Recent research highlights stress- and fatigue-management policies and interventions in order to reduce work-related accidents with HGVs [7]. Hence, several small decisions from the top level down to the driver level may have triggered the actual accident.

This paper is a contribution to the road safety literature and has two aims. First, the study seeks to identify the important factors in managing road traffic safety for work-related driving of HGVs. By conducting a literature review, an overview of what the research literature deems to be important factors will be presented. The literature review has a focus on the management perspective and does not cover legal nor other perspectives.

Safety training and education are highlighted as important factors in managing road safety for work-related driving of HGVs [3,8,9]. In a recent study by Llamazares, J., S. A. Useche, L. Montoro and F. Alonso [10], similarities between commuting crashes and the work environment of professional drivers are suggested. It is stated that time pressure and fatigue are potential enhancers of commuting accidents the same way these factors are enhancers of accidents involving professional drivers. An important finding in their study is that 44% of the commuting crashes involved drivers with less than ten years of tenure. The study therefore concludes with the importance of job experience and training as protective factors.

Even though safety training and education are highlighted as important factors, there is little research into how such training could be executed and the potential content of such training and/or education. This study's second aim is therefore to propose an overall framework for how safety training could be executed and its overall content. Safety training would thereby be directed towards all parties in the system of work-related driving of HGVs. However, most attention will be given to safety training directed at drivers, and detailed safety training is illustrated by a Norwegian case study. This leaves the study with the following two research questions: (I) What are important factors to manage road traffic safety for work-related driving of HGVs? (II) How can an overall safety training framework be arranged to enhance road safety for work-related driving of HGVs?

A presentation of the methodology and results is provided below. Thereafter, results are discussed in regards to previous literature. Finally, a conclusion is proposed.

## 2. Methods

### 2.1. Literature Review

This study's first question is answered by using literature review as a method. The purpose of this literature review is to identify important factors to enhance road safety for work-related driving of HGVs. The literature review was conducted according to the method described in [11]. The method differs from a systematic literature review because the method allows broader topics where many different study designs might be applicable. Additionally, the method does not address very specific research questions, nor does it assess the quality of the studies included. The main aim of the method is to map relevant literature regarding important factors to manage road safety for work-related driving of HGVs. The stages of the literature review are as follows:

(1) Identifying the research question, (2) finding relevant studies, (3) selecting the studies, (4) charting and collating the data and (5) summarizing and reporting the results.

#### Step 1: Identifying the research question

As stated in the Introduction, this paper seeks to identify research literatures which present important factors that affect the management of road traffic safety for work-related driving of HGVs. Appendix A, Table A1, provides an overview of the studies included in the review, as well as a summary of the aim of the study, main findings and which factors have been identified.

#### Step 2: Finding relevant studies

The review was carried out according to the method described by Hart, C. [12]. The literature search was conducted in two phases. The first phase was conducted in October–December 2019 and the second phase was conducted in October–December 2021. In the first phase (October–December 2019), an extensive search was performed of eight different databases. The databases providing the most references were Google Scholar, Oria, Proquest, Science Direct, and Taylor and Francis. In addition, a second literature search phase was conducted (October–December 2021). This search was performed based on

literature the researcher was familiar with and perceived as relevant to the study objective. Moreover, the search also included new research published from the years 2019–2021. The keywords used in the search were ‘risk management, safety culture, transport and/or road transport’.

#### Step 3: Selecting the studies

The initial search included studies of all transport modes, such as road, train, air and sea. Based on titles, studies that involved transport modes other than road transport and duplications were excluded. The remaining road transport studies had to present factors that could influence the management of road traffic safety for work-related driving of HGVs. Hereby, studies that take a management perspective. Other inclusion criteria (Table 1) were that the articles had been published between 2014 and 2021, were online, peer-reviewed and written in English.

**Table 1.** Inclusion and exclusion criteria.

	Included	Excluded
Databases	ABI/Inform, Google Scholar, Oria, Proquest, Sage, Science Direct, Springer Link, Taylor and Francis (London, UK), Web of Science	Other
Timeframe	2014–2021	Articles published before 2014
Publication type	Peer-reviewed articles available online	Books and book chapters, ‘grey literature’ (reports, governmental reports, etc.), Other
Focus	Studies focusing on road safety concerns with HGVs	Studies focusing on other transport modes (train, air, sea)
Language	English	Other

#### Step 4: Charting and collating the data

Articles were then critically reviewed according to the method described by Hart, C. [12]. The following statistics were registered for each article: the study’s origin, authors, year of publication, method used, aim of study, main result and HGV road safety factors identified (Appendix A).

#### Step 5: Summarizing and reporting the results

Main findings from all included studies were organized on a chart, compared and summarized. In addition, a descriptive text about specific HGV road safety factors linked to each study was produced (Appendix A).

## 2.2. Case Study

This study’s second question, concerning how an overall framework for safety training could be arranged to enhance road safety for work-related driving of HGVs, was answered by using the results from the literature review, as well as a small-scale case study [13].

A case study affords the researchers an in-depth understanding of the phenomena that is being studied. There are mainly three types of case studies: intrinsic, instrumental and collective case studies [14]. In this study, an instrumental case study has been used, meaning that the case study uses a particular case to study the phenomena [14]. The study was conducted according to the description in [14].

#### Step 1: Defining the case

The case that was studied was the practical driving in periodic training of professional drivers (a more detailed description of mandatory periodic training in relation to the case study will be provided in Section 4.3) [15]. The research question that was to be answered was how an overall framework for safety training could be arranged to enhance road safety for work-related driving of HGVs.

#### Step 2: Selecting the case

The reasoning behind the selection of the case was that the practical driving part of the periodic training of professional drivers could be an illustrative case, to develop a

framework for safety training that is not too resource-demanding. Implementation of such a framework could be assumed to be easier for road transport organizations.

In addition, the case was chosen because of its accessibility for the researchers. Researchers were given access to instructors, professional drivers who attended the course, vehicles and locations.

#### Step 3: Collection of the data

Data were collected through observation of the course at a Norwegian training center and an interview with one instructor. In addition, driver performance results were collected for the practical driving. Results extracted from these data are presented in Section 4.3.

#### Step 4: Analyzing, interpreting and reporting the data

The data that were collected through observation and the interview were analyzed and interpreted with the research question in mind. Observation and interview notes were read and re-read to be familiar with the data. After this phase, the researchers identified important factors that could be used as a basis for the framework for safety training for work-related driving of HGVs. In addition, driver performance results were used to show improvement in driver behavior.

### 3. Results

In the following sections, the results from the literature review and the case study will be presented.

#### 3.1. Literature Review

##### 3.1.1. Search Results

A total of 805 studies were identified by the keywords used in the literature search and the additional manual search. However, after assessing the studies according to the inclusion criteria and removing duplicates, 93 studies were potentially relevant. The abstracts of these 93 studies were then reviewed. After this, 22 studies were included in the review (Table 2).

**Table 2.** Search results.

	Search Terms	Results	Potentially Relevant	Included in Review	Excluded due to Non-Relevance or Duplication
Google Scholar	Risk management + Safety culture + Road transport	205	42	1	204
Oria	Risk management + Safety culture + Transport	420	31	8	412
ABI/Inform	Risk management + Safety culture + Road transport	6			6
Proquest	Risk management + Safety culture + Road transport	13	2		13
Sage	Risk management + Safety culture + Transport	31			31
Science Direct	Risk management + Safety culture + Transport	31			31
Taylor and Francis	Risk management + Safety culture + Transport	76			76
Web of Science	Risk management + Safety culture + Transport	5			5
Manual search by reviewing reference list, etc.		32	18	13	5
<b>Total</b>		<b>805</b>	<b>93</b>	<b>22</b>	<b>783</b>

### 3.1.2. Descriptive Presentation—Outcome

The analysis of the 22 included articles was conducted with the following research question in mind: What are important factors to manage road traffic safety for work-related driving of HGVs? Analysis of the articles showed that they could be categorized into three distinct groupings: articles with factors contributing to road traffic safety on an (I) organizational level, (II) driver level and (III) third-party organizations and regulatory bodies level. In the following sections, a presentation of the factors at each level is provided.

### 3.1.3. Organizational Level

There is a need for management of road transport organizations to implement a system-thinking approach and safety management systems (SMS) in road transport organizations [3,4,16–19]. Accidents involving HGVs are likely to be a result of systems issues involving a network of interlinked contributory factors [19]. A reductionist perspective of finding the cause of an accident will not inform effective interventions or policy development [19]. Instead, the focus will be on identifying unsafe driver behavior, implying that the driver is solely to blame for the accident [7]. A collectivistic perspective is required in order to improve knowledge sharing and situational safety practices in transport [8]. Moreover, it must be acknowledged that the transport system has characteristics of a complex sociotechnical system, whereby all parties should be taken into consideration when an accident occurs [7]. A systematic approach to workplace road safety would acknowledge that responsibility for road traffic safety is shared across the system and that resources allocated to plan and manage workplace road traffic safety should be focused across all levels of the system, and not solely on the behavior and practice of the individual driver [1].

It is stated that transport organizations have little focus on organizational safety management (OSM), and thereby also little focus on SMS [4]. This is a particular challenge for small transport companies with limited resources. Consequently, an OSM strategy for small transport companies was developed in one of the studies [4]. To develop this OSM strategy, Nævestad et al. identified a set of evidence-based organizational safety measures that fulfilled five criteria. They had to: (1) address risk factors found in previous research, (2) have an effect on safety outcomes in previous research, (3) be attainable at a relatively low cost, (4) not be too complex, content-dependent or comprehensive and (5) be complemented to existing safety management standards. The measures identified on the basis of these five criteria were then arranged on a ladder, whereby the organizations start at the lowest level, before proceeding to: level (1) safety commitment of managers and employees, level (2) follow-up of driver speed, driving style and seat belt use, level (3) focus on work-related factors' influence on traffic safety (e.g., organization of transport) and level (4) safety management system (e.g., ISO 39001). It is argued that the safety culture increases at each level of the ladder, while the accident risk decreases [2].

It is stated that driver behavior is affected, among other factors, by the perceived level of stress. How transport schedule planning is conducted influences this perception (e.g., fatigue risk due to long working hours, as drivers get paid for actual production). Route planners must be aware of this risk when scheduling transport routes. The implementation of training programs for managers is highlighted as important [20–23].

The review of the literature showed some factors that stand out as important for the management of road safety for work-related driving of HGVs at an organizational level. In particular, there is a need for a systems approach and the implementation of safety management systems (SMS). It is crucial that the SMS include such elements as follow-up on driver behavior, training programs for both management and drivers and awareness about route planning, stress and fatigue. An overview of the literature is presented in Table 3.

**Table 3.** Organizational level.

Source	Findings
Newnam et al. [19]	There is a need for systems-thinking for management of transport companies.
Li and Itoh [16] Mooren et al. [3] Moreen et al. [17] Nævestad et al. [18] Phillips et al. [22] Warmerdam et al. [24] Nævestad et al. [4] Nævestad et al. [2] Grinerud et al. [25]	There is a need for the implementation of a safety management system (SMS) in road transport and for systematic safety management work. Effective workplace management programs must also include the drivers, who should be seen as the companies' responsibility. Implement training programs for managers of drivers.
Li and Itoh [16] Newnam et al. [26] Nævestad et al. [27]	Focus on building a good safety culture/climate in transportation companies.
Dawson et al. [20] Phillips et al. [22]	Fatigue amongst drivers must be addressed by implementing fatigue management systems.
Thompson et al. [23]	How drivers are paid affects the safety level. Payment systems should be 'flat-range' wage systems.
Li and Itoh [16] Grytnes et al. [8] Grinerud et al. [25]	Increase communication between drivers and management and their willingness for teamwork.

#### 3.1.4. Driver Level

At the individual driver level, several studies highlight the importance of driver/safety training and monitoring of driver behavior. This is argued to be the management of road transport organizations' responsibility: to provide their drivers with the right competence to execute their work. It is highlighted that safety training is closely linked to safety outcomes [3,4]. It is stated that such safety training could be arranged differently in terms of both informal courses/coaching/knowledge sharing, and formal training/education. The management of road transport organizations must provide an opportunity to identify and reduce the frequency of unsafe driving behavior by implementing corrective measures, such as coaching. The authors of [9] highlight the importance of a collectivist practice among drivers that can be utilized to improve knowledge sharing and situational safety practices. Li, Y. and K. Itoh [16] suggest more formal training, whereby they highlight proper safety training to give drivers more realistic views of stress/workload effects on their performance at work. Furthermore, in 2009, mandatory periodic freight transport training was implemented in Europe [15]. It is stated that after completing this periodic training, the driver/student will: (I) drive optimally and safely, (II) demonstrate professionalism in the execution of the profession and (III) protect their own and others' safety at work when the vehicle is stationary. Elvebakk, B., T.-O. Nævestad and L. C. Lahn [15] state that the periodic training is a success in many ways. This conclusion is based on Norwegian students' self-reporting that they have acquired new knowledge and changed their driving practices after completing 35 h of mandatory periodic training (a more detailed description of mandatory periodic training will be provided in relation to the case study in Section 4.3).

However, even though proper safety training is likely to have a positive outcome for road safety, few road transport organizations systematically provide non-mandatory safety training for their drivers [25]. The reasons for the lack of such programs is cost, a lack of information about efficient training programs, logistics and a lack of senior management support [26]. Nonetheless, there are also findings that suggest that by providing regulatory driver/safety training, road transport organizations have an advantage when recruiting new drivers, as many drivers perceive driver/safety training as important [25]. In addition to driver/safety training, studies also highlight the importance of follow-up on driver

behavior (e.g., [4]). It is stated that technology and organizational follow-up on driver behavior are important for managing road safety with work-related driving of HGVs.

After reviewing the literature, some factors stand out as important for the management of road safety for work-related driving of HGVs at a driver level. They particularly include that drivers should have proper safety training and education in terms of driving behavior and that this behavior should be regularly followed up. An overview of the literature is presented in Table 4.

**Table 4.** Driver level.

Source	Findings
Luke and Heyns [28] Mooren et al. [17] Nævestad et al. [4]	Monitor driving performance and behavior and implement measures (i.e., coaching).
Li and Itoh [16] Mooren et al. [3] Grytnes et al. [8] Warmerdam et al. [24] Grinerud et al. [25] Elvebakk et al. [15]	Implement safety training for drivers. Improve driver competence and communication between drivers. Implement safety rules.

### 3.1.5. Third-Party Organizations and Regulatory Bodies

Different studies highlight third-party organizations and regulatory bodies as important parties that can influence safe road transport using HGVs. In this study, third-party organizations are limited to focus on buyers of road transport services. Nævestad, T.-O., R. O. Phillips and B. Elvebakk [18] state that time pressure is a critical problem in the transport industry. It is said that, for example, transport buyers and forwarding agents are likely to put pressure on/stress drivers. This means that drivers take greater risks while driving due to tight time margins for assignments [5,9,18]. Transport buyers and forwarding agents can also influence safe road transport through the requirements they set. These requirements include that drivers must have winter driving proficiency before transporting their goods on winter roads [9]. It is stated that a lack of skills to drive on Norwegian winter roads is a road safety challenge [29]. The management of road transport organizations' choice of strategy is influencing what kind of customers they acquire. Hereby, customers that enhance or decrease road traffic safety for work-related driving of HGVs [25].

Governmental and regulatory bodies are important for the management of road safety for work-related driving of heavy goods vehicles. In this study, governmental bodies are limited to be those who approve legal acts, while regulatory bodies are limited to those who enforce laws and regulations. They play a key role in maintaining safety at all levels through their regulations and policies [7]. For example, if regulatory bodies' inspections fail to detect deficiencies in road transport organizations' maintenance procedures, this may result in HGVs with non-functional brakes being allowed on the road. Further, if governmental and regulatory bodies approve and enforce laws and regulations that are not in line with actual day-to-day transportation, challenges for drivers and road transport organizations in applying these regulations will occur. To prevent these challenges, frequent communication and collaboration between parties is highlighted as important.

After reviewing the literature, some factors stand out as important for the management of road safety for work-related driving of heavy goods vehicles at a third-party organizational and regulatory body level. It is particularly important that third-party organizations and governmental and regulatory bodies increase their collaboration, so that the different parties are familiar with the challenges at different levels. An overview of the literature is presented in Table 5.

**Table 5.** Third-party organizations and regulatory bodies.

Source	Findings
Newnam et al. [6] Newnam et al. [19] Nævestad et al. [18] Nævestad et al. [29] Grinerud et al. [5] Grinerud [9] Grinerud [25]	Increase collaboration with other stakeholders (i.e., governmental and regulatory bodies, NGOs, transport buyers and researchers).

3.2. Case Study

In the following, results collected from (1) interviewing an instructor and (2) observing actual driver training in module 5 in periodic training for professional drivers are reported.

The actual training in module 5 was conducted as shown in Table 6.

**Table 6.** Actual driver training module 5.

What	Who
Introductory conversation between instructor and driver	Instructor and driver in dialogue
60 min of driving	Driver active, instructor is a passive observer
Feedback conversation	Instructor and driver in dialogue
60 min of driving	Driver active, instructor active with clues and feedback on driving behavior
Feedback conversation	Instructor and driver in dialogue

The driving rounds of 60 min are exactly the same for both rounds. The driver is measured by explicit factors in both rounds, so that improvement can be registered. These factors are fuel consumption, speed, number of stops and time consumption. The overall aim is to drive optimally, defensively and safely, and it is proposed that these factors can serve to illustrate whether this aim is achieved or not. For example, if fuel consumption is lower in round two, this is most probably because the driving is better planned, and hence safer. Less stops in round two also indicate better planned driving and thereby more optimal and safe driving. Full stops with HGVs are time-consuming because it takes time to stop and accelerate heavy weight. Unnecessary stops increase time and slow down the overall speed. In addition, the professional instructors use their experience to assess whether the driving is optimal, defensive and safe. This includes whether speed is adjusted to the circumstances, distance to others and positioning on the road in general and in particular towards intersections or other similar situations. The results for 17 drivers (Table 7) showed a better score for almost every factor from round 1 to round 2.

An example could be Driver 17, who reduced their fuel consumption by 0.37 L, increased the average speed by 6 km/h, reduced the number of stops from 7 to 2 and reduced time consumption by 11 min. In addition, the professional instructor stated that the driving in round 2 was more optimal, defensive and safe due to the driver’s improved planning of driving behavior.

**Table 7.** Results for safe driving training module 5.

Driver	Fuel Consumption (liters)			Average Speed (km/hr)			Number of Stops			Time Used (minutes)		
	Round 1	Round 2	Dif.	Round 1	Round 2	Dif.	Round 1	Round 2	Dif.	Round 1	Round 2	Dif.
1	1.17	1.12	0.05	46	49	3	7	3	4	63	58	5
2	2.1	2.0	0.1	45	45	0	4	2	2	63	62.5	0.5
3	3.54	3.62	0.08	44	45	1	1	1	0	66	64	2
4	1.33	1.29	0.04	47	48	1	5	1	4	63	62	1
5	2.2	2.1	0.1	43	45	2	1	1	0	66	64	2
6	4.24	4.19	0.05	45	48	3	3	2	1	64	62	2
7	1.09	1.07	0.02	46	48	2	2	2	0	61	58	3
8	2.3	2.1	0.2	45	45	0	8	3	5	63	62.5	0.5
9	1.35	1.35	0	50	51	1	6	1	5	60	58	2
10	4.03	3.77	0.26	46	46	0	3	1	2	62	62	0
11	3.81	3.68	0.13	41	44	3	4	3	1	68	64	4
12	3.54	3.31	0.23	43.6	44.6	1	7	0	7	65	64	1
13	3.53	3.0	0.53	36	43	7	9	5	4	75	63	12
14	1.28	1.26	0.02	42	49	7	6	0	6	70	60	10
15	1.15	1.05	0.1	41	48	7	10	2	8	70	61	9
16	3.34	3.14	0.2	37.8	43.2	5.4	5	2	3	76	66	10
17	3.85	3.48	0.37	37	43	6	7	2	5	74	63	11

#### 4. Discussion

This study's first aim was to identify important factors to manage road traffic safety for work-related driving of HGVs. These factors were categorized into three groups: how management of road transport organizations' decisions could affect road traffic safety for work-related driving of HGVs on an organizational, driver and third-party level.

##### 4.1. Important Factors to Manage Road Safety for Work-Related Driving of HGVs

The majority of the studies in the review see road traffic safety for work-related driving of HGVs as a complex phenomenon. This means that the driver is not solely to blame when a road accident involving an HGV occurs. A systematic approach to road safety for HGVs is essential. It is stated that third-parties such as governmental and regulatory bodies must develop and enforce laws and regulations in line with road transport organizations and driver challenges [6]. Other third parties such as buyers of road transport services must be made aware of their power to influence road safety and to set requirements that do not reduce safety levels [5,9]. The road transport organizations by which the drivers are contracted must facilitate good conditions for drivers. Pay and working hours must be acceptable, and it must be possible to implement routes without drivers having to break the law in terms of driving and resting times, etc. [18,27]. At the driver level, it is stated that accidents that can be related directly to unsafe driver practices are often a result of speeding, following too closely, frequent or rapid lane changes, unsafe braking and acceleration, driver distraction or inattention and failing to wear a seat belt [4,28].

The aforementioned factors should be easy to handle at each level. This means that when governments and regulators develop laws and regulations, these laws and regulations should make sense for those developing them. Road transport organizations should not face any challenges in terms of facilitating good conditions for drivers, since after all they are the ones hiring the drivers. However, a challenge for management of safety in this system is a lack of communication and collaboration between different parties in the system [1,9,27]. There is a need for parties to be aware of the challenges experienced by other parties at different levels of the system. Governments and regulators must develop laws and regulations that make sense for those who will be affected by these laws and regulations, namely road transport organizations, drivers, etc. Moreover, road transport organizations must facilitate good conditions for drivers, and the drivers must decide what good driving conditions are. As a consequence, all factors must be viewed in context, in order to manage road traffic safety for work-related driving of HGVs. Latent failure can only be detected if knowledge, competence and experience are shared between all parties in the system. Latent failures in this context refer to errors that may occur due to actions

and decisions made by management or others who are removed from the direct control interface. Such latent errors could, in the next step, lead to active failures. That is where the consequences are instantly visible, and where there is a clear relationship between cause and effect [30], for example when an HGV driver is involved in a road accident [31].

Based on the results of the literature review, empirical findings in the case study and previous research, this study proposes a framework for a safety training program for work-related driving with HGVs. In addition to improve driver skills, the framework also aims to increase communication and collaboration between different parties in the system of work-related driving with HGVs.

#### 4.2. Safety Training

This study's second aim was to propose a framework for a safety training program for work-related driving of HGVs.

A measure/intervention to increase knowledge between parties at different levels could be joint safety training and education. Safety training, education and/or competence are highlighted as crucial to safety management in several studies, e.g., [3,9,15,16,32]. This could be seen as a surprising finding in this current literature review as previous research conclusions often highlight that driver education and training have little or no effect on road traffic safety [33,34].

Even though safety training and education are highlighted as important interventions in this literature review, there is little research to be found on the content of such safety training and education. Nævestad, Elvebakk and Phillips [4] come closest to suggesting content through their safety ladder, but this study is not specific concerning the content of safety training and education for parties in the system of road transport for work-related driving of HGVs. However, a very important statement in their study is about the complexity of the safety training. They highlight the importance of not making these programs too complex and resource-demanding. The reasoning behind this is the fact that the road transport industry is a low-earning industry, and there are few resources. Hence, complex safety programs will not be implemented due to the competition between safety and production goals.

An example of a complex safety program is the international standard ISO 39001: 2012 Road traffic safety (RTS) management systems—requirements with guidance for use. This standard is complex and demands numerous resources to implement. It is demanding for all road transport organizations to implement, in particular for small road transport organizations since they often have fewer resources to invest in safety programs.

The current study suggests a safety training framework directed towards decision makers and parties in the road transport system for work-related driving of HGVs (Figure 1). There is an aim that the safety training framework should also be possible to implement for smaller road transport organizations. Hence, it is constructed to be simple, effective and easy to implement with few resources. Consequently, the framework is not in competition with ISO 39001: 2012 Road traffic safety (RTS) management systems, but instead it aims to be a substitute targeting both small and large road transport organizations.

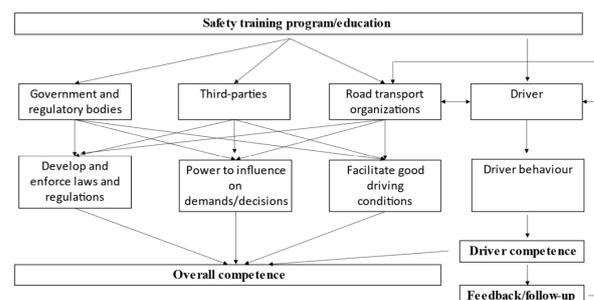


Figure 1. Safety training program.

The suggested safety training program is divided into two parts. One training program directed towards decision makers and parties at the higher levels of the system, and one training program directed towards drivers. The reasoning between this division is based on findings in the literature review. It is stated that communication between all parties in the system is important, to ensure familiarity with each other's challenges and opportunities [30,35]. Consequently, communication is a key component of the management of road traffic safety for work-related driving of HGVs. One intervention to increase communication could be joint safety training for every party in the system.

By developing a safety training program directed towards governmental/regulatory bodies, third-parties and road transport organizations, and customizing the content towards these parties, challenges and opportunities will be made known for every party. The challenges and opportunities experienced by each party are well-documented in the research literature, and the safety training content should be based on this. Most important is that each party is made aware of other parties' challenges and opportunities, and that collaboration and cooperation are presented as an important tool to increase road traffic safety for HGV businesses and drivers.

It is suggested that an arena where governmental/regulatory bodies, third-party organizations and road transport organizations can discuss with each other is established (Figure 1). In this arena, the different parties can present their area of responsibility as well as their challenges, e.g., regulatory bodies such as the NPRA present their concern(s) about what they detect during road traffic controls of HGVs. Road transport organizations (which own the HGVs) are given the opportunity to explain their concerns towards the same road traffic controls. By communicating to, and not against, each other, joint solutions for the challenges can be established. Furthermore, when the management of road transport organizations and buyers of road transport services communicate with each other to find solutions on time pressure, route planning, loading capacity, etc., it is assumed that challenges can be solved. By establishing such an arena for these parties, competence for each party will increase individually and as a group. Together, they will contribute to enhance the overall competence.

Finally, the actual transportation on the roads must be completed by competent drivers to minimize the possibilities of road accidents. Therefore, a safety training program aiming towards increasing the drivers' competence is of importance. In the following, a suggestion for such a training program is proposed.

### *4.3. Safety Training Program for HGV Drivers*

#### *4.3.1. Introduction*

As a part of the European Union's road traffic safety work, a new directive related to basic and periodic training for professional drivers was implemented in all EU member states in 2008/2009 (EU directive 2003/59/EC). The directive concerns compulsory basic training of 280/140 h and periodic training of 35 h every 5 years [15]. The training consists of 5 modules. Modules 1–4 are mostly theoretical, with some practical tasks such as securing cargo, first aid, correct use of tire chains and correct use of fire extinguishers. Module 5 concerns the topic of 'safe behavior on the road' and consists of both theoretical classroom teaching and practical driving (EU directive 2003/59/EC). In the periodic training, most training centers spend an average of 28 h on modules 1–4 and 7 h on module 5, with around 2 h as practical driving with a professional instructor, where the aim is to drive optimally, defensively and safely [15].

A significant proportion (26.2%) of respondents in Elvebakk et al.'s study [16] completely agreed that they had improved their defensive driving skills after completing module 5. The current study therefore proposes a safety training program for HGV drivers based on two data sources:

- Post-training studies
- Results collected from actual driving training in module 5 as periodic training for professional drivers

#### 4.3.2. Outcome

According to the research literature, follow-up on driver behavior is of great importance to managing road safety for work-related driving of HGVs [2,4,28,31]. By prioritizing follow-up on driver behavior, management can demonstrate their commitment to safety. The management also acknowledges company influence on and responsibility for speed and driving style [4]. When the research literature uses the phrase ‘follow-up’ concerning driver behavior, this mostly refers to such measures as self-monitoring facilitated by technology (e.g., on-board monitoring systems) and management monitoring and support. However, it should also be possible to suggest that driver behavior could be followed up more practically and more regularly than through periodic training every five years. The research literature therefore also highlights driver training as an important measure to increase road safety [3,15].

The current study proposes a framework for and the content of a safety training program for HGV drivers, based on module 5 ‘safe behavior on the road’ collected from periodic training for professional drivers and from the research literature (Table 8). The aim of this framework and content is to increase each driver’s knowledge and competence. This will increase the drivers’ opportunities to drive optimally, defensively and safely by making correct decisions while driving. Follow-up on driver behavior is stated to be an important measure to increase road safety for HGVs. Consequently, periodic training every five years will be too seldom to function as a follow-up on driver behavior. In addition, research shows that many transport organizations do not perform frequent follow-ups on driver behavior themselves [25].

**Table 8.** Safety training program for HGV drivers.

Time	Topic
Approximately 30 min	Theoretical discussion about optimal, defensive and safe driving
30 min	Driving round 1: Driving with a professional instructor. The instructor does not interfere with the driving. He/she solely observes the driving.
Approximately 15 min	Conversation between instructor and driver about the first round of driving. Which practice was optimal, defensive and safe driving and what are the potential areas for improvement?
30 min	Driving round 2: Exactly the same route is driven one more time. However, this time, the instructor gives the driver feedback, clues and advice directed at how to drive optimally, defensively and safely.
Approximately 15 min	<p>Conversation between instructor and driver about the second round of driving. Were there improvements? Measures used to detect improvements could be:</p> <ul style="list-style-type: none"> <li>• Effectiveness (time spent on round 2 compared to round 1)</li> <li>• How many times the driver had to stop (due to lack of planning for situations or intersections)</li> <li>• Fuel consumption</li> <li>• Distance to others</li> <li>• Comfortable driving</li> </ul>

The current study’s proposed safety training program for HGV drivers is proposed to be executed between the periodic training programs every five years. Once every 6–12 months is suggested, which makes it important that the safety training program is not too time-consuming. Consequently, the framework and content suggested could be executed over two hours. It is assumed that when the training is not too time-consuming,

more frequent execution of the program within each road transport organization will be possible. In between the execution of the safety training programs, it is proposed that drivers be followed up through on-board systems and dialogue with supervisors. The practical safety training program is proposed to be organized as outlined in Table 8.

For this safety training program to work, each road transport organization must educate supervisors/professional instructors. These individuals plan and schedule execution together with each driver. In this way, the program could be executed while the drivers are at work performing their regular jobs. Consequently, the resources needed to execute the program would be kept at a minimal level.

#### 4.3.3. Limitations

This study does present some limitations. First, the number of articles included in the literature review was relatively low ( $n = 22$ ). However, the articles included tended to describe similar challenges. It is therefore assumed that the literature review reveals the overall picture. The study was limited to factors that affect the management of road traffic safety on an organizational, third-party and driver level. Consequently, technical and mechanical factors have not been identified. Moreover, factors such as roadway geometric design and specific traffic control measures were not emphasized in this study. The reasoning behind this limitation is that the focus of the study has been on the management and their decisions at the above-mentioned levels. Second, the framework and content of the proposed safety training program were not empirically tested. It is proposed that the program should be empirically tested in future studies.

#### 4.3.4. Implications and Further Research

It is assumed that the proposed safety training program will increase communication and collaboration between all parties and thereby enhance road traffic safety for work-related driving of HGVs. As a consequence of safer road transport, it is also assumed that minor damage to vehicles and equipment will decrease. Consequently, implementation of the proposed training program will reduce road transport organizations' costs related to accidents and minor damages and the safety training program could provide a financial gain for the organization. However, more research should be conducted. It is suggested that a practical study of how the program functions within a road transport organization should be conducted.

### 5. Conclusions

This study's research questions were: (I) What are important factors to manage road traffic safety for work-related driving of HGVs? (II) How can an overall framework for safety training be arranged to enhance road traffic safety for work-related driving of HGVs? By using literature review as a method, important factors to manage road traffic safety for work-related driving of HGVs were identified. These factors were categorized at different levels in the system of road transport safety. This revealed the important factors for management of road traffic safety at the governmental level, third-party level, organizational level and driver level.

Developing and enforcing laws and regulations in line with road transport organizations and driver challenges was categorized as the most important factor at the governmental and regulatory levels. At the third-party level, the factor highlighted as important was these parties' power/opportunity to influence safety and set requirements. An important factor highlighted at the organizational level was the facilitation of good conditions for drivers. Lastly, at the driver level, skilled and experienced drivers were highlighted as important to manage road traffic safety. Most important, however, is that a systematic approach to road traffic safety for HGVs is essential. This means that every party is jointly responsible, and parties must communicate and work together to increase road traffic safety for work-related driving of HGVs.

By developing a safety training program for all parties in the system, the current study proposed a method for increased communication, collaboration and cooperation between the parties. A safety training program directed towards parties at the higher levels of the system, as well as a safety training program directed towards HGV drivers, were proposed. It is assumed that by executing a joint safety training program for parties at the higher levels of the system, parties will gain more knowledge and insight into each other's challenges and opportunities. When such knowledge is held, it is assumed that each party will be more capable of viewing things from another perspective, consequently becoming more solution-oriented. The safety training program for HGV drivers was developed with the aim of increasing HGV drivers' knowledge and competence. This will enhance the drivers' opportunities to drive optimally, defensively and safely by making correct decisions while driving.

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## Appendix A

**Table A1.** Studies included in the review.

Study (Country)	Sample/Method	Aim of Study	Main Result	HGV Road Safety Factors
Grytnes et al. (2016) Denmark, [8]	Participant observation Semi-structured interviews	Analysis of heavy goods vehicle (HGV) drivers' and managers' differentiated understandings of risk and safety and management within an organizational context.	Drivers have individual attitudes towards safety, although they frequently share knowledge with other drivers. The companies' structure shapes this individual thinking towards safety. Risk-taking is prevalent among HGV drivers, and the management of such risk is one's own responsibility.	Increase communication between drivers and between drivers and management. Implement safety rules with a collectivistic approach.
Nævestad et al. (2018) Norway, [4]	Systematic literature review	Develop an organizational safety management (OSM) strategy for small road transport companies.	Identified a set of evidence-based organizational safety measures that fulfill five criteria. The measures have been arranged on a 'safety ladder'. The companies start at the bottom before proceeding to the next step.	Work systematically with management of safety. Follow-up on drivers' speed, driving style and seat belt use. Focus on work-related factors' influence on traffic safety.
Li and Itoh (2014) Japan, [16]	Questionnaire survey	Develop a safety climate scale for the trucking industry.	Significant correlations with safety outcome measures were identified for several safety climate factors. A good safety climate contributes positively to safety performance.	Continuous assessment of safety climate. Increase willingness to engage in teamwork. Implement safety management system (SMS), including safety training.
Mooren et al. (2014) Australia, [3]	Questionnaire survey	Identify differences in management characteristics between companies with good and poor safety records, using vehicle insurance claim.	Low-claiming companies (good performing) were smaller, did more safety-related checking, checked accident history at recruitment, paid drivers for all time worked and monitored driver work and workload. High-claiming companies conducted more safety training and had more safety policies.	Monitoring drivers instead of safety training. Implement safety management system (SMS) that is suitable for the company's size.
Thompson et al. (2015) Australia, [23]	Simulated transport system (STS) using the NetLogo ABM platform (Wilensky, 2013)	Determine whether agent-based modelling may be usefully applied to explore the effect of driver payment methods on driver fatigue and crash risk.	Drivers operating under 'per-km' and 'per-trip' piece rate incentive systems were significantly more likely to drive while fatigued, with the subsequent occurrence of all associated issues (loss of license, increased crash risk, increased fines), than those paid under 'flat-rate' wage conditions.	Implement 'flat-rate' payment for drivers.

Table A1. Cont.

Study (Country)	Sample/Method	Aim of Study	Main Result	HGV Road Safety Factors
Newnam and Oxley (2016) Australia, [32]	Case study	Describes a new and innovative conceptual framework for a program designed to improve work-related driver safety. The focus of this program is on developing the skills of supervisors in identifying situations in which their drivers may be at risk on the road (e.g., drivers are tired, stressed, or under pressure to meet deadlines) and in managing these situations through effective safety leadership.	The program develops the key, yet largely unrecognized, safety management skills of supervisors using developmental techniques, including 360-degree feedback, behavioral self-monitoring, leadership coaching and communities of practice.	Implement training program for managers of the drivers.
Nævestad et al. (2015) Norway, [18]	Mixed methods—Document analysis and interview	This report outlines the results of a study of severe road traffic accidents in Norway, triggered by drivers at work. The aim has been to examine whether and to what extent risk factors of these types triggering drivers and their vehicles can be traced back to work-related factors.	The quantitative analysis of AAG data shows that excessively high speeds for the circumstances, failure to use a seat belt and insufficient information gathering were the most important risk factors in fatal accidents triggered by drivers at work. The qualitative analysis of reports from AIBN and expert interviews uncovered the following work-related factors considered central for traffic safety: follow-up of drivers' speed, driving style and use of seat belt, pay systems, safety culture, risk assessments, procedures/ work descriptions and training. The AIBN reports and the interviews indicate that the following framework conditions influence traffic safety: time pressure, competition, type of transport and accident investigations/inspections. Most of the interviewees held that work-related factors with potential implications for traffic safety are insufficiently monitored in controls and inspections.	See the drivers as the company's responsibility. Implement safety management system (SMS).
Warmerdam et al. (2017) Australia, [24]	Semi-structured interviews	Use a benchmarking tool developed by the National Road Safety Partnership Program to assess industry maturity in relation to risk management practices.	Overall, the results demonstrated varying levels of maturity of risk management practices across organizations, highlighting the need to build accountability within organizations, improve communication practices, improve journey management, reduce vehicle-related risk, improve driver competences through an effective workplace road safety management program and review organizational incident and infringement management.	Implement risk management practice.
Newnam et al. (2017) Australia, [19]	Document analysis	Efforts to understand crash causation should be focused beyond the driver and identify contributing factors at other levels within the road freight system.	There was a lack of evidence to suggest an understanding of system-based reform based on the identification of reductionist-focused recommendations. It is concluded that researchers and practitioners (i.e., government and industry) need to work together to develop prevention efforts focused on system reforms. Systems-thinking-based data collection and analysis frameworks are urgently required to help develop this understanding in road freight transportation.	Implement systems-thinking in the organization. Collaborating with others (i.e., transport buyers, regulatory bodies).

Table A1. Cont.

Study (Country)	Sample/Method	Aim of Study	Main Result	HGV Road Safety Factors
Newnam et al. (2017) Australia, [26]	Interviews	Explore the role of high-performance workplace systems (HPWS) in influencing safe driver behavior.	HPWS practices are not designed or implemented with consideration of the safety of drivers. Organizations with employees that need to drive for work should integrate driver safety within the broader Occupational Health and Safety (OHS) System.	Build organizational culture with both a top-down and bottom-up approach.
Dawson et al. (2014) Australia, [20]	Literature review	Critically review currently available and emerging fatigue technologies.	Fatigue detection technology has the potential to improve management of fatigue in transportation companies. However, the effectiveness must be documented through studies providing converging evidence. This is not the case at the current time.	Implement fatigue management system (levels 1–5).
Phillips et al. (2017) Norway, [22]	Literature review	Review fatigue-related risk and exposure factors and control measures for operators of land- and sea-based transport forms.	Review 13 types of measures identified for the monitoring or control of fatigue risks, and two systematic measures needed to anchor risk mitigation in safety management systems (SMS), organizational learning and training.	Implement fatigue management system in the companies' SMS.
Nævestad et al. (2018) Norway, [27]	Literature review	Map interventions that can be used to develop good safety culture in transport companies and assess expected effects of interventions on safety culture and safety outcomes, and identify factors influencing safety culture change.	Safety culture interventions seem to be effective, but they are often comprehensive and resource-demanding.	Focus on developing a good safety culture.
Mooren et al. (2014), [17]	Literature review	Collate the evidence concerning safety management characteristics or practices that produce demonstrable differences in injury rates and other safety improvement indicators and reveal which characteristics or practices these effects have.	Found limited research that provides the beginning of an evidence base for a set of safety management characteristics that have been associated with improved safety outcomes. However, some characteristics have evidence from many studies supporting their preliminary inclusion in a safety management system (SMS) suitable for heavy vehicle transport operations (management commitment, safety training, scheduling and journey planning).	Implement safety management system. Safety training.
Luke and Heynes (2014) South Africa, [28]	Literature review and case study	Identify the riskiest driver behaviors in commercial fleets in South Africa. Determine the business impact of such behavior and establish a framework for the management of such behavior.	Risky incidents were significantly reduced on implementing a driver risk management system (DRMS).	Monitor driver performance and behavior. Analyze risky driving events. Implement measures (i.e., coaching).
Newnam and Goode (2015) Australia, [6]	Rasmussen's accimap technique is applied to the analysis of road freight transportation crashes. Thematic analysis used to identify factors and relationships	Capture the complex system of factors influencing road transport crashes by applying Rasmussen's risk management framework and associated accimap technique.	System approach can increase knowledge. A reductionist view of crash causation does not tell the whole story.	Increase collaboration between the transport company and others (i.e., transport buyers and regulatory bodies).
Grinerud (2021) Norway, [9]	Interviews	Explore how buyers of road transport services can contribute to safe road transport of goods in northern Norway and through this become important parties in reducing fatal traffic accidents.	Buyers of road transport services can contribute to safer road transport by emphasizing 5 factors: (1) develop detailed formal contracts with road transport organizations, (2) use new technology, (3) evaluate their decision criteria for ordering road transport, (4) good communication and (5) be aware of how knowledge and trust in a transport organization could affect judgement regarding revisions and controls.	Put more responsibility for safe road transport on buyers of road transport services. Increase collaboration between buyers of road transport services and road transport organizations.

Table A1. Cont.

Study (Country)	Sample/Method	Aim of Study	Main Result	HGV Road Safety Factors
Grinerud, Aarseth and Robertsen (2021) Norway, [25]	Interviews	Investigate how management decisions can affect road transport organizations' ability to develop a good safety culture.	Road transport organizations that choose a low-cost strategy struggle to be profitable. Moreover, such strategies lead to high rivalry between organizations. Such rivalry makes it difficult to be profitable, so there are fewer resources available to invest in building a good safety culture. In contrast, road transport organizations that choose a differentiation or focused leadership strategy are more likely to be profitable. As a consequence, they have more resources to invest in building a safety culture.	Management commitment and resources must be available to develop a good safety culture in road transport organizations.
Nævestad, Phillips, Levin and Hovi (2017) Norway, [29]	Analysis of personal injury accident data and survey	Examine the safety outcomes of increasing internationalization in Norwegian road transport of goods and discuss the importance of potential risk factors related to increasing proportions of foreign HGVs on Norwegian roads.	Foreign HGVs have a three times greater risk of single-vehicle accidents and twice the risk of head-on collisions. They are also more likely to trigger fatal accidents. Two risk factors are highlighted as important: experience with Norwegian roads and winter driving.	Foreign drivers need more experience and education in driving on Norwegian roads (especially winter driving). Buyers of road transport services need to take more responsibility for hiring competent drivers.
Elvebakk, Nævestad and Lahn (2020) Norway, [15]	Document analysis, case studies and survey	Evaluation of the mandatory periodic training of professional drivers in Norway.	In many ways, the periodic training is a success. Considerable numbers of students report that they have acquired new knowledge and changed their driving practice.	Education and training as a tool for safer road transport.
Nævestad, Blom and Phillips (2020) Norway, [2]	Interviews and survey	Validate the safety ladder approach [4] in empirical research by comparing safety structure, safety culture and accident risk for trucking companies. The study has four aims: (1) to map the safety structure at the different levels of the safety ladder, (2) examine whether safety culture is improved with increased structural measures at each safety ladder level, (3) examine whether the accident risk decreases at each safety ladder level and (4) discuss practical implications.	Based on interview results, increasing structural safety measures for the companies at each level of the safety ladder are registered. Survey results indicate increasing safety culture scores at each level of the safety ladder, while the accident risk decreases. The study concludes by suggesting the concrete management practice related to each level as good practice, as these seem to be related to the increases in safety culture and decreases in accident risk.	Safety commitment of managers and employees. Follow-up on driver behavior. Focus on work-related factors' influence on traffic safety. Safety management system.
Grinerud, Sætren and Aarseth (2020) Norway, [5]	Interviews	Discuss how buyers of road transport services can contribute to sustainability and safety in the chain of transport and to the Vision-Zero Ideology.	Findings indicate that buyers of road transport services have an impact on both sustainability and safety in the chain of road transport, by exerting influence through pricing and delivery demands.	Transport buyers must set requirements for the road transport they order, be willing to pay for safe road transport and be aware of how their delivery demands have an impact on driver behavior.

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