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Traffic accidents triggered by drivers at work - a survey and analysis of contributing factors

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Abstract

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 triggering drivers and their vehicles can be traced back to work-related factors. The study is based on data from the Accident Analysis Groups (AAG) of the Norwegian Public Roads Administration (NPRA), reports from The Transport Accident Investigation Board Norway (AIBN) and interviews with nine experts. The quantitative analysis of AAG data shows that too high speed for the circumstances, failure to use 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, accident investigations/inspections. The majority of the interviewees held that work-related factors with potential implications for traffic safety are insufficiently monitored in controls and inspections.

1. Introduction

Road transport often represents the greatest risk that we are exposed to during a regular working day. This is especially true for professional drivers and other employees driving during work. In these cases, employers have a legal responsibility to ensure that employees' traffic safety is optimal.

It seems that employees driving in their work are more accident prone than other employees. Data from 1988-1993 shows that the accident risk of occupational drivers was 9.5 fatalities per 100 million person hours, while it was three for other occupations (Elvik 2005).

Traffic accidents account for between 20 and 40 percent of work-related accidents in industrial countries (ETSC, 2010a; Fort et al., 2010). If we include the journey to and from work, the rate may be as high as 60 percent (ETSC, 2010a).

Overall, 39 percent of fatal occupational accidents in the EU are traffic accidents (ETSC, 2009), while between 22 and 24 percent of work-related deaths in the United States are caused by traffic accidents (Driscoll et al., 2005). In Australia and New Zealand, the shares are 31 and 16 percent respectively (Driscoll, et al., 2005).

In Norway 36 percent of fatal road accidents involve employees driving at work (Phillips & Meyer 2012). Although work-related accidents make up substantial shares in the accident statistics of road transport, knowledge is lacking on the relationship between accidents and work-related risk factors in transport organizations.

A better focus on work-related, underlying organizational causes in transport organizations may inform preventive measures and improve transport safety (Banks 2008; Gregersen, Brehmer & Morén 1996; Murray, Ison, Gallemore & Nijjar 2009). Norway's National Transport Plan (2010-2019) states that organizations should include transport safety as an important part of their Health, Safety and Environment (HSE) work. This is also emphasized by the European Occupational Safety and Health Agency (OSHA 2012), and the European Transport Safety Council (ETSC 2010). As knowledge is lacking on the relationship between accidents and work-related risk factors in transport organizations, these important risk factors are neither addressed properly by transport organizations, nor by regulatory authorities.

This paper outlines the results of a study of severe road traffic accidents in Norway triggered by drivers at work. The aim of the study has been to examine whether and to what extent risk factors of these triggering drivers and their vehicles can be traced back to work-related factors.

The study is based on information available in the Norwegian Public Roads Administration's (NPRA) Accident Analysis Groups (AAG) database on fatal accidents in the period 2005-2011, 10 reports from the Accident Investigation Board Norway (AIBN) and information from nine research interviews conducted with experts from government bodies engaged in accident investigations, worksite inspections and roadside controls.

2. Previous research on work-related road transport accidents

2.1 Prevalence of work related transport accidents

Phillips and Meyer (2012) map the incidence of work-related accidents in Norway in the period 2005-2010. They find that a total of 41 percent of fatal road accidents in Norway involve at least one driver who is at work, or driving to or from work. Thirty percent of fatal road accidents involve professional drivers at work (at least one), while six percent involve at least one person who is driving in his/her work but who is not a professional driver. Ten percent of fatal accidents involve at least one person driving to or from work.

The European Transport Safety Council (ETSC) has made risk associated with work related driving a priority. In 2009, the ETSC launched the project PRAISE (Preventing Road Accidents and Injuries for the Safety of Employees) (ETSC 2010b). According to a PRAISE thematic report, 40 percent of traffic accidents involve drivers at work, or driving to and from work. In the UK, between 25 and 33 percent of all serious road accidents are work related (i.e. only driving at work), out of which 23 percent involve commercial vehicles "on the job" and seven percent light vehicles "on the job" (SafetyNet, 2009). According ETSC (2009), vehicles involved in work-related accidents are: light car (42 percent), heavy vehicle (heavy goods vehicles, buses) 28 percent and vehicles with two or three wheels (6 percent).

In France, ten percent of all traffic accidents are probably work-related (driving at work) (Charbotel, Martin, & Chiron, 2010). In France, it is also estimated that 18 percent of traffic accidents involve people driving to or from work. In Australia, there are three times as many traffic accidents involving driving to and from work as accidents driving at work (Boufous & Williamson, 2006).

Even if the proportion of work related traffic accidents is constant over time, the number of work-related traffic accidents can still change. Therefore, it is crucial to measure the risk when driving at work, or to/from work. According to Driscoll (2005), the risk of death per 100,000 person years of driving at work is 1.69 in Australia, 0.99 in New Zealand, and 0.92 in the USA, as compared to 2.3 in France (Charbotel, et al., 2010).

2.2 Causes of work related transport accidents

Assum and Sørensen (2010) conducted a thematic analysis of fatal accidents involving heavy goods vehicles (HGVs) in the period 2005-2008. 135 HGVs were involved in 130 accidents during the period. HGVs refer to goods vehicles weighing more than 3,5 tonnes, e.g. lorries with and without trailer, tractors with or without semi-trailers, tank lorries (cf. Nævestad et al 2014).

Their study of risk factors in the 44 fatal accidents where HGVs were the triggering party indicates the following risk factors: *Driver*: high speed for the conditions reported in 28 accidents. Inattention, fatigue and lack of seat belt use were each reported in 7-9 accidents. *Vehicle*: insufficiently /faulty secured goods, bad brakes, blind spots and tyres were the most frequently reported factors. *Road*: fixed objects near the road, poor road surfaces, high asphalt kerbs, slippery roads and lack of median guard rails were most frequently mentioned.

Phillips and Meyer (2012) find that time pressure/stress/fatigue and lack of seat belt are the most important risk factors for drivers at work. A total of 37 percent of drivers who were working when the fatal accident occurred did not use safety equipment (usually seat belts). 25 percent of the drivers who drove to or from work when the fatal accident occurred, did not use safety equipment (usually seat belts).

The majority of work-related road accidents in the UK are caused by a collision between two vehicles (Husband, 2011). In Australia, cars and vans skidding on slippery roads to collide with oncoming vehicles are described as typical of work-related accidents (Mitchell, Driscoll, & Healey, 2004). Typical risk factors were high speed, possible fatigue, and wet weather, and/or alcohol/drugs.

Compared to other drivers in general and to people driving their own cars at work, those who drive company cars in their work have a heightened risk of all types of accidents, even when controlling for exposure (Broughton, Baughan, Pearce, Smith, & Buckle, 2003). This so called "fleet car effect" has been demonstrated in several countries (Lynn & Lockwood, 1998).

Drivers of heavy vehicles have a lower death risk per hour than other drivers (Elvik, 2007). Although it is difficult to establish to what extent this is due to driver behaviour, and to what extent it is due to the protection provided by a heavier vehicle, we know that the latter factor is important (Elvik, 2007). Drivers of European HGVs and buses are killed in only 13 percent of the fatal accidents they are involved in (DaCoTa, 2010). It is also the case in Norway that accidents involving heavy vehicles carry a greater risk of death to other drivers than for drivers of heavy vehicles (Haldorsen, 2010).

According to data from EU-19, fatal accidents involving HGVs are most frequent on weekdays between 6:00 a.m. and 6:00 p.m. Fatal bus accidents occur with the same frequency on weekends as on weekdays. On weekdays, fatal bus accidents are more frequent during peak hours, both early morning and late afternoon (DaCoTa, 2010).

Finnish research shows that drivers of passenger cars between ages 50 and 65 who are employed or self-employed, have a higher risk of work-related accidents than younger drivers (Salminen 2000). Research in France shows that drivers between 25 and 34 years are more prone to accidents on the way to or from work (Charbotel, et al., 2010). British research shows that men are even more over-represented in work-related accidents than in other road accidents (Husband, 2011).

Several studies show that company cars often are involved in accidents at high speeds. Newnam, Watson and Murray (2004) found that work-related drivers would report more speeding and a higher intention to speed in a work vehicle than their personal vehicle. Studies from the UK and Australia have shown that fleet car drivers are more prone than others to drive at high speeds, when tired, and without a seat belt (Husband, 2011; Symmons & Haworth, 2005). Risky behaviour can therefore at least partly explain the fleet car effect.

To sum up, it seems that few of the studies analysing accidents involving drivers at work focus on work related risk factors. Some studies do, however direct attention to organizational factors and framework conditions. Bjørnskau and Longva (2009) compare safety culture and safety outcomes in various modes of transport. In this study, the authors developed and tested a model that describes the relationship between framework conditions, managements' focus on safety, formal safety systems, safety culture, individual attitudes and behaviour and safety outcomes. They found clear differences in safety culture between different modes of transport. Aviation scored highest on the safety culture index, followed by metro and bus. These differences were in line with the level of safety in the transport sectors.

3. Methods

3.1 Conceptual clarification

Work-related traffic accidents. In this article, the term work-related accidents refers to accidents involving professional drivers at work and employees driving in connection with their jobs. The term does not include drivers going to/from work, as in Phillips and Meyer (2012). Working drivers, unless self-employed, are employed by organizations committed through the Working Environment Act to facilitate good road safety for their drivers/employees through HSE work.

Work-related risk factors. Work-related risk factors refer to all factors that are influenced by employees' work situation, and which may in turn influence transport safety. These can be traced back to management and organization, but also more general factors which are usually not associated with HSE, e.g. pay systems, work scheduling systems, organization of drivers' contact with forwarding agents and customers (Nævestad & Bjørnskau 2014).

Fatal road accidents. In Norway and most other European countries, fatal road accidents are defined as traffic accidents leading to at least one fatality within 30 days of the accident (Elvik, et al. 2009)

Risk factors. In road safety work, the term "risk factor", rather than the term "cause" is normally used to explain accidents (Sørensen, Nævestad and Bjørnskau 2010). Risk factors are divided into accident factors and injury factors. Accident factors are factors contributing to the occurrence of the accident, while injury factors are factors contributing to the accident's serious consequences. Risk factors are also divided into factors associated with the driver, the vehicle, the road and the road environment. Finally, risk factors are also divided into triggering risk factors and underlying risk factors. Triggering risk factors include events that occurred during the last seconds before the accident (e.g. falling asleep), and which triggered the accident. Underlying risk factors refer to factors that can explain and contextualise the triggering risk factors (e.g. long working hours, stress).

Triggering vehicle: In this study, we look at accidents with drivers of vehicles that the AAG define as triggering for the accident. The AAG database requires that one of the involved road users is defined as “triggering”. The term "triggering" is not necessarily, but frequently, synonymous with legal liability. It generally refers to vehicles with the *decisive* triggering risk factors. (As we will see below, AAG rate risk factors according to their importance.) Defining a triggering vehicle may, however, sometimes be difficult, as accidents may involve several parties which have made mistakes and triggered the accident. It may for instance be difficult to identity one triggering party in an accident where unit A has failed to give way, while unit B has exceeded the speed limit considerably on a road with right of way (Haugvik and Holten 2013).

3.2 Analysis of data from the Accident Analysis Groups

All fatal road accidents are investigated by the NPRA in the form of regional Accident Analysis Groups (AAG). Since 2005 every fatal accident has been documented by means of in-depth reports describing the course of the accident, road and weather conditions and relevant aspects of involved road users and vehicles. (Haldorsen, 2010; Sørensen, Nævestad, & Bjørnskau, 2010).

The reports are based on a common template, and use different data sources, such as print-outs from police interviews with the road users, or technical reports from accident sites and on vehicles involved (Haldorsen, 2010). For the vast majority of fatal accidents, there thus exists a separate report that can be reviewed to investigate its triggering or contributing factors. The AAG indicates the importance of each factor by weighting them according to the extent to which they have influenced the course of events. This scale runs from 1 to 3, where 1 = little, 2 = great and 3 = decisive.

Some of the variables from the in-depth reports are transferred to an AAG database. This database can be used for studying fatal accidents and accident factors quantitatively (Sørensen, et al., 2010).

The AAG database does not originally contain variables on driving at work. The data we use in the present study is therefore based on the work of (Phillips and Meyer 2012), who read through all the AAG reports and updated the AAG database with variables on drivers at work. The AAG reports contain information that can be used to identify drivers at work, although this information is not found in the AAG database, Especially, the AAG reports frequently report road users’ trip purposes, which is now part of the report template.

In addition to using information on trip purpose, Phillips and Meyer defined drivers as professional drivers if the report stated that transport of goods or persons was this person’s main task at the time of the accident, and if there was reason to believe that the driver was a driver by profession. In practice, this mostly applied to HGV, bus or taxi drivers at work. In this way, they created new variables and updated the AAG database. The most important new variables were: 1) professional driver, 2) driving to or from work, 3) other driving at work.

Following the methodology of Phillips and Meyer (2012), we have read through all AAG reports from 2011 in order to update the AAG database with figures from 2011.

Since we have data on all drivers at work in the AAG material, including those who have not been defined as triggering, we also make comparisons of characteristics of triggering and non-triggering working drivers. This enables us to examine whether working drivers triggering fatal accidents differ from those who do not, when it comes to risk factors related to drivers and vehicles. Given that being involved in fatal accidents as a non-triggering party strikes drivers relatively arbitrary, it could be argued that the non-triggering drivers represent a kind of random selection and that certain characteristics associated with triggering drivers can be considered risk factors. We conducted such comparisons among the professional drivers in the sample (N = 430).

3.3 Analysis of reports from the Transport Accident Investigation Board

The AIBN has since September 2005 investigated road traffic accidents. AIBN conducts independent investigations clarifying the causes and course of traffic accidents in order to issue safety recommendations that may improve traffic safety. The AIBN only investigates some traffic accidents, especially accidents involving professional drivers, and accidents with a potential for learning. We have read through all of the AIBN reports, and focus on the 10 (of a total of 27) reports with safety recommendations on work related factors.

In the analysis of AIBN data, we have compiled a list of the risk factors that are mentioned, and how often they are mentioned in the reports. We also focus on the AIBN's description of individual work related factors, and the AIBN's view of the causal relationship between work-related factors and factors related to the triggering drivers and vehicles.

3.4 Interviews

We chose to interview nine experts from different organizations involved in either inspections, controls or investigations of professional drivers and other employees who drive at work. We conducted these interviews to benefit from the experience of these experts on the importance of work related factors for traffic safety. We also wanted to get their views on challenges related to controls and inspections and their suggestions on potential measures addressing work related traffic safety.The interviewees were encouraged to present their impressions of and views on different topics. We used a semi structured interview guide in the interviews, focusing on results from AAG data, organizational risk analyses, procedures, training, seat belt use, speed/driving style, driving time and rest periods, vehicle inspections, salary, identifying risky work related factors and

positively influencing work related factors. [1] The analysis of interview data largely follows the topics of the interview guide. The topics and questions in the interview guide were for the most part based on our analysis of the AAG database and AIBN reports.

4. Results from the Accident Analysis Groups

4.1 Road transport accidents triggered by drivers at work

The original number of vehicles in the AAG database for the period 2005-2011 is 2177. This figure, however, includes some vehicles on which we do not have complete information. We have therefore excluded these vehicles from the analysis. When excluding these, the total number of vehicles studied is 1.646. These were involved in 1.410 fatal accidents. A total of 501 vehicles involved in these accidents were driven by professional drivers, or others at work.

Table 1 shows how many of the 501 vehicles driven by professional drivers or others at work involved in the 1410 fatal accidents in the period 2005-2011, that were defined by the AAG as the triggering vehicle. The table shows the number of vehicles.

Table 1: Vehicles involved in fatal accidents in the period 2005-2011 by type of driver, and whether the driver was defined as triggering.

	Triggering vehicle?		Total
Type of driver	Yes	No	
Professional driver at work	151	279	430
Other driver at work	40	31	71
Not at work	828	371	1145
Total	1019	627	1646

Table 1 shows that 501 (430+71) of the 1646 involved vehicles that we have sufficient information about were driven by a person at work. 191of the 501 involved vehicles that were used by drivers at work were classified as the triggering part of the accidents by the AAG. 151 of the 191 vehicles were driven by professional drivers, and the remaining 40 were driven by other drivers at work

Figure 1 shows shares of triggering drivers in different groups of drivers.

[1] This is given in Norwegian in Nævestad & Phillips (2013).

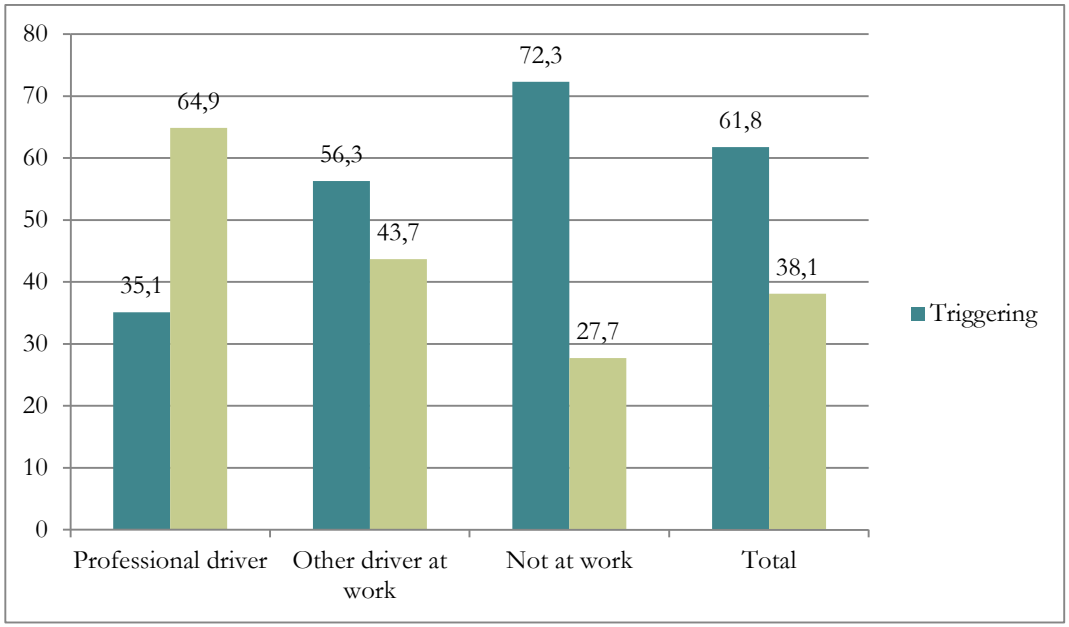

Figure 1: Vehicles involved in fatal accidents 2005-2011, based on type of driver and whether the vehicle was defined as the triggering part by the AAG. Percentages (N=1646).

Figure 1 shows that the share of drivers defined as the triggering part were lowest among professional drivers, somewhat higher among other drivers at work and highest among the drivers whose driving were not work-related.

4.2 Causes of the accidents triggered by drivers at work

As noted, we define risk factors as accident factors, triggering accidents, and injury factors influencing the severity of the accidents.

Figure 2 shows the accident factors of the triggering drivers that the AAG defined as great or decisive.

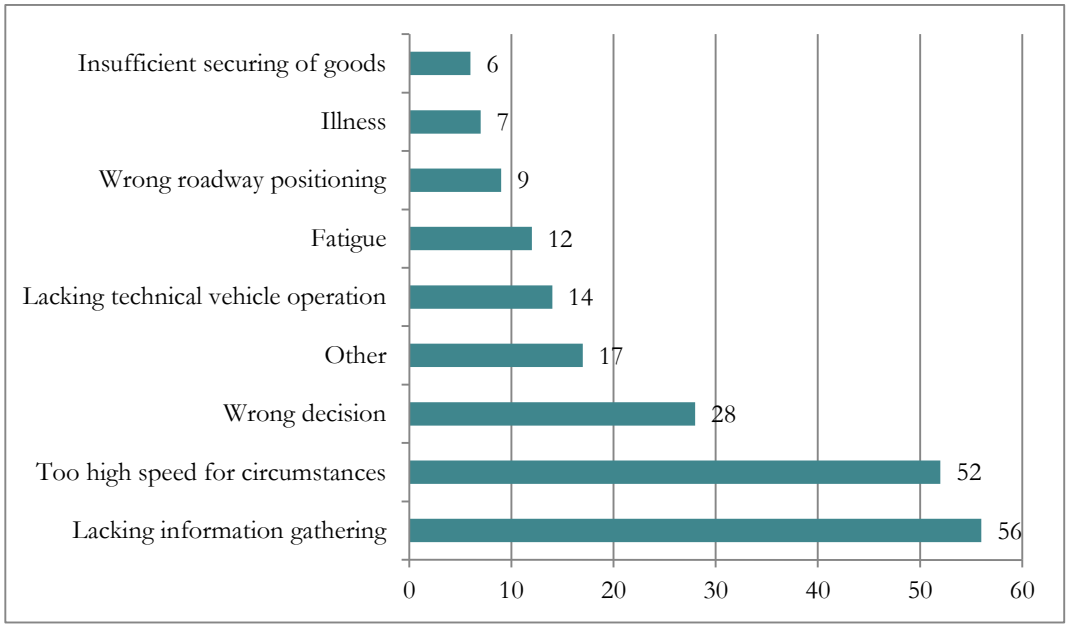

Figure 2: The seven most frequent driver accident factors of great and decisive importance in the AAG's analyses of fatal accidents involving triggering drivers at work. Number of times given great and decisive importance in accident reports in the period 2005-2011.

Figure 2 shows that "lacking information gathering', "too high speed for the circumstances" and "wrong decision" are accident factors given great or decisive importance by the AAG. The risk factor "lacking information gathering" generally refers to road users failure to notice e.g. signage, road conditions or other road users. This may be a result of inattention, distraction, failure to look and so forth. The risk factor "other" can be any conceivable accident factors, including work-related factors.

The most frequently identified injury factors, contributing to the severity of the accidents are: "too high speed for the circumstances", "lack of seat belts", "illness/disease", "securing of goods" and "well above speed limit".

In conclusion, the analysis of AAG data shows that speed too high for the circumstances, failure to use seat belt and insufficient information gathering were the most important risk factors in fatal accidents triggered by working drivers on Norwegian roads 2005-2011. This conclusion was supported by the analyses of the AIBN reports.

Figure 3 shows the accident factors related to vehicles given great or decisive importance by the AAG.

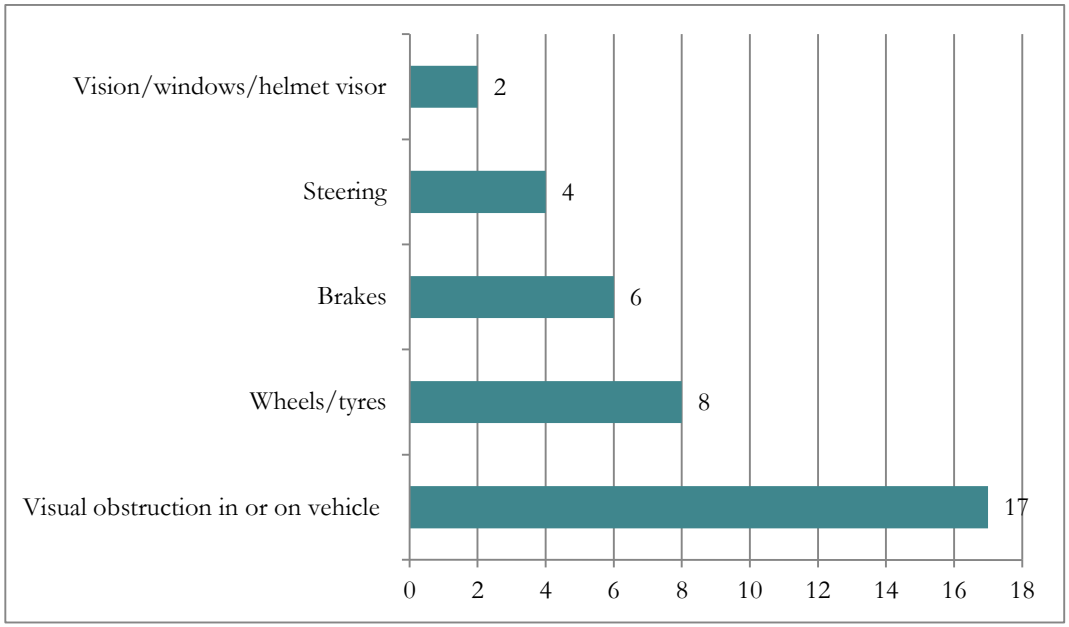

Figure 3: The five most frequent vehicle accident factors of great and decisive importance in the AAG's analyses of fatal accidents involving triggering drivers at work. Number of times given great and decisive importance in accident reports in the period 2005-2011.

The main accident factors related to vehicles were "visual obstruction in or on vehicle" (perhaps contributing to lacking information gathering), "wheels/tyres", "brakes and steering". The most frequently occurring injury factors related to vehicles were: "critical striking point", "passenger car against heavy vehicle" and "insufficient chassis safety". In conclusion, the analyses of the AAG data shows that the two most important risk factors related to vehicles in the accidents triggered by drivers at work were obstacles to vision in or on vehicles and wheels/tyres.

4.3 Triggering drivers versus non-triggering drivers

Since we have data on all drivers at work in the AAG material, including the non-triggering ones, we study whether working drivers triggering (N=151) fatal accidents differ from non-triggering (N=279) ones, when it comes to certain aspects of drivers and vehicles. For the sake of simplicity, we only do these comparisons for the professional drivers in the sample (N = 430).

In Figure 4, we show how non-triggering and triggering professional drivers are distributed over age groups.

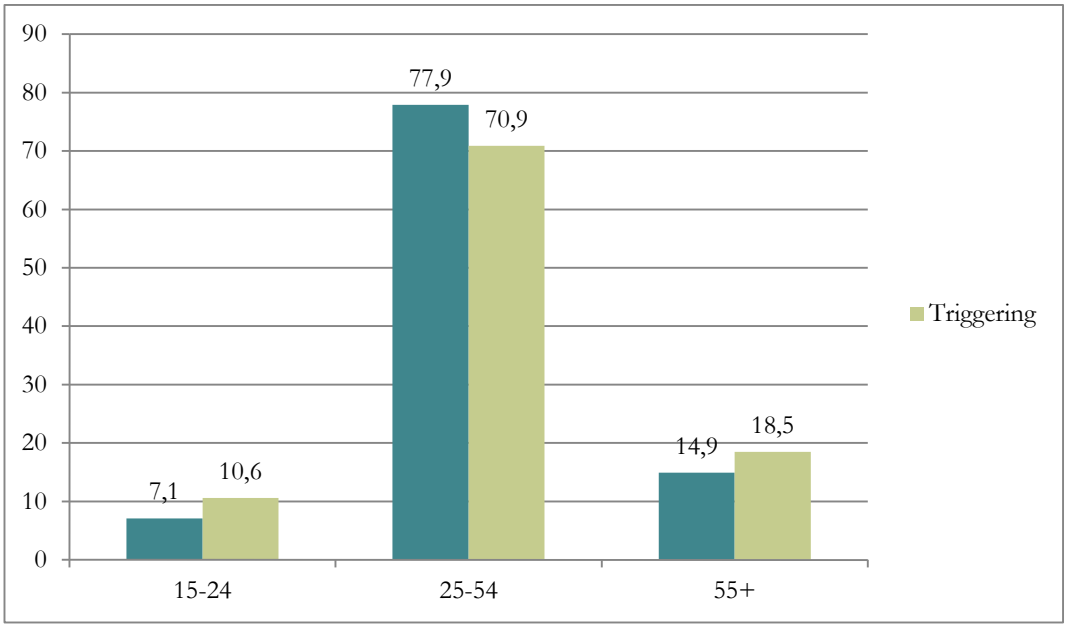

Figure 4: Driver's age for vehicles defined as triggering (N = 151) and non-triggering in fatal road accidents in Norway 2005-2011 (N = 279).

Figure 4 shows that the triggering professional drivers constitute larger proportions in the youngest and oldest group of drivers. However, a Chi-square test for independence indicated no significant association between age group and the share of triggering drivers, Chi-square (2, n = 432) =2.9, p=.24. Despite the lack of statistical proof, a tendency is apparent that is in line with other road safety research demonstrating that young and elderly drivers have higher accident risk than other age groups (Elvik et al 2009). It is also in accordance with abovementioned French and Finnish research on drivers at work (Salminen 2000; Charbotel, et al., 2010).

Figure 5 shows the states of triggering and not triggering professional drivers, as they are reported by the AAG. Information on the state of the drivers was missing for 150 of the 430 professional drivers in fatal road accidents.

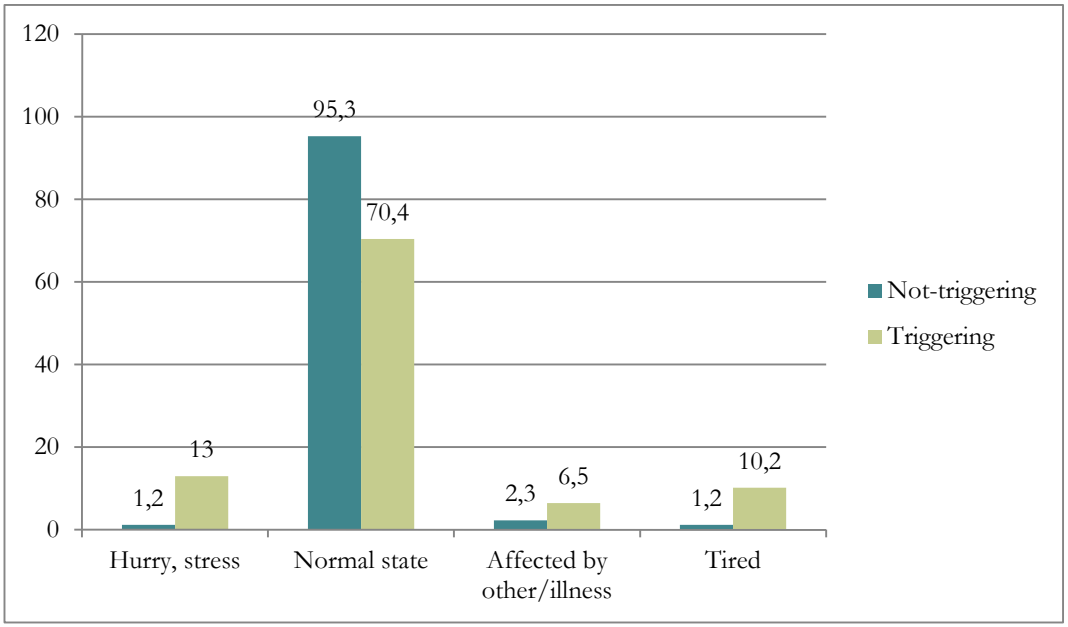

Figure 5: Shares in different states for triggering (N=108) and non-triggering professional drivers (N=172) in fatal road accidents in Norway 2005-2011.

A Chi-square test for independence indicated a significant association between the state that the drivers were in at the time of the accident and the contribution they made to triggering the accident, Chi squared (3, n=280) = 35.5, p <.001. Comparing triggering and not-triggering professional drivers, it is evident that the triggering drivers to a greater extent were in a state of hurry/stress, tired and under the influence by "other" (e.g. drugs or illness). The share of professional drivers in a normal state was somewhat lower among the triggering drivers than it was among the not-triggering drivers.

Figure 6 shows how vehicles driven by non-triggering and triggering professional drivers are distributed according to the vehicle's year of manufacture.

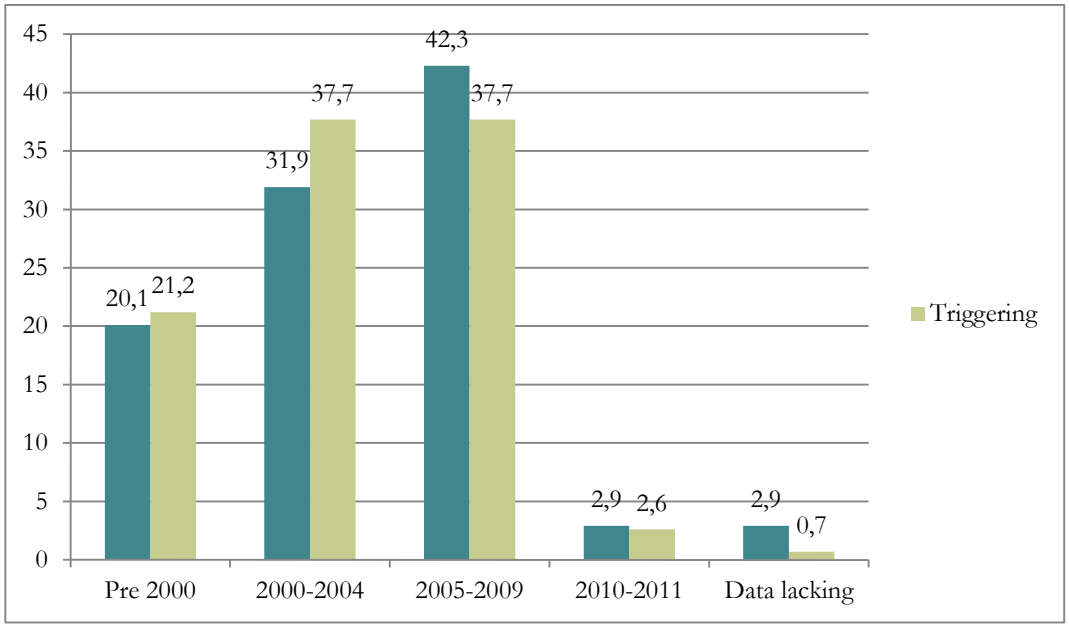

Figure 6: Production years among triggering (N = 151) and non-triggering vehicles (N=279) in fatal road accidents in Norway 2005-2011.

Comparing the vehicles driven by triggering and non-triggering professional drivers, we see that the vehicles that triggered fatal accidents are somewhat older than vehicles that did not trigger fatal accidents. The average year of manufacture for all vehicles triggering accidents between 2005 and 2011 was 2002, while the average year for vehicles not triggering accidents was 2003. However, the difference in year of manufacture was not significant, F (1, 403) =3.51, p=.06.

4.4 Measures suggested by the AAG

The AAG recommends a total of 57 different categories of measures against the fatal accidents where the triggering vehicle was driven by a working driver. In the same way that several risk factors are identified in each accident, the AAG recommends several measures for each accident. In total, the AAG recommends 675 measures aimed at the fatal accidents involving the 191 vehicles driven by triggering working drivers.

The majority (44 %) of the recommended measures were aimed at road/road environment, 26,9 % of the measures were aimed at the vehicle, 14,3 % were aimed at the driver and 14,6 % were aimed at what we refer to as “other” factors. It is important to note that the measures are classified by us and not by the AAG.

5. Results from AIBN-reports and interviews

We have seen that the AAG database focus little on work related causes, although it has been mentioned that such factors may be discussed in the AAG reports. In

order to obtain data on work related factors, we have therefore analyzed AIBN reports and conducted expert interviews.

5.1 Work related risk factors influencing road transport safety

The Norwegian Work Environment Act (WEA) of 1977 obliges transport organizations to facilitate good transport safety for their employees through their HSE work. The Internal Control (IC) Regulations of 1996, require the managing director of an enterprise to ensure that the enterprise obliges with the WEA and works systematically with HSE. Employees must actively participate in this. Working actively with HSE means for instance to set safety objectives, defining responsibilities, identifying HSE problems, obtaining overviews of laws, planning HSE measures, following up and undertaking annual reviews of the company's HSE work together with safety representatives.

5.1.1 Speed and seat belt as an organizational concern

The most important risk factors in the AAG data were speeding and lacking seat belt use. Speed too high for the circumstances and failure to use seat belts are risk factors that employers may prevent by means of, e.g. organizational speed and driving style policy (approved, signed and followed by the drivers), organizational seat belt policy, monitoring the speed and driving style of each driver, installing maximum speed limiter (e.g. on 80 km/h instead of the mandatory 90 km/h) and seat belt warning. Such measures are suggested in the AIBN reports.[2]

The interviewees did however, say that their experience indicate that transport companies largely treat the seat belt use of their drivers as drivers' individual concern and not as the concern of the organization. The situation is somewhat different when it comes to drivers' speed and driving style, primarily as this has economic implications for the companies.

5.1.2 Pay systems

When asked whether they had the impression that pay systems influence traffic safety in the transport industry, the majority of the interviewees said yes. They stated that most drivers have fixed salaries, salaries based on assignments, and that some element of piecework often is involved. This may motivate drivers to focus on keeping a high speed, finish assignments as early as possible, to be able to take extra trips to increase the salary, violate provisions on driving time and rest periods, and so forth. Several interviewees indicated that recording working hours and receiving pay based on hours of work to a little extent occur among goods transport drivers. We lack information on the prevalence of different pay

[2] A recent Norwegian study shows that three transport companies with good safety cultures have implemented such measures (Nævestad & Bjørnskau 2014).

systems in the AAG and AIBN data, and suggest that more research should be devoted to this issue.

5.1.3 Safety management system

The 10 AIBN reports that we have studied often conclude that the companies employing the triggering drivers have failed to:

1) Conduct (and document) risk assessment of especially critical operations,

2) Use these risk assessments as a basis for work descriptions/procedures that the drivers could have consulted prior to work operations, or

3) Use these risk assessments and work descriptions/procedures as a basis for a training program for drivers to make them prepared for the risks of their work operations.

In the accidents described in the AIBN reports, the companies in question have failed in either one of these processes, or all of them. The AIBN refers to these three processes as a "safety management system", and suggest that such systems should be mandatory for companies applying the government for transport permits. In practice, it seems that these requirements are in accordance with the requirements in the Internal Control Regulation of the Work Environment Act. The interviewees did not believe that most transport companies on a regular basis undertake risk analyses of especially critical operations, that they have a strong focus on work descriptions/procedures, or that they in general give drivers sufficient training. More research is needed on this issue.

5.1.4 Safety culture

When asked about the most important measures that transport companies may take to prevent accidents, several interviewees stated that feelings of responsibility and attitudes among employers is a central challenge. Several interviewees underlined that goods transport companies to a greater extent must recognize that they set the premises for the safety of their drivers' work. Some interviewees suggested that there is a cultural challenge in transport of goods, as companies in practice put a lot of responsibility for traffic safety on the driver, although the employer has a legal responsibility to ensure that the traffic safety of employees is optimal. We return to this.

5.2 Framework conditions influencing traffic safety

The AIBN reports and the interviews indicate that work related factors in transport companies are influenced by what we may refer to as framework conditions.

5.2.1 Time pressure and stress from transport buyers/forwarding agents

The majority of the interviewees believed that transport buyers and forwarding agents were pressing/stressing drivers. They had, however, no clear conceptions of the scope of such pressure. This is an issue requiring more research.

Forwarding agents and transport buyers set the premises for drivers' speed and driving style as they decide when goods is bound to arrive and when drivers can start their trips. Interviewees stated that, route planning often is based on a minimum-time schedule, and factors that may cause delays are not necessarily taken into consideration. Several interviewees suggested that measures adding responsibility to transport buyers and forwarding agents should be introduced, as these may influence traffic safety.

As noted, the analysis of AAG-data shows that the triggering drivers to a greater extent than non-triggering drivers were in a state of hurry/stress, tired and affected by other things. The majority of interviewees underlined that time pressure is a crucial problem in the transport industry, but that transport companies not necessarily focus on stress and hurry as a possible cause of accidents. Interviewees argued that time pressure is especially prevalent in companies working under less predictable conditions, for instance: short time assignments with low predictability, little long term planning and short client relationships (e.g. 2-3 weeks).

The majority of interviewees did not believe that severe violations to the driving and resting time provision are prevalent in Norwegian transport companies. This was explained by the NPRA's good control routines of driving and resting time. It was mentioned, however, that controls have indicated some quite severe violations of work time rules, as many employees work several hours loading and unloading their cars without recording this kind of work. In these cases, the drivers may put their tachograph on “rest”.

5.2.2. Competition

Interviewees stated that time pressure is especially prevalent in the segments of the goods transport market that are characterized by the hardest competition. One interviewee mentioned that transport buyers often may say that they "know someone who is willing to do the job for a lower price". This may lead to drivers taking assignments with tight time margins, and make it difficult for companies and drivers focusing on delivering goods on time. Time pressures may cause high speed, and we have seen that too high speed is a very central risk factor in the AAG data. More research is needed on this issue.

5.2.3 Type of transport

Most interviewees held that traffic safety is better in public transportation than it is in goods transport. They explained this by stating that people is more "valuable" than goods, and that the requirements for public transport therefore are stricter.

These requirements apply to both drivers and equipment, making the standards of drivers and vehicles in public transportation better than those of goods transport. Interviewees suggested that public transport generally have a better safety culture and a higher prioritization of safety.

Accordingly, interviewees stressed that transport of dangerous goods is characterized by high standards relating to drivers and vehicles, as the consequences of accidents are severe in this line of transport. Thus, this line of transport has special provisions with requirements regarding driver training, vehicles and so forth. This illustrates how type of transport has consequences for governmental requirements, transport companies' prioritization of safety and safety level.

5.2.4 Regulation of transport safety in Norway

The Norwegian Labour Inspection Authority (LIA) is responsible for overseeing that the Work Environment Act is complied with in transport organizations, and LIA must also be notified about fatal accidents. LIA was, however, only notified about 30 of about 66 fatal accidents involving drivers at work, 2005-2010 (Phillips & Meyer 2012). LIA defines the transport sector as an "exposed industry" that it will direct much of its attention to in the period 2013-2016. The NPRA is responsible for technical vehicle control and for overseeing and controlling compliance with the drive- and rest rules in transport companies together with LIA. LIA and NPRA have both road side controls and company controls together, and they share responsibility for supervising the compliance with the provision regulating professional drivers' working hours. The police is also involved in road side controls of vehicles, and often cooperates with the NPRA.

The majority of the interviewees held that work related factors with potential implications for traffic safety are insufficiently monitored in controls and inspections. When asked whether the government has sufficient tools versus companies at risk of experiencing traffic accidents, opinions of the interviewees were mixed. Interviewees answering yes largely said that the government has good enough tools at their disposal, but that they must use them more actively. Interviewees answering no stated that the government should focus more on heavy vehicles and latent, deeper causes. Most of them agreed that the AIBNs suggestion to make it mandatory for transport companies to have a system of safety management to get transport permits could be a good way of filtering dubious companies out of the industry.

Finally, interviewees mentioned that the government is facing a great challenge when it comes to following up controls of foreign transport companies. It may be difficult to know how to issue obligations to these companies, and not the least ensure that they pay possible fines.

6. Concluding discussion

This paper has outlined 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 triggering drivers and their vehicles can be traced back to work related factors.

6.1 Methodological limitations

The major data source in the study is the quantitative AAG-data on all on fatal accidents triggered by drivers at work in Norway in the period 2005-2011. We have used the AAG-database to describe all the existing risk factors related to these accidents. Results show, however, that the AAG database contain little information on work related risk factors.[3] We therefore conducted interviews with relevant experts and studied reports of the Accident Analysis Investigation Board for Transport in Norway (AIBN). Both these qualitative data sources provided us with information on work related risk factors, and shed light on the risk factors we found in the AAG-data related to drivers and vehicles

Nevertheless, the qualitative interviews (N=9) and AIBN-reports (N=10) are based on fewer cases than the quantitative AAG-data (N=2177). The AAG-data include all road accidents involving drivers at work in the period 2005-2011. Although we do not know to what extent the qualitative data are representative of the actual situation on Norwegian roads, they are one of the few data sources that we can use to shed light on the aim of our study. Although the AIBN data include relatively few cases, they provide insights in work related risk factors that require time consuming in-depth investigations, thus limiting the number of studied cases. Moreover, though the interviews may be biased by the interviewees' subjective opinions, these opinions are based on the interviewees' vast professional experience from government bodies engaged in accident investigations, worksite inspections and roadside controls.

For these reasons, we stress that the qualitative data in our study depict hypothesized relationships between framework conditions, work related risk factors and risk factors related to drivers and vehicles. These relationships should be examined further in future research, and the results of this research could be used to improve the AAG-databases, e.g. by including work related risk factors.

6.2 Professional drivers trigger fewer accidents than other drivers

The study shows that the share of drivers defined as the triggering part were lower among professional drivers and drivers at work, than among other drivers. This is

[3] Administrators of the AAG-database indicated in conversations that the AAG reports generally contain more information about work-related matters than the database, and that some of this information is lost when transmitted from reports. We therefore recommend that variables for work-related factors should be included in the AAG database.

in line with previous research, which shows that professional drivers' risk of triggering accidents is less than half the risk of other road users' risk of triggering accidents (Blower 1996; Wang, Knipling, and Blincoe, 1999; Craft, 2000). The suggested explanation to this is professional drivers' comprehensive driving experience (TSH 2014).

6.3 Excessive speed, lacking seat belt use and lacking information gathering

The quantitative analysis of AAG data, based on over 2000 accidents, supports other studies suggesting that surplus speed is a main cause of accidents triggered by drivers at work (Newnam, Watson, & Murray, 2004; Mitchell, Driscoll & Healey 2005; Husband 2011).

Our data also support that fatigue is a major risk factor, and that a high share of accident-involved working drivers do not wear seatbelts. The data also supports previous studies suggesting that the very oldest and youngest working drivers may be more likely to trigger serious road accidents (Fig 4) (cf. Blower 1994); and that time pressure is an important contribution to serious accidents triggered by working drivers (Fig 5).

International research also reports that drink driving is a risk factor in work related driving (e.g. Symmons & Haworth, 2005; Mitchell, Driscoll & Healey 2005). We found that triggering drivers to a greater extent than non-triggering were affected by "other" (e.g. alcohol/drugs).

6.4 Ways in which fatigue and stress can trigger fatal road accidents

Our study also adds to existing studies by identifying ways in which factors such as fatigue and time pressure can trigger fatal road accidents. Most often, drivers at work who trigger fatal road accidents:

- fail to gather essential information from the traffic environment;

- make poor decisions in traffic;

- operate the vehicle unskilfully; and

- position the vehicle wrongly in the road.

Our study supplements existing studies by attempting to identify work-related risk factors that may contribute to serious accidents triggered by drivers at work. In addition to speeding, time pressure and fatigue, our quantitative findings suggest that vehicle deficits often play a decisive role in triggering work-related road accidents (Assum and Sørensen 2010). The analyses of the AAG data shows that the two most important risk factors related to vehicles in the accidents triggered by drivers at work were obstacles to vision in or on vehicles and wheels/tyres.

6.5 Framework conditions and work related factors influence safety

Findings from the in-depth AIBN report analysis and qualitative interviews also suggest how risk factors associated with work-related driving may be rooted in framework conditions. For instance pay systems may encourage drivers to drive too long and too fast. Our findings suggest that work-related accident risks may best be reduced by addressing the systems that encourage driver behaviour, rather than addressing the driver behaviour itself.

In the foregoing, we discussed Bjørnskau og Longva's (2009) model of safety culture in different transport sectors. Figure 7 shows our revised version of this model. We have adapted it to our above mentioned data on the importance of framework conditions and work-related factors influencing road safety. The model depicts hypothesized relationships that should be tested in future research.

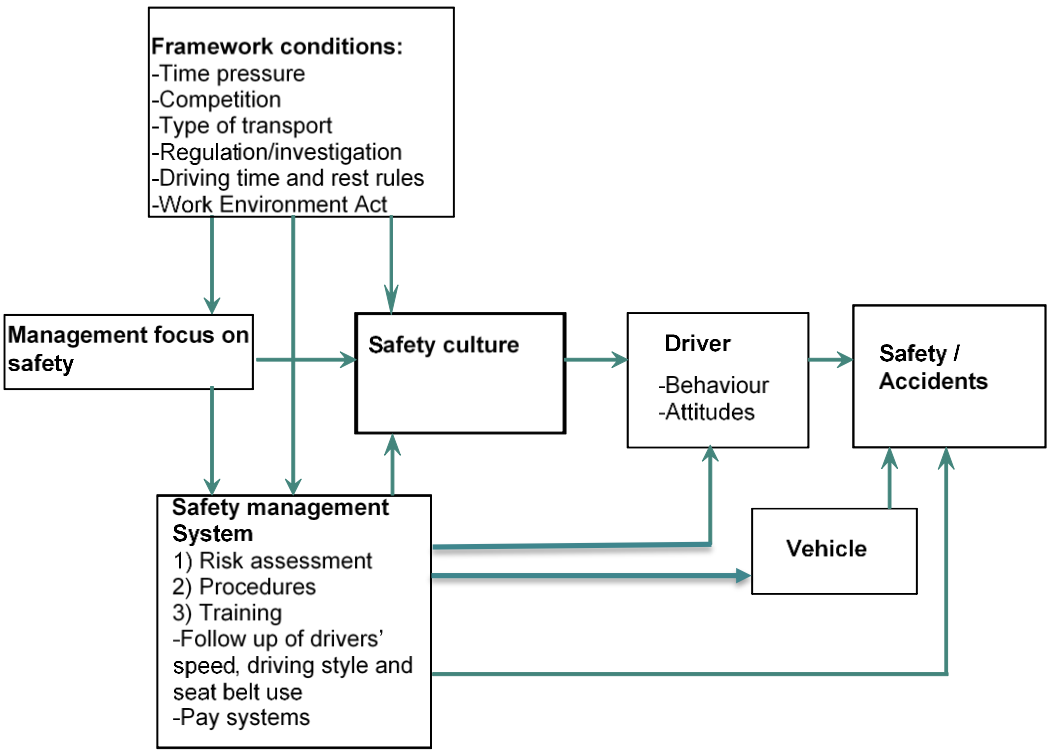

Figure 7: Modified safety culture model, based on Bjørnskau og Longva (2009). (Hypothesized relationships that should be tested in future research)

The causal arrows in the model indicate, in accordance with the findings reported in the current study, that the level of safety among drivers at work results from drivers' actions and vehicle quality, which are influenced by safety culture and safety systems, stimulated by management's emphasis on safety which finally is effected by framework conditions, e.g. time pressure, competition, type of transport (goods or people), regulation, driving time and rest rules and the Work Environment Act. These six framework conditions were highlighted in the interviews and the AIBN reports.

Analysis of reports from AIBN and expert interviews brought forth 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.

We may also refer to work-related risk factors as organizational risk factors, which can be traced both to formal and informal aspects of organizations' safety work. While organizational safety structure refers to the formal aspects of safety work (how things should be done), organizational safety culture refers to informal aspects (how things are actually done) (Antonsen 2009; Nævestad 2010).

If an organization is to control hazards effectively, it must systematically work with both its formal and informal defences (barriers) against those hazards (Reason 1997). The purpose of this organizational defence is both to prevent organizational members from acting in unsafe manners, and to minimize the consequences if they act unsafe or are subjected to danger in their work.

Excessive speed for the conditions and lack of seat belt use are risk factors that employers can take formal actions against, for instance through a speed limit policy, seat belt policy, monitoring of each individual's speed and driving style, maximum speed limiters (e.g. on 80 km/h), and seat belt warning. Following the advices of the AIBN, transport organisations should also establish formal management systems involving; 1) risk assessments of current risks, that 2) inform company procedures, that lay the ground for 3) safety training of employees.

However, for such formal safety measures to work properly, the informal, daily focus on safety both among managers and employees must be in place. We may refer to this as organizational safety culture, which often is treated as shared and safety relevant way of thinking or acting that is (re)created through the joint negotiation of people in social settings (Nævestad 2010). Managers' focus on safety is a key element of good safety culture (Reason 1997). Organizational safety culture is crucial for transport safety, as it is the single factor most likely to influence other organizational barriers against hazards (Reason 1997). Above, we noted however several safety cultural challenges in organizations with drivers at work.

6.6 Little focus on work-related risk factors in road transport

The present study indicates that there is potential for a stronger focus on work related risk factors both in the AAG-database, among government bodies inspecting and controlling the sector and among transport companies. Perhaps this situation will change as the Norwegian Labour Inspection Authority defines the transport sector as an "exposed industry" that it will direct much of its attention to in the period 2013-2016.

When it comes to the transport companies, some interviewees suggested that there is a cultural challenge in transport of goods, as companies in practice put a lot of responsibility for traffic safety on the driver. This is done in spite of the fact that the employer has a legal responsibility to ensure that the traffic safety of employees is optimal. Some explanations were suggested by the interviewees describing this cultural challenge: 1) The Norwegian Road Traffic Act establishes that the driver has the main responsibility for traffic safety, regardless of whether he or she is employed, 2) There is a tendency among employers to believe that professional drivers do not need training as they have a driver's license, and 3) There is a tendency among employers to treat employed drivers as self-employed drivers. We do not know the prevalence of these attitudes, but they nevertheless point to questions that could be examined in future research.

In conclusion, it seems that employees in transport companies are in a special position compared with employees in other companies. Additionally, they often work alone on the road, and they may seldom see their colleagues or manager. It has been suggested that it is difficult to regulate safety in transport organizations, as employees generally are on the move, away from the main office. These issues should be examined in future research.

6.7 Issues for further research

It is important to note that the depicted relationships in the model presented in figure 7 sum up the quantitative and qualitative results of our study. We have not tested these relationships, and they should therefore be treated as issues and hypotheses that should be examined in future research.

We recommend that future research aiming to improve safety among professional drivers and drivers at work should focus on the following issues:

1. Speeding
2. Seat belt use
3. How fatigue and stress is manifested in driver behaviour
3. Time pressure and stress from transport buyers/forwarding agents
4. Pay systems in the road transport sector
5. Systems for safety management in the road transport sector
6. Drivers' vs. organizations' responsibility for traffic safety
7. Safety culture.

6.8 Measures that could improve transport safety

In the following, we sum up different measures that may strengthen the efforts directed at surveying and improving work related factors with implications for traffic safety:

1. measures directed at speed too high for circumstances and seat belt use
2. System for safety management (as a requirement for transport permits)
3. Increasing the responsibility of transport buyers/forwarding agents
4. Variables for work related factors in the AAG database
5. Control of and sanctions directed at foreign goods transporters
6. Focus on transport companies at risk
7. Transport of dangerous goods as a source of inspiration

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