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The safety ladder: developing an evidence-based safety management strategy for small road transport companies

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ABSTRACT

Traffic accidents account for between 20% and 40% of work-related accidents in industrial countries, and research indicates that road transport companies often have little focus on organisational safety management (OSM). There is thus a huge and largely untapped road safety potential in improving the safety of people who drive in their work, by focusing on OSM. Road transport companies in European countries are often small, however, with limited resources in terms of time, financial resources and competence on road safety. The main aim of the present article is therefore to develop an OSM strategy for small road transport companies. Based on a systematic literature review, taking Norwegian research as its point of departure, the article concludes that four measures seem to be most realistic for small goods-transport businesses, and that these measures seem to have the greatest safety potential. These four measures can be arranged on a ladder, where businesses start at the lowest and most basic level, before proceeding to the next step. While our stepwise safety-ladder approach has not been validated, it is expected that further research would confirm the value of the strategy proposed.

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1. Introduction

Traffic accidents account for between 20% and 40% of work-related accidents in industrial countries (Fort et al., 2010; ETSC, 2010a), and employees driving at work seem to be more accident prone than other employees. Data from 1988 to 1993 shows that the accident risk of occupational drivers was 9.5 fatalities per 100 million person hours, when compared to three for other occupations (Elvik, 2005). Overall, 39% of fatal occupational accidents in the EU are traffic accidents (ETSC, 2009), while between 22% and 24% of work-related deaths in the U.S.A. are caused by traffic accidents (Driscoll, Takala, Steenland, Corvalan, & Fingerhut, 2005). In Australia and New Zealand, the shares are 31% and 16% respectively (Driscoll et al., 2005). A Norwegian study shows that 36% of fatal road accidents in Norway from 2005 to 2010 involved at least one driver who was "at work" at the time of the accident (Phillips & Meyer, 2012). Another Norwegian study indicates that 40% of the personal injury road accidents are work-related (Nævestad, Phillips, & Elvebakk, 2015). An

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average of 1500 people is injured in these accidents each year, and about 290 of these are drivers at work (Nævestad et al., 2015). Hence, most of the people injured in work-related road accidents are other road users. There is thus a huge and largely untapped road safety potential in improving the safety of people who drive in their work.

Norwegian research indicates that goods-transport companies often have little focus on the significance of work-related risk factors for transport safety, and subsequently that they focus little on organisational safety management (OSM) (Nævestad et al., 2015). Similar tendencies have been found in research from other countries (e.g. Mooren et al., 2014; Wills, Watson, & Biggs, 2006). Work-related road safety has traditionally been managed using single driver-focused measures, and not OSM (e.g. Gregersen, Brehmer, & Morén, 1996; Newnam & Watson 2011). We define OSM as the combination of formal and informal organisational measures to achieve safety in organisations (cf. Section 4.1). The formal aspects of OSM refer to safety structure ("how things should be done") as described in procedures, routines and organisational charts, etc. These aspects are often referred to as safety management systems (SMSs), which typically include management policy, appointment of key safety personnel, reporting systems, hazard identification and risk mitigation, safety performance monitoring, etc. (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2009; Lerman et al., 2012; Thomas, 2012). The informal aspects of OSM refer to safety culture ("how things are actually done"), as indicated by shared work practices, shared ways of thinking, managers' and employees' commitment for safety, etc. (Antonsen, 2009; Nævestad, 2010).

A better focus on OSM in transport organisations may inform preventive measures and improve transport safety (Banks, 2008; Gregersen et al., 1996; Hughes, Newstead, Anund, Shu, & Falkmer, 2015; Murray, Ison, Gallemore, & Nijjar, 2009). The European Occupational Safety and Health Agency (OSHA, 2012), and the European Transport Safety Council (ETSC, 2010b) both emphasise that organisations should include transport safety as an important part of their Health, Safety and Environment (HSE) work, and it is also a stated ambition in Norway's National Transport Plan (2010–2019). The 89/391/EEC framework directive on the health and safety of workers requires every employer in Europe to undertake a risk assessment according to the principles of prevention, which "should include all employees travelling for work".

The low focus on OSM in the road sector is especially evident when we compare with other transport sectors. SMS fostering positive safety culture are required in aviation, in the maritime sector and in rail (Amtrak, 2015; Hudson, 2003; Lappalainen, Kuronen, & Tapaninen, 2014). In contrast, formal SMSs for companies in the road sector are so far voluntary (e.g. NO:ISO-39001, UK Department for Transport/HSE's Driving at Work: Managing Work-Related Road Safety).

The prevalence of small companies in the road sector could be a barrier to implementation of OSM (Nævestad, 2016). Smaller companies have limited resources (in terms of staff, finances and competence) for implementing SMS, and management by formal documents and processes may be less important than safety cultural and attitudinal aspects (Fourie, Holmes, Hildritch, Bourgeois-Bougrine, & Jackson, 2010). In Norway, over 85% of goods-transport companies employ five or fewer persons (Steen Jensen et al., 2014). In almost all the EU countries for which relevant data are available, the share of micro-companies (less than 10 employees) is about 80% or more (European Commission, 2009, p. 27), while the share of companies with more than 50 employees is very small (usually about 1%). Given that research also shows that company size could be a risk factor (Nævestad et al., 2015), it is essential to develop sound safety management strategies for small road transport companies. Standards and other industry guidance (e.g. ISO39000 and UKDoT/HSE) are potentially valuable in this situation.

The main aim of the article is therefore to develop an OSM strategy for small road transport companies. The main aim gives rise to three auxiliary objectives: (1) Why do accidents with drivers at work occur? (2) How can these risk factors be addressed? and (3) How can these risk factors be addressed in small road transport companies?

2. Methodological approach

The article is based on a systematic literature review, taking Norwegian research as its point of departure. The literature review is systematic, as it seeks to identify all relevant publications and discuss these in light of methods, results and strengths/weaknesses (cf. Tables 1 and 2). The key Norwegian study which the article takes as its departure, especially when fulfilling the first objective, is Nævestad et al.'s (2015) analysis of fatal road traffic accidents in Norway, triggered by drivers at work. The aim of the study was to examine whether and to what extent risk factors relating to these drivers and their vehicles could 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 nine research-interviews conducted with experts from government bodies engaged in accident investigations, worksite inspections and roadside controls.

A literature search was conducted to identify peer-reviewed publications and research reports relating to the objectives. The search included the following four scientific online libraries: ScienceDirect, ISI Web of Knowledge, Google Scholar and Springerlink, and were primarily conducted in the period June–November 2016, but studies were also included in March 2017. The relevance of each publication was assessed on the basis of titles and abstracts. The literature searches were supplemented by research literature we were already familiar with, and which we perceived as relevant to the study objectives.

The literature search included key terms such as "occupational driving", "occupational transport", "occupational driving", "work-related road safety", "occupational travel", "work-related driving", "work-related", "driving at work", "professional transport", "occupational transport", "truck driver" and "road transport". When searching for studies relevant to the first objective, we combined these with terms such as "accidents" and "transport accidents". We found seven studies relevant to the first objective. We present focus, methods, results, strength/weaknesses of the studies relevant to the first objective in Table 1. When searching for studies relevant to the second objective, we combined the first group of terms with terms such as: "safety measures", "safety interventions", "safety training" and "fleet safety". We found 24 studies, which are described in Table 2. When searching for studies relevant to the third objective, we used terms such as "small carriers", "small companies" and "road", "small hauliers", "company size" and "hauliers". We did not find enough relevant studies. Thus, when developing an OSM strategy for small hauliers, we systematically discuss the OSM measures from Table 2 by considering five criteria (cf. Section 5), addressing specific needs and challenges of small hauliers.

Table 1. Studies relevant to the study's first objective: "Why do accidents with drivers at work occur?".

Study/country	Sample/method	Identified risk factors	Strengths/weaknesses
Assum and Sørensen (2010) (Norway)	135 heavy goods vehicles (HGVs) in 130 fatal accidents, 2005–2008	(1) Driver: high speed for conditions, inattention, fatigue, failure to use seat belt (2) Vehicle: insufficiently secured goods, bad brakes, blind-spots, tyres (3) Road: fixed objects near the road, poor road surfaces, high asphalt kerbs, slippery roads, lack of median guard rails	Systematic study. No work-related factors
Department of Transportation U.S. (2006)	967 crashes, including 1127 large trucks, 959 non-truck motor vehicles, 251 fatalities and 1408 injuries, 2001–2003	(1) Driver: speeding, fatigue, insufficient information-gathering, decision errors, fatigue (2) Vehicle: brake problems (3) Road: risk factor in 16% of two-vehicle crashes (4) Weather: 13% of the crashes (5) Road: interruption in traffic flow 25% of two-vehicle crashes	No focus on work-related risk factors
ETSC (2001) (Europe)	Review of the role of driver fatigue in commercial road accidents	Driver fatigue is a significant factor in approximately 20% of commercial road crashes	Detailed review of the role of fatigue in work-related accidents, focusing on work-related risk factors and OSM
Husband (2011) (GB)	Short overview of data on accidents involving drivers at work in GB and worldwide	(1) Males over-represented (2) Fatigue main contributory factor (3) Speeding, driving under the influence (DUI)	Only short overview. No focus on work-related risk factors
Mitchell et al. (2004) (Australia)	All work-related road deaths in Australia 1989–1992	(1) Driver: speeding, fatigue, DUI (2) Situation: vehicle type, location, weather	No focus on work-related risk factors
Nævestad et al. (2015) (Norway)	501 fatal accidents 2005–2011), 10 AIBN reports, interviews with nine experts Risk factors in accidents triggered by drivers at work	(1) Driver: speeding, failure to use seat belt, insufficient information-gathering (2) Vehicle: vision obstacle, wheel/tyre (3) Work-related factors: follow-up of drivers' speed, driving style and use of seat belt, pay systems, safety culture, risk assessments, procedures/work descriptions, training (4) Framework conditions: time pressure, competition, type of transport, accident investigations, inspections	Data on work-related risk factors and framework conditions is only obtained through qualitative data: interviews, and AIBN reports
Symmons and Haworth (2005) (Australia)	Analysis to examine the role of risky driving behaviours in crashes of fleet and non-fleet vehicles	Higher crash rate, but safer behaviours among fleet drivers, who were less likely to be speeding, driving while fatigued, or with an illegal BAC. Fleet drivers were less likely to use seat belt	Limited by focus on transport safety behaviours

Table 2. Studies relevant to the study's second objective: "How can risk factors related to accidents with drivers at work be addressed?".

Study/country	Method/sample	Main results	Strengths/weaknesses
SMSs			
Mooren, Williamson, et al. (2014) (Australia)	Questionnaire on safety management to 50 organisations operating heavy vehicles	Organisations with low insurance claim rates focus more on proactive risk assessment	Some counterintuitive results
Naveh and Marcus (2007) (U.S.A.)	Retrospective analysis of data 2-year pre-/2-year post-ISO9002:1994 certification. 40 certified U.S. trucking companies and 40 matched "control" groups	Certified companies showed significant increase in safety performance (28/40), higher than matched controls (18/40)	Rare comparison of certified versus non-certified companies Not prospective. No focus on internal mechanisms
Thomas (2012) (International)	Literature review of SMS in transport and general	19 studies estimate effect of SMS on objective safety metrics. Some indicate positive outcomes	Difficult to assess the importance of SMS elements
Safety culture			
Arboleda et al. (2003) (U.S.A.)	116 U.S. trucking firms. Studies association between four item safety culture scale and management practices	Significant associations between safety culture, drivers' fatigue training, driver opportunity for safety input and top management commitment	Large company sample, but only study of associations. Indicates importance of management commitment
Goettee et al. (2015) (U.S.A.)	Test group and a matched control group. 2009 ($N = 117$)–2013 ($N = 177$)	Improvements identified in the number of safety audit failures, roadside violations and crashes (up to 84% reduction)	Self-selection challenge, as participation in test group was voluntary
Gregersen et al. (1996) (Sweden): driver training, campaign information, group discussions, group bonus for no accidents	Quasi-experimental prospective design, with measures of treatment and control groups for 2-year period before, at start and the 2-year period following intervention. 5 groups of company drivers ($n = 900$–1000 in each); 4 test groups, 1 control group	Significant reductions in accident risks largest in driver training and group discussion. Significant reductions in accident costs in all treatment groups, but largest in group discussions group	Robust evaluation design. Does not account for accident seriousness. Conclusions about specific, tailor-made measures cannot be generalised to all instances
Naveh & Katz-Navon (2015): safety climate intervention	Longitudinal pre-/post-test controlled experiment	Road safety climate was found to mediate effect of intervention on violation tickets	Controls for gender, employee driving experience, driving distance and whether driver is professional
Newnam and Oxley (2016) (Australia)	Before–after study ($N = 36$) without test group. 8 respondents in after study	Improved safety climate	Low numbers prevent statistical analysis. No control group
Salminen (2008) (Sweden): group discussion and 1-day course in anticipatory driver training	2 groups of electricians driving vans and lorries ($N = 172$ and 179)	Significant and large (72%) decrease in traffic-related accidents	No exposure measure, use of safety audit outcomes makes effect hard to understand and compare. Lacking control
Safety culture and SMSs			
Mooren, Grzebieta, et al. (2014) (International)	Review of literature on safety management interventions in occupational health and safety and road safety. Assesses applicability to reducing crash and injury outcomes in heavy vehicle transport	Management commitment, safety training and work scheduling are robustly linked to safety outcomes across three different types of study design	Indicates that we need more research on OSM in road sector

Murray et al. (2012) (Australia): comprehensive programme structured by Haddon Matrix	Case study describing programme events from 2005 til 2009, with evaluation of associated outcomes	100% increase in risk compliance, 56% reduction in insurance claims, and collision costs 55% less in 2009 than 2004	Inspiring, but fail to account for external events such as national trends in accident statistics, or to pin down effect of individual interventions
Murray et al. (2009) (UK)	Descriptive case study of occupational road safety programme	Almost halving of 3rd party collisions per vehicle, and £500k savings on uninsured cost recoveries	Inspiring, but lacks detail on individual measures; hard-to-link effects and measures. Does not account for external influences
Nævestad and Bjørnskau (2014) (Norway)	Survey data and interviews in 3 goods companies with high safety level	Identifies 10 common OSM practices in the well-performing companies	Case study examining correlations. No controls. More robust designs are needed
Wallington et al. (2014) (UK): comprehensive programme	Case study of long-term trends in collision numbers, rates and claims in British Telecom with 95,000 workers in the period 2001–2012. Compared to national trend	Large and significant decrease in collision rate and insurance costs, in line with increasing training and risk assessment	Effect not established, as road traffic accidents in the UK decreased substantially during study period. No attempt to establish causative relationship between programme elements and effect e.g. by studying behaviour as mediator
Fatigue management			
Feyer et al. (1997) (Australia): fatigue management	37 long-haul truck drivers measured on a routine 4500 km round trip	Overnight rest, and two-up driving most effective for managing fatigue	Relevant to long-haul truck drivers
Gander et al. (2005): fatigue management training	Quasi-experimental pre-/post-training assessment without control. 275 heavy and 350 light vehicle drivers	Most drivers improved knowledge of fatigue countermeasures	Shows increase in fatigue knowledge, but not whether this affects safety performance
Moore-Ede et al. (2004) (U.S.A.): fatigue-risk-informed schedule alterations	800 U.S. truck drivers	Significant fall in fatigue scores 23% reduction in accident rates	No control group
Technology and organisational follow-up of and feedback on driving style			
Hickman and Geller (2005) (U.S.A.): driver self-management process: identify target behaviour; select goal and strategy to promote and monitor behaviour	Quasi-experimental with interrupted time series. 33 short-haul truck drivers	For 21 drivers, time spent speeding reduced by 30% and extreme braking incidents by 64% during intervention	Low numbers, drivers may adjust behaviour in response to being monitored
Hickman and Hanowski (2011) (U.S.A.): behavioural coaching based on monitoring by onboard cameras/ accelerometers	Quasi-experimental design, 4-week baseline with monitoring equipment not activated. 13-week intervention with monitoring, analysis, feedback	Significant reduction in recorded safety-related events by 37% (Carrier A) and 52% (Carrier B)	No evidence of improved performance at start of intervention may indicate that drivers not responded to being monitored. No control group
Musicant, Lotan, and Albert (2015) (Israel) IVDR from Drive Diagnostics	Prospective pre-/post-intervention study. IVDR equipment is present in pre-period, but no feedback given. 103 drivers from fleets of 6 organisations	Exposure to feedback from IVDR is associated with a 40% reduction in crash rates; 80% reduction in crash costs	Role of precise feedback mechanism used not clear. Subjective reactivity accounted for
Myers, Russi, Will, and Hankins (2012): DriveCam onboard event recorder before and after g-forces are triggered	Retrospective review and analysis of events triggered over time since intervention began. 54 ambulances	Significant decrease over time in number of all events and severe events per mile, with use of recorder, review and feedback	Descriptive study of the organisation's process. No control, and no accounting for external events

(*Continued*)

Table 2. Continued.

Study/country	Method/sample	Main results	Strengths/weaknesses
Olson Anger, Wipfli, and Gray (2009) (U.S.A.): safe driving competition with computer-based training, motivational interviewing and self-monitoring	Single group pre-/post-test quasi-experimental design, no control. 29 truck drivers from 4 companies	Significant improvement in safe driving intentions and hard braking events	Drivers volunteered, therefore motivated? Large variation in effect among organisations highlights importance of organisational context
Toledo et al. (2008): driver feedback based on-vehicle data recorder (IVDR)	Prospective pre-/post-intervention evaluation, with IVDR installed but no feedback in the 8-week pre-intervention.	Significant reduction in all, but decrease in at-fault crashes is smaller and non-significant	Crash rate of rest of company fleet decreased by 19%, but not clear whether accounting for this would affect result's significance
Wouters and Bos (2000): driver feedback on acceleration, braking and fuel use, based on-vehicle data recorder (IVDR)	Prospective pre-/post-intervention, with "pseudo-experimental" treatment group and matched control group	Significant reduction in road traffic accidents of vehicles with IVDR of 20%	Wide variation in effect among fleets. Post-period begun when IVVDR was fitted, meaning we cannot rule out subject reactivity

3. Why do accidents with drivers at work occur?

In road safety work, the term "risk factor", rather than the term "cause" is normally used (Nævestad et al., 2015). Risk factors are often 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, vehicle, the road and road environment.

The driver is the main risk factor in all the seven studies presented in Table 1. Three of the studies also highlight vehicles as a risk factor, while two also highlight the road and the road environment as risk factors. One also focus on situational risk factors (e.g. weather). Only one study (Nævestad et al., 2015) highlights the importance of work-related risk factors and framework conditions.

3.1. Risk factors related to drivers

Speeding is highlighted as important in five studies (Assum & Sørensen, 2010; Department of Transportation U.S., 2006; Mitchell, Driscoll, & Healey, 2004; Nævestad et al., 2015; Symmons & Haworth, 2005). Assum and Sørensen's analysis of risk factors in 44 fatal accidents triggered by HGVs found high speed for the conditions to be reported in 28 of the 44 accidents. In comparison, inattention, fatigue and lack of seat-belt use were each reported in seven to nine accidents (Assum & Sørensen, 2010). Vehicle speed is one of the main contributing factors to serious accidents (Elvik, 2006). A EU directive prescribes maximum speed-limiters for 90 km/h in HGVs and 100 km/h in buses, but it is still possible for professional drivers to exceed safe speeds.

Fatigue is highlighted as important in four studies (cf. Assum & Sørensen, 2010; Department of Transportation U.S., 2006; Husband, 2011; Mitchell et al., 2004), in addition to the study devoted to fatigue (ETSC, 2001). Failure to use seat belt is identified as important in three studies (Assum & Sørensen, 2010; Nævestad et al., 2015; Symmons & Haworth, 2005). Use of seat belts reduces the probability of being killed by 40–50% for drivers and passengers in the front seat (Elvik, Vaa, Erke, & Sorensen, 2009). Insufficient information-gathering or inattention (and decision errors) were identified as important in three of the studies (Assum & Sørensen, 2010; Department of Transportation U.S., 2006; Nævestad et al., 2015). This could be related to distraction.

The results of Symmons and Haworth (2005), indicating that crashed fleet drivers were less likely to be speeding, driving while fatigued, or drive with an illegal BAC (blood-alcohol-level) compared to non-fleet drivers, may seem contrary to the other studies in Table 1. These other studies do, however, not necessarily compare behaviours of drivers at work with drivers who are not at work; instead they only look at risk factors related to drivers at work in accidents, or compare groups within this category (e.g. triggering versus non-triggering). Additionally, other studies find that professional drivers report more speeding and a higher intention to speed in a work vehicle than in their personal vehicle (e.g. Newnam, Watson, & Murray, 2004).

3.2. Risk factors related to vehicles

Three studies in Table 1 highlight vehicles as a risk factor. In the fatal accidents triggered by drivers at work, 315 of the identified accident risk factors were related to drivers, while

50 were related to vehicles (Nævestad et al., 2015). The two most important were obstacles to vision in or on vehicles and wheels/tyres. Assum and Sørensen's (2010) study of risk factors in the 44 fatal accidents triggered by HGVs indicates the following risk factors related to vehicles: insufficiently/faulty secured goods, bad brakes, blind-spots and tyres. A U.S. review of accidents involving large trucks found brake problems to be a risk factor in about 30% of the accidents (Department of Transportation U.S., 2006).

3.3. Risk factors related to the road and the road environment

Only two of the studies in Table 1 highlight the road and the road environment as a risk factor. The most frequently mentioned risk factors related to this in Assum and Sørensen's (2010) study were objects on the side of the road, poor road surface, high asphalt edge and slippery surface. Absence of median barriers was also mentioned. The mentioned U.S. review found the road to be a risk factor in 16% of the two-vehicle crashes (Department of Transportation U.S., 2006). It also pointed to interruption in the traffic flow (previous crash, work-zone, congestion) as a risk factor in almost 25% of two-vehicle crashes.

3.4. Work-related risk factors

One study (Nævestad et al., 2015) in Table 1 highlights the importance of work-related risk factors. It is, however, important to note that the conclusions of this study on the importance of work-related risk factors are largely based on qualitative interviews and analysis of AIBN reports. These results are therefore uncertain. Work-related risk factors refer to all factors that are influenced by employees' work-situation, which may in turn influence transport safety. These can be traced back to management and organisation, but also to more general factors which are usually not associated with HSE, e.g. pay systems, work scheduling systems, organisation of drivers' contact with forwarding agents and customers (Nævestad et al., 2015).

3.4.1. Stress and time pressure

Nævestad et al.'s (2015) comparison between triggering and non-triggering professional drivers involved in fatal accidents revealed that the triggering drivers to a greater extent were in a state of haste/stress, tired or subject to some other sort of external influence (e.g. drugs or illness). This may suggest that stress is a key risk factor in fatal accidents triggered by drivers at work (Nævestad et al., 2015). Drivers' level of perceived stress and pressure could influence their speed (Nævestad et al., 2015).

3.4.2. Speed and seat belt as an organisational concern

Interviewees in Nævestad et al.'s (2015) study suggest that speed too high for the circumstances and failure to use seat belts are risk factors that employers may prevent by means of, for example, organisational speed and driving style policy (approved, signed and followed by the drivers), organisational 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. Nævestad et al. (2015), however, found that according to interviewees, transport companies largely treat the seat-belt use of their drivers as an individual rather than as organisational concern. The situation is somewhat different when it comes to speed and driving style, primarily as this has economic implications.

3.4.3. Working-hours and fatigue

Table 1 indicates the importance of fatigue as a risk factor in work-related road accidents. International research shows that 36–64% of professional drivers' report having fallen asleep behind the wheel one time or another (Crum & Morrow, 2002; Feyer & Williamson, 1995; Sagberg & Bjørnskau, 2004). Work-related factors such as working-hours and scheduling may influence drivers' fatigue (Lerman et al., 2012; Maldonado, Mitchell, Taylor, & Driver, 2002).

3.4.4. Pay systems

Interviewees in Nævestad et al.'s (2015) study mentioned pay systems as a possible risk factor in work-related accidents. There is evidence to suggest that payment systems rewarding production (e.g. km's, transported tonnes) may influence safety outcomes negatively (e.g. Johansson, Rask, & Stenberg, 2010; Mooren, Williamson, et al., 2014; Williamson & Friswell, 2013).

3.4.5. Inadequate SMS

The 10 AIBN reports from fatal accidents with professional drivers reviewed in Nævestad et al. (2015) often conclude that the companies employing triggering drivers have failed to: (1) conduct (and document) risk assessment of particularly critical operations, (2) use these as a basis for work descriptions/procedures that the drivers could have consulted before operations or (3) use risk assessments and procedures as a basis for training of drivers to prepare them for risks. The AIBN refers to these three processes as an SMS. Interviewees in Nævestad et al.'s (2015) study did not believe that most transport companies perform these three processes adequately, and thus that SMS often are inadequate in road transport companies.

3.4.6. Employers' perceived responsibility for safety

When asked about the most important measures that transport companies may take to prevent accidents, several interviewees in Nævestad et al.'s (2015) study stated that feelings of responsibility and attitudes among employers is key. We may also refer to this as safety culture (cf. Section 4.1.2). Several interviewees underlined 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.

3.4.7. Framework conditions

The one study in Table 1 highlighting framework conditions (Nævestad et al., 2015) point to four such conditions. The first is the relationship to transport buyers/forwarding agents. These set the premises for drivers' speed and driving, decide when goods should arrive and when drivers can start their trips. The second is competition, which may lead to drivers taking assignments with tight time margins, which might cause time pressures and high speed. The third is type of transport. HGVs transporting dangerous goods have a 75% lower accident risk than do other lorries (Elvik et al., 2009), illustrating how type of transport has consequences for regulations and for transport companies' prioritisation of safety and safety levels. The fourth is enforcement, inspections and regulation of transport safety. Inspections influence accident risk (Elvik, 2002). A majority of interviewees in Nævestad et al.'s (2015) study held that work-related factors with potential implications for road safety are insufficiently monitored in inspections.

4. How can the risk factors be addressed?

4.1. Organisational safety management

Safety measures targeting drivers at work may be directed at different levels (e.g. the individual driver, the vehicle, companies employing drivers, transport buyers and other stakeholders, the road/road environment, regulatory authorities auditing and/or supervising the drivers' organisations and national/international rules/regulations) (cf. Hughes et al., 2015, 2016). In this article, we choose to focus on the companies employing the driver, as there seems to be a low focus on OSM, and thus a considerable potential for safety improvement.[1]

We define OSM as the combination of safety structure and safety culture (cf. Section 1). OSM may also refer to other safety measures that cannot necessarily be categorised as culture or structure, such as equipment and technology (vehicle type, speed-limiter), and other measures not necessarily associated with safety, e.g. payment systems (Nævestad et al., 2015).

Three studies in Table 2 focus on safety structure, six on safety culture, five focus on both, while three focus on fatigue management. Seven studies concern fleet management technology and organisational follow-up of driving style. All of the studies in Table 2 describe interventions leading to improved safety performance. It may however be difficult to learn from some of these studies for two reasons. The first applies to the case studies (e.g. Murray et al., 2009; Murray, White, & Ison, 2012; Nævestad & Bjørnskau, 2014; Wallington, Murray, Darby, Raeside, & Ison, 2014). These describe relatively comprehensive and context-dependent OSM measures, which are eclectic, combining cultural and structural measures. Many of the case studies do not account statistically for external factors, e.g. national trends in accident reductions. They inspire by detailing "good" practice, rather than establish causative relationships between programme elements and safety effects. Additionally, they may be tailored to specific companies, and measures may be difficult to transfer to other companies. The second reason that it may be difficult to learn from some of the studies is that they rely on a too-poor empirical basis, although they provide interesting results (e.g. Goettee, Spiegel, Tarr, Campanian, & Grill, 2015; Newnam & Oxley, 2016). Thus, the remaining discussion primarily draws on studies that are not seriously affected by these two critiqiues, though we point to the affected studies to exemplify.

4.1.1. Organisational safety structure

Just as we define safety culture as aspects of culture in organisations that are relevant to safety (Hale, 2000), we define safety structure as safety-relevant aspects of organisational structure. Organisational structure refers to the way tasks in an organisation are divided, how work flows, how this flow is coordinated and the forces and mechanisms that allow this coordination to happen (McShane & Travaglione, 2003). Coordination can be achieved by: (1) informal communication, (2) formal hierarchy, involving direct control and (3) standardisation of tasks, with formal instructions, goals (standardisation of outcomes) or training (standardisation of knowledge) (McShane & Travaglione, 2003).

4.1.1.1. Safety management system (SMS). Thomas (2012) concludes that there seems to be a relationship between SMS and objective safety outcomes (e.g. behaviours, accidents). Although there is a lack of agreement about which SMS components contributing the most, he concludes that management commitment and safety communications seem important. The methodologically robust study of Naveh and Marcus (2007) supports the conclusion that SMS is associated with improved safety performance, although this is a study of a quality management system (ISO9000), focusing on systematic documentation and adherence between procedures and practice. Risk assessment is another key component in SMS, and in a study of heavy vehicles operators' insurance claims, Mooren, Williamson, et al. (2014) found that low claimers seemed to focus more strongly on proactive risk assessment. Murray et al. (2009, 2012) and Wallington et al. (2014) also provide good examples of key SMS elements in the road sector: risk assessment, documentation, continuous improvement and communication.

4.1.1.2. Organisation of transport assignments. Stress, time pressure and speeding are key risk factors in accidents involving drivers at work. Mooren, Grzebieta, Williamson, Olivier, and Friswell (2014) found scheduling or journey planning to be robustly linked to lower crash risk across three different types of study design. Moore-Ede et al. (2004) find that fatigue-risk-informed schedule alterations reduce driver fatigue, while Feyer, Williamson, and Friswell (1997) provide analogous results relevant to long-haul drivers.

4.2.1. Organisational safety culture

It is widely recognised that safety culture is important for safety in organisational settings in hazardous industries (Nævestad, 2010). Research also indicates a relationship between safety culture and safety performance in road transport, although this relationship is challenging to measure (Bjørnskau & Nævestad, 2013). Safety culture is often referred to as safety-relevant aspects of organisational culture (Hale, 2000). Despite diversity in definitions, studies of organisational safety culture often seem to treat safety culture as a shared and safety-relevant way of thinking or acting that is (re)created through the joint negotiation of people in social settings (Nævestad, 2010).

4.2.1.1. Management commitment to safety. One of the key findings in Mooren, Grzebieta, et al.'s (2014) review is that management commitment is robustly associated with safety outcomes. Management commitment is also highlighted by Arboleda, Morrow, Crum, and Shelley (2003), and the SMS review of Thomas (2012). Senior management commitment to safety is the most studied and best-documented characteristic of a good safety culture, independent of sector (DeJoy 2005; Flin, Mearns, O'Connor, & Bryden, 2000; Guldenmund, 2000; Pidgeon & O'Leary, 2000). It tends to influence all other safety-related aspects of organisations, and it influences professional drivers' safety motivation (Newnam, Griffin, & Mason, 2008), and is directly related to safety rankings (Zohar, 2002).

4.2.1.2. Driver training and group discussions. The third main result of Mooren, Grzebieta, et al.'s (2014) review is that safety is training closely linked to safety outcomes. Gregersen et al. (1996) find that the reductions in accident risks are largest in the treatment groups that received driver training and group discussions. Training and group discussions aiming to improve awareness and attitudes are also important elements in other studies described in Table 2 (e.g. Gander, Marshall, Bolger, & Girling, 2005; Murray et al., 2009, 2012; Naveh & Katz-Navon, 2015; Salminen, 2008; Wallington et al., 2014).

4.2.1.3. Safety communication. Open communication about safety issues is another key safety culture aspect highlighted in studies described in Table 2 (e.g. Arboleda et al., 2003; Murray et al., 2009, 2012; Thomas, 2012; Wallington et al., 2014). Managers' safety communication and employees' reporting of incidents and safety issues are key in a learning culture, where members continually reflect on their own practice (Pidgeon & O'Leary, 2000; Reason, 1997). Such a reporting, just and learning culture is not yet in place in the road sector (Mellum, 2015), although there are examples of companies with incident reporting, continuous risk assessments and learning (Nævestad & Bjørnskau, 2014; Wallington et al., 2014).

4.2.3. Fleet management technology and organisational follow-up of driving style

The seven studies of fleet management technology and organisational follow-up of and feedback on driving style indicate positive outcomes: safer driving and/or fewer accidents. These interventions seem to rely on a combination of driver self-monitoring by means of technology and management monitoring and support. The main methodological challenges of these eight studies are that the drivers' driving style may be influenced by the fact that their behaviours are recorded in the study period, and that some of the studies lack control groups or pre-periods with the equipment fitted to evaluate the importance of this mechanism. Hickman and Hanowski (2011), Wouters & Bos (2000) and Toledo, Musicant, and Lotant (2008) provide examples of relatively robust designs.

5. Safety management strategy for small road transport companies

5.1. The safety ladder for road safety management

In developing an OSM strategy for small haulier companies, we have sought to identify a set of evidence-based organisational safety measures that fulfil five criteria. They:

(1) Address the most important risk factors found in previous research (Crit.1).
(2) Have been proved to have effect on (or be closely related to) safety outcomes in previous research (based on a sound methodology) (Crit.2).
(3) Are attainable at a relatively low cost, both in terms of financial and human resources even to small enterprises (Crit.3).
(4) Are not too complex, context-dependent or comprehensive (Crit.4).
(5) Can complement the existing safety management standards in such a way that they can serve as an introduction to the formal standards, but also be effective in cases where they do not eventually lead to full certification (of e.g. ISO39001) (Crit.5).

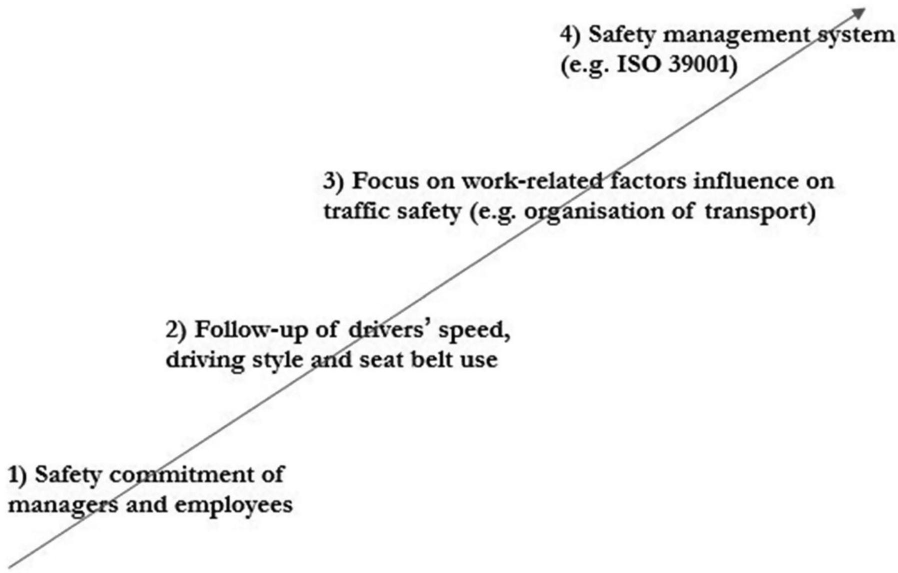

Figure 1. Safety ladder for safety management in goods transport.

The measures that we have identified based on these criteria can be arranged on a ladder, where businesses start at the lowest level, before proceeding to the next step, as illustrated in Figure 1.

The idea behind the safety ladder is that companies start at the bottom of the ladder if they do not have any measures targeting work-related risk factors in the company. This idea is based on literature that suggests this sequence in terms of significance and priority (Flin et al., 2000; Thomas, 2012). Based on previous research, we assume that the lowest levels are most attainable, and have the greatest impact.

The safety ladder for goods transport is based on two important premises. The first is that goods-transport companies often have little focus on the significance of work-related risk factors for transport safety (Nævestad et al., 2015). The second premise is that road transport companies in Norway and in EU countries are small (European Commission, 2009; Steen Jensen et al., 2014). We therefore assume that most of them have limited resources available for developing comprehensive SMSs (Fourie et al., 2010). Against this background, we suggest that firms with limited time, competence on road safety and financial resources can start by focusing on the most fundamental issues, rather than by moving straight ahead to comprehensive SMS such as ISO39001.

5.2. Managers' and employees' commitment to safety

Senior management's commitment to safety is the most fundamental step of the safety ladder because research shows that this is a prerequisite for companies' safety work to succeed (Flin et al., 2000). Thus, it is the most basic premise of addressing the most important risk factors (Crit.1,5). It is the OSM characteristic most closely related to safety outcomes (Flin et al., 2000; Thomas, 2012) (Crit.2). Additionally, it is a universal measure that is not complex, comprehensive or context-dependent (Crit.4). If managers do not wholeheartedly support measures adopted by the company, indirectly communicating that they are not very important, it is likely that the staff that is to turn the measures into everyday practice will not consider them important (cf. Schein, 2004). Schein (2004) outlines "six primary embedding mechanisms" that managers can use to shape culture (Schein, 2004, p. 246):

(1) What managers pay attention to, measure and control on a regular basis,
(2) How managers react to critical incidents and organisational crises,
(3) How managers allocate resources,
(4) Deliberate role modelling, teaching and coaching,
(5) How managers allocate rewards and status, and
(6) How managers recruit, select, promote and excommunicate.

It is important to heighten managers' awareness that their sustained and whole-hearted endorsement and promotion of road safety is likely to have a practical effect on their employees' safety behaviours, and, eventually, on safety outcomes. Becoming aware of this responsibility could serve as a considerable incentive. A possible way to foster management commitment to road safety in businesses without much prior awareness of the issue could be to focus on financial and human costs associated with incidents and accidents, and the economic benefits of working systematically with OSM. Hammer, Pratt, and Ross (2014) estimate that each work-related traffic fatality costs U.S. employer over 500,000 dollars and each non-fatal injury 74,000 dollars. Bidasca and Townsend (2014) argue that SMSs can lead to direct cost savings such as decreased accident and repair costs, insurance premiums, reduction in uninsured loss recoveries, and indirect cost savings, including better quality, customer service and efficiency. Thus, this measure is not only attainable at a low cost (Crit.3); it also brings economic benefits.

5.3. Follow-up of drivers' speed, driving style and use of seat belts

The second step in the safety ladder is "Follow-up of drivers' speed, driving style and use of seat belts". This addresses the key risk factors associated with the driver that we saw in Table 1 (Crit.1). The research described in Table 2 indicates that fleet management technology and organisational follow-up of driving style is closely related to safety outcomes (Crit.2). The most important aspect of this step is that management recognises company influence on and responsibility for speed and driving style (cf. Nævestad & Phillips, 2013). The economic costs related to this are uncertain (Crit.3), but low-cost solutions should be available with increasing technological development. This measure relies on a combination of self-monitoring facilitated by technology and management monitoring and support. Norwegian research exemplifies low-cost solutions. Well-performing goods-transport companies in Nævestad and Bjørnskau (2014) had organisational speed, driving style, seat-belt and mobile phone policies (approved, signed and followed by the drivers), they had regular talks with drivers on these issues and monitored 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 warnings. Managers sanctioned unsafe driving. If such measures are chosen, they are not necessarily complex, or comprehensive (Crit.4), as they target well-defined behaviours. These measures can serve as an introduction to further SMS measures (Crit.5).

5.4. Focus on work-related factors' influence on road safety

The third step in the safety ladder is "Focus on work-related factors' influence on transport safety". Given little focus on OSM, this step means to develop an awareness of how work-related factors influence transport safety. This step comes after organisational follow-up of speed, driving style and seat belt, as it is more general. Unfortunately, there is little research on the relationship between OSM and safety outcomes in the road sector (Mooren, Grzebieta, et al., 2014). We have however seen that some OSM measures are backed by robust empirical research (Crit.2). Fortunately, this applies to measures targeting the most important risk factors (i.e. over speeding, stress, time pressure, fatigue) (Crit.1). Our review indicates that "organisation of transport" is closely associated with safety outcomes (Feyer et al., 1997, 1995; Mooren, Grzebieta, et al., 2014). This refers to organisational measures aiming to minimise negative safety outcomes of transport arrangements, e.g. fatigue, stress and time pressure, which may lead to over speeding. Such measures could be scheduling, journey planning, switch drivers along the road, regulating drivers' contact with customers, avoiding piecework, commission pay, etc. Many of these measures are attainable at a low cost (Crit.3); it seems that the key element is organisational awareness about the importance of this, and a will to implement countermeasures. This measure is more context-dependent than the others (Crit.4), as it relies on the specific activities and challenges of transport companies. Finally, it can also complement other SMS measures (Crit.5), as it may serve as a gradual introduction to this way of thinking.

5.5. Implementation of a SMS

The fourth step in the safety ladder is to implement an SMS, such as ISO39001 or similar alternatives. This measure does not necessarily address the most important risk factors found in previous research (Crit.1), as it is general. It should, however, address these if it is used properly. SMS has been proved to influence safety outcomes in previous research (Crit.2), but it is probably not attainable at a low cost in terms of financial and human resources (Crit.3). SMS is relatively comprehensive and complex (Crit.4). This is why SMS is the final step in the safety ladder, reserved for companies with many resources, which have reached a certain level of OSM maturation. It is important, however, to remember that implementing an SMS is largely about developing awareness of the central risk factors companies relate to, to carry out risk assessments, introduce measures (such as training and procedures) related to these and document the process.

6. Concluding discussion

6.1. Methodological limitations

An important challenge facing studies of accidents and studies learning from accidents (like the present) is that they employ more or less implicit accident models, involving a set of assumptions about how accidents happen and what the important factors are (Lundberg, Rollenhagen, & Hollnagel, 2009). Such models influence what investigators and researchers studying accidents look for, and hence their conclusions. This has been called the "What-You-Look-For-Is-What-You-Find", or WYLFIWYF tendency (Lundberg et al., 2009). This tendency may also limit our learning and our ability to implement safeguards against future accidents. According to Lundberg et al. (2009), the identified causes typically become specific problems to be fixed during an implementation of solutions, following that they refer to as the "What-You-Find-Is-What-You-Fix" or WYFIWYF tendency. For example, Hughes, Anund, and Falkmer (2016) suggest that other causal factors are relevant but not commonly included in OSM or road safety generally (e.g. economic, social or transport system factors).

In our view, the WYLFIWYF tendency provides a particularly important challenge in the road sector, as the importance of the organisational level for accident prevention often is omitted in road accident investigations and associated safety measures (Elvebakk, Nævestad, & Ranestad, 2017). Table 1 illustrates that analyses of work-related road accidents largely are limited to "traditional" risk factors used by the accident investigators (i.e. driver, vehicle, road), and that little attention is paid to work-related risk factors or organisational factors. Only one of the studies (Nævestad et al., 2015) highlights the importance of work-related risk factors and framework conditions.

In the present study, we try to reduce the effect of the WYLFIWYF and WYFIWYF tendencies (Lundberg et al., 2009), by also basing our analyses of accidents and suggested measures on OSM perspectives derived from other transport sectors and other industries. Our approach to OSM has been developed in studies of safety in the maritime sector, light inland helicopter (cf. Nævestad et al., 2015) and in the petroleum industry (e.g. Nævestad, 2010). Moreover, when discussing OSM, we also draw on other OSM research from all sectors and industries. When we look at the road sector with this perspective, it is evident that most road transport companies have a considerable potential for improvement. The low focus on OSM indicates that it is necessary for the road sector to learn from other transport sectors and industries (cf. Elvebakk et al., 2017).

6.2. Suggestions for further research

It is important to remember that our stepwise safety ladder (i.e. starting with one particular step before the next) approach has not been validated, neither by us, nor in previous research. Nevertheless, the elements in the individual steps in the ladder are supported by previous studies, as indicated in Section 5. As our literature review suggests, the lack of empirical evidence for OSM measures is a challenge which applies to the road sector in general. Several authors highlight the lack of peer-reviewed, robust evaluations of work-related road safety as a major research gap (e.g. Fourie et al., 2010). There is also the problem of publication bias. Grayson and Helman (2011) claim that they know of many unpublished case studies showing no reduction in accidents. The lack of empirical evidence for OSM measures probably reflects the limited implementation of such measures in the road sector.

Research is lacking on the importance of different elements of safety culture (e.g. reporting culture, learning culture, communication about safety) for safety in road transport companies. The same applies to the association of specific elements of SMS (e.g. risk analysis, procedures) with safety outcomes. Future research should also look further into how fleet management technologies can be combined with management policies and safety management, perhaps focusing on low-cost solutions. Perhaps follow-up of drivers' speed, driving style and use of seat belts can be conducted largely by means of technology, with improved fleet management systems and automated driving technology in the future. With increasing technological developments, future research should also examine the extent to which drivers are integrating tablets, GPS-systems and social media in their driving behaviours, consequences for distraction and possible countermeasures.

Although our stepwise ladder approach not is scientifically validated, we hope that it may represent a fruitful start and a "compromise" for the road sector, which currently does little on OSM, and which largely seems to be made up of small actors with little resources. We hope that the ladder approach can be followed up, and that its elements can be refined or changed, based on future research focusing on the elements that are likely to provide the largest risk reduction to the lowest cost. The ladder approach can perhaps also be adapted to sub-sectors (e.g. distribution versus long distance transport) and to other sectors (e.g. maritime). Additionally, it is also important to note that other criteria than the five that we have based the safety ladder on can be used when specifying steps in the ladder or adding steps to it. For instance, "value for money", or "consistency with company or staff procedures and culture".

The tiered safety-ladder approach can also be applied to safety work in medium and large-goods companies. In contrast to smaller companies, larger companies are less able to manage employees through direct personal contact, and they therefore depend more on formal systems, procedures and standardised training to control and coordinate employees (cf. McShane & Travaglione, 2003). For these large companies, already dependent on extensive formal systems, the transition to formal SMSs such as ISO39001 is likely to be smaller. Nevertheless, the safety ladder may also provide larger companies with an OSM strategy – for example, if they do little on road safety, lack resources or if they want a gradual introduction to work-related road safety. However, as safety work in smaller company is likely to be more informal and dependent on direct communication and personal relationships, we hypothesise that the safety ladder is more relevant in smaller companies, and that it may provide a gradual professionalisation, formalisation and systematisation of the safety work in these companies. This hypothesis should be examined in future research, aiming to validate the safety-ladder approach.

Note

1. The role of regulatory authorities is also important, as they may set the premise for safety management in companies, both through auditing compliance with rules, and supervising companies (Kringen, 2009).

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