
Summary:

Work-related accidents in Norwegian road, sea and air transport: prevalence and risk factors

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The study maps the prevalence of work-related accidents in road, sea and air (light helicopter inland) transport, and examines risk factors related to these accidents, focusing especially on work-related risk factors. About 40 % of the road transport accidents is work-related. A conservative estimate indicates that about 11 drivers at work are killed and 287 injured each year in work trips on Norwegian roads. A total of 1500 people is injured in these accidents each year. On average 8 drivers are killed on their way to/from work and 286 are injured each year. An average of 15 ship crew members are killed and 424 injured per year on Norwegian ships in the period 2004-2013. Two crew members are on average injured/killed each year on inland helicopters, and although this is low compared with other transport sectors, it reflects an accident risk which is high compared with other forms of air transport (e.g. 10 times higher than offshore helicopters). Results show a considerable decline in the number of people injured in work-related accidents in recent years in both the road and the maritime sector, and this seems to reflect a reduced accident risk. Accidents with inland helicopter, however, have not declined. These are therefore defined as a possible high-risk group together with non-professional drivers, commuters, small fishing vessels ("sjark") and small helicopter operators. Although the quantitative databases include little information on work-related risk factors, our qualitative analyses of work-related risk factors of accidents in investigation reports of the AIBN show that fatigue/stress and insufficient safety management systems were common in the sectors. Our analyses also show that framework conditions (e.g. market/competition, rules and regulation) influence transport safety. The report concludes that current databases on work-related accidents and risk factors are insufficient, because of underreporting and lacking registration of such accidents and their work-related causes.

Background and aims

Work-related accidents refer to accidents involving transport operators at work, both employees driving in connection with their jobs, and self employed transport operators. Work-related risk factors are all factors that can be traced to transport operators' work situation, and which may influence transport safety.

According to the accident statistics, substantial shares of accidents in road and maritime transport are work-related, but knowledge is lacking on the relationship between accidents and work-related risk factors in transport organisations. A recent 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). In 2010, 495 maritime accidents were registered by the Norwegian Maritime Authority (NMA) (2011). About half of these were labelled work/personnel accidents. Nearly 20 years have passed since the last accident involving serious passenger injury or death on a Norwegian scheduled flight operation (Civil Aviation Authority 2013a). However, light inland helicopter has for several years

been considered to be the most accident prone sector within commercial aviation. Light inland helicopter operations have 10 times higher risk than offshore helicopters.

As knowledge is lacking on the relationship between accidents and work-related risk factors in transport organisations, these important risk factors are neither addressed properly by transport organisations, nor by regulatory authorities.

The main aims of the study are to:

- 1) Map the prevalence of work-related accidents in Norwegian road, sea and air (light helicopter inland) transport.
- 2) Examine the risk factors related to work-related accidents in Norwegian road, sea and air transport (light helicopter inland), with a specific focus on work-related risk factors.

The study documented in this report is part of a larger research project “Work-related accidents in road, sea and air transport: prevalence, causes and measures”, financed by the TRANSIKK program of the Research Council of Norway. The project lasts for three years, from March 2014 to March 2017. The continuation of the project will examine regulatory authorities' and transport companies' understanding of their role and responsibilities in relation to work-related risk factors and accidents, and survey and suggest specific measures that both transport companies and authorities can implement to reduce the risk of work-related transport accidents.

Data sources and methods

In the road sector, we use accident databases from the Accident Analysis Groups (AAG) of the Norwegian Public Roads Administration (NPRA) and Statistics Norway's (SN) database of police reported personal injury accidents. We also use the Norwegian Maritime Authority's (NMA) database of all maritime accidents along the Norwegian coast, both with Norwegian and foreign registered ships, and with Norwegian ships in foreign waters (i.e. NIS). In all three sectors, we have studied reports from the Transport Accident Investigation Board Norway (AIBN).

Our analyses of helicopter accidents are based on a broader set of data and analysis methods than the analyses of road and sea accidents. These analyses were part of a larger project on safety in inland helicopter transportation carried out by Safetec Nordic, in collaboration with Flight Safety Forum, the Civil Aviation Authority (CAA) and the Ministry of Transport and Communications. The final report from the project was published in 2013 with data from 2000-2011 (Bye et al. 2013a; Bye et al. 2013b). The present study conducts new analyses of the data material, and updates and sums up results from this material. Additionally, new analyses of AIBN-data have been conducted.

Prevalence of work-related injuries

11 drivers at work are killed and 287 injured annually

A conservative estimate based on Statistics Norway's database on police reported traffic accidents with personal injury 2007-2012, indicates that about 287 drivers at work are injured each year in work trips on Norwegian roads. Our estimates are labelled conservative, as results indicate a share of 30 % of underreporting of “work”

as a trip purpose, suggesting that our numbers in some instances only cover about 70 % of the actual numbers of drivers at work. AAG data indicates that about 11 drivers at work are killed annually. An average of 1500 people is injured in these accidents each year (287 of these are as noted drivers at work). Thus, we see that most of the injured road users in accidents involving drivers at work are not at work, and that drivers at work to a lower extent than others are injured in the accidents that they are involved in. About 40 % of the road transport accidents is work-related. SN-data shows that a total of 44 % of the trips involving police-reported personal injury accidents with known trip purpose had work (27 %), or to/from work (commuting accidents) as purpose (17 %). This supports an assertion found in EU-research, although the share of road accidents that are work-related in Norway appears to be higher than those found by studies in several other countries.

Non-professional drivers at work as a potential risk group. AAG-data show that 31 % of all fatal road accidents involve professional drivers at work, while 7 % involve non-professional drivers at work. Results indicate that the latter may be a high risk group, as accidents involving these do not appear to have decreased from 2005 to 2013, despite clear downward trends in other types of accidents. We do, however not know the accident risk of this group. Little is known about non-professional drivers at work, and more research is needed on this group.

Commuters as a potential risk group. AAG and SN-data show that on average 8 drivers are killed on their way to/from work and 286 are injured each year. Thus although there were more drivers in accidents with work as a purpose than to/from work as purpose, the numbers of injured drivers are fairly similar for two these groups. This is probably due to the fact that drivers at work to a larger extent drive heavy vehicles in which they are more protected than drivers on their way to/from work. It is likely that the exposure (i.e. million vehicle kilometres) of drivers at work is higher than that of commuters, indicating that commuters have a higher injury accident risk. Future research should obtain exposure data, in order to compare the accident risks of the two groups.

SN-data based on police reported accidents show that 40 % of the vehicles in work-related accidents were heavy goods vehicles (HGVs), followed by private/estate cars and buses. AAG-data show that about 90 % of the professional drivers involved in fatal accidents drove heavy vehicles, and that most (65 %) of the non-professional drivers at work drove light cars or vans at the time of the fatal accident.

15 killed and 424 injured annually on Norwegian ships

We have examined the number of deaths and personal injuries among crew members for fishing vessels, cargo ships and passenger ships with Norwegian (NIS/NOR) and foreign flags in Norwegian waters, and ships with Norwegian flags (NIS) in foreign waters for the period 2004-2013. There were on average six dead and 129 injured per year for fishing vessels, eight dead and 170 injured per year for cargo ships, and one dead and 125 injured per year for passenger ships. This gives a total average of 15 dead and 424 injured per year. In comparison, over 30 people are killed in leisure boat accidents each year. The share of severe injuries (over 72 hours work absence) was 15 percentage points higher for fishing vessels than other vessel types. This may partly be due to the fact that many of these are self-employed and do not see the benefits of reporting minor incidents. European statistics from the European Maritime Safety Agency shows that between 2011 and 2013 there were 4015 ship casualties and 1801

occupational accidents reported. Most incidents occurred on cargo ships, followed by passenger ships, service ships and fishing vessels.

Low numbers, but high risk for light inland helicopters

Ten crew members were killed and sixteen injured in nineteen light inland helicopter accidents in the period 2000-2012. Based on numbers from 2000-2012, we may expect two light inland helicopter crashes per year, with a probability of more than 50 % of at least one fatality during the course of the year. Although these absolute numbers are low compared with other transport sectors, they reflect an accident risk which is high compared with other forms of air transport, for instance more than 10 times higher than that of offshore helicopters operating to and from installations on the continental shelf. It is suggested that this difference is due to major differences in terms of e.g. helicopter types, navigation instruments, protective equipment, experience level of the pilots (total flight hours), composition of the crew (e.g. use of co-pilots within offshore helicopters), the standardization of flight procedures, extent of training and the size and extent of the flight organisation.

Risk development in the sectors

Results have shown a general decline in the number of people injured in work-related accidents in recent years in both the road- and the maritime sector. Although the numbers are very small compared with the other sectors, light helicopter inland has not experienced the same strong and stable reduction in work injuries in the period 2007-2012, as figure S.1 illustrates.

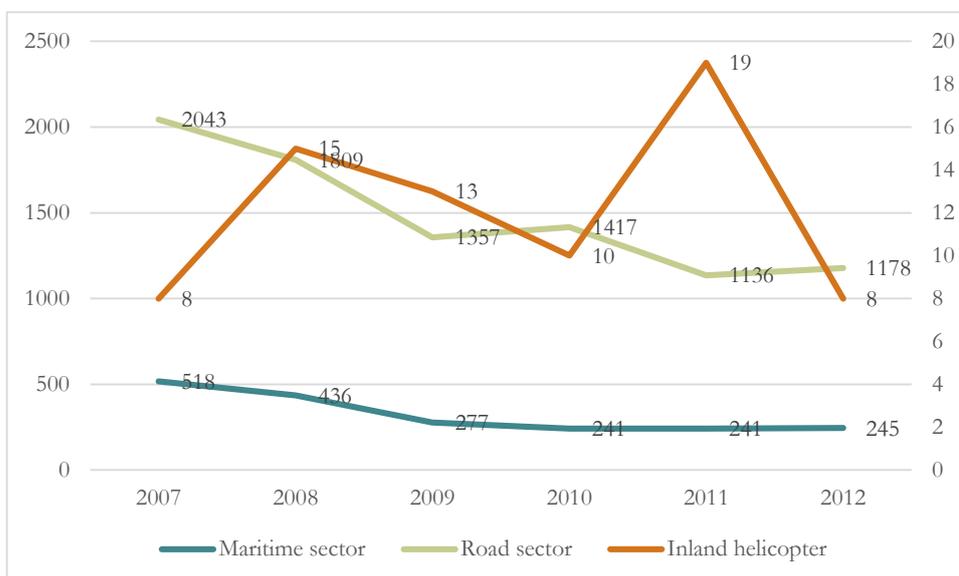


Figure S.1. Primary axis: Number of people injured in police reported traffic accidents in Norway 2007-2012, with work as the purpose of the trips and personal injuries per year for on vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2007-2012. Secondary axis: events with personal injury and/or material damage in Norwegian inland helicopter flights per year 2007-2012. Absolute numbers.

Figure S.1 shows tendencies in absolute numbers of injuries and events. Additional analyses of accident risk (i.e. also taking into account exposure measures) indicate a reduced risk of work accidents in the road- and the maritime sectors, while risk

estimates for inland helicopters do not show any clear trends. Again, it is important to note that the estimates for helicopters are based on low absolute numbers of accidents.

Sector-specific risk factors in work-related transport accidents

In the following we will present sector-specific and common risk factors in the studied work-related accidents. It is important to note that the identification of the risk factors that we present in this report are based on the interpretation of the people investigating and recording the accidents, our interpretations of these risk factors in our analyses, and finally our hypotheses on relationships between the risk factors. These are, as we underline, only hypotheses, and should therefore be treated as suggestions for future research. Figure S.2 illustrates our hypothesized relationships between typical risk factors in work accidents on Norwegian roads. The hypothesized relationships are based on our analyses of quantitative and qualitative data.

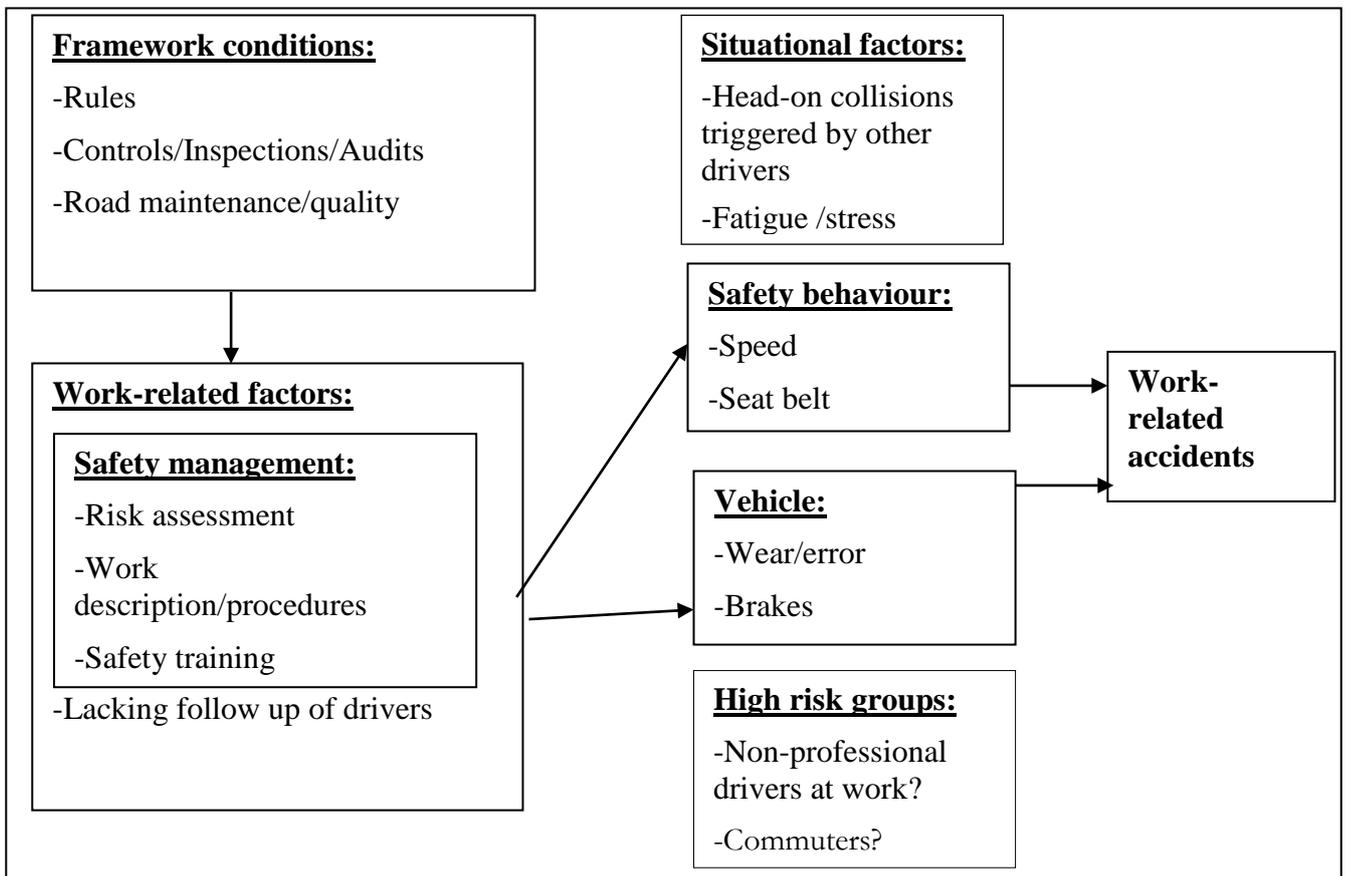


Figure S.2 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to operators and vehicles in work-related accidents in the road sector. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and qualitative data.

Results show that speeding and lack of seat belt use were typical risk factors related to drivers in serious accidents. AIBN-reports show that these risk factors often can be related to work-related factors like companies' follow up of drivers (e.g. speed, seat belt use, driving style), and companies' safety management systems (risk assessments, procedures, training). Additionally, AIBN-reports also show that work-related factors

often can be understood in light of framework conditions such as rules and safety requirements, controls, inspections, audits, and road maintenance and quality.

Results also show that professional drivers are less likely than other road users to trigger accidents. On the other hand, they are more likely than other road users to become involved in head-on collisions with drivers who are tired, ill, influenced by drugs or alcohol, speeding or intending to commit suicide.

Figure S.3 illustrates our hypothesized relationships between typical risk factors in maritime work accidents. The hypothesized relationships are based on our analyses of quantitative and qualitative data.

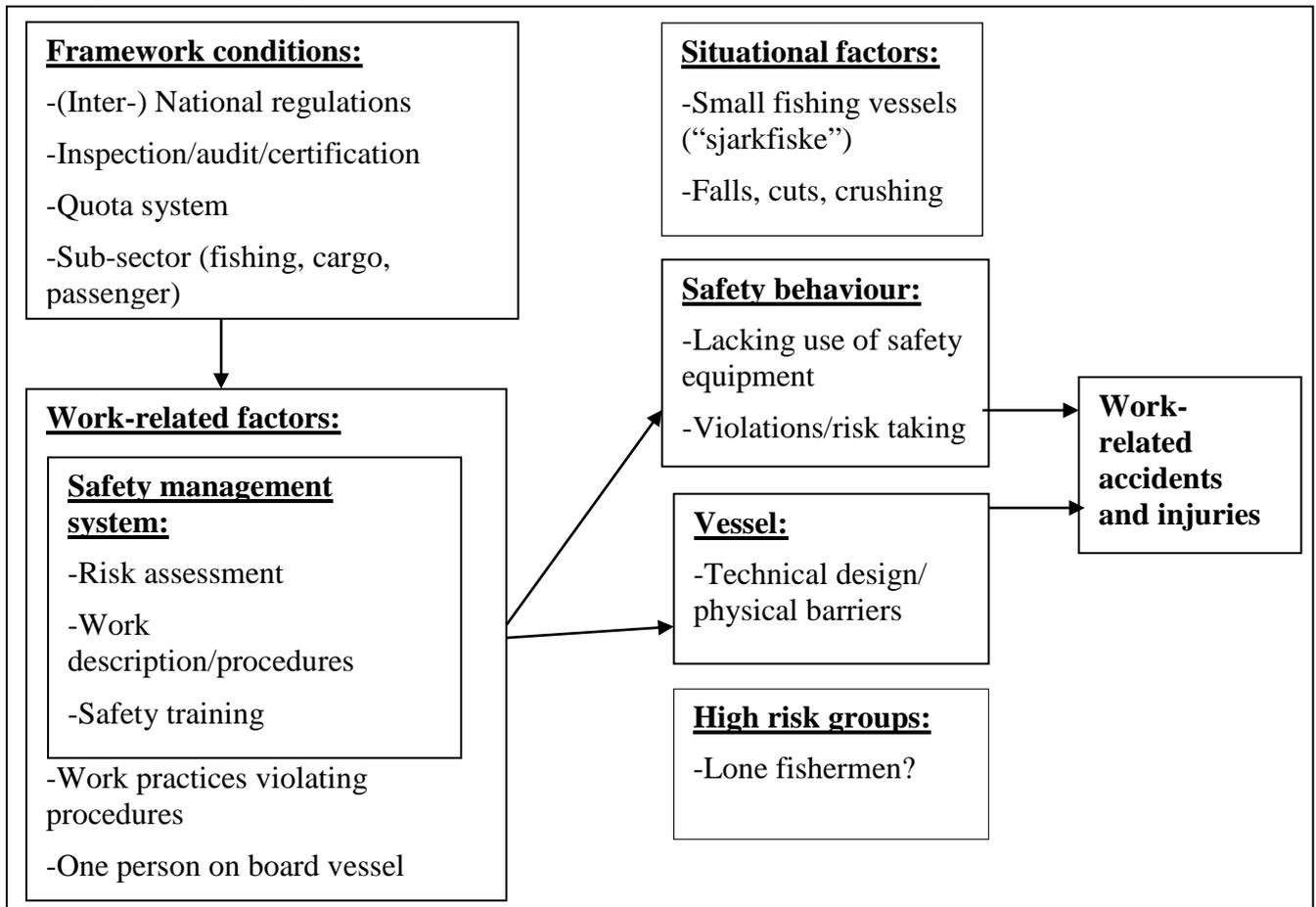


Figure S.3 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to safety behaviour/vessels. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and qualitative data.

Our analyses of the maritime work accidents were based on the NMA-database and AIBN-reports. These show that lack of use of safety equipment was the most frequent risk factors related to safety behaviour. The three elements that make up safety management systems were the most frequently mentioned work-related risk factors: risk assessments, safety procedures and safety training. Only one person aboard vessel was also a prevalent work-related risk factor. AIBN-reports also show that work-related factors often can be understood in light of shipping companies' and vessels' framework conditions, like international/national regulations, inspection/audit/certification, and organisation of the industry, (e.g quota systems).

The highest share of the people injured were fishermen, followed by sailors and engine room crew. A total of 77 % of the injuries involved Norwegians, while 9 % involved

crew from the Philippines. These shares are probably not representative of the population of seafarers in the NMA accident database, presumably due to national differences in reporting.

Injuries at dock seem to represent a potential high risk situation. Nearly a third of the injuries aboard the ships in our study occurred at dock with crew aboard the ship. Given the (presumably) fairly limited time spent at dock compared with the time spent at sea, future research should examine e.g. safety while at dock. Time spent at dock is probably hectic, as it requires a lot of work to be done within a given time, for instance loading/unloading and various maintenance work. The most prevalent injury types both at dock and at sea for fishing, cargo and passenger vessels were: falls, crushing and cut/stab injuries. Results indicate that small fishing vessels (sjark) with lone fishermen make up a high-risk group within the sector, both because of higher likelihood of accidents but also because the consequences of accidents are more severe when they are alone. AIBN-reports also indicate the need for clear national rules (and governmental regulation) applying to fishing vessels below 15 meters, e.g. requiring risk assessments. More research is needed on this issue.

Figure S4 illustrates our hypothesized relationships between typical risk factors in work accidents involving light inland helicopters. The hypothesized relationships are based on our analyses of quantitative and qualitative data

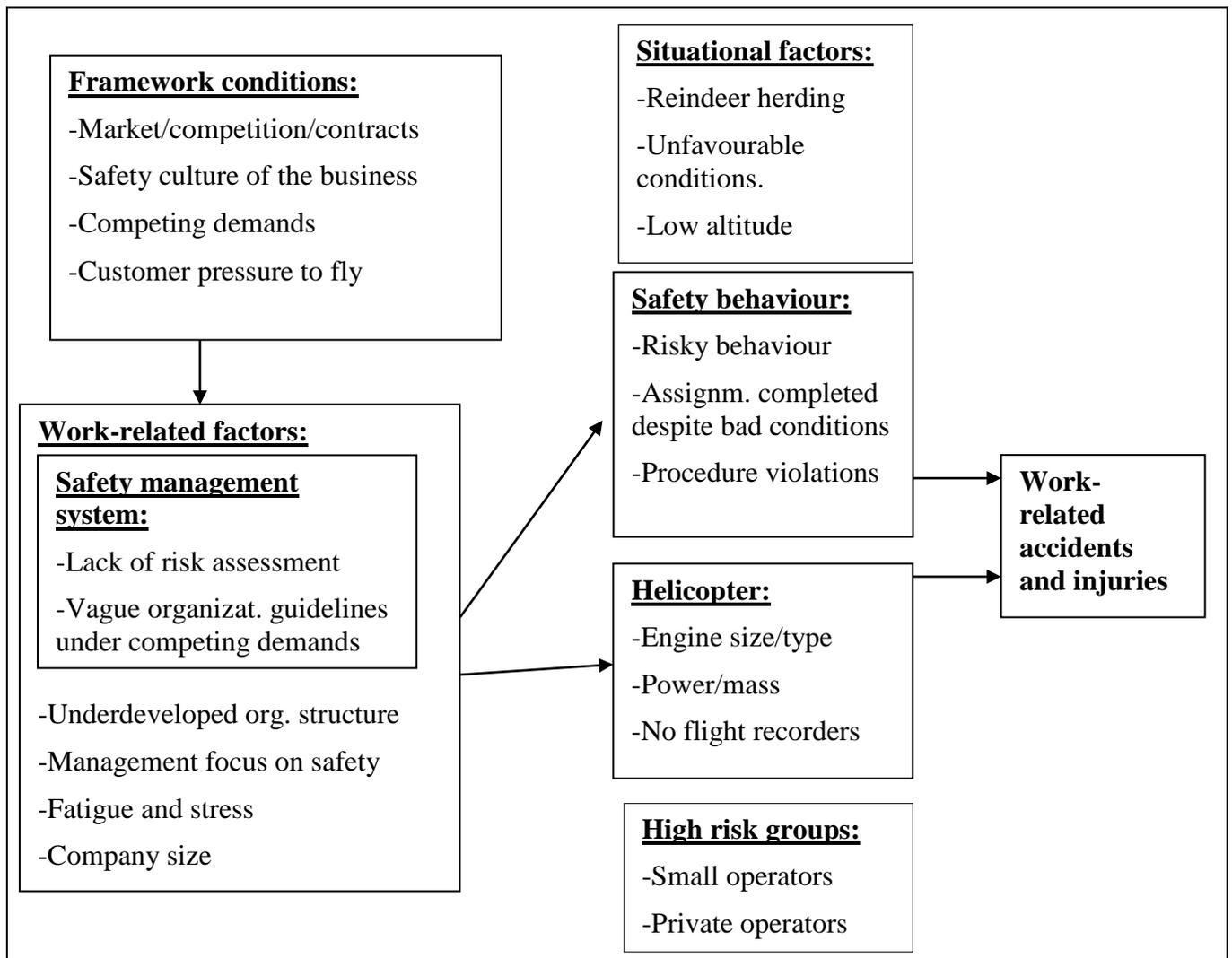


Figure S.4 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to pilots and helicopters. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and qualitative data.

Our results, based on a range of different surveys, interviews and analyses of accidents and accident data, show significant differences between companies' accident risk, depending on their size. Small operators (less than five helicopters) make up a high-risk group within the sector. Police and ambulance helicopters had the lowest risk. Private operators also make up a high-risk group, but are not (officially) "at work". These are not included in the main analyses.

Assignment completed in spite of unfavourable conditions and risky behaviours were the most frequent forms of unsafe pilot behaviour mentioned in the AIBN-reports. Unfavourable conditions could for instance refer to bad weather or darkness and low visibility. Pilots' choice to continue operations in spite of unfavourable conditions must be understood in light of work-related risk factors and framework conditions. Compared with ambulance and police pilots, pilots flying commercial aerial work (AW) and passenger transportation (PAX) experience more pressure to fly (from customers and flight operations managers), break safety regulations more often, fly more often in spite of being fatigued and in spite of poor weather conditions. Analyses indicate that some pilots find it hard to negotiate the competing demands of safety versus efficiency, and we have noted the need for clear - and clearly enforced - guidelines specifying when assignments should be aborted for safety reasons.

The AIBN refers to a general safety culture challenge in the business, stating that it is challenging for inland helicopter companies to create a safety culture influencing pilots to avoid risky behaviour when they are alone on an assignment, and "nobody" sees what they do. Market conditions, competition and contracts also influence helicopter safety. Large operators have long (governmental) contracts with detailed safety requirements, while small operators often have contracts limited for single assignments.

Reindeer herding represents a high-risk situation. We have seen that the fatal helicopter accidents are most likely to occur during operations with animals, like reindeer herding. This is time-critical work, dependent on how the herd moves in the terrain. Under these conditions, pilots fly close to the ground and sometimes under bad weather conditions.

Common risk factors in work-related transport accidents

Risky operator behaviour. Results show that risky operator behaviour is a common factor among transport operators in all transport sectors, e.g. speed too high for conditions, lack of information gathering, and mistaken decisions in the road sector. The NMA-data do not include information on risky behaviours of injured ship crew members, but information on behaviour is included in the AIBN-reports. "Risky behaviours" is also the most frequently mentioned factor in the AIBN-reports on helicopters, e.g. "assignment completed in spite of unfavourable conditions".

Lack of/lacking use of safety equipment. Another risk factor common to transport operators in all the three sectors was lack of safety equipment. Over half of the professional drivers involved in fatal accidents did not use a seatbelt at the time of the accident. In contrast, we saw that people who drove for leisure had a reported seat belt use that was nearly twice as high as those driving for work.

Safety management systems. Our analyses of AIBN-reports shows that the most frequently mentioned risk factor is lack of complete, written risk assessment. Risk assessment is the cornerstone in what AIBN road refers to as *safety management systems*, consisting of three elements:

- 1) Transport companies must perform (and document) risk assessments of critical operations.
- 2) These risk assessments must be used as the basis for job descriptions/ procedures that transport operators can consult prior to operations.
- 3) The risk assessments and job descriptions/procedures must be used as the basis for a training programme for transport operators to prepare them for the risks related to their work.

Taken together, these three processes summarize an ideal of how transport operators should relate to risk and how they should work with safety management. Future research should examine whether the implementation of safety management systems require a certain company size, as several AIBN aviation and maritime reports point to underdeveloped safety management systems in small transport organisations. The report discusses the focus on formalized risk analyses and safety management systems in accident investigation reports. It is suggested that future research should compare the existence of such systems in transport organisations that have been and not been involved in accidents, in order to judge its importance for safety.

Fatigue and stress. Our analyses of the AAG-data show that fatigue and stress are important risk factors for drivers triggering accidents at work. We have also seen that AW/PAX helicopter pilots experience more pressure from customers and flight operations managers to fly than police/ambulance pilots do. Unfortunately, we lack data on this in the maritime accidents we have studied.

Framework conditions. Our analyses of AIBN-reports indicate that the different framework conditions of transport companies often can be invoked to shed light on safety behaviours of transport operators, work-related risk factors and accidents. Typical framework conditions are national/international rules, regulation/inspection /controls and market/competition, customer pressure and the safety requirements in contracts.

Methodological limitations

Different events in different sectors are studied

It should be noted that we compare one small sub-sector in aviation with two large sectors in this study, and that we perhaps also would find sub-sectors within the road and maritime sectors that have not experienced the general risk reductions that we have seen in this study. It is also important to note that we study different kinds of events from different accident databases.

Identified risk factors reflect interpretations, and indicate suggestions for future research

As noted, the identification of the risk factors are first based on the interpretation of the people investigating and recording the accidents. This may be companies (e.g. in shipping) or police (e.g. in the road sector) or AIBN or AAG personnel, who are

professional investigators. Second, we have to some extent interpreted these risk factors in our analyses, e.g. categorizing them under common headings, and ascribed them status as risk factors related to framework conditions, work-related risk factors, risk factors related to vehicle/vessel, safety behaviour, and situational factors. Many of these are terms that are not used by the investigators themselves, and thus they are a result of our analysis. Third, we also present our hypotheses on relationships between the risk factors. These are, as we underline, only hypotheses, and should therefore be treated as suggestions for future research.

Are the identified risk factors also prevalent in organisations that have not been involved in accidents?

Above we presented our hypotheses about the relationships among risk factors. We do, however, not know the prevalence of these risk factors in organisations that have not been involved in accidents, and future research should therefore examine this in order to assess the importance of the risk factors that we have suggested.

Multivariate analyses are required for the road and maritime sector

Our analyses of risk factors in work-related road and sea transport accidents are mainly bivariate. When interpreting these results, we must remember that the observed relationships may be a result of confounding factors that we have not controlled for. This does not apply to helicopter results, which are based on a much broader set of data. Above we have suggested that company size may be such a confounding factor, that could provide an explanation of poor safety and poor safety management systems in small companies; small companies may sometimes have few resources for safety management; and thus lack safety management systems.

Underreporting of work-related transport accidents

In general, we found that about 30 % of the work accidents on Norwegian roads that involved vehicles which usually are driven by people at work (i.e. HGVs, buses, taxis) had a “missing” trip purpose in the accident database of Statistics Norway. This indicates underreporting of “work” as a trip purpose, which probably means that our estimates over drivers at work in some instances only cover 70 % of the actual numbers of drivers at work. This is why we term our estimates conservative.

Maritime data also indicate underreporting of foreign ships to Norwegian authorities. Although 99 % of the personal injuries were aboard ships flying the Norwegian flag, our analysis of data from the Norwegian Coastal Authority shows that 52 % of the cargo ships along the coast of Norway sailed under foreign flags in 2012 (Nævestad et al. 2014). Thus, we should expect more than about 1 % of the personal injuries on foreign ships in the period 2005-2013.

Missing information on work-related risk factors

The quantitative road accident database of Statistics Norway, the AAG-database and the sea accident database of the NMA include little information on work-related risk factors. We have largely relied on qualitative analyses of AIBN-reports to obtain information on this. We recommend that the accident databases should be improved in order to include a correct estimate of work-related accidents, and that the databases and the future registrations should be expanded to include work-related risk factors. Knowledge on work-related risk factors is key to informing preventive measures and improving transport safety.