TØI report 1428/2015

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

TØI Report
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Summary:

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 are 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. There are on average 15 ship crew members killed and 424 injured at work per year on Norwegian ships. Two crew members are in average killed/injured/ 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. Risky behaviour, lacking use of protective equipment, fatigue/stress and insufficient safety management systems were common risk factors in the sectors. Our analyses also indicate that framework conditions influence transport safety, and that current databases on work related accidents and risk factors are insufficient.

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Tittel: Arbeidsrelaterte ulykker i norsk veg-, sjø- og lufttransport: forekomst og risikofaktorer

Forfattere: Tor-Olav Nævestad, Ross Owen Phillips, Beate Elvebakk, Rolf Johan Bye, Stian Antonsen

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Sammendrag:

Studien kartlegger forekomsten av arbeidsrelaterte ulykker i vegtrafikk, sjøfart og luftfart (lett innlandshelikopter) og undersøker risikofaktorer knyttet til disse ulykkene, spesielt arbeidsrelaterte risikofaktorer. Rundt 40 % av vegtrafikkulykker er arbeidsrelatert. Et konservativt anslag antyder at omtrent 11 sjåfører i arbeid dør hvert år og at 287 skades årlig i arbeid på norske veger. Det skades totalt 1500 personer i disse ulykkene hvert år. I gjennomsnitt 8 førere på veg til/fra jobb dør og 286 skades hvert år. I gjennomsnitt omkommer årlig 15 mannskapsmedlemmer, mens 424 blir skadet på norske skip (2004-13). For innlandshelikopter blir to mannskapsmedlemmer i gjennomsnitt drept eller skadet per år, og selv om tallet er lavt sammenlignet med de andre sektorene, gjenspeiler det en høy ulykkesrisiko sammenlignet med annen luftfart. Risikoatferd, manglende sikkerhetsutstyr, trøtthet (fatigue)/stress og utilstrekkelige sikkerhetsstyringssystemer var felles risikofaktorer for sektorene. Analysene våre indikerer også at rammebetingelser påvirker transportsikkerheten, og at de eksisterende databasene om arbeidsrelaterte ulykker og risikofaktorer er utilstrekkelige.

This report is available only in electronic version.

Rapporten utgis kun i elektronisk utgave.

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Preface

This report on work-related accidents in road, sea and air (light helicopter inland) transport is part of a larger research project "Work-related accidents in road, sea and air transport: prevalence, causes and measures" which lasts for three years, from March 2014 to March 2017. The project is financed by the TRANSIKK program of the Research Council of Norway. Our contact persons at the Research Council of Norway have been Lise Johansen and Mette Brest Jonassen. The main aims of the project are to survey the prevalence, causes and understanding of work-related accidents in road, sea and air transport (light helicopter inland), and to provide a scientific knowledge base that can be used to develop measures against work-related risk factors. 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.

The study is based on accident databases from the Accident Analysis Groups (AAG) of the Norwegian Public Roads Administration (NPRA) and Statistics Norway's 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, 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).

The project involves cooperation with Rolf Johan Bye at Safetec and Stian Antonsen at Sintef. Safetec Nordic has, in collaboration with the Committee for helicopter safety - Inland operations, the Civil Aviation Authority (CAA) and the Ministry of Transport and Communications, assessed reported events with personal injury in inland helicopter from 2000 to 2012. These analyses were part of a larger project on safety in inland helicopter transportation. Results from this project were reported in 2013. The current report builds on and updates these analyses, in addition to summarizing results from previous analyses of the helicopter sector.

We are thankful to the members of the reference group of the project, who gave us valuable feedback in a meeting October, 2014, where we compared and discussed safety challenges in each of the studied transport sectors. We are also very thankful for the reference group members' comments on an initial version of the current report. The comments were very helpful, and we hope that we have been able to take them all into account.

Tor-Olav Nævestad has written the report with help from Ross Phillips, project leader Beate Elvebakk, Rolf Johan Bye (Safetec) and Stian Antonsen (Sintef). Phillips has conducted the analyses of AAG-data, while Bye and Antonsen have conducted and described the analyses of helicopter data. Nævestad has conducted analyses of Statistics Norway data for the road sector and the injury data from the Norwegian Maritime Authority. Elvebakk and Nævestad have conducted analyses of accident data in the reports of the AIBN.

Fridulv Sagberg is responsible for the quality assurance of the report, while Trude Rømming has prepared the report for publication.

Oslo, August 2015
Institute of Transport Economics

Gunnar Lindberg
Managing director

Fridulv Sagberg
Senior Research Psychologist

Contents

Abbreviations used in the report

AAG (UAG): Accident Analysis Groups

AW: aerial work

AIBN (SHT): Accident Investigation Board Norway

AIS: Automatic Identification System

CAA: Civil Aviation Authority (Norway)

HGV: Heavy Goods Vehicle

HSE: Health Safety & Environment

IC: Internal Control

LIA: Labour Investigation Authority

NIS: Norwegian International Ship Register

NMA: Norwegian Maritime Authority

NOR: Norwegian Ordinary Ship Register

NPRA: Norwegian Public Roads Authority

PAX: Passenger

SMS: Safety Management system

SN (SSB): Statistics Norway

WEA: Working Environment Act

Institute of Transport Economics
Norwegian Centre for Transport Research

Summary:

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

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Oslo 2015, 114 pages

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.

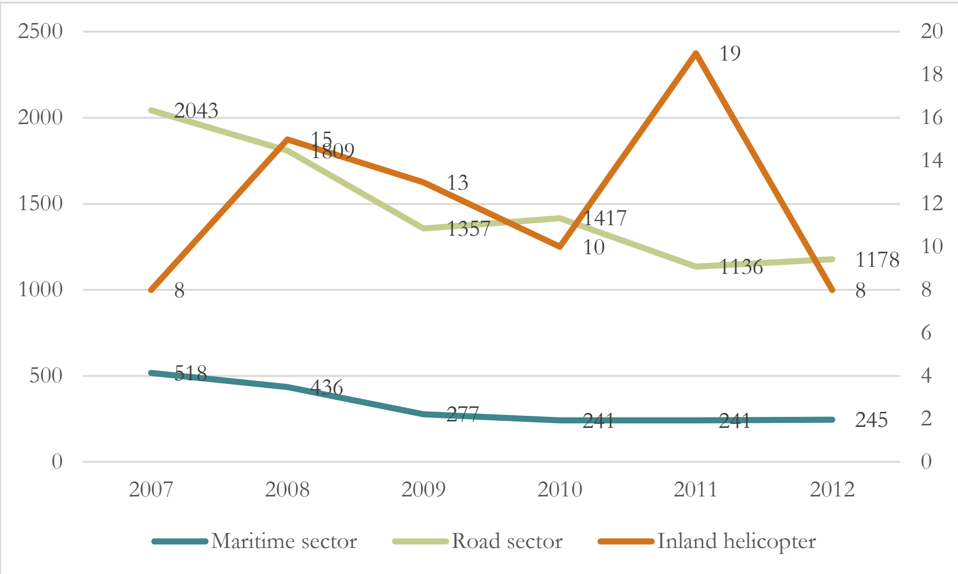

Figure S.1. Primary axis: Number of people injured in police reported traffic accidents in Norway 2007-2012, with work as the purpose of the trips and personal injuries per year for on vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign 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.

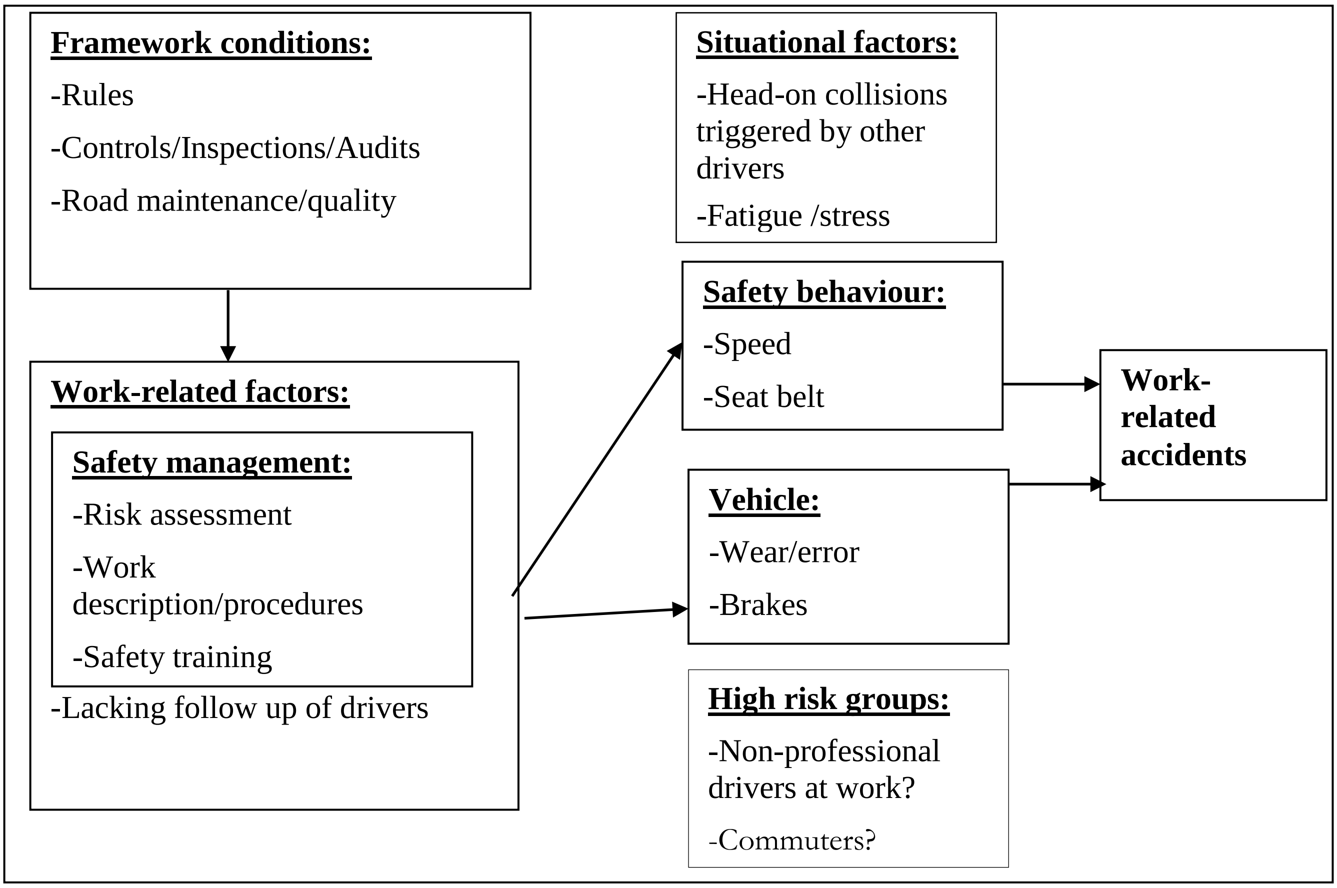

Figure S.2 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to operators and vehicles in work-related accidents in the road sector. Situational factors and potential high risk groups are also mentioned.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

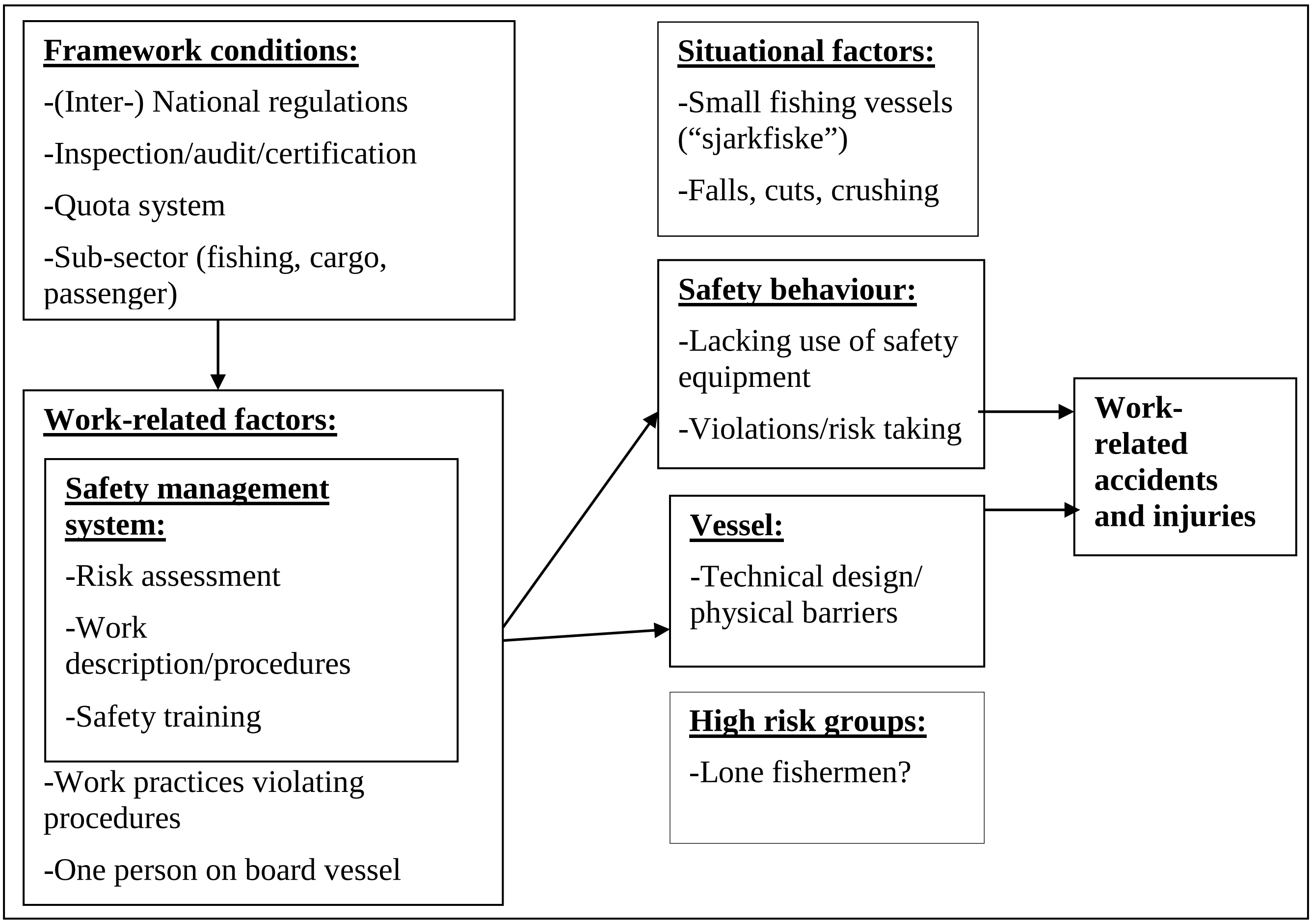

Figure S.3 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to safety behaviour/vessels. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative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

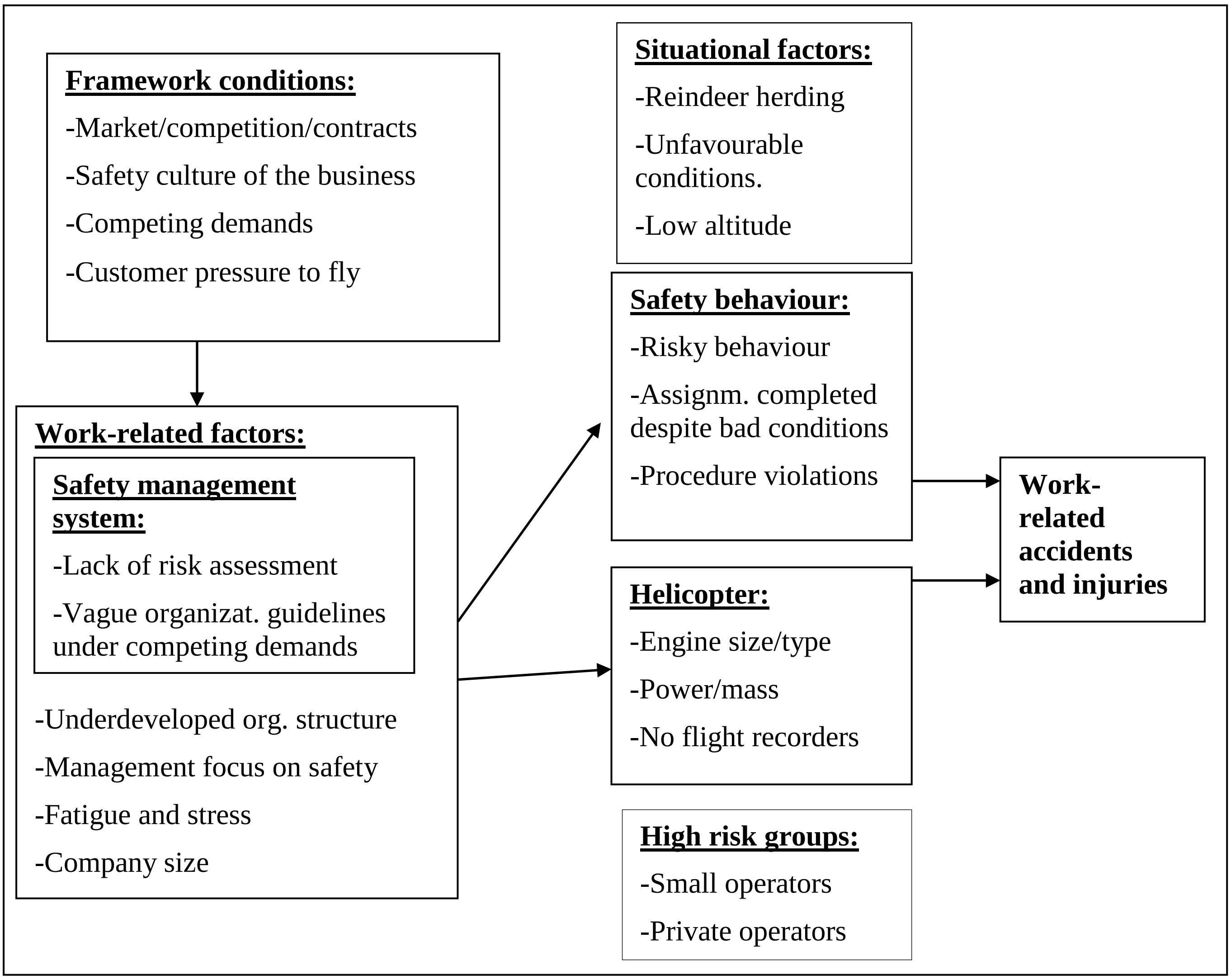

Figure S.4 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to pilots and helicopters. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and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

Sammendrag

Arbeidsrelaterte ulykker i norsk veg-, sjø- og lufttransport: forekomst og risikofaktorer

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Denne rapporten kartlegger forekomsten av arbeidsrelaterte ulykker i vegtrafikk, sjøfart og luftfart (lett innlandshelikopter) og undersøker risikofaktorer knyttet til disse ulykkene, spesielt arbeidsrelaterte risikofaktorer. Rundt 40 % av vegtrafikkulykker er arbeidsrelatert. Et konservativt anslag antyder at omtrent 11 sjåfører i arbeid dør hvert år og at 287 skades årlig i arbeid på norske veger. Det skades totalt 1500 personer i disse ulykkene årlig. I gjennomsnitt åtte personer dør mens de kjører til/fra jobb mens 286 skades hvert år. I gjennomsnitt omkommer årlig 15 personer i arbeid, mens 424 blir skadd på norske skip (2004-13). For innlandshelikopter blir to mannskapsmedlemmer i gjennomsnitt drept eller skadd per år, og selv om tallet er lavt sammenlignet med de andre sektorene, gjenspeiler det en høy ulykkesrisiko sammenlignet med annen luftfart (f.eks. ti ganger høyere enn for offshore helikoptre). Resultatene viser en betydelig nedgang i antall skadde i arbeidsrelaterte ulykker både innen vegtrafikk og sjøfart, og dette ser ut til å gjenspeile en redusert ulykkesrisiko. Ulykker med lette innlandshelikoptre har imidlertid ikke blitt redusert. Disse blir derfor identifisert som en mulig høyrisikogruppe, sammen med ikke-profesjonelle sjåfører i arbeid, sjåfører som kjører til/fra jobb, sjarkfiskere og små helikopteroperatører. Våre analyser indikerer at risikoatferd, manglende sikkerhetsutstyr, trøtthet (fatigue)/stress og utilstrekkelige sikkerhetsstyringssystemer er felles risikofaktorer for sektorene. Analysene våre indikerer også at rammebetingelser (f.eks. marked/konkurranse, lover og regelverk) influerer på transportsikkerheten. Rapporten antyder at de eksisterende databasene om arbeidsrelaterte ulykker og risikofaktorer er utilstrekkelige, på grunn av underrapportering og manglende informasjon om disse temaene.

Bakgrunn og mål for studien

Vi definerer arbeidsrelaterte transportulykker som ulykker som involverer en transportoperatør i arbeid, både ansatte og selvstendig næringsdrivende. Arbeidsrelaterte risikofaktorer viser til alle faktorer som kan spores til arbeidssituasjonen til transportoperatører i transportselskap, og som kan påvirke transportsikkerheten.

Selv om arbeidsrelaterte ulykker utgjør en betydelig andel av transportulykkene innen veg- og sjøtransport, mangler vi kunnskap om forholdet mellom ulykker og arbeidsrelaterte risikofaktorer i transportselskaper. En norsk studie viste nylig at 36 % av dødsulykker på norske veger involverte minst én sjåfør som var "på jobb" da ulykken skjedde. I 2013 registrerte Sjøfartsdirektoratet 499 sjøulykker med norskregistrerte fartøy. Rundt halvparten av disse ble klassifiserte som arbeids- og personulykke. Innen luftfarten er det nesten 20 år siden siste ulykke på et norsk rutefly, som medførte alvorlig skade eller død for passasjerer. Imidlertid har lett helikopter innland i mange år blitt betraktet som den mest ulykkesutsatte formen for kommersiell luftfart. Oppdrag med lette innlandshelikoptre har ti ganger høyere risiko enn det vi finner blant offshore helikoptre.

Siden vi mangler kunnskap om forholdet mellom ulykker og arbeidsrelaterte risikofaktorer i transportselskaper, er det vanskelig for både transportselskaper og regulerende myndigheter å forebygge disse på en systematisk måte.

Hovedmålene med denne studien er:

1) Å kartlegge omfanget av arbeidsrelaterte ulykker innen vegtransport, sjøfart og luftfart (lett helikopter innland).

2) Å undersøke risikofaktorer knyttet til arbeidsrelaterte ulykker innen vegtrafikk, sjøfart og luftfart, med spesielt fokus på arbeidsrelaterte risikofaktorer.

Studien som presenteres i den foreliggende rapporten, er en del av et større forskningsprosjekt "Arbeidsrelaterte ulykker i veg sjø og lufttransport: forekomst, årsaker og tiltak", finansiert av Forskningsrådets transportsikkerhetsprogram "TRANSIKK". Prosjektet varer i tre år, fra mars 2014 til mars 2017. I fortsettelsen av prosjektet undersøkes regulerende myndigheters og transportselskapers forståelse av sine roller og ansvar i forhold til arbeidsrelaterte risikofaktorer og ulykker. I tillegg skal prosjektet undersøke og foreslå spesifikke tiltak som transportselskaper og myndigheter kan iverksette for å redusere risikoen for arbeidsrelaterte transportulykker.

Datakilder og metoder

Innenfor vegsektoren benytter vi ulykkesdatabasene fra Statens vegvesens ulykkesanalysegrupper (UAG) over dødsulykker og Statistisk sentralbyrås (SSB) databaser over politirapporterte trafikkulykker med personskade. Innen sjøfart bruker vi Sjøfartdirektoratets databaser som omfatter alle sjøfartsulykker langs norskekysten, både med norskregistrerte og utenlandskregistrerte skip. Vi inkluderer også ulykker med norskregistrerte skip i andre farvann (NIS). Vi har studert rapporter fra Statens havarikommisjon for transport (SHT) innenfor alle de tre sektorene.

Våre analyser av helikoptersikkerhet bygger på et bredere sett med data og metoder enn analysene av sikkerhet på veg og sjø. Disse dataene var del av et større prosjekt om sikkerhet i innenlands helikoptertransport utført av Safetec Nordic i samarbeid med Flysikkerhetsforum, Luftfartstilsynet og Samferdselsdepartementet. Sluttrapporten for prosjektet ble publisert i 2013, og inneholdt data for perioden 2000-2011 (Bye et al. 2013a; Bye et al. 2013b). Den foreliggende studien gjennomfører nye analyser av datamaterialet, samt oppdaterer og oppsummerer resultater fra dette materialet, i tillegg til at det er gjort nye analyser av SHT-rapporter.

Omfang av arbeidsrelaterte ulykker

11 dødsfall og 287 skader blant sjåfører i arbeid hvert år

Et konservativt anslag basert på Statistisk sentralbyrås (SSB) database over politirapporterte ulykker med personskader 2007-2012 tyder på at 287 sjåfører i arbeid skades årlig på norske veger. Vi refererer til våre tall som konservative anslag, siden resultatene indikerer en andel på omtrent 30 % underrapportering av reiser med "arbeid" som formål, og at våre tall kanskje derfor kun dekker 70 % av det riktige antallet reiser med arbeid som formål. UAG-data viser at det i gjennomsnitt dør 11 sjåfører i arbeid i året på norske veger. Det skades totalt 1500 personer i disse ulykkene hvert år (287 av disse er som nevnt sjåfører i arbeid). Vi finner altså at flertallet av de skadde i ulykkene med sjåfører i arbeid er trafikanter som ikke er i arbeid, og at sjåfører i arbeid i lavere grad enn andre trafikanter skader seg i ulykkene de er involvert i.

Rundt 40 % av vegtrafikkulykker er arbeidsrelatert. SSB-data viser at 44 % av reisene i ulykker med personskade hadde «arbeid» (27 %), eller «til/fra arbeid» (17 %) som formål. Dette er i tråd med resultater fra EU-forskning, men Norge har høyere andeler arbeidsrelaterte vegulykker enn det man har funnet i en del andre land.

Andre sjåfører i arbeid som potensiell risikogruppe. UAG-data viser at 31 % av alle dødsulykker på veg involverte minst én yrkessjåfør i arbeid, mens 7 % involverte "andre" sjåfører i arbeid som ikke var yrkessjåfører. Resultatene tyder på at den sistnevnte gruppen kan være en høyrisikogruppe, siden ulykkestallene for denne gruppen ikke ser ut til ha falt i perioden 2005 til 2013, til tross for en klar reduksjon for andre ulykkestyper. Vi vet lite om sjåfører i arbeid som ikke er yrkessjåfører, og det er behov for mer forskning på denne gruppen.

Sjåfører som kjører til/fra arbeid som potensiell risikogruppe. UAG og SSB-data viser at et gjennomsnitt på 8 sjåfører som kjører til/fra arbeid dør hvert år mens 286 skades. Selv om sjåførene "i arbeid" er involvert i flere ulykker enn de som kjører "til/fra arbeid", er antallet skadde sjåfører per år temmelig likt for disse to gruppene. Det skyldes antakelig at sjåførene i arbeid i større grad kjører tunge kjøretøy (for eksempel lastebil, buss), som gir dem mer beskyttelse enn det sjåførene som kjører til/fra arbeid har i sine kjøretøy. Det er imidlertid ikke utenkelig at eksponeringen (millioner kjøretøy km) til sjåfører i arbeid er høyere enn eksponeringen til sjåfører som kjører til/fra arbeid. Det indikerer at sistnevnte gruppe kan ha høyere ulykkesrisiko. Fremtidig forskning bør innhente eksponeringsdata, slik at ulykkesrisikoen til de to gruppene kan sammenliknes.

SSB-data viser at 40 % av kjøretøyene som er involvert i arbeidsrelaterte ulykker, var tunge godsbiler, fulgt av personbiler og busser. UAG-data viser at rundt 90 % av yrkessjåførene som var involverte i dødsulykker, kjørte tunge kjøretøy, og at de fleste (65 %) av de ikke-profesjonelle sjåførene i arbeid kjørte person- eller varebiler da dødsulykken inntraff.

15 dødsfall og 424 skadde på norske skip hvert år

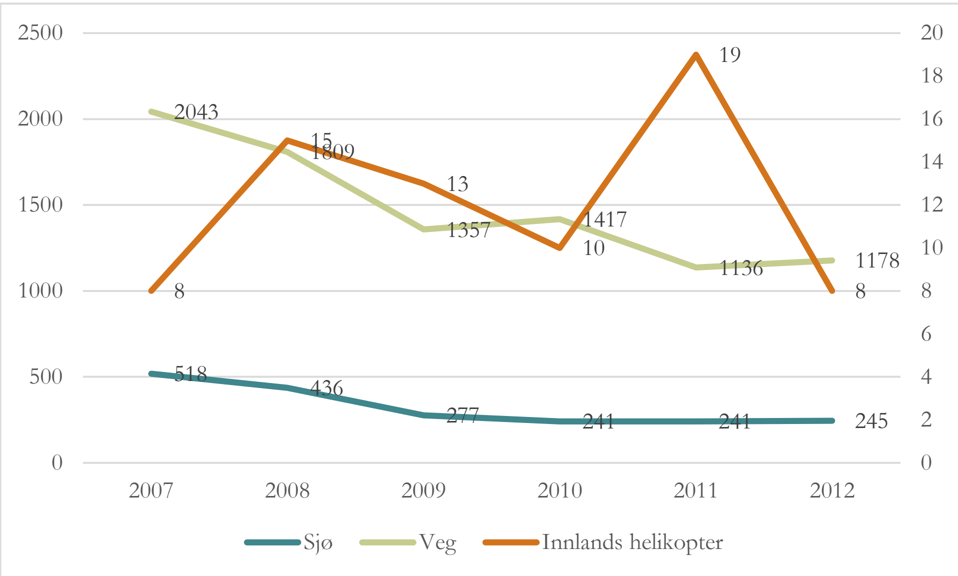
Vi har undersøkt antallet drepte og skadde personer i arbeid for norske (NIS/NOR) og utenlandskregistrerte fiskefartøy, lasteskip og passasjerskip i norsk farvann og for norskregistrerte skip (NIS) i utenlandsk farvann i perioden 2004-2013. I gjennomsnitt fant vi seks dødsfall og 129 skadde per år for fiskefartøy, åtte dødsfall og 170 skadde for lasteskip, og et dødsfall og 125 skadde for passasjerskip i perioden. Totalt utgjør dette 15 dødsfall og 424 skadde per år. Til sammenligning omkommer over 30 personer i fritidsbåtulykker hvert år. Andelen alvorlige skadde (over 72 timers fravær fra arbeid) var 15 prosentpoeng høyere for fiskefartøy enn for andre typer fartøy. Dette kan delvis bero på at mange av fiskerne har enkeltmannsforetak, og kanskje ikke ser nytten av å rapportere mindre ulykker. Europeisk statistikk fra European Maritime Safety Agency viser at det mellom 2011 og 2013 ble rapportert 4015 dødsfall på skip og 1801 yrkesulykker. De fleste hendelsene var på godsskip, etterfulgt av passasjerskip, servicefartøy og fiskefartøy.

Lave ulykkestall men høy risiko for lette innlandshelikoptre

Ti besetningsmedlemmer omkom og 16 ble skadd i 19 ulykker med lett helikopter innland i perioden 2000-2012. Basert på tallene fra 2000-2012, kan vi årlig forvente to havarier med lett helikopter innland, og med mer enn 50 % sannsynlighet for minst et dødsfall. Selv om de absolutte tallene er lave sammenlignet med andre transportsektorer, gjenspeiler de en høy ulykkesrisiko sammenlignet med andre former for luftfart, f.eks. mer enn ti ganger høyere enn risikoen for offshore helikoptre som opererer på norsk sokkel. En tidligere undersøkelse foreslår at dette kan skyldes store forskjeller relatert til helikoptertyper, navigasjonsinstrumenter, beskyttelsesutstyr, pilotenes erfaring (totalt antall flytimer), sammensetning av mannskap (bruk av co-piloter offshore i helikopter), flyprosedyrer (standardiserte flyprosedyrer offshore), opplæring (omfattende opplæring til offshorepiloter) og organisasjonsstørrelse.

Risikoutvikling i sektorene

Resultatene viser en generell nedgang i antall personskader i arbeidsrelaterte ulykker både innen vegtrafikk og sjøfart. Selv om vi har svært små tall når det gjelder lett helikopter innland, viser ikke disse den samme sterke og stabile nedgangen i perioden 2007-2012, som illustrert i figur S.1.



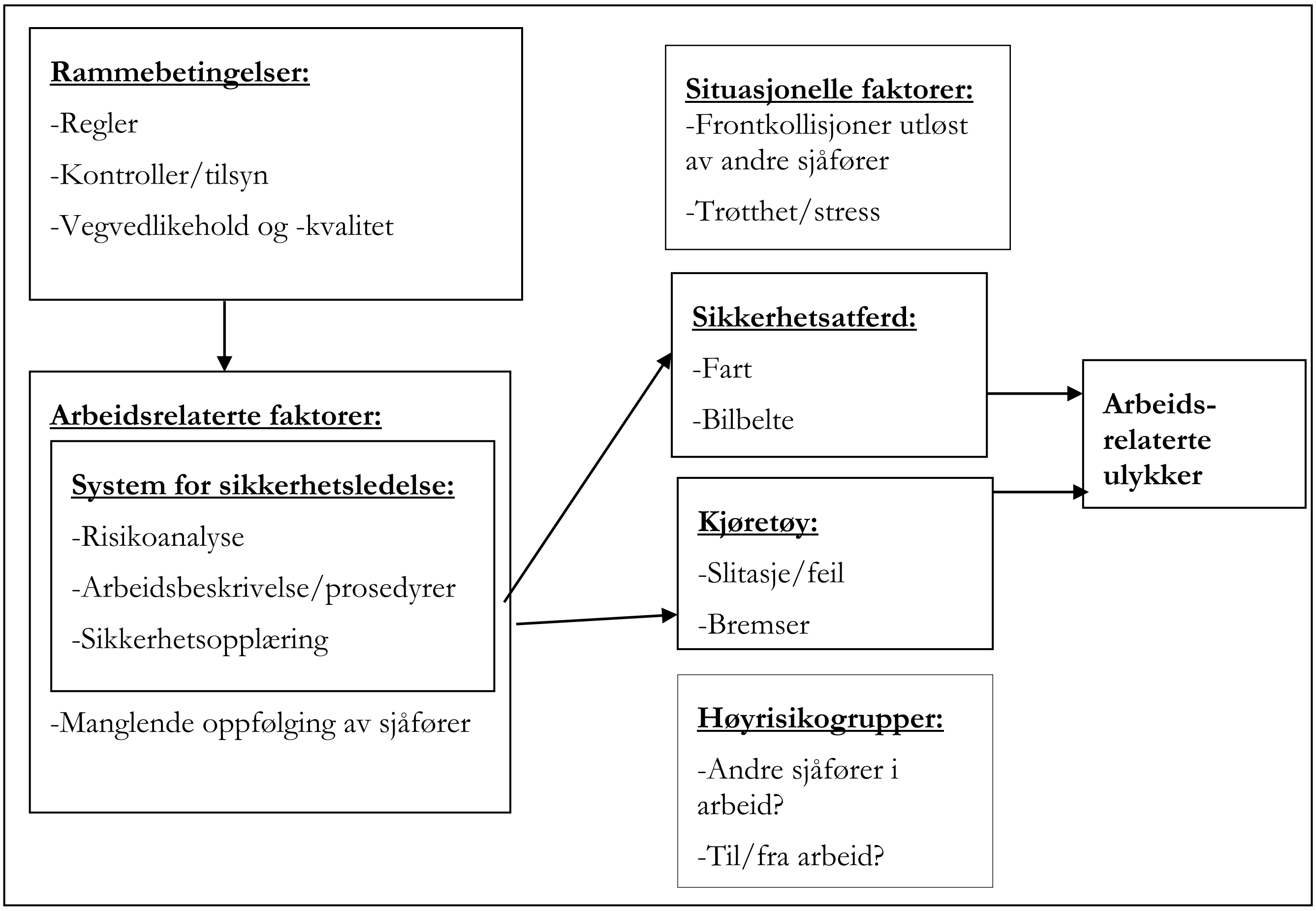
Figur S.1. Primærakse: personer skadd i politirapporterte trafikkulykker i Norge 2007-2012, der "arbeid" var oppgitt som formålet med turen, og personskade per år for norskregistrerte (NIS/NOR) og utenlandskregistrerte fartøy i norsk farvann, og norskregistrerte fartøy i utenlandsk farvann i perioden 2007-2012. Sekundærakse: hendelser med personskade og/eller materiellskade i norsk innlandshelikopter per år 2007-2012. Absolutte tall.

Figur S.1 viser tendensene i *absolutte tall* for skader og hendelser. Analyser av ulykkesrisiko (som tar hensyn til eksponeringsmål) indikerer at tendensen i absolutte tall som fremkommer i figur S1 gjenspeiler en redusert risiko for arbeidsulykker, i hvert fall innen vegtrafikk og sjøfart. Våre risikoestimater for innlandshelikopter viser ikke noen klare tendenser. Igjen er det viktig å understreke at disse estimatene er basert på lave ulykkestall sammenlignet med de andre sektorene.

Sektorspesifikke risikofaktorer i arbeidsrelaterte ulykker

I det følgende presenteres sektorspesifikke og felles risikofaktorer i arbeidsrelaterte transportulykker. Det er viktig å merke seg at identifiseringen av risikofaktorene er basert på tolkninger og skjønn fra personene som har registrert og eventuelt gransket ulykkene, i tillegg til at vi har tolket risikofaktorene i våre analyser. I tillegg er våre hypoteser om sammenhenger mellom risikofaktorene også basert på skjønn og tolkninger. Vi understreker at dette kun er hypoteser og at de derfor må leses som forslag til videre forskning på temaet.

Figur S.2 illustrerer våre hypoteser om sammenhenger mellom typiske risikofaktorer og ulykker i arbeidsrelaterte ulykker på norske veger. De hypotetiske sammenhengene er basert på våre analyser av kvalitative og kvantitative data.

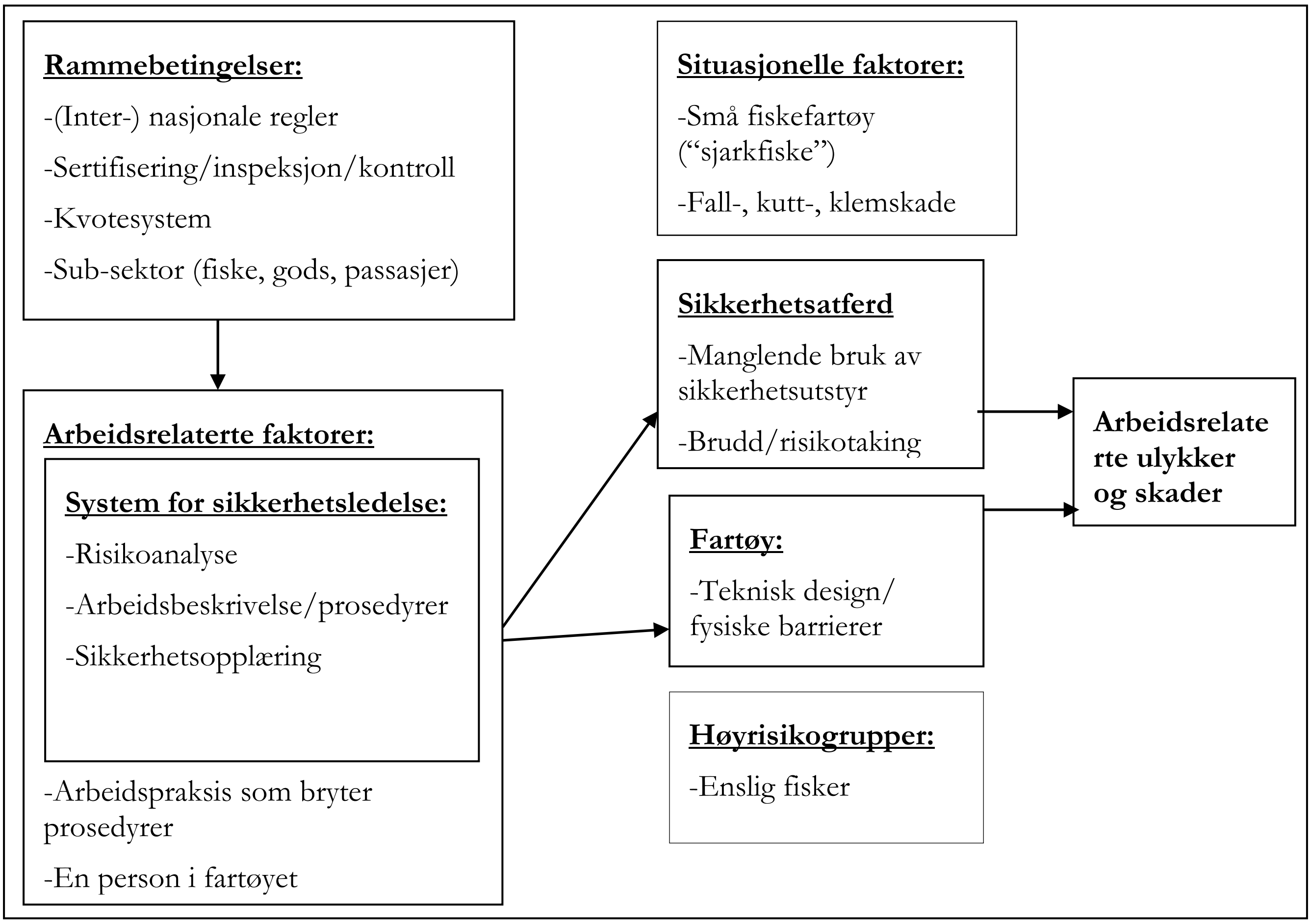


Figur S.2 Illustrasjon av hypoteser om sammenhenger mellom typiske risikofaktorer knyttet til rammebetingelser, arbeidsrelaterte faktorer og risikofaktorer knyttet til operatører og kjøretøy i arbeidsrelaterte ulykker innen vegsektoren. Situasjonelle faktorer og potensielle høyrisikogrupper er også inkludert i modellen. Hypotesene er basert på våre analyser av kvantitative og kvalitative data.

Resultatene viser at for høy fart og manglende bruk av bilbelte var de hyppigst nevnte risikofaktorene knyttet til sjåfører i de alvorlige ulykkene. SHT-rapporter viser at disse risikofaktorene kan ses i sammenheng med arbeidsrelaterte faktorer som selskapenes oppfølging av sjåførene (f.eks. når det gjelder fart, beltebruk og kjørestil), og med selskapene sikkerhetsstyringssystemer (risikoanalyse, prosedyrer, opplæring). SHTs rapporter viser i tillegg at arbeidsrelaterte faktorer ofte kan forstås i lys av selskapenes rammebetingelser, som regler og sikkerhetskrav, kontroll, inspeksjon, tilsyn og vedlikehold samt tilstand på vegen.

Yrkessjåfører har mindre sannsynlighet enn andre trafikanter for å utløse ulykker. På den annen side har de høyere risiko enn andre for å bli involvert i ulykker der det andre kjøretøyet kommer over i motgående kjørefelt som følge av trøtthet, alkohol- eller medikamentpåvirkning, høy fart eller ønske om selvmord.

Figur S.3 illustrerer våre hypoteser om sammenhenger mellom typiske risikofaktorer ved arbeidsrelaterte ulykker i maritim sektor. De hypotetiske sammenhengene er basert på våre analyser av kvalitative og kvantitative data.



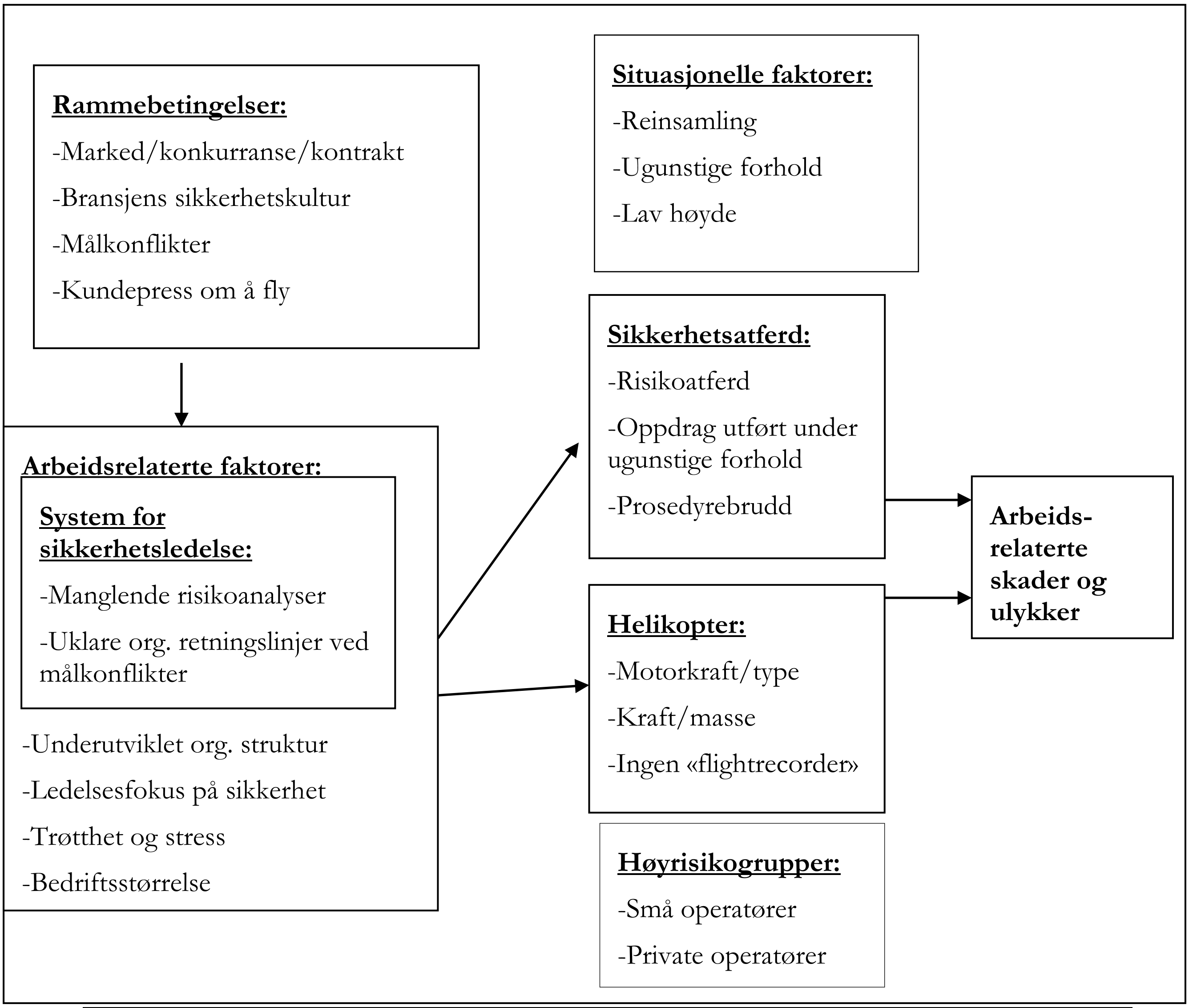
Figur S.3 Illustrasjon av hypoteser om sammenhenger mellom typiske risikofaktorer knyttet til rammebetingelser, arbeidsrelaterte faktorer og risikofaktorer knyttet til sikkerhetsatferd og fartøy. Situasjonelle faktorer og potensielle høyrisikogrupper er også inkludert i modellen. Hypotesene er basert på våre analyser av kvantitative og kvalitative data.

Våre analyser av arbeidsrelaterte ulykker i maritime sektor er basert på Sjøafartsdirektoratets ulykkesdatabase og SHT-rapporter. Disse viser at manglende bruk av sikkerhetsutstyr var den vanligste risikofaktoren knyttet til sikkerhetsatferd. De hyppigst nevnte arbeidsrelaterte risikofaktorene var: risikoanalyse, sikkerhetsprosedyrer og sikkerhetsopplæring. Disse utgjør til sammen det som SHT-veg kaller for et «system for sikkerhetsledelse». En annen utbredt arbeidsrelatert risikofaktor var fartøy bemannet med én person. SHT-rapportene viser også at arbeidsrelaterte faktorer ofte kan forstås i lys av rederienes og fartøyenes rammebetingelser, som internasjonale/nasjonale regelverk, inspeksjon/tilsyn/sertifisering, og organiseringen av næringen, som kvotesystemer.

Flertallet av de tilskadekomne var fiskere, fulgt av matroser og mannskap i maskinrom. 77 % av de tilskadekomne var nordmenn, mens 9 % var fra Filippinene. Disse andelene er trolig ikke representative, på grunn av antatte nasjonale forskjeller når det gjelder rapportering.

Nesten en tredjedel av skadene skjedde mens fartøyene lå ved havn. Gitt den (antatt) begrensede tiden tilbrakt ved havn sammenlignet med tid til havs, bør fremtidig forskning vurdere forekomst av ulykker mens fartøyene ligger til havn. Denne tiden kan være hektisk, siden mye skal skje på en gang, f.eks. lasting/lossing og forskjellig vedlikeholdsarbeid. De vanligste skadetypene både ved havn og undervegs på fiskefartøy, lasteskip og passasjerskip var fall, klemskader og kuttskader. Endelig indikerer resultatene at små fiskefartøy (sjark) med enslig fisker om bord er en høyrisikogruppe. SHT-rapporter indikerer også at det er behov for et tydelig regelverk (og oppfølging fra myndighetene) rettet mot fiskefartøy under 15 meter, for eksempel regler med krav om systematiske risikoanalyser. Det er behov for videre forskning på denne gruppen.

Figur S.4 illustrerer våre hypoteser om sammenhenger mellom typiske risikofaktorer i arbeidsrelaterte ulykker med lett helikopter innland. De hypotetiske sammenhengene er basert på våre analyser av kvalitative og kvantitative data.



Figur S.4 Illustrasjon av hypoteser om sammenhenger mellom typiske risikofaktorer knyttet til rammebetingelser, arbeidsrelaterte faktorer og risikofaktorer knyttet til piloter og helikoptre. Situasjonelle faktorer og potensielle høyrisikogrupper er også inkludert i modellen. Hypotesene er basert på våre analyser av kvantitative og kvalitative data.

Våre resultater, som er basert på en rekke ulike spørreundersøkelser, intervjuer og analyser av ulykker og ulykkesdata, viser signifikant sammenheng mellom selskapers ulykkesrisiko og selskapsstørrelse. Små selskaper (færre enn fem helikoptre) utgjør en høyrisikogruppe innen sektoren. Den laveste risikoen har politi- og ambulansehelikoptre. Private operatører utgjør også en høyrisikogruppe, men er ikke (offisielt) i arbeid.

De hyppigst nevnte formene for usikker pilotatferd i SHTs rapporter var oppdrag som ble gjennomført til tross for ugunstige forhold og risikoatferd. Ugunstige forhold kan f.eks. bestå i dårlig vær eller mørke og dårlig sikt. Pilotenes avgjørelse om å gjennomføre oppdrag til tross for ugunstige forhold må forstås i lys av arbeidsrelaterte risikofaktorer og rammebetingelser. Sammenlignet med politi- og ambulansepiloter, opplever piloter som driver med ulike kommersielle oppdrag "aerial work" (AW) og passasjertransport (PAX) større press fra sine kunder og operasjonsledere om å fly, de bryter oftere sikkerhetsregler, og flyr oftere når de er trøtte eller under dårlige værforhold. Analysene tyder på at noen piloter har problemer med å finne balansen mellom krav til sikkerhet og effektivitet, og vi ser et behov for klare – og klart håndhevede – retningslinjer som angir når oppdrag bør avbrytes av sikkerhetshensyn.

SHT trekker frem sikkerhetskultur som en generell utfordring innenfor bransjen, ved at det er utfordrende for helikopterselskapene å skape en sikkerhetskultur som gjør at pilotene unngår risikoatferd når de er alene på oppdrag, og ingen observerer hva de gjør. Marked, konkurranse og kontrakter virker også inn på helikoptersikkerhet. Store selskaper har ofte langsiktige kontrakter med offentlige etater som stiller detaljerte sikkerhetskrav, mens små selskaper ofte har kontrakter for enkeltoppdrag.

Reinsamling representerer en risikosituasjon. Vi ser at dødsulykker med helikopter er mest utbredt under oppdrag med dyr, som reinsamling. Dette er tidskritisk arbeid, hvor man må tilpasse seg til hvordan dyrene beveger seg i terrenget. Dette gjør at pilotene flyr nær bakken og tidvis under dårlige værforhold.

Felles risikofaktorer for arbeidsrelaterte ulykker

Risikabel transportoperatøratferd. Resultatene viser at risikabel atferd er en faktor som går igjen innen alle de tre sektorene, f.eks. for høy fart etter forholdene, manglende informasjonsinnhenting eller feilbeslutninger innen vegtrafikk. Dataene fra Sjøfartsdirektoratet omfatter ikke informasjon om risikabel atferd hos tilskadekommet mannskap, men denne informasjonen finnes i rapportene fra SHT. "Risikoatferd" er også den hyppigst nevnte faktoren i SHTs rapporter om helikopterhendelser, som f.eks. "oppdrag gjennomført til tross for ugunstige forhold".

Manglende bruk av sikkerhetsutstyr. En annen felles risikofaktor som vi fant i alle sektorene var manglende bruk av sikkerhetsutstyr. Over halvparten av yrkessjåførene som var involvert i dødsulykker, brukte ikke bilbelte. Beltebruken var til sammenligning nesten dobbelt så høy blant fritidssjåførene.

Sikkerhetsstyringssystemer. Vår analyse av SHT-rapportene avdekker at den hyppigst nevnte risikofaktoren er mangel på fullstendig, skriftlig risikovurdering. Risikovurderingen er hjørnesteinen i det SHT-veg omtaler som *sikkerhetsstyringssystemer*, og som består av tre elementer:

1) Transportselskaper skal gjennomføre (og dokumentere) risikovurderinger av kritiske operasjoner.

2) Disse risikovurderinger skal brukes som grunnlag for arbeidsbeskrivelser/ prosedyrer som operatørene kan konsultere før oppdrag gjennomføres.

3) Risikovurderinger og arbeidsbeskrivelser/prosedyrer skal brukes som grunnlag for opplæringsprogrammer for operatørene, som forbereder dem på risikoene de møter i sitt arbeid.

Disse tre prosessene representerer til sammen et ideal for hvordan transportbedrifter bør forholde seg til risiko og arbeide med sikkerhetsstyring. Videre forskning bør undersøke om innføring av sikkerhetsstyringssystemer krever en viss selskapsstørrelse, siden flere rapporter fra SHT luftfart og sjø peker på at små transportselskaper har underutviklede sikkerhetsstyringssystemer. Rapporten diskuterer betydningen som ulykkesgranskninger legger på formaliserte risikoanalyser og sikkerhetsstyringssystemer. Det foreslås at fremtidig forskning sammenlikner eksistensen av slike formelle systemer i transportorganisasjoner som har og som ikke har vært involvert i ulykker for å vurdere betydningen av sikkerhetsstyringssystemer for sikkerheten.

Trøtthet (fatigue) og stress. Våre analyser av UAG-data viser at trøtthet og stress er viktige risikofaktorer for de ulykkesutløsende sjåførene i arbeid. Vi ser også at AW/PAX helikopterpiloter opplever sterkere press fra kunder og operasjonsledere for å fly enn politi/ambulansehelikopterpiloter. Dessverre mangler vi data om denne risikofaktoren når det gjelder sjøfartsulykker.

Rammebetingelser. Vår analyse av SHT-rapporter tyder på at transportselskapenes ulike rammebetingelser ofte kan kaste lys over operatørenes sikkerhetsatferd, risikofaktorer og ulykker. Typiske rammebetingelser er nasjonalt og internasjonalt regelverk, regulering/tilsyn/kontroll, marked/konkurranse, press fra kunder og sikkerhetskrav i kontrakter.

Metodologiske begrensninger

Studien fokuserer på ulike hendelser i forskjellige sektorer

I denne studien sammenlikner vi en liten subsektor innenfor luftfart med to store transportsektorer, og vi kan ikke utelukke at vi også kan finne subsektorer innenfor veg- og sjøtransport som heller ikke har hatt de samme betydelige nedgangene i ulykker som det vi har sett i denne studien. Det er også viktig å huske at vi sammenlikner ulike typer hendelser fra ulike databaser.

De identifiserte risikofaktorene er et resultat av tokning, og de må forstås som forslag til videre forskning

Som nevnt er identifiseringen av risikofaktorene basert på skjønn, for det første fra personene som har registrert og eventuelt gransket ulykkene. Dette kan være selskapene selv (i maritim sektor) eller politiet (i vegsektoren), eller profesjonelle granskere fra SHT eller UAG. For det andre har vi tolket risikofaktorene i våre analyser, f.eks. når vi plasserer risikofaktorer under de samme overskriftene og når vi kategoriserer dem som risikofaktorer relatert til rammebetingelser, arbeidsrelaterte forhold, fartøy, sikkerhetsatferd eller situasjonelle faktorer. Dette er i stor grad begreper som ikke brukes av granskerne eller de som registrerer ulykkene. For det tredje er også våre hypoteser om sammenhenger mellom risikofaktorer basert på våre tolkninger. Vi understreker at dette kun er hypoteser og at de derfor må leses som forslag til videre forskning på temaet.

Er de identifiserte risikofaktorene også tilstede i samme utstrekning i organisasjoner som ikke har vært involvert i transportulykker?

Vi har presentert våre hypoteser om sammenhenger mellom risikofaktorer over. Vi vet imidlertid ikke forekomsten av disse risikofaktorene i transportbedrifter som ikke har vært involvert i ulykker. Fremtidig forskning bør derfor fokusere på dette temaet, for å undersøke betydningen av de risikofaktorene vi har foreslått.

Det bør utføres multivariate undersøkelser for veg og sjø

Våre analyser av risikofaktorer i arbeidsrelaterte transportulykker på veg og sjø er stort sett bivariate, og kan derfor være resultat av såkalte spuriøse effekter, som betyr at det vi tror er en sammenheng mellom to variabler egentlig er et resultat av en tredje variabel som påvirker begge. Når vi tolker resultatene for veg og sjø, må vi derfor være oppmerksomme på mulighetene for slike tredjevariabler. Vi har f.eks. foreslått at bedriftsstørrelse kan være en slik tredjevariabel som kan kaste lys på utilfredsstillende sikkerhet og dårlig utviklede sikkerhetsstyringssystemer i små bedrifter; små selskaper kan noen ganger ha få ressurser til å innføre slike styringssystemer.

Underrapportering av arbeidsrelaterte ulykker i transport

Våre data indikerer at "arbeid" som turformål er underrapportert i SSBs statistikk over vegtrafikkulykker. Omtrent 30 % av ulykkene som involverte kjøretøy som vanligvis kjøres av yrkessjåfører (vogntog, buss, taxi) hadde ikke oppgitt formål for turen i SSBs database. Dette betyr antakelig at våre estimater over førere i arbeid i noen tilfeller kun dekker 70 % av det reelle antallet førere i arbeid. Det er derfor vi betegner estimatene som konservative. Data fra sjøfarten tyder også på en underrapportering fra utenlandske skip til norske myndigheter. Selv om 99 % av personskadeulykkene skjedde på norskregistrerte skip, viser vår analyse av Kystverkets AIS-data at 52 % av lasteskipene langs norskekysten var utenlandskregistrerte i 2012. Vi ville derfor forvente at en høyere andel av personskadeulykker på utenlandskregistrerte skip i perioden 2005-2013.

Manglende informasjon om arbeidsrelaterte risikofaktorer

SSB-databasen over vegtrafikkulykker, UAG-databasen og Sjøfartsdirektoratets sjøfartsulykkedatabase inneholder lite informasjon om arbeidsrelaterte risikofaktorer. Vi har hovedsakelig benyttet SHTs rapporter for å finne informasjon om disse. Vi anbefaler at ulykkesdatabasene forbedres slik at de gir et korrekt estimat over arbeidsrelaterte ulykker, og at databasene utvides slik at fremtidige registreringer også omfatter arbeidsrelaterte risikofaktorer. Økt kunnskap om arbeidsrelaterte risikofaktorer er en forutsetning for å kunne utforme målrettede tiltak mot ulykker og forbedre transportsikkerheten i fremtiden.

1 Introduction

1.1 Background

1.1.1 A substantial share of transport accidents are work-related

Forty-four people were killed at work in Norway in 2014, and land-based transport was placed in the top three out of eleven work sectors in terms of fatality numbers (LIA 2015). Although substantial shares in the accident statistics of road and maritime transport are work-related accidents, 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). Being a professional driver is a high risk occupation; that becomes evident when we compare risk per million man hours with other occupations. Data from 1988-1993 show that the risk of professional drivers was 9.5 deaths per 1000 million man-hours, while it was three for other occupations (Fosser og Elvik 1996, Elvik 2005). In 2013, 499 maritime accidents were registered by the Norwegian Maritime Authority (NMA) (2014). About half of these were labelled work/personnel accidents. Nearly 20 years have passed since the last time there was an 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 as the most accident prone sector within commercial aviation, with ten times higher risk than offshore helicopters.

1.1.2 Knowledge is lacking on work-related risk factors

The Norwegian Work Environment Act (WEA) of 1977 obliges transport organisations to facilitate good transport safety for their employees through their Health, Safety and Environment (HSE) work. In line with this, the Norwegian 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. This means setting safety objectives, defining responsibilities, identifying HSE problems, obtaining overviews of laws, planning HSE measures and following up and undertaking annual reviews of the company's HSE work together with safety representatives. The WEA applies to companies with employees in all sectors except shipping, fishing, trapping and military aviation. Thus, the WEA applies to the road sector and civil aviation. The latter has has a sector-specific provision on working environment. The CAA was given the main regulatory responsibility for working environment in avation in 2010, and cooperates with the LIA: CAA regulates activities in the air, while LIA regulates activities on the ground. Finally, the WEA does not apply to the maritime sector, which has its own laws governing working environment: the Ship Labour act with its associated provisions, and the rules on working hours for seafarers.

Norway's National Transport Plan (2010-2019) underlines that organisations should include transport safety as an important part of their HSE-work. This is also emphasized by the European Occupational Safety and Health Agency (OSHA 2012), and the European Transport Safety Council (ETSC 2010).

A lack of knowledge on work-related contributors to accidents in transport organisations could mean that these important risk factors not being addressed, both by transport organisations and by regulatory authorities (Nævestad & Phillips 2013; Bye et al. 2013a; Norwegian Maritime Authority 2011: 12). Work-related risk factors refer to all factors that can be traced to transport operatorswork situation, and which may influence transport safety (Nævestad & Phillips 2013).

It has been suggested that it is difficult to regulate safety in transport organisations, as employees generally are on the move, away from the main offices (Nævestad & Phillips 2013). Shared and overlapping areas of responsibility between authorities may also hamper an efficient focus on organisational conditions for transport safety.

There are, however, important differences between transport sectors. While neither regulators nor transport companies in the road sector seem to have a sufficient focus on organisational preconditions for transport safety (Nævestad & Phillips 2013), the aviation industry is considered to have an exemplary safety level because of the strong focus on work-related risk factors, both among companies and regulators (Hudson 2003).There are however differences within the aviation sector. Light helicopter inland, which represents the aviation transport with the highest accident risk are facing challenges related to both work-related risk factors and framework conditions (Bye et al. 2013a; Civil Aviation Authority 2013a). This is why we focus on light helicopter inland in this study.

There is also potential for improvement when it comes to the maritime industry's focus on organisational risk factors. The Norwegian Maritime Authority stresses that the majority of the approximately 500 accidents reported per year is not subject to any official in-depth investigation or inquiry with regards to causal relations. Thus most of the data in the database is based upon shipowners subjective reports. As per NMA experience, reports generally have poor information on underlying latent causes. Knowledge on work-related risk factors is important, as a better focus on work-related, underlying organisational causes in transport organisations may inform preventive measures and improve transport safety (Banks 2008; Gregersen, Brehmer & Morén 1996; Murray, Ison, Gallemore & Nijjar 2009; Norwegian Maritime Authority 2011).

1.2 Aims of the study

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 for work-related accidents in Norwegian road, sea and air transport, with a specific focus on work-related risk factors, i.e. all factors that can be traced to transport operators' work situation, and which may influence transport safety. The present study primarily focuses on the prevalence of, and descriptions of these risk factors.

2 Methods

2.1 Introduction

In the present chapter we describe how we will map the prevalence of work-related accidents in Norwegian road, sea and air (light helicopter inland) transport, and examine the risk factors for work-related accidents in these sectors. This report does not consider work-related transport accidents in the rail sector. We consider work-related transport safety standards in rail already to be high relative to the road and maritime sectors in general, and relative to the private light helicopter branch. The last serious passenger rail accident occurred in Norway in Åsta in 2000 and, although they occur more often, cargo rail accidents also occur relatively infrequently. The main challenge for rail safety is unlawful trespass on tracks and level crossing incidents, which the public are largely responsible for.

2.2 Definitions

Work-related accidents refers to accidents involving transport operators at work, both employees driving in connection with their jobs, and self employed transport operators. The difference between the two is considerable, as working transport operators, unless self-employed, are employed by organisations committed through the Working Environment Act to facilitate good transport safety for their employees through HSE work. Thus, although the context of employed and self employed transport operators are very different, for instance in terms of safety measures, we focus on both in this report, as several of the databases and investigation reports focus on transport operators "at work" (defined by the purpose of the trip), and do not discern between employed and self-employed.

Work trips are defined by the purpose of the trips. In the police-reported SN-data the purpose is given. Whether the injured person was a crew members or not is also given in the AIBN-data, and in the NMA-data for maritime accidents, although it is difficult to determine whether the accident happened after working hours in the latter case. We specify below how we have determined whether a trip is a work trip in the AAG-data. This has been done by reading AAG-reports. Work trips are distinguished from commuter trips.

Risk factors. We follow the terminology from road safety work, where the term "risk factor", rather than the term "cause" is normally used to explain accidents (Sørensen, Nævestad & 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 safety behaviour of transport operators, technology/vessel/vehicle, work-related risk factors and risk factors related to framework conditions. We also use the term situational factors in this report, which refer to common characteristics of the situations in chich the accidents or the injuries occurred, e.g. activities, work, state, accident type. 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).

Work-related risk factors. Work-related risk factors refer to all factors that are influenced by transport operators' work situation, and which may in turn influence transport safety. These can be traced back to management and organisation, but also 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 & Bjørnskau 2014).

Different events are studied in the sectors. Because of different safety levels, we focus on different kinds of accidents in the three sectors. In the road sector, we focus on accidents involving personal injuries, i.e. fatal accidents from the AAG-data and police-reported personal injury accident data from the database of Statistics Norway. 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). It is important to note that in the road sector, we only focus on road accidents, and not accidents related to (un)loading. This is a limitiation of the report, as research shows that several accidents and injuries among drivers at work occur while (un)loading (Shibuya, Cleal & Mikkelsen 2008). We will therefore follow this up in future research.

In the maritime sector, we focus on personal injuries casued by either work accidents or ship accidents. Some ship accidents and all work accidents contain one (or more) injury to people. The NMA defines, however, work accidents as accidents with only personal injuries and no damage to vessels. In order to be able to compare with other sectors, the current report focuses on all personal injuries, i.e. injuries caused by both ship accidents and work accidents. The focus is on crew members and not on passengers. Moreover, because of changes in reporting, we distinguish between injuries involving work absence of more and less than 72 hours.

In the aviation sector (i.e. light helicopter inland), we primarily focus on fatal accidents and serious injury accidents, but also serious incidents in some cases (e.g. near misses). All reported events are related to civil inland helicopter traffic. Military, foreign and offshore operators are excluded. In order to be able to compare with the other sectors, the analyses mainly exclude events resulting only in damage to materials and equipment. The total amount of accidents with personal injury to helicopter crew is relatively low, with 19 reported accidents between 2000 and 2012. As a consequence, incidents with only material damage are included in some of the analyses, but it is important to note that these kind of events are vulnerable to changes in reporting. Accidents with private helicopter pilots (i.e. not commercial) are mainly excluded from the analyses.

2.3 Analysis of accident-databases

We will use accident databases to survey the prevalence and causes of work-related transport accidents.

2.3.1 Road

Data from Accident Analysis Groups

In the road sector we look at fatal accidents and personal injury accidents involving at least one person who was at work or commuting at the time of the accidents. In these accidents we focus on the number of killed and injured people, also counterpart drivers when these are present. Additionally, we analyse identified risk factors in to the accidents, related to drivers, vehicles, work-related factors and framework conditions.

As of 2005, all fatal road accidents are investigated by the Norwegian Public Roads Administration's (NPRA's) regional accident analysis groups (AAG). The results of each investigation are documented in a report that describes, among other things, the course of the accident, road and weather conditions, and relevant aspects of road users and vehicles involved (Haldorsen 2010; Sørensen, Nævestad & Bjørnskau 2010). The reports are produced according to a template and are based on the AAG's own inspections, police interviews with involved parties, technical reports from the accident sites and involved vehicles, etc. (Haldorsen 2010). For the vast majority of fatal accidents it is thus possible to examine the factors that have triggered or contributed to the accident.

Certain variables from the in-depth reports are included in an AAG-database. This database can be used to quantitatively analyse fatal accidents and accident factors (Sørensen et al. 2010). The AAGs refers to direct causes as "triggering factors" and underlying causes as "situational factors". The AAGs indicate the importance of the different factors by weighting them according to the extent to which each factor has influenced the course of events. The scale runs from 1 to 3, where 1 is to a small extent, 2 is to a significant extent and 3 indicates that the factors played an essential role/was decisive. In seeking to identify the situational factors, the AAGs focuses on incident factors. An example of an incident factor is falling asleep, for instance caused by the situational factor "fatigue". The AAG report usually lists situational factors to describe the various incident factors.

Phillips & Meyer (2012) made use of AAG-data to study the prevalence of fatal accidents involving drivers at work. The original AAG-*database* does not contain variables on work-related driving, although AAG-*reports* provide relevant and often indirect information about this (Nævestad & Phillips 2013). For instance, the reports often mention road users' travel purpose. On the basis of travel purposes, among other things, it can be deduced whether the various road users involved in the accident were driving at or to/from work, even though the AAG reports rarely state directly whether the car trip took place during the driver's working hours. Based on all AAG reports from the period 2005-2010, Phillips and Meyer added a new variable on driving during working hours to the AAG-database. It was, for example, concluded that the driver in question was a professional driver if the report stated that the transport of people or goods 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 heavy goods vehicles, bus or taxi drivers at work.

Nævestad & Phillips (2013) use and update Phillips & Meyer (2012) for mapping and analysing serious work-related road accidents (2005-2011). The difference is that Nævestad & Phillips focus on fatal accidents *triggered* by drivers at work, rather than those *involving* drivers at work. The goal of Nævestad & Phillips' (2013) study was to investigate whether, and to what extent, the contributing factors related to the triggering drivers at work and their vehicles could be connected to the work-related aspects of the triggering driver's workplace. The report is also based on reports from the Accident Investigation Board (AIBN) and interviews with nine experts. In the analysis of AAG-data, Nævestad & Phillips (2013) found that too high speed for conditions, failure to use seat belts and lack of information gathering were the main risk factors in fatal accidents triggered by drivers at work.

For the present report, we have updated the database developed through the two previous projects. We have updated for the years 2012 and 2013 the variables described previously for drivers at work (Phillips & Meyer, 2012). We have also computed new variables that allow us to analyse driver, vehicle and accident variables according to whether the vehicle that is either involved in or responsible for triggering the accident was driven by a working driver. As in previous analyses, each driver in the AAG-database was coded according to whether they had been a professional driver at work, another driver at work, or a driver on the way to or from work. Again, only drivers for which we had definite information were included in the final analyses. The information available in the AAG reports was insufficient for us to decide whether the driver in question was a professional driver at work in 5.5 % of cases (i.e. 150 drivers out of a total of 2721 in the database for 2005-2013). Information was insufficient to code for drivers as to whether they were another sort of driver at work in 24 % of cases (655/2721). Information was insufficient to code for drivers as to whether they were on the way to or from work in 25 % of the cases (675/2721). In this report we exclude all indefinite cases from further analysis.

Data from police-reported injury accidents

Statistics Norway records data from all police-reported traffic injuries. Originally the data was recorded on a physical form filled out by the police, but the reports are now computer registered. We analyse the data by means of the data processing program SPSS.

The data file is predominantly organised around the unit of "people involved", who are people injured in accidents and uninjured drivers. The data file includes all kinds of road users, both drivers and passengers and vehicles. First, we therefore select the value driver on the variable "vehicle road-user", so we exclude passenger, pedestrian, etc.. Second, we focus only on the drivers who drove in connection with work. This is revealed by the variable "Purpose of the journey".

Our analyses of accidents and risks focus on the drivers that have been involved in police-reported accidents with injury to people from 2007 to 2012. The accident data from Statistics Norway contain a number of variables. We categorize these variables in order to learn about risk factors related to 1) driver (for example: age, gender, driving license), 2) vehicle (type of vehicle, safety equipment in use), 3) road/road environment (road surface, speed limit, visibility, weather) and factors to illustrate 4) work-related conditions.

2.3.2 Sea

We use the Norwegian Maritime Authority's (NMA) database which presents systematic information on maritime accidents and their causes, providing key variables related to each accident. The NMA continually registers and annually publishes annually data on accidents and near misses along the Norwegian coast, on both Norwegian and foreign registered ships. Moreover, accidents with Norwegian ships in foreign waters (i.e. Norwegian International Ship register) are also included in the statistics. We include all these data in our analyses.

In the NMA database an accident is recorded as either a ship accident or a work accident, depending on whether the accident involves damage to the vessel or not. Both ship and work accidents may involve personal injuries, which are also recorded as a separate variable. In practice, some ship accidents and all work accidents contain one (or more) injury to people. The NMA defines, however, work accidents as accidents with only personal injuries and no damage to vessels (NMA 2014: 16). In order to be able to compare with other sectors, the current report focuses on all personal injuries, i.e. injuries caused by both ship accidents and work accidents.

Ship accidents are accidents where the ship has been involved in an accident. For these accidents, the statistics represents all recordings made by the NMA of accidents and damages to the ship itself. This includes events such as; fire/explosion, grounding, severe weather damage, capsizing, collision, contact damage, leakage, breakdown of machinery, environmental damage/pollution, stability failure (without capsizing), missing/disappeared vessel and a category for “other accident”, which does not fall under the listed categories. These ship accidents are not included in our analyses, if they did not involve personal injuries of people at work.

Our analyses of risk factors and trends when it comes to accident types, involved ships and functions and so forth, focused on the last ten years, i.e. 2004-2013. We do this to ensure that the results are as up to date as possible. In our analyses, we exclude accidents occurring in lakes and rivers. We also exclude accidents involving leisure vessels and mobile offshore units (“flyttbar innretning”). Finally personal injuries involving passengers and people external to the ships are also excluded.

2.3.3 Aviation (inland helicopter)

Our analyses of helicopter accidents are based on a broader set of data and analysis methods than the analyses of road and sea accidents. The reason is that the helicopter accident analysis to a large extent is based on previous studies. Our helicopter study condcucts new analyses of an updated data material, sums up and conducts an overall analysis of the previous studies, and it also adds new analyses of AIBN-data.

Safetec Nordic carry out the analysis of helicopter accidents with personal injury in this report. In collaboration with Committee for Helicopter Safety - Inland Operations , the Civil Aviation Authority (CAA) and the Ministry of Transport and Communications, Safetec Nordic has previously assessed the reported events with personal injury in inland helicopter from 2000 to 2011. These analyses were part of a larger project on safety in inland helicopter transportation. The final report from the project was published in 2013 (Bye et al. 2013a; Bye et al. 2013b). The analyses in the present report are conducted with an updated database which also includes events from 2012.

All reported events are related to civil inland helicopter traffic. Military, foreign and offshore operators are excluded. In 2013, there were 18 operators, of which three were dedicated to ambulance/police operations In addition to these 18 operators, private pilots are included in some of the analyses for comparative purposes.

Events resulting only in damage to materials and equipment are excluded. The total amount of accidents with personal injury to helicopter crew is relatively low, with 19 reported accidents between 2000 and 2012. In addition to presenting overall numbers, the events from 2005 to 2012 have been standardized to represent accident risk per 100 000 flight hours.

The aerial work (AW) and passenger transport (PAX) operators are divided into categories by their size (the number of helicopters they operate). Small operators have five or fewer helicopters, medium operators have between six and 14 helicopters, while large operators have more than 14 helicopters.

In addition to the updated overview of accidents with personal injuries (both the actual numbers and estimated by 100 000 flight hours) results from previous analysis of the helicopter sectors have been summarised (Bye et al. 2013a; Bye et al. 2013b). This includes:

- Statistical analysis of incident data in order to identify potential risk influencing factors (Aasprang et al. 2013, Aasprang & Bye 2013a)
- Analysis of obtained operator data (Aasprang & Bye 2013b)
- Analysis of survey data (Bye 2013, Aasprang & Seljelid 2013)
- Analysis of interview data (Bye et al. 2013c)

In order to identify potential risk influencing factors and causes of helicopter crashes, binary logistic regression (Eikemo & Clausen 2012) analysis and correspondence analysis (Clausen 2004, 2009) was conducted. The dependent variable in the regression analysis was whether an accident (assuming that an accident has happened) will be a helicopter crash or another form of landing (planned or unplanned). The independent variables were e.g. type of operation, type of helicopter, type of operator, age and pilots' flight hours. The correspondence analysis was used as a supplementary method in order to identify association between different variables (Bye et al. 2013).

In order to obtain information regarding different operators and their helicopter fleet, personnel, operations, organisation, customers and market conditions, a questionnaire was constructed and distributed to the 18 operators. The information was used to develop descriptive statistics.

The survey was conducted by distributing an electronic questionnaire, consisting of 68 items, to known employees of inland helicopter operators. 56 % of the reported population of 258 pilots responded (N=146). The central tendency in the material was examined by comparing the means for each different item between the different groups of employees. Statistically significant mean differences were identified by the use of a t-test with a 95 % confidence level.

The interview data stems from 36 interviews with a total of 50 informants. The interviews were conducted by the use of an interview guide addressing the following themes:

- Causes of accidents
- Work practice (including procedures, interaction and communication, risk assessments)
- Reporting
- Organisational support
- Training
- Market conditions
- Governmental regulation

The interviews were analysed by focusing on concurrences and discrepancies in the statements from differently situated informants.

2.4 Analysis of reports from the Accident Investigation Board Norway

The AIBN is a public committee of inquiry. The purpose of AIBN investigations is to clarify the sequence of events and factors which are assumed to be of importance for the prevention of transport accidents, and it shall not apportion blame or liability. The AIBN consists of four departments, for aviation, road, railway and marine safety. We have not reviewed the reports from the railway sector for this report, as it falls outside of the scope of the project. As noted, we consider work-related transport safety standards in the rail sector to be high relative to the road and maritime sectors in general, and relative to the private light helicopter branch (see section 2.1).

The AIBN investigates all accidents and incidents in aviation in accordance with ICAO Annex 13, and was established in 1989. Their work in the road and maritime sectors is more recent with these departments being operational since 2005 and 2008 respectively. In these sectors, however, the AIBN does not investigate all accidents and incidents, but a subset.

In accordance with legislation, the board investigates a selection of marine accidents involving Norwegian passenger ships, as well as accidents involving other Norwegian ships, including fishing vessels, where crew, shipmaster or others have or are assumed to have lost their life or sustained significant injuries. Especially accidents involving fatalities are studied. Further, the board may investigate accidents involving foreign ships that occur in Norwegian territorial waters in addition to accidents with foreign ships in other waters when the flag state consents or if Norwegian jurisdiction can be applied in accordance with international law. The Accident Investigation Board may also investigate other marine accidents, including accidents with recreational craft, if clarification of the causes may contribute to increased safety at sea.

In the road sector, the AIBN is tasked with investigating accidents with "high potential risk". Its notification is often limited to serious accidents involving heavy goods vehicles or buses, accidents in tunnels, or accidents involving transport of hazardous goods. Accidents with private cars may also be investigated if they for instance may provide opportunities for learning. The obligation to notify the AIBN also includes other accidents in cases where the Police or the NPRA consider that the AIBN may have an interest in investigating. AIBN's road department has no statutory requirements concerning which accidents to investigate. The department chooses the accidents it investigates based on preliminary investigations and received information. When selecting the accidents and incidents to investigate, emphasis is placed on the severity of the accident, whether it is an example of series of similar accidents or if an investigation can be expected to provide new knowledge.

The review presented in the current report is based on published reports from the Accident Investigation Board Norway (AIBN. For sea and aviation, all reports concerning accidents and incidents taking place between 01.01.2009 and 01.01.2014 published by January 2015 have been included in the analysis. For the road sector we include reports in the period 2006-2014, building further on a previous review

(Nævestad & Phillips 2013). The AIBN reviews encompass road accidents, maritime accidents, and accidents and incidents with light inland helicopters.

The number of relevant reports differs significantly between sectors. In the aviation sector, the total number of reports pertaining to light inland helicopters is twenty, whereas in the marine sector, the number of accident reports from the period is much higher, with 48 reports. A much higher share of maritime reports discusses work-related risk factors, than what is the case for light inland helicopters. The reason is probably that helicopters involved in accidents more often seem to be piloted by private individuals, who use the helicopter in a non-professional capacity.

All reports have been downloaded, and the AIBN-reports' discussions, conclusions, and recommendations have been studied and searched for work-related risk factors. In cases where the relevant factor has already been addressed in previous recommendations, the AIBN does not issue recommendations where the same risk factors are found to occur again. (In the maritime sector, 21 of the 48 reports did not conclude with a recommendation. For light helicopter inland, of the 20 reports published by the AIBN, only three resulted in safety recommendations). This however, does not mean that the relevant factor was not present in these cases. We should also note that whether a factor is «work-related» is necessarily a question of judgment. For instance, in some cases, the AIBN directs recommendations to public agencies rather than to companies, which seems to suggest that the problem uncovered relates to the regulatory or supervisory environment rather than to working conditions in the companies. This is, however, not necessarily the case; the factor might still be under the control of the companies, but changing regulations or supervision may be considered a more effective way of influencing companies' practices than issuing a report to one or several companies.

The wording of conclusions and recommendations also varies between reports, so that frequently a "factor", in our analysis, is constructed out of what we deem to be sufficiently similar cases that are referred to under different names in the individual reports. Also, in some cases, a number of different factors are grouped together under a single heading in this report, so that, for instance, lack of seatbelts and lack of helmets will both be "lack of safety equipment". Whether two different problems discussed in separate reports are in fact two different instances of the "same" factor, is thus a judgment made during the analysis. Note that the fact that a factor has been discussed in a report, does not imply that this was the cause of the incident or accident investigated, as the real cause was in some cases impossible to establish with certainty.

2.5 Quality assurance

The report has been submitted to quality assurance both internally and externally. To ensure that the results of our analyses and our interpretations of the results are as correct and plausible as possible, we have sent the report to relevant sector experts for quality assurance before publication; i.e. to relevant authorities, employer organisations, employee organisations and other user groups. These sector experts were mainly recruited from the project's reference group, but experts from outside the reference group was also used for quality assurance. The experts conducting the quality assurance were invited to comment on the results, our analyses and our interpretations. We are very grateful for their help. The reference group members are from the Norwegian Coastal Administration, The Norwegian Maritime Directorate, The Norwegian Public Roads Administration, the Norwegian Labour Inspection

Authority, the Norwegian Civil Aviation Authority, the Norwegian Ministry for Transport and Communications, the Transport Accident Investigation Board Norway and the Swedish Transport Agency (covering all transport sectors).

3 Work accidents in the road sector

3.1 Analysis of in-depth reports on fatal road accidents

3.1.1 Number of accidents involving working drivers

Table 3.1 shows the total number of fatal road accidents in Norway (2005-2013) involving different types of working drivers.

Table 3.1 Number of fatal road accidents in Norway (2005-2013) involving drivers at work and commuter drivers, according to an analysis of AAG reports. The number of accidents found to involve different types of driver is given, as well as an adjusted estimate calculated to allow for accidents for which there were insufficient information to say whether the drivers were working or not.

Description of involved driver	No. accidents in which driver involved	Total no. accidents with sufficient driver information	Total no. accidents in AAG-database	Adjusted no. accidents in which driver involved
Professional driver at work	503	1635	1719	529
Other driver at work	89	1226	1719	125
Driver on way to/from work	131	1220	1719	185

Using the numbers in Table 3.1 we can calculate that 31 % of the accidents involved professional drivers at work, 7 % involved other drivers at work, and 11 % involved drivers who were commuting.

3.1.2 Change in the number of accidents involving working drivers

The last decade has witnessed a decline in the annual number of fatal road accidents involving any type of driver in Norway. The downward trend suggests a decline of 33 % since 2005 (Figure 3.1).

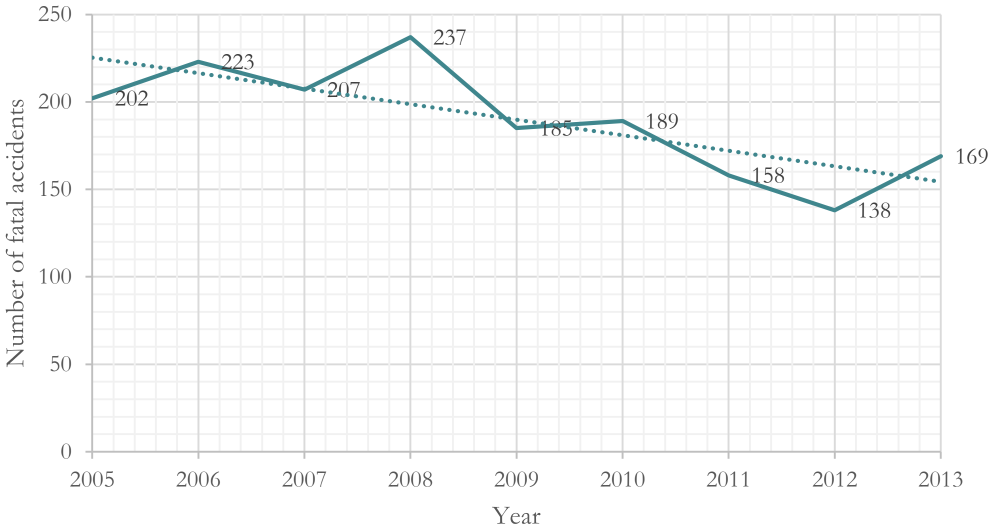


Figure 3.1 Annual numbers of fatal road accidents in Norway involving any type of driver. Based on the AAG-database.

The number of fatal road accidents involving professional drivers also appears to have declined. In this case the trend line suggests a decrease of 17 % (Figure 3.2). The number of accidents involving other drivers at work does not appear to have decreased since 2005, while the number of accidents involving drivers on the way to or from work has only slightly decreased.

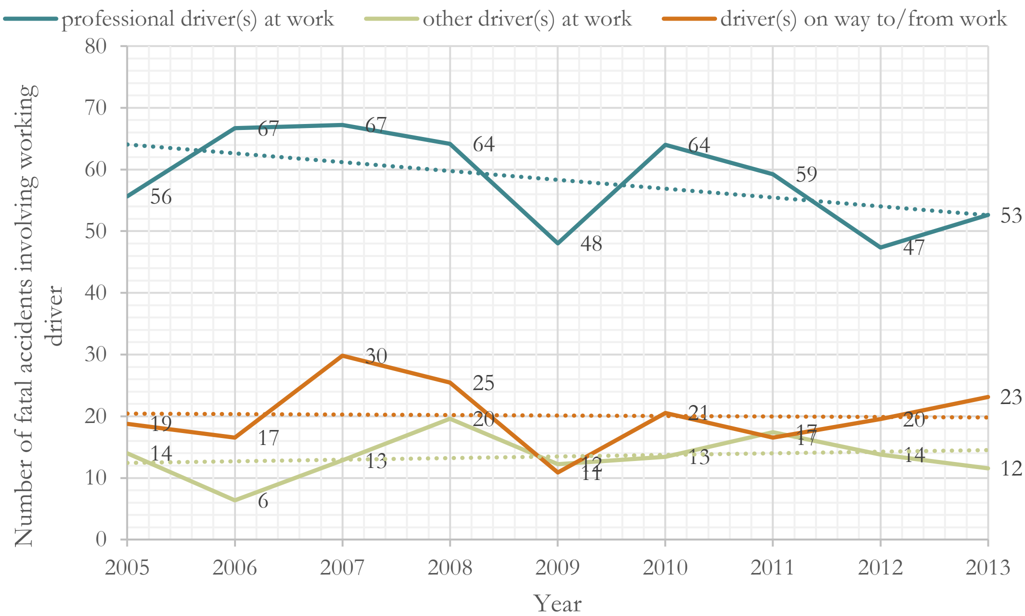


Figure 3.2 Annual numbers of fatal road accidents in Norway involving different types of working driver. We have upwardly adjusted the number of accidents to account for involvement of working drivers in accidents for which there was insufficient information (cf. Table 3.1.)

3.1.3 Number of working drivers involved in fatal road accidents

According to the AAG-database, 4488 road users (i.e. drivers, passengers and other road users) were involved in fatal road accidents in Norway between 2005 and 2013. Of these, 2721 were drivers. The AAG reports contained enough information in the case of 2571 drivers to say whether or not they were professional drivers at work at the time of the accident. We found that of these 2571 drivers, 533 (21 %) were professional drivers. Adjusting to account for those reports with missing information, we estimate that 564 professional drivers were involved in fatal road accidents in Norway between 2005 and 2013.

There was enough information in the AAG reports to say whether or not 2029 of the drivers were other types of driver at work at the time of the accident. We found that of these 2029 drivers, 92 (4.5 %) were other drivers at work. Adjusting this number to account for those reports with missing information, we estimate that 117 non-professional drivers at work were involved in fatal road accidents in Norway between 2005 and 2013.

Thus our analysis estimates that a total of 681 drivers at work have been involved in fatal road accidents in the period from 2005 to 2013. Drivers at work therefore make up 25 % of all drivers involved in fatal road accidents.

In addition, there was enough information in the AAG reports to say whether or not 1978 of the drivers were on the way to or from work at the time of the accident. We found that of these 1978 drivers, 141 (7.1 %) were on the way to or from work. Adjusting this number to account for those reports with missing information, we estimate that 194 commuter drivers were involved in fatal road accidents in Norway between 2005 and 2013.

3.1.4 Number of working drivers killed or injured

Table 3.2 gives the numbers of working drivers involved in fatal road accidents according to injury level and year. The data are for accidents for which there is sufficient information in the corresponding AAG report, and must therefore be regarded as conservative estimates, particularly in the case of other driver at work and drivers on the way to or from work.[1]

It is difficult to comment on a change in the number of killed or seriously injured, due to the large variation and relatively low numbers involved. Despite this, the data give little indication that there has been a reduction in the number of working drivers killed or injured since 2005.

Table 3.2 also shows that proportionately far fewer professional drivers than other drivers at work (or commuting drivers) are killed or seriously injured. For instance 65 out of 533 (12 %) of professional drivers were killed compared with 38 out of 92 (41 %) of other drivers at work. This is partly because professional drivers tend to drive heavier vehicles, and are protected by the weight and momentum of the vehicle that they operate.

[1] These numbers have not been adjusted, because the chance that information about the purpose of the driver's trip is missing from the AAG reports varies according to how seriously the driver was injured.

Table 3.2 Number of working drivers involved in fatal road accidents in Norway (2005-2013), according to year and degree of injury. Reports with insufficient information about the working state of the driver have been excluded from this analysis, and so the numbers must be regarded as conservative estimates.

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2005-2013
Professional drivers at work	Killed	9	8	5	7	8	8	5	3	13	65
	Serious injury	1	3	1	1	2	0	5	2	0	15
	Minor injury	10	10	3	11	2	11	8	7	7	69
	No injury	37	48	59	44	34	52	41	34	35	384
	Total	57	68	68	63	46	71	59	46	55	533
Other drivers at work	Killed	1	0	4	6	4	4	5	6	8	38
	Serious injury	1	0	0	0	0	2	2	1	1	7
	Minor injury	3	0	2	2	3	0	3	1	0	14
	No injury	5	4	1	4	3	5	4	5	2	33
	Total	10	4	7	12	10	11	14	13	11	92
All drivers at work	Killed	10	7	9	13	12	12	10	9	21	103
	Serious injury	2	3	1	1	2	2	7	3	1	22
	Minor injury	13	10	5	13	5	11	11	8	7	83
	No injury	42	52	60	48	37	57	45	39	37	417
	Total	67	72	75	75	56	82	73	59	66	625
Commuting drivers	Killed	6	5	8	7	4	11	10	10	9	70
	Serious injury	1	0	1	1	0	1	0	2	4	10
	Minor injury	2	2	3	4	2	1	2	1	3	20
	No injury	5	3	9	6	1	4	3	4	6	41
	Total	14	10	21	18	7	17	15	17	22	141

3.1.5 Vehicles at work at the time of the accident

Figure 3.3 shows the different types of vehicle driven by professional drivers involved in fatal road accidents. It confirms that over 90 % of professional drivers are behind the wheel of a heavy vehicle at the time of the accident.

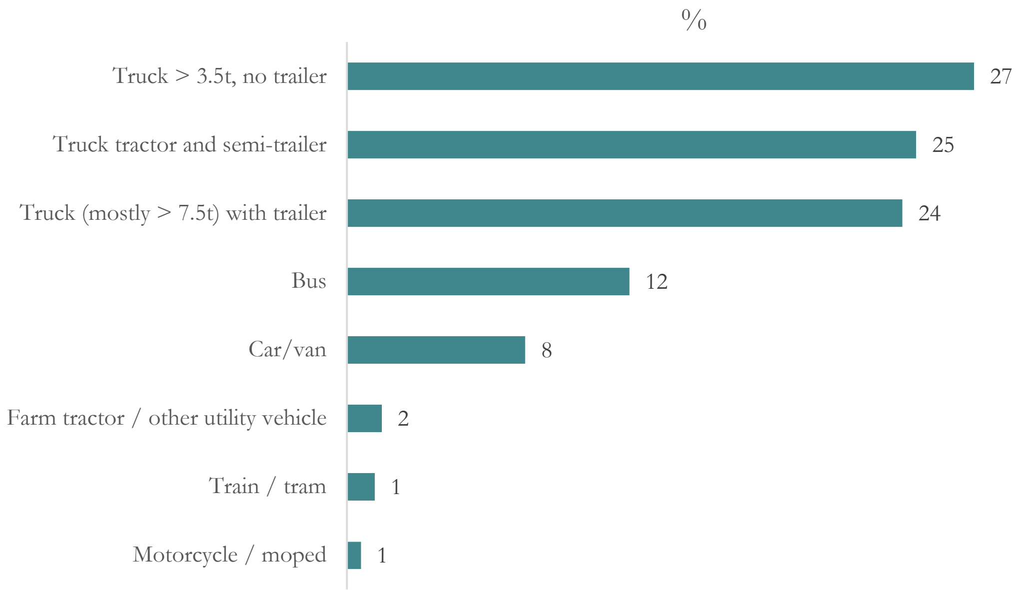


Figure 3.3 Vehicle types driven by professional drivers at work (N=533) involved in fatal road accidents in Norway (2005-2013). Per cent.

In contrast, most of the other drivers who are at work at the time of the fatal accident drove light vehicles, although a considerable share also drive heavier vehicles such as utility vehicles (mostly tractors) or light trucks (Figure 3.4). Drivers of utility vehicles pose a threat to other road users not only due to the weight that they often carry, but because they can carry protruding or sharp objects that can cause serious injury at relatively low speeds.

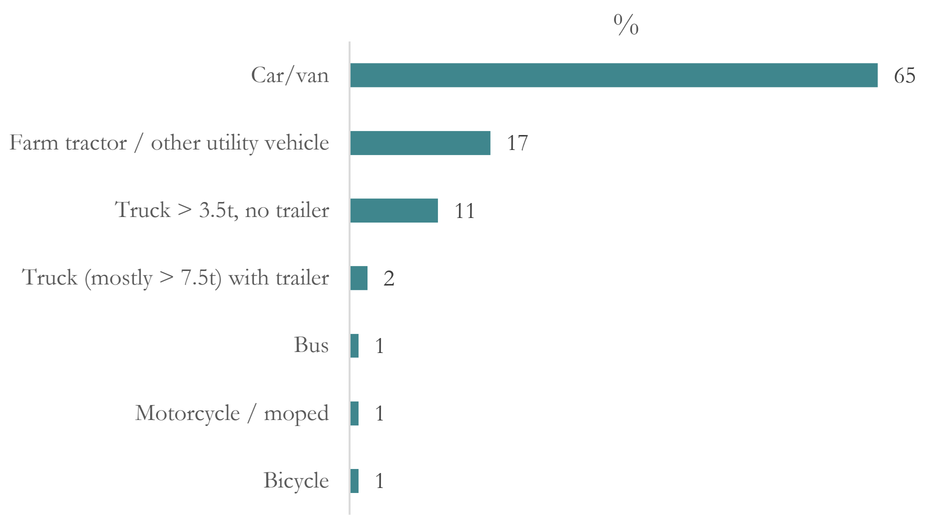


Figure 3.4 Vehicle types driven by other drivers at work (=93) involved in fatal road accidents in Norway (2005-2013). Per cent.

As expected, most of the drivers on the way to or from work at the time they were involved in a fatal accident drove cars, motorcycles, mopeds or bicycles (Figure 3.5). However, 5 % of these drivers drove heavy vehicles. These were presumably owners of heavy vehicles driving between an assignment and home.

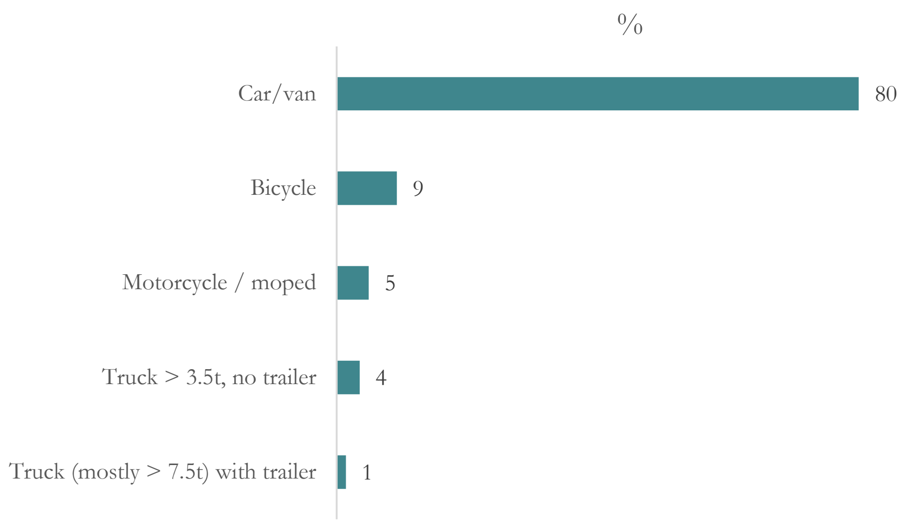


Figure 3.5 Vehicle types driven by drivers on way to/from work (N=141) when involved in fatal road accidents in Norway (2005-2013). Per cent.

3.1.6 Regional variation in work-related road accidents

Of the different regions in Norway monitored by the AAG, the greatest number and greatest share of work-related accidents occurred in the East (Figure 3.6). This is perhaps not surprising since this region includes a greater share of the population, several of the larger cities, many transport hubs and a lot of work-related activity.

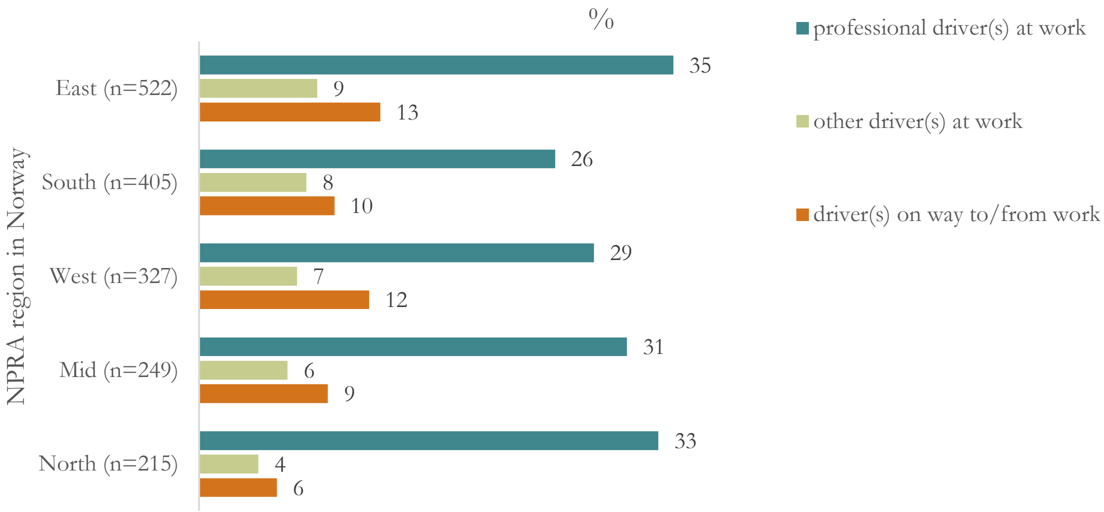


Figure 3.6 Share of accidents involving one or more of the indicated types of working driver, according to region in Norway. Per cent.

The lowest share of accidents involving professional drivers occurred in the South, and the lowest share of accidents involving other driver at work was in the North. Despite some variation it is clear that regardless of the location in Norway, substantial shares of fatal road accidents involve people at work.

3.1.7 Share of accidents triggered by vehicles at work

Using its collective experience and knowledge of the accident, the AAG decides for each accident which vehicle triggered the accident.[2] Based on this analysis, we looked at the share of *all* fatal road accidents in Norway (2005-2013) triggered by vehicles operated by different types of working driver. The results are shown in Figure 3.7. We see that a total of 14 % of accidents were triggered by vehicles operated by drivers at work (professional or other), while a further 5 %were triggered by vehicles driven on the way to or from work.

[2] This is a group-level decision reached at review meetings of the AAG. In most cases one vehicle is assigned as the triggering vehicle, but it is possible that more than one vehicle or no vehicles are assigned as triggering.

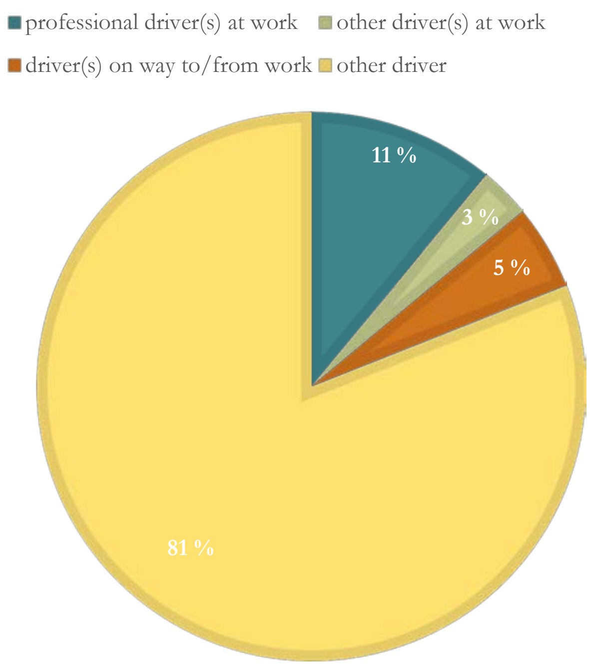


Figure 3.7 Share of all fatal road accidents in Norway (2005-2013) triggered by vehicles operated by working drivers, for those accidents with sufficient information (N=1719).

We were also interested in the relative likelihood that different types of working driver trigger fatal road accidents. One way to look at this is to analyse accidents triggered by working drivers as a proportion of those in which they are involved. Figure 3.8 gives the results of this analysis, and indicates that professional drivers at work are less likely to trigger fatal accidents in which they are involved than other drivers at work are. Counterpart road users trigger most (61 %) of the accidents involving professional drivers, which implies that professional drivers would benefit from increased knowledge about the behaviour of other road users that leads to fatal crashes with heavy vehicles.

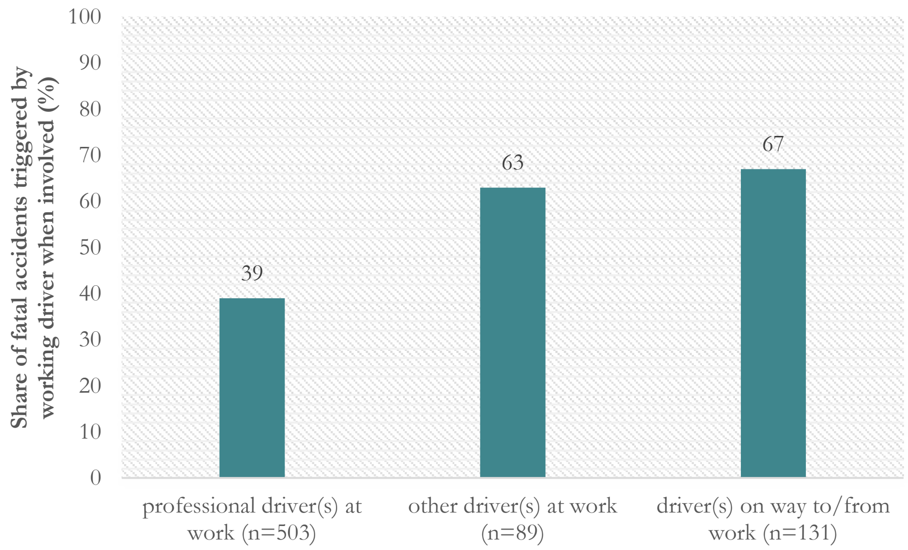


Figure 3.8 Share of fatal road accidents triggered by vehicles operated by different types of working driver in Norway (2005-2013), of those accidents in which they are involved. Per cent.

3.1.8 Types of accident involving working drivers

In order to learn how to prevent working drivers operating vehicles that trigger fatal road accidents, it would help to know what sort of road accidents are triggered. In the interest of preventing deaths to all road users, it may also be useful to know what sorts of fatal road accidents working drivers become involved in even though they do not trigger them.

Figure 3.9 gives the number of different sorts of accidents that working drivers trigger or are involved in. It shows that head-on collisions involving, but not triggered by, professional drivers are by far the most common sort of fatal work-related road accident. Considering that the AAG-database excludes the considerable number of head-on collisions involving professional drivers that are suicides by counterpart road drivers, this number is very large and raises questions about how these accidents affect professional drivers psychologically.

Figure 3.9 shows that professional drivers are most likely to trigger fatal accidents involving pedestrians, head-on collisions with other vehicles, or road exit accidents involving no other vehicle. Pedestrian accidents may be likely in busy urban areas with a complex traffic picture. Blind spots are a particular problem for drivers of heavy vehicles, and play an important role in many pedestrian accidents triggered by professional drivers. Head-on collisions can be caused by poor positioning in the road by the professional driver, or loss of vehicle control, for instance due to poor road conditions or surplus speed.

Head-on collisions, pedestrian accidents and road exit accidents are also the most abundant sorts of accidents triggered by other drivers at work. Here it is more difficult to generalise, as varying vehicle types are involved. Non-professional drivers at work who become involved in (but do not trigger) a fatal road accident, are most likely to be involved in head-on collisions.

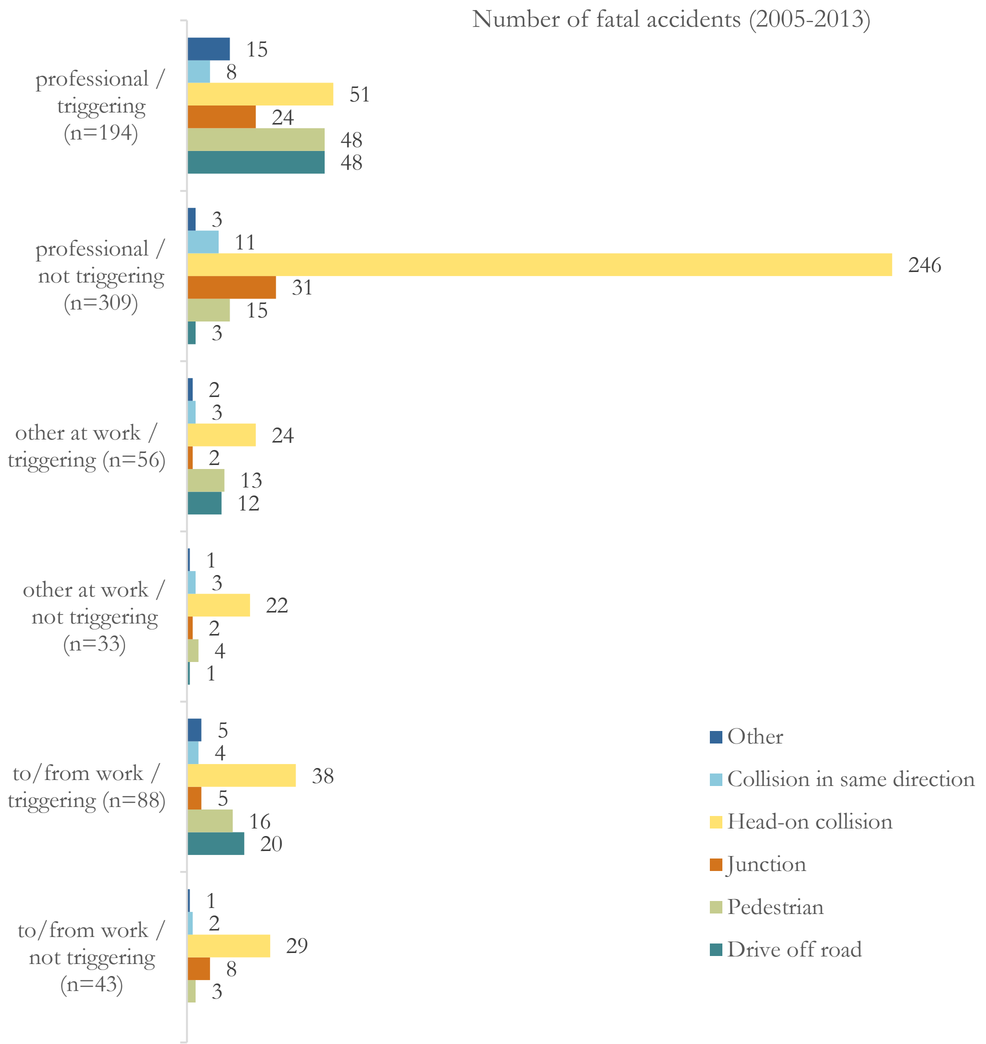


Figure 3.9 Number of accident types involving one or more working drivers, according to different types of working driver. The absolute numbers underestimate the actual numbers, because some AAG reports do not contain sufficient information about whether or not the driving is work-related.

3.1.9 Age and gender of working drivers who trigger accidents

Age distributions for working drivers operating the triggering vehicle in a fatal road accident is given in Figure 3.10. The age of professional drivers who triggered accidents was fairly evenly spread across the working age range. However, a relatively large proportion of other drivers at work who triggered accidents were 55 years old or over. In contrast, a high proportion of drivers under the age of 25 triggered accidents while on the way to or from work.

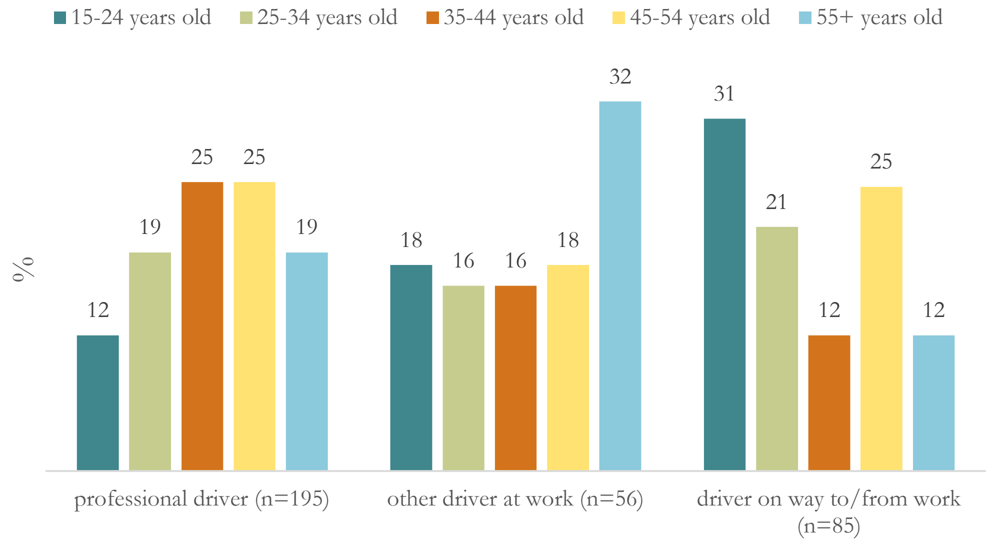


Figure 3.10 Age distribution of working drivers operating the triggering vehicle in fatal road accidents in Norway (2005-2013). Per cent.

Of professional drivers operating the triggering vehicle in a fatal road accident, 5 % were female, compared with 7 % of others at work who operated a triggering vehicle. The share of "triggering" commuters that were female was somewhat higher, at 21 %.

3.1.10 Condition of working drivers at the time of the accident

The AAG-database contains a variable describing the condition of each road user at the time of the accident, according to whether they are tired, under the influence of medicine/drugs or alcohol, in poor health, or stressed. We used this variable to look for differences between working drivers who drove vehicles triggering accidents versus those who did not trigger accidents. When considering this data, it is important to remember that a certain driver condition may or may not have contributed to the precipitation or resulting scale of the accident.

Figure 3.11 shows the condition of professional drivers at the time of the accident, according to whether or not they drove a triggering vehicle. It can be clearly seen that a greater share of those driving a triggering vehicle were in an "abnormal" condition at the time of the accident. Of note, 10 % of "triggering" professional drivers were fatigued and 9 % were stressed and/or under time pressure at the time of the accident. It is also of note that almost all professional drivers who were involved but did not trigger the accident, were not registered as being in an "abnormal" condition.

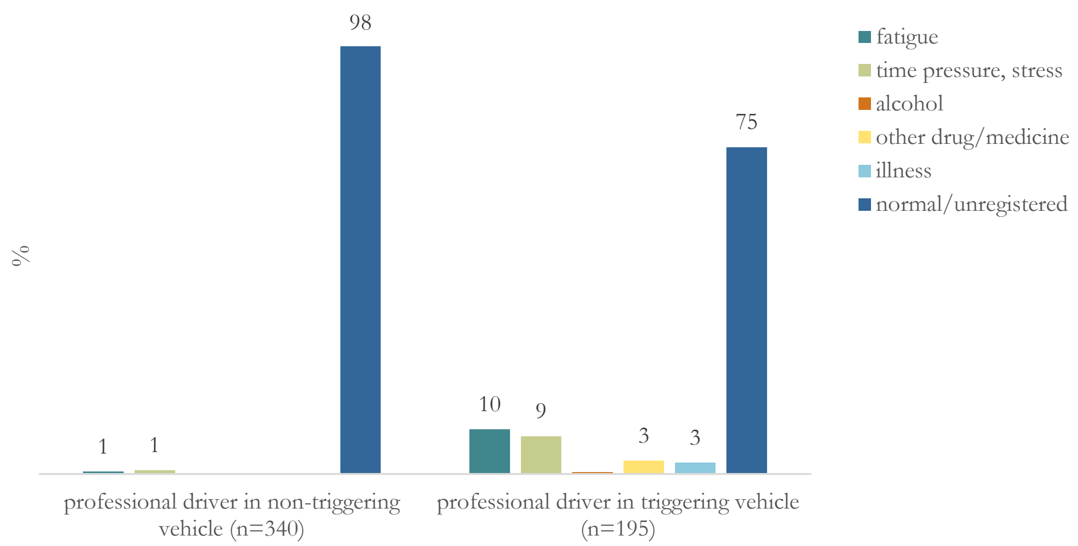


Figure 3.11. Condition of professional drivers involved in fatal road accident in Norway (2005-2013).

It is difficult to make conclusions on the data for other drivers at work given in Figure 3.12, because of the small numbers involved. From the data we have it appears that non-professional drivers at work who drive the triggering vehicle in a fatal accident are more likely to be stressed and under pressure. However, drivers may be fatigued whether or not they drive the triggering vehicle. Only 56 % of non-professional drivers who triggered accidents were not registered as having an "abnormal" condition, compared with a corresponding share of 75 % for professional drivers.

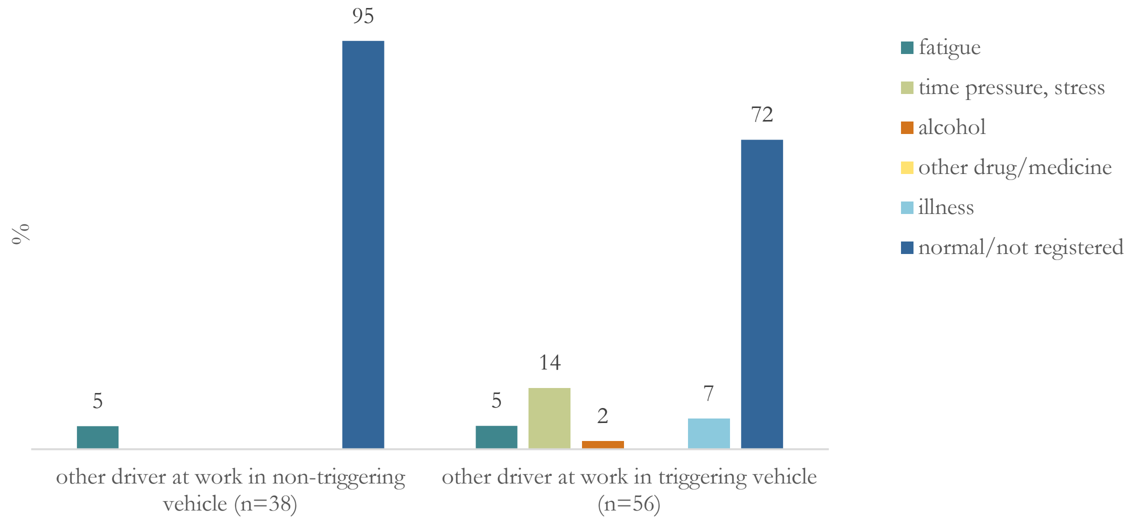


Figure 3.12 Condition of other drivers at work involved in fatal road accident in Norway (2005-2013).

Corresponding data for drivers involved in accidents on the way to or from work are given in Figure 3.13 These suggest that fatigue is a challenge for a considerable share of commuter drivers, and may be an important contributor to the accidents triggered by them.

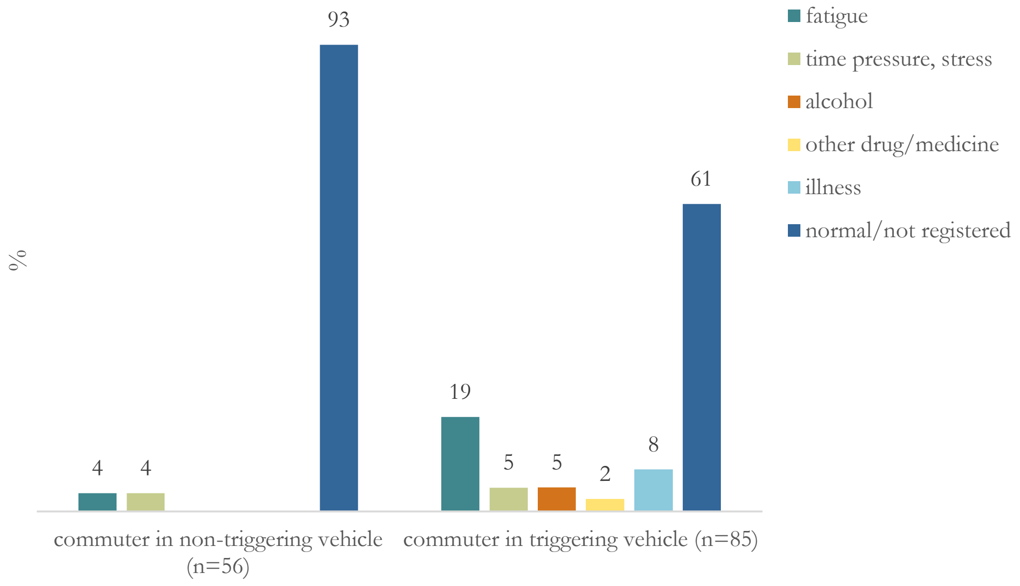


Figure 3.13 Condition of commuter drivers involved in fatal road accident in Norway (2005-2013).

3.1.11 Seatbelt use by working drivers at time of accident

Here we present data on whether or not working drivers were wearing a seatbelt at the time of the accident, according to the AAG material. The data is complicated by the varying shares of unregistered cases among different types of working driver. In particular, seatbelt use is not registered for 44 % of professional drivers (compared with 21 % for other drivers at work and 13 % for commuter drivers), and we are not sure why this is so. A possible explanation is that these drivers use a seat belt during the accidents and are usually unharmed because of this and the protection provided by their heavy vehicle. Thus, they step out of their vehicle before the police comes, and it is therefore difficult for the police to assess whether they used a seat belt. Nevertheless, it seems reasonable to assume that registered cases give a reasonable idea of the distribution of wearers and non-wearers within each driver category. For this reason we have excluded non-registered cases from the analysis in Figure 3.14.

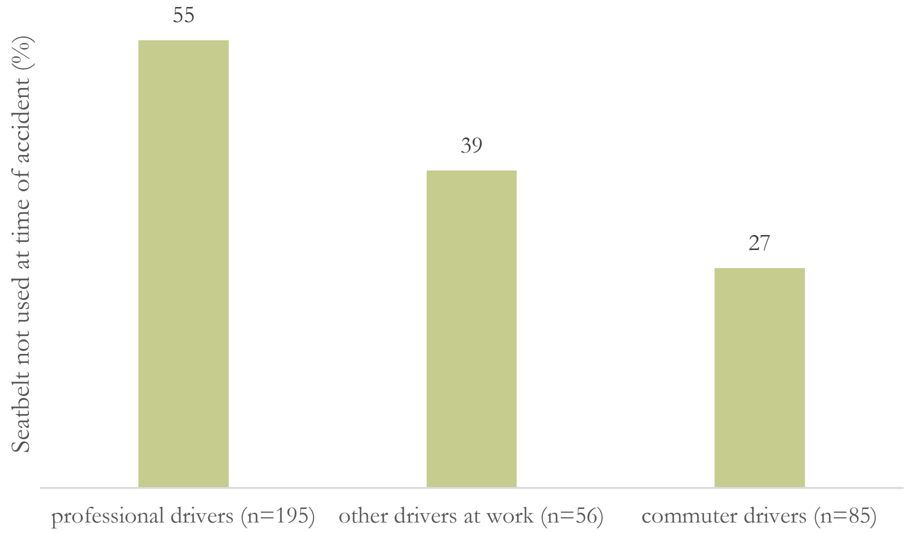


Figure 3.14 Registered seatbelt use at time of fatal road accident in Norway (2005-2013), according to type of working driver involved in the accident. Per cent

The relatively low share of professional drivers registered as using seatbelts is somewhat striking. Less than half of professional drivers involved in fatal accidents were using a belt at the time of the accident, and this will have had serious implications for the injuries that resulted from crashes. The AAG suggests that the potential life saving effect of seat belt is greater in heavy vehicles because of the characteristics of the accidents. Compared with fatal road accidents with other drivers (i.e. young drivers), professional drivers of heavy vehicles involved in fatal accidents are sober and not wearing seat belt. Thus, given the non-existence of other risk factors (i.e. intoxication), it is easier to determine whether seat belt use would have saved the life of the driver of the heavy vehicle.

A greater proportion of other drivers at work used seatbelts, but there were still 39 % registered as not wearing a seatbelt at the time of the accident. For commuter drivers, almost all of whom drove lighter vehicles, the implications of failure to use a seatbelt are even greater in the event of a crash with another vehicle, but even here 27 % of those registered were not using a seatbelt at the time of the accident.

3.1.12 Contributors to accidents triggered by professional drivers

Even though it is useful to consider the demographics, condition and seatbelt use of working drivers at the time of the accident, in many cases we cannot be certain whether such factors precipitated the accident or contributed to injury. For instance, it does not necessarily follow that fatigue contributed to an accident just because one of the drivers was tired. In many cases, however, the AAG reports determine the importance of a factor in contributing to the accident or the injury, e.g. stating whether seat belt use would have saved the life of the driver (chapter 9 in the AAG reports).

Factors that contribute to fatal work-related accidents (accident factors)

To inform about the *causes* of work-related road accidents, the AAG-database contains a list of accident factors. These are factors that the AAG believe may have played a role in precipitating the accident. Factors can be attributed either to the vehicle and driver triggering the accident or other road users and vehicles that may have been involved. "Neutral" factors may also be assigned, such as poor driving conditions or road environment at the time of the accident. Furthermore, each accident factor is graded by the AAG according to its perceived significance as a contributing factor. Factors are rated as having no, little, large or decisive significance for accident causation.

In the subsequent analysis we consider only those factors assigned large or decisive significance by AAG. This analysis is resource intensive, and so has been restricted to accidents involving professional drivers at work in the period *2010 to 2013*.

Accident factors found for accidents triggered by professional drivers are given in Figure 3.15.

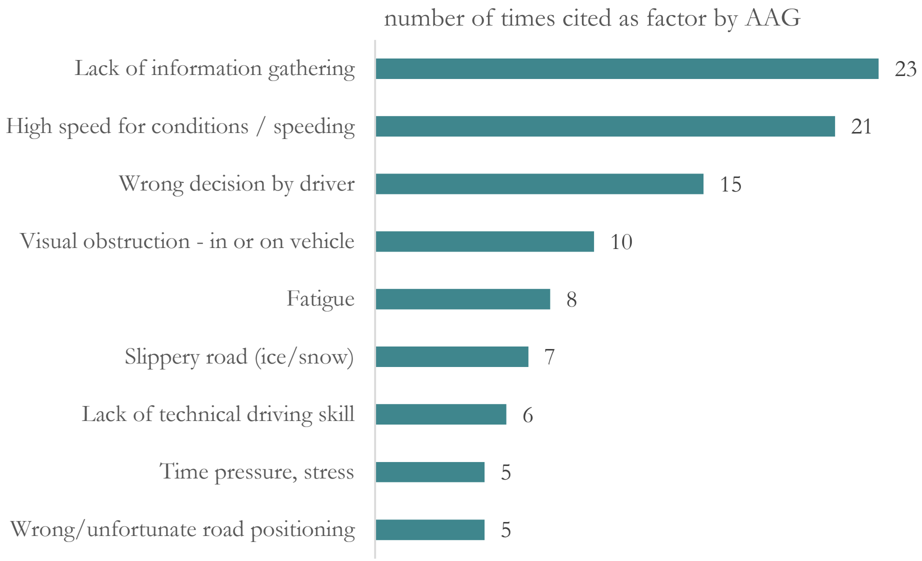
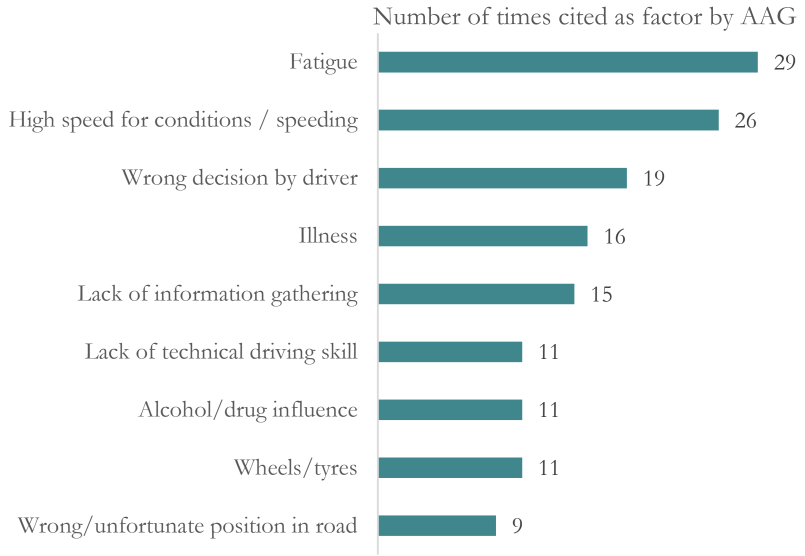


Figure 3.15 Important contributory accident factors in 87 fatal road accidents triggered by a vehicle operated by a professional driver at work, between 2010 and 2013. Factors assigned to other road users involved in these accidents are excluded. Only factors rated as playing a large or decisive role in the accident are included, and only if they are assigned at least five times by AAG.

The most common factors are lack of information gathering (failure to see a warning sign, notice another road user etc.) and surplus speed, either in relation to the prevailing conditions or the speed limit. Wrong decisions by professional drivers are also common, as is driver fatigue. Visual obstructions often play a role in accidents with pedestrians and cyclists, causing the drivers to miss them.

Accident factors assigned to counterpart drivers triggering accidents in which professional drivers are involved are somewhat different (Figure 3.16). Here driver fatigue is the most common factor. Sleeping drivers often drift into the path of an oncoming vehicle, and is more likely to result in death for that driver where the vehicle is a heavy vehicle, as they often are when professional drivers are involved.

This is consistent with the large number of head-on collisions seen for accidents involving (but not triggered by) professional drivers in Figure 3.9. Drivers who are suddenly ill (e.g. suffer a seizure, stroke or heart attack) may also drive into the path of oncoming traffic, and "illness" is also a common accident factor, according to AAG (Figure 3.16). Poor tyres and driving under the influence of alcohol may also cause drivers of light vehicles to lose control and collide with professional drivers of heavy vehicles.



Figur 3.16 Important contributory accident factors in 136 fatal road accidents involving professional drivers who did NOT trigger the accident, for the period 2010 to 2013. Factors relate to the triggering counterpart driver or his or her vehicle. Only factors rated as playing a large or decisive role in the accident are included, and only then if they are assigned at least five times by AAG.

Factors that influence the scale of a triggered accident (injury factors)

The previous analysis considers accident factors, which are factors that play a role in triggering accidents. In addition to accident factors the AAG-database contains injury factors. These are factors that help determine the scale of the resulting accident and level of injuries sustained by all involved road users (e.g. through seatbelt use). As for accident factors, injury factors can be attributed either to the vehicle or driver triggering the accident, or to other road users and vehicles that may have been involved . "Neutral" factors can also influence the scale of the accident e.g. a steep drop at the side of the road after a vehicle has driven off the road. Again, each accident factor is graded by the AAG according to its perceived significance for the scale of the accident. Factors are rated as having no, little, large or decisive significance for accident scale and injuries sustained.

In the subsequent analysis we consider only those injury factors assigned large or decisive significance by AAG. Again the analysis is restricted to accidents involving professional drivers at work in the period 2010 to 2013.

Figure 3.17 shows the most important and common injury factors for accidents triggered by professional drivers. The working driver is of interest here, i.e. we have excluded those few factors assigned to other road users when the professional driver is triggering. Figure 3.17 shows that failure to use a seatbelt is the most common injury factor, i.e. factor limiting the damage of accidents, once they have occured

This should be considered alongside the finding in Figure 3.14. The consequences of hazardous road sides for vehicles leaving the road are perhaps most serious for drivers of heavy vehicles, and this is also reflected in Figure 3.17 where "dangerous road side" is the second most common injury factor. This factor may be important in the large number of drive-off-road accidents that result in deaths for professional drivers triggering accidents.

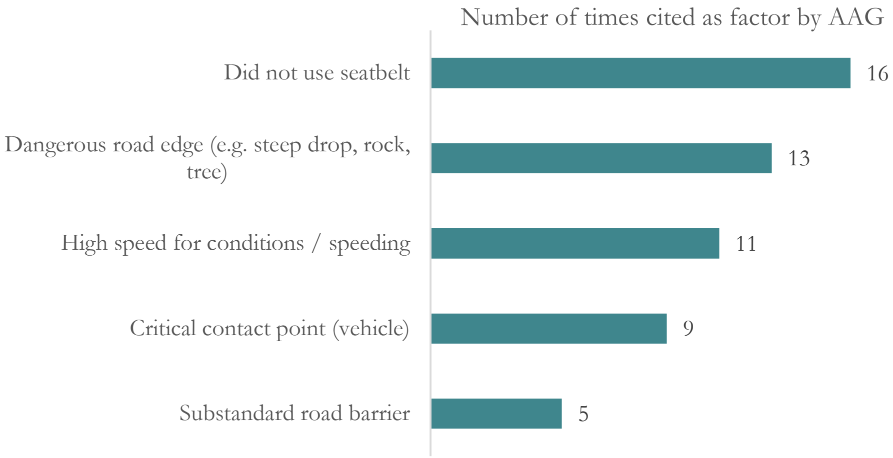


Figure 3.17 Important contributory injury factors in 87 fatal road accidents triggered by a vehicle operated by a professional driver at work, between 2010 and 2013. Factors assigned to other road users involved in these accidents are excluded. Only factors rated as playing a large or decisive role in the resulting scale of the accident are included, and only if they are assigned at least five times by AAG.

Figure 3.18 gives data on injury factors for accidents involving, but not triggered by, professional drivers. Because most drive heavy vehicles, it is important to consider the injuries such vehicles inflict when they are involved in road accidents.

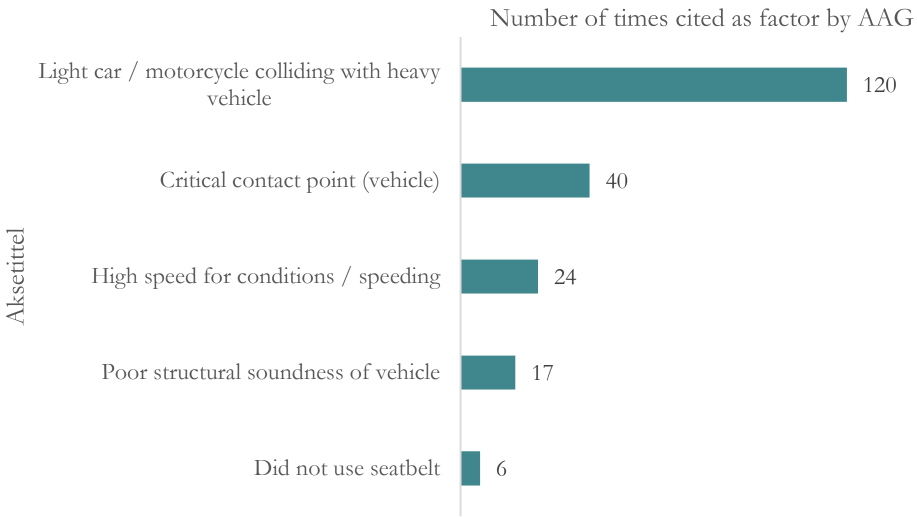


Figure 3.18. Important contributory injury factors in 136 fatal road accidents involving professional drivers in which a counterpart triggered the accident (2010-2013). Factors relate to the triggering counterpart driver, his/her vehicle or the road environment. Only factors rated as playing a large or decisive role in the accident are included, and only if they are assigned at least five times by AAG.

Reflecting our previous findings, Figure 3.18 shows that the physical forces involved in a collision between a heavy and light vehicles moving at speed in opposite direction is by far the most common injury factor for accidents involving professional drivers that are triggered by counterpart drivers. It is also often the case that the point of contact between the vehicles plays a role in increasing the level of resulting material and personal injury ("critical contact point"). If the counterpart vehicle is less structurally safe it will be less able to absorb the large physical forces involved in the crash with a heavy vehicle, and this also plays and important role in the resulting accident scale. Finally, the higher the speed, the higher the forces involved in the crash will be, and thus speed is also an important injury factor.

3.2 Analysis of traffic accidents with personal injuries

3.2.1 Trip purposes of drivers involved in accidents

In the following we analyze data from Statistics Norway's database on police-reported traffic accidents with personal injury. The analyses present both absolute numbers and shares on key variables indicating various risk factors in accidents involving drivers at work. As we have not taken exposure numbers (e.g. kilometres driven by drivers at work and other drivers) into account, it is important to remember that we only look at characteristics of accidents involving drivers at work. Thus, we are unable to compare the accident risk of the different categories of drivers that we study, e.g. drivers at work, drivers on their way to/from work and people driving for visits, leisure. The main reason that we have not taken exposure measures into account is that we for the time being lack detailed exposure measures (e.g. relating to the different characteristics that we focus on here, like road type, speed limit, light conditions).

Statistics Norway's database on police-reported traffic accidents with personal injury in Norway contains a variable on the purpose of the trip for each involved road user. The database contains 89 833 units (people) for the period 2007-2012. Among these units, a total of 31 550 people are defined as drivers of a vehicle in the database. Table 3.3 shows purposes of the trips of 31 550 drivers of vehicles involved in police-reported traffic accidents with personal injury in Norway each year 2007-2012.

Table 3.3 Drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to drivers' trip purpose.

Purpose of trip	Total	Per cent	Excluding unknown	Adj. est. total	Adjusted avg. year
To/from work	3607	11 %	17 %	5387	898
Work	5603	18 %	27 %	8430	1405
Visit, leisure	8308	26 %	39 %	12 391	2065
To/from shop, bank etc.	1007	3 %	5 %	1530	255
Other	2556	8 %	12 %	3812	635
Unknown	10 469	33 %			
Total	31 550	31 550	21 081	31 550	

The table shows that trip purpose is unknown in 33 % of the cases. The most frequent purpose is trips related to visit and leisure, followed by trips made by drivers at work and drivers on their way to/from work.

Excluding the trips with unknown purpose, we see that, of the trips with known purpose 39 % were related to visit/leisure, 27 % had work as purpose and 17 % had to/from work as purpose. Thus, we see that of the trips with police-reported personal injury accidents and known purpose, 44 % had work (27 %) or to/from work as purpose (17 %.)

If we assume that the 33 % of the drivers with unknown trip purpose are distributed as the drivers with known trip purpose, we see that a total of 8430 drivers in accidents had work as trip purpose in the period.[3] This gives an annual average of 1405 drivers with work as trip purpose involved in police-reported traffic accidents with personal injury. The corresponding numbers for drivers with "to/from work" as trip purpose are 5387 accident involved drivers in the period and 898 per year.

Figure 3.19 shows the development with respect to drivers involved in traffic accidents in the period 2007-2012. The number of drivers involved in police-reported traffic accidents with personal injury has decreased in the period for drivers at work, to/from work and those who drive for the purpose of visit and leisure. The downward trend is stronger for people driving for leisure than for those driving at work or to/from work. Both tendencies are in accordance with results from the AAG-data.

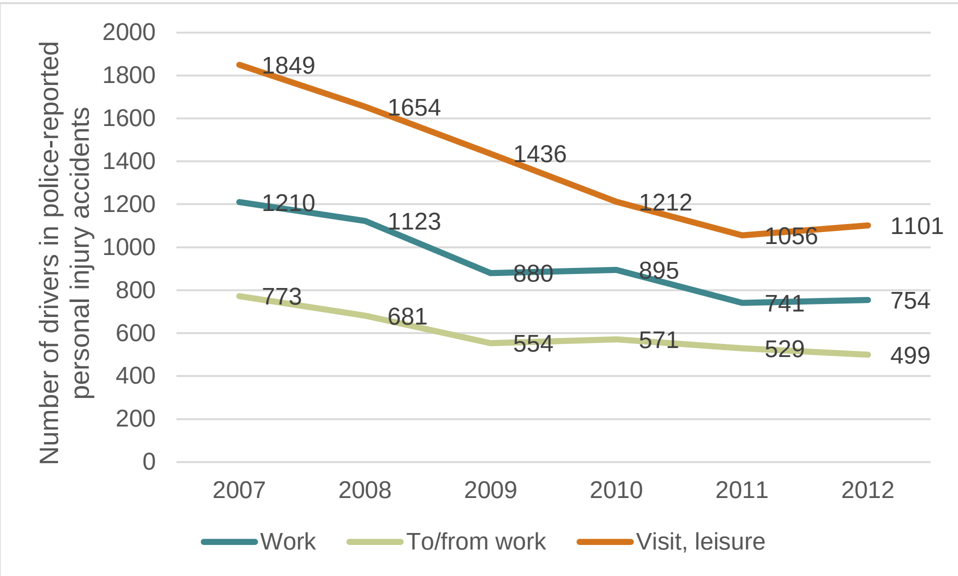


Figure 3.19 Number of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to purpose of the trip.

3.2.2 Vehicle types of working drivers involved in accidents

Table 3.3 shows that we have data from 5603 vehicles/drivers with work as trip purpose that have been involved in police-reported traffic accidents with personal injury in the period. In Table 3.4 we show the numbers and types of vehicles involved in these "at work" accidents.

Table 3.4 Number and types of vehicles involved in police-reported traffic accidents with personal injury in Norway 2007-2012, with work as the purpose of the trip.

[3] The "unknown trip pupose" may be even higher among non-traditional drivers at work, i.e. those who are not bus, HGV and taxi drivers, as traditional work drivers are easier to identitfy for the police. Thus it is likely that there are more private cars used at work with unknown purpose.

Type of vehicle	Total	Per cent
Heavy goods vehicle	2241	40 %
Private, estate car	1640	29 %
Bus, minibus	728	13 %
Van	698	12 %
Cab, mini bus	219	4 %
Emergency vehicle	62	1 %
Other/unknown	15	0 %
Total	5603	100 %

Figure 3.20 shows the number and types of vehicles involved in police-reported traffic accidents with personal injury in Norway 2007-2012, with work as the purpose of the trip.

Among the vehicles in accidents with "work" as trip purpose, heavy goods vehicles (HGVs have the largest share, followed by private/estate cars and buses. Moreover, the number of vehicles involved in "at work" accidents has decreased substantially from 2007 to 2012.

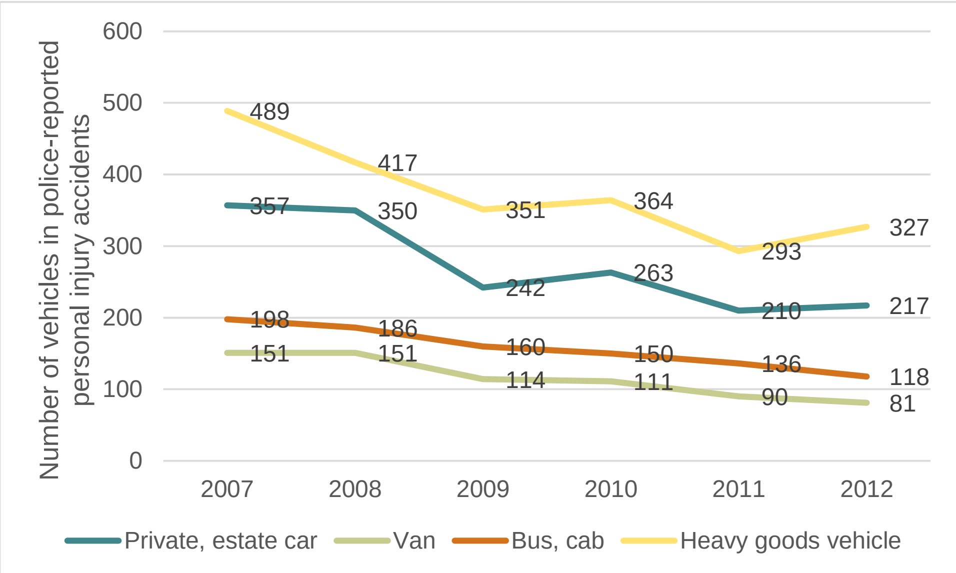


Figure 3.20 Number and types of vehicles involved in police-reported traffic accidents with personal injury in Norway 2007-2012, with work as the purpose of the trip.

The number of all types of vehicles involved in "at work" accidents has decreased substantially over the study period. The number of HGVs involved increased slightly from 2011 to 2012.

3.2.3 Severity of driver injuries

Table 3.5 shows the development with respect to injured drivers involved in traffic accidents in the period 2007-2012. The table shows drivers with work, to/from work or leisure/visit as trip purpose.

As noted, the AAG-data shows that an average of 11 drivers at work are killed annually. We exclude the killed drivers in table 3.5, as this number is obtained from the AAG-data. According to the SN-data the average number of killed drivers at work is 7 per year, but as mentioned we should estimate a missing share of purpose of about 30 % among the drivers at work. Based on this, the AAG number of 11 killed drivers at work in average each year seems reasonable. Thus, the numbers of injured drivers at work and to/from work in table 3.5 represent conservative estimates (in some instances probably only representing about 70 % of the actual numbers).

Table 3.5 Number of injured drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to purpose of the trip. Killed drivers are excluded from the table.

Year:	Work	To/from work	Leisure/visit
2007	366	349	859
2008	356	321	792
2009	268	253	685
2010	290	283	582
2011	215	258	503
2012	226	251	527
Total:	1721	1715	3948
Average:	287	286	658

Based on the accidents with known purpose, an average of 287 drivers at work was injured each year in police-reported personal injury accidents with work as purpose (for 2007-2012). An average of 286 drivers was injured each year in police-reported personal injury accidents with "to/from work" as purpose (for 2007-2012). The numbers have decreased gradually in the period for all groups presented in the table.

Moreover, we also see that although there were more drivers in accidents with work as a purpose than to/from work (cf. Table 3.3), the numbers of injured drivers are fairly similar for these groups. This is probably due to the fact that drivers at work to a larger extent drive heavy vehicles in vhich they are more protected than other drivers, e.g. drivers on their way to/from work. The same tendency was found in the AAG-data (cf. Table 3.2). Finally, the table shows that the decrease in injured drivers has been larger for those with the purpose leisure/visit than work and to from work.

The numbers of injured people are substantially higher when we look at all injured road users involved in the accidents involving a driver at work. These are not included in the table. An average of 1490 people is injured each year in these accidents (287 of these are as noted drivers at work). These numbers have also decreased each year, from 2043 in 2007, followed by 1809 (2008), 1357 (2009), 1417 (2010), 1136 (2011) to 1178 in 2012.

Figure 3.21 shows the shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to severity of driver injury.[4]

[4] We have not tested whether the differences between the groups' shares are statistically significant (confer table 3.4 for the absolute numbers of each group). This also applies to the other figures presenting bivariate analyses of SN-data.

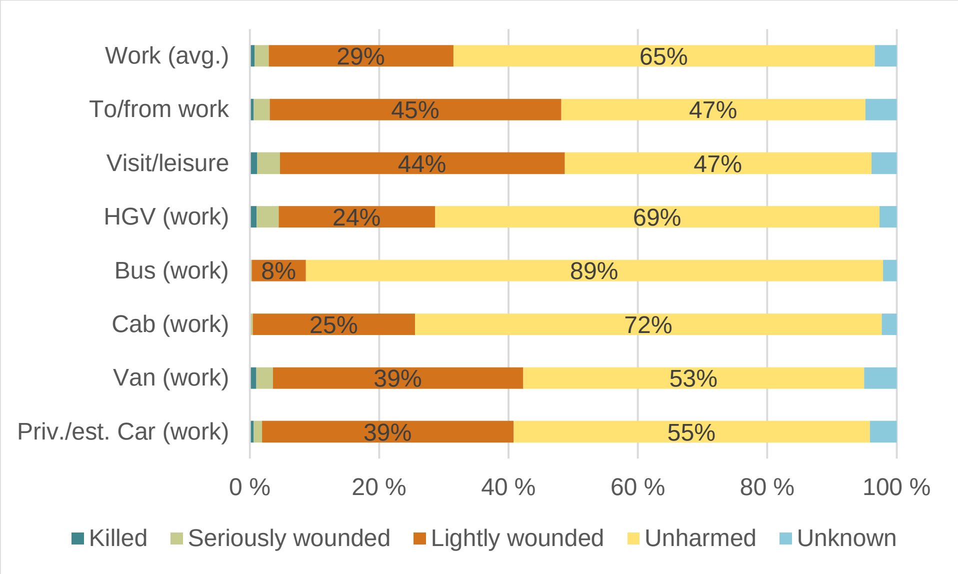


Figure 3.21 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to severity of drivers injury, trip purpose and vehicle type.

Interestingly, the figure shows that the severity of driver injury is lower for people driving at work than for people driving for other purposes, probably as these more often drive heavy vehicles. It also shows that driver injury is no more severe in accidents with people driving to/from work than it is for people driving for leisure. This is in line with the results from the AAG-data.

The traditional professional drivers (cab, bus, HGV) have the highest shares of unharmed drivers. Bus- and HGV-drivers use bigger and heavier vehicles, in which they are more protected. Moreover, there are probably more bus accidents on roads with lower speed limits, decreasing the risk of serious bus driver injury in case of accidents. However, because of the weight and mass of heavy vehicles, accidents with heavy vehicles are more severe for other involved road users (Assum & Sørensen 2010). Cab drivers are not as protected as bus- and HGV-drivers, and it is therefore hard to explain their large share of unharmed drivers. Perhaps considerable shares of their accidents are at low speeds.

3.2.4 Drivers in accidents based on month/season

Figure 3.22 shows shares of drivers in traffic accidents per month, with work, driving to/from work and leisure as purpose of the trip.

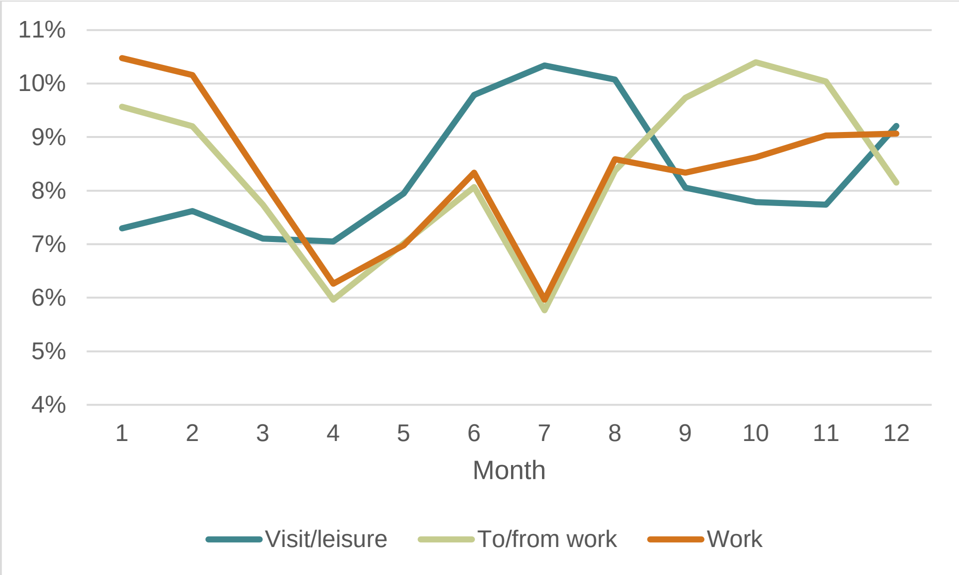


Figure 3.22 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway per month, 2007-2012. Work, to/from work and leisure as purpose of trip

As expected, we see that in the summer months, the shares of drivers involved in accidents are highest for those with leisure as the purpose, and lowest for those with work and to/from work as purpose. December has fairly high shares for all groups. The differences in the first and last months of the year are substantial.

Figure 3.23 shows the distribution of drivers in accidents per summer (Apr.-Sept.) and winter (Oct.-March).

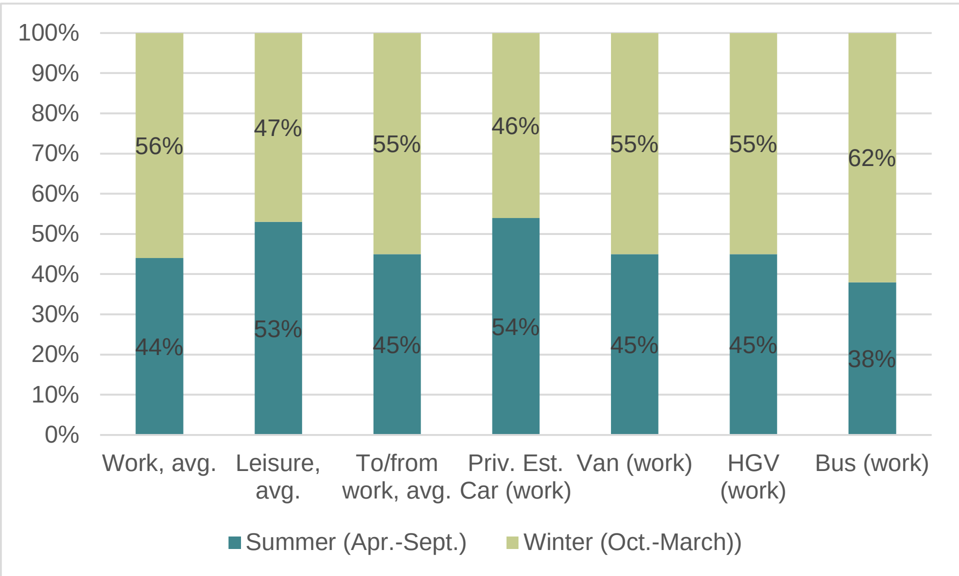


Figure 3.23 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to season, trip purpose and vehicle type.

Buses have the highest share of drivers in accidents in the winter. Given that buses' work volume is the same in the summer and the winter, we may assume that the accident risk of buses is higher in the winter, most likely because of demanding driving conditions (i.e. ice, snow, less daylight). Seasonal variation in bus accidents may also be influenced by variation in the density of road traffic in urban areas at peak times between winter and summer.

Private/estate cars driven at work and vehicles people driving for leisure have the lowest shares in the winter.

3.2.5 Drivers in accidents based on speed limit

Figure 3.24 shows shares of drivers in accidents according to speed limit on the road, for 2007-2012. Information on road type was missing for 1508 of the drivers which had work as the purpose of the trip.

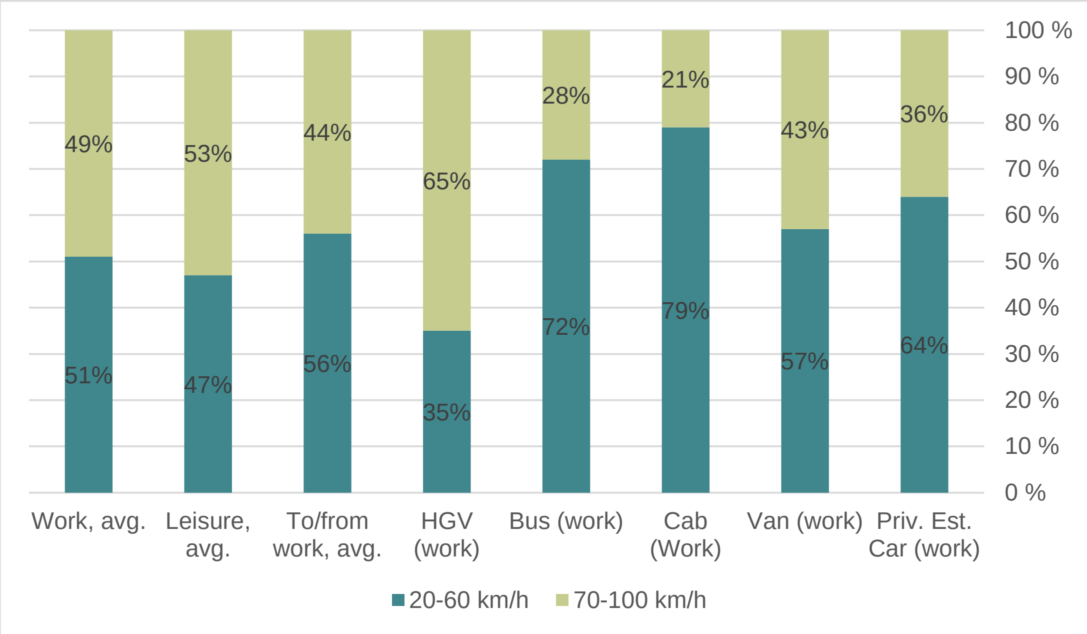


Figure 3.24 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway per speed limit on the road 20-60 km/h and 70-100 km/h, 2007-2012. Also distributed according to trip purpose and vehicle type.

Comparing drivers at work, to/from work and drivers with leisure as purpose, we see that the latter has the highest share of accidents on roads with speed limits of 70 km/h and more. The difference between the average shares of work and leisure drivers are, however, not substantial.

Cabs and buses have the highest shares of accidents on roads with the lowest speed limits. HGVs have the highest share on roads with higher speed limits. This probably gives rise to differences in severity, which is influenced by speed (Assum & Sørensen 2010).

The accident database also includes information on driverss in accidents according to road type at the time of the accident, for 2007-2012, but here there were few differences. Most of the accidents (>80 %) occurred on what is referred to as “regular road/street”. Other road types were for instance motor ways type A and B residential streets and other.

3.2.6 Drivers in accidents based on road and weather conditions

Figure 3.25 shows shares of drivers in accidents distributed according to road conditions. Information on road conditions was missing for 234 of the drivers which had work as the purpose of the trip and 64 for those driving to/from work and for leisure. We have simplified the five alternatives in the accident database into two categories: clear road (wet and dry) and snow/ice/slippery.

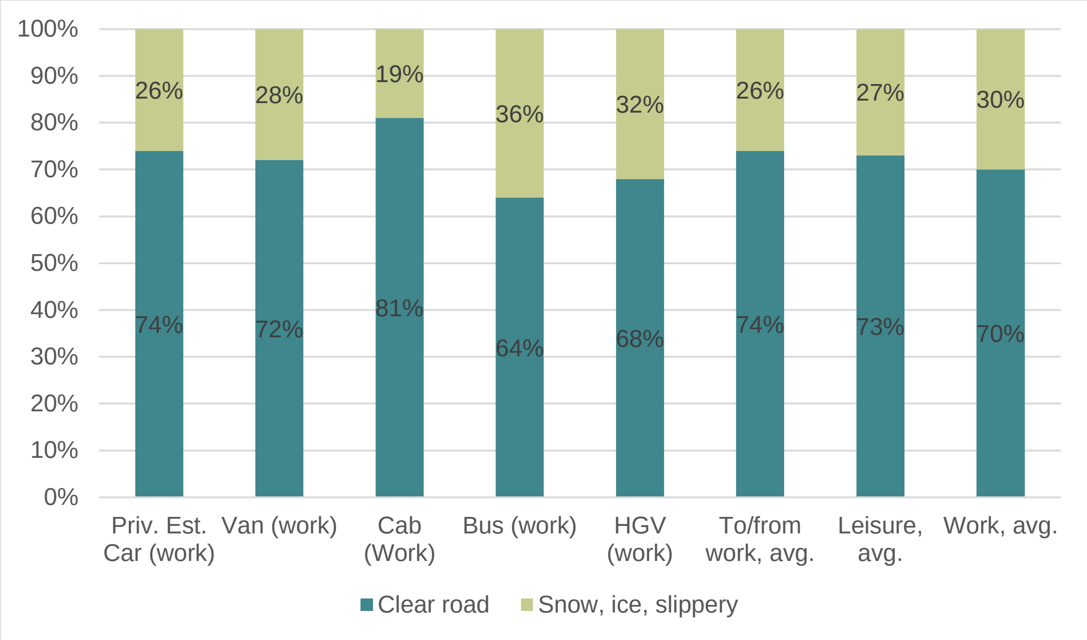


Figure 3.25 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to road conditions (Clear road vs. Snow, ice, slippery), trip purpose and vehicle type.

Buses are involved in the highest share of "snow, ice, slippery" accidents. This is probably because buses following certain routes/time tables must follow the same time table through the year, and cannot choose to wait or take another route in spite of bad weather as some other vehicles can. However, HGVs are the other vehicle groups with a high share of accidents on snow/ice/slippery roads. This could indicate that vehicle weight may be a risk factor in the winter.

The accident database also includes information on visibility conditions at the time of the accident, but here there were no important differences between the different groups.

Figure 3.26 shows shares of drivers in accidents distributed according to light conditions. Information on light was missing for 183 of the drivers which had work as the purpose of the trip and 54 for those driving to/from work and for leisure.

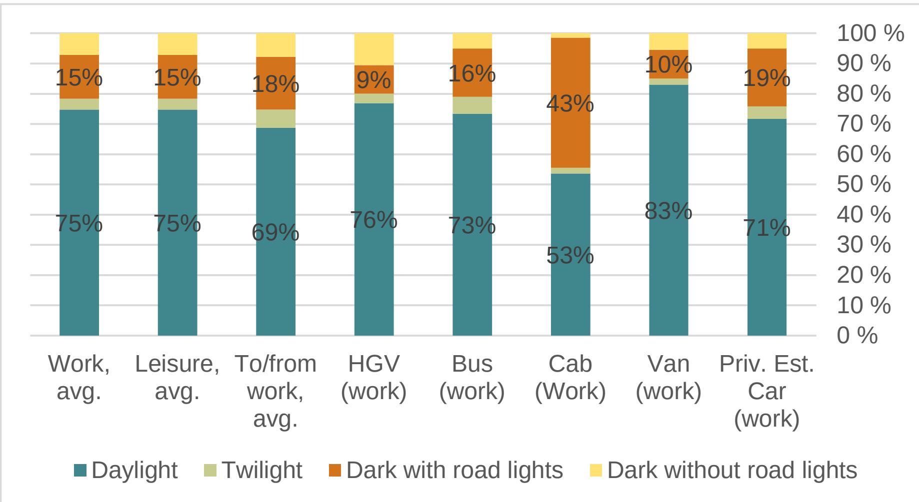


Figure 3.26 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to light conditions, trip purpose and vehicle type.

Comparing drivers at work, those driving to/from work and for leisure, we see that the shares are similar for those driving at work and for leisure. The share of accidents with people driving to/from work occuring in daylight is somewhat smaller.

Of accidents involving cabs, 43 % occur on dark roads with street lights, which is high relative to those involving private/estate cars, buses, vans and HGVs (Figure 3.27). The high share for cabs probably reflects the prevalence of night shifts worked by cab drivers, and perhaps a higher accident risk at night for cabs.

3.2.7 Drivers in accidents based on safety equipment in use

Above, we saw that few of the drivers are killed, while between 1 % and 4 % are seriously wounded. The latter share is for leisure drivers while the former is for people who drove private/estate car in work. When it comes to lightly wounded, to/from work and leisure drivers have the highest shares, while bus drivers and HGV-drivers have the smallest share. This is probably due to the fact that they drive bigger heavier vehicles, in which they are more protected.

Figure 3.27 shows shares of drivers in accidents distributed according to safety equipment in use.

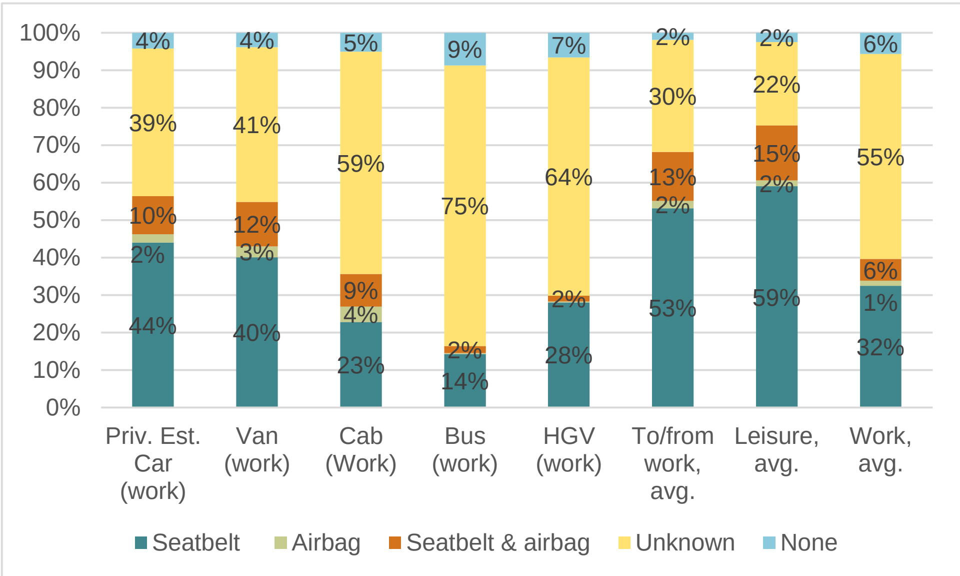


Figure 3.27 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to safety equipment in use, trip purpose and vehicle type.

Comparing drivers at work, to/from work and people driving for leisure, we see that those driving for leisure have a reported seat belt/airbag use (76 %) that is nearly twice as high as those driving at work (39 %), and slightly higher than the share for those driving to/from work (68 %). This is contrary to the severity of injury for the groups. We must, however, note the considerable shares for “unknown”, i.e. instances without information on the relevant characteristic, which in this case is safety quipment Nevertheless, it seems that this issue indicates a considerable potential for improvement. These results are in line with what we saw in the analyses of the AAG-data.

The reported seat belt/airbag use is lowest for bus drivers (16 %), followed by HGV drivers (30 %) and cab drivers (36 %). The seat belt/airbag use for drivers of private/estate cars at work (56 %) is 3.5 times higher than it is for bus drivers.

3.2.8 Age of drivers in accidents

Figure 3.28 shows shares of drivers in accidents distributed according to their age. The bus drivers stand out with the highest share of drivers aged 49 years or more, followed by cab and leisure drivers. However, drivers of private/estate cars involved in accidents have the same age distribution as leisure drivers. People driving for leisure have, however, the largest share of drivers in the group of drivers of 58 years and more.

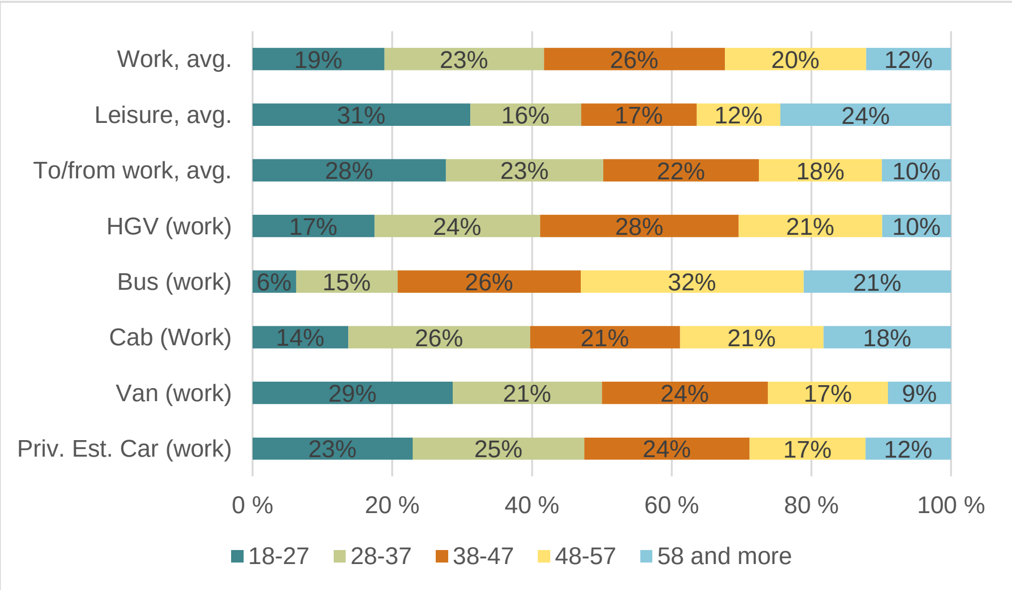


Figure 3.28 Shares of drivers involved in police-reported traffic accidents with personal injury in Norway 2007-2012, distributed according to their age, trip purpose and vehicle type.

3.3 Results from AIBN-reports

Table 3.6 lists risk factors related to the driver, vehicle and workplace in 25 reports published between 2006 and 2014.[5] Reports may mention risk factors related to drivers or vehicles, even when they are not ascribed any significance for the accident or its serious consequences, and sometimes these assessments are uncertain.

[5] This is an update of the analysis in Nævestad & Phillips (2013), which studied ten AIBN-reports.

Table 3.6: Risk factors related to driver, vehicle and workplace in AIBN-reports with drivers who have driven at work and been involved in a serious accident.

	Risk factors	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Driver	**Speed too high for circumstances**	1	1	1	1		1		3	1	9
	Missing seat belts	1	1	1	1		1		1	1	6
	Insufficient check of equipment		1		1	1		1			4
	Inadequate securing of cargo		1				1	1			3
	Insufficient familiarity with vehicle		1	1	1					1	4
	Inadequate loading knowledge		1				1				2
Vehicle	**Wear/malfunction**			1	1	1		1		1	5
	Brakes				1	1			2	1	5
	Faulty/inappropriate design		2	1				1		1	6
	Tyres				1						1
	Blind spot		1								1
Work-related factors	**Inadequate work descriptions/procedures**		2	1	2	1	1	1	1	3	12
	Insufficient training in company	1	2	1	1	1	1	1		2	10
	Inadequate risk assessments		2	1	2		1	1		2	9
	Inadequate follow-up of driver during assignment/drivers driving style	1	1		2			1	2	1	8
	Inadequate choice/ maintenance of equipment		2	1	1	1		1	1		7
	Insufficient HSE focus in company	1	1	1	1	1	1				6
	Working hours/fatigue	1					1		1	1	4
	Company adherence to regulations	1		1	1				1		4
Framework conditions	**Controls/inspection/ audits/enforcements**	1	2		2	2	1	2	6		16
	Rules/safety requirements	1	2	1	1	1	1	1	1	2	11
	Road maintenance/ quality	1				1	1		3		6

3.3.1 Risk factors associated with driver

Excessive speed for conditions: In accordance with AAG and SN-data based on police reports, we see that this is the most prevalent risk factor related to drivers. The speed may not have been above speed limits, but for instance above critical topple speed or excessive relative to the road's condition (curves, friction). Given certain loads and malfunctions, reports often show that critical topple speed is often below speed limits in certain curves. Reports often comment on whether and to what extent the driver's speed and driving style have been followed up by the employer and whether drivers were under time pressure from employers. We return to this.

Missing seat belts: Missing seat belts is an injury factor, i.e. a factor that contributed to the accidents' serious consequences. Reports frequently discuss whether the workplace had a mandatory seat belt policy. In the cases studied, this was not the case, and the AIBN emphasizes that such a policy would have made drivers more likely to use seat belts. In the bus accidents, missing passenger seat belts are also discussed, and the focus on the bus drivers' important role in this respect is underlined.

Insufficient equipment checks: The reports emphasize that professional drivers are obliged to check their equipment before each assignment, to ensure that it is not deficient. Drivers must also monitor equipment such as brakes and warning lights while driving. The reports also discuss expected driver competence for such checks, on the background of their professional training. In some cases, reports find that modifications of equipment were inadequate or illegal, but that drivers cannot be expected to have the skills to discover this. It is emphasised that it is important that drivers and their employers have good procedures in this area, but the quality of the driver's check depends on the training, procedures and monitoring during transport assignments provided by the driver's employer.

Inadequate familiarity with vehicle: In these accidents, drivers are often involved in accidents with vehicles with which they have little experience, and hence do not have sufficient basis for evaluating risks related to the particular vehicle, e.g. critical topple speed in curves, and how the vehicle behaves on the road. In these cases, the driver is accorded little blame for accidents. The reports typically point to inadequate training by the employer.

Inadequate securing of cargo: This risk factor relates to accidents partly caused by how the vehicle was loaded, and the cargo's centre of gravity being too high. This has caused critical toppling speed in curves to be low, and accidents occur when this speed is exceeded. Inadequate securing of cargo can to some extent be traced to individual drivers who have approved the loading. The AIBN, however, point out that employers should carry out risk analyses and have procedures for "extreme" loading operations, so it is not up to the drivers to decide what should be done in practice.

3.3.2 Risk factors associated with vehicle

Wear/malfunction: These are accidents partly caused by technical malfunction of vehicles, where these malfunctions are the result of wear and lack of maintenance. This risk factor differs from inappropriate design because it concerns damaged components (worn brakes, weld fractures), which should have been identified and repaired. Technical malfunctions are a result of wear and lack of maintenance. Both the driver and the driver's employer are responsible that equipment is in good technical condition. The driver shall, for instance, check equipment before each assignment, and monitor warning lights etc. during assignments, whereas employers who provide equipment must ensure that this is properly maintained.

Faulty/inappropriate design: These cases relate to the construction and design of equipment, standards for equipment and equipment rebuilt inappropriately. This factor is akin to what we might call misuse of equipment, but it differs from this in that drivers are relatively ignorant of the deficient equipment that contributed to the accidents. This risk factor is about situations where drivers have received defective equipment from their employer, or the information or training related to the equipment has been deficient.

3.3.3 Work-related risk factors

Inadequate work descriptions/procedures: This is the most prevalent work-related risk factor in the road accidents studied by AIBN. The AIBN considers job descriptions/procedures as dynamic documents that reflect and the company's continuous risk assessments. Procedures are an important element in the transport companies' safety management system, along with risk assessments and training. The reports emphasise that companies should first perform a risk analysis, work out procedures for drivers on assignments, and provide training on the basis of this.

Inadequate training in company: The reports often assess the driver's actions in relation to the training received from the employer. If the employer has not provided driver training relevant to the risk factors, the driver is given little blame for having acted incorrectly or overlooked risk. AIBN emphasises that internal company training should provide drivers with the skills to perform their work safely, and also strengthen their sense of responsibility for safety in general.

Inadequate risk assessment: Inadequate risk assessment is probably the most central work-related risk factor in the AIBN-reports, since risk assessments form the basis for the other two items of a safety management systems, i.e. training and procedures. If risk assessments are not conducted and documented by the company, it is up to individual drivers to assess the risk associated with each single operation. Several reports demonstrate that this latter approach results in accidents. They also show that companies providing a given form of transport should have a systematic approach to the risks which that transport entails, and enable drivers to carry out assignments as safely as possible. The reports emphasise that risk assessments should also cover relevant road stretches, equipment and operations.

Taken together, risk assessments, procedures and training make up what AIBN road refers to as *safety management systems*, summarizing an ideal for how transport operators should relate to risk and how they should work with safety management. Safety management systems, consist 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.In the accidents described in the AIBN-reports, it is often concluded that one or several of these processes have failed.

Inadequate follow-up of drivers during assignments and driving style generally: This risk factor indicates lack of systems for monitoring drivers before and during assignments, and lack of documentation and systematic plans to follow up drivers. This risk factor is often, but not necessarily, present when other aspects of HSE fails. It is most commonly mentioned in relation to drivers' speeding, driving style and failure to use a seat belt. This risk factor is, however, generally mentioned in all settings where a certain kind of risk behaviour has been pivotal in causing an accident and (should have been) known to the company. Report 2006/01 concludes that driving style and substance abuse had not been not sufficiently followed up by the employer.

Insufficient focus on HSE in company: We might consider this a collective term used either when the company has not been able to manage a specific safety problem, or if the company does not have a (good) safety management system. The absence of the elements of a safety management system is often explained with reference to an inadequate focus on HSE. This risk factor is subordinate to the other three, since it is very general and often indicates the absence of the three more specific work-related risk factors.

3.3.4 Framework conditions

Controls/inspection/audits/enforcements: this is the most cited issue in the AIBN road reports. In 16 of the reports, it is suggested that certain changes related to controls, inspections or audits could have prevented the accidents studied, or could prevent similar accidents in the future. The authorities that this risk factor addresses are first and foremost the Norwegian Public Roads Administration (NPRA) and the Norwegian Labour Inspection Authority (LIA). In most cases, the reports stress either that the NPRA or LIA did not detect certain risk problems in the afflicted companies in their inspections or that they did not inspect the companies, although they were at risk. Often reports suggest that inspections should focus on certain risk problems that the accidents reveal, e.g. that audits of bus companies do not focus on traffic safety (2009/1).

Rules/safety requirements. In accordance with this, eleven of the 25 studied reports from AIBN road focus on insufficient rules and safety requirements, suggesting changes or new rules to regulate certain risk problems that the studied accidents suggest the importance of. The suggested new rules often concern safety requirements, and the most interesting one is the suggestion that adequate safety management systems should be a precondition for granting transport permits to transport companies (2009/1). Five of the reports suggest that poor road maintenance/quality was a risk factor, and three suggest improved reporting of accidents/incidents in order to increase transport safety.

3.4 Summing up

1. About forty percent of the road transport accidents are work-related. The data from Statistics Norway (SN) show that a total of 44 % the police-reported personal injury road accidents with known trip purpose had work (27 %), or to/from work (17 %) as purpose. AAG-data show that 31 % of all fatal road accidents involve professional drivers at work, while 7 % involve drivers at work who are not professional drivers.

2. Approximately 298 drivers at work (and a total of 1500 people) killed/injured each year in average. An average of 287 drivers at work were injured each year in police-reported personal injury accidents with work as purpose (for 2007-2012). (11 were killed annually, according to the AAG-numbers.) The numbers represent a conservative estimate, as a third of the accidents did not have a purpose assigned. The numbers have decreased gradually in the period.

The numbers of injured people are substansitally higher when we look at all injured road users involved in the accidents involving a driver at work. An average of 1490 people are injured each year in these accidents. Thus, we see that most of the injured road users in accidents with 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.

3. Among the vehicles in accidents with "work" as trip purpose, heavy goods vehicles (HGVs) have the largest share. SN-data based on police reports show that forty percent of the vehicles in work-related accidents were HGVs, followed by private/estate cars and buses. AAG-data show that most (65 %) of the non-professional drivers at work drove light cars or vans at the time of the accident, but the rest drive a range of different vehicle types. About 90 % of the professional drivers in the AAG-data drove heavy vehicles.

4. Decline in number of work-related accidents, but no decline in work-related accidents with non-professional drivers from 2005 to 2013. Both SN-data based on police reports and AAG-data indicate that the annual number of drivers in work-related accidents decreased substantially in the period studied. SN-data based on police reports show that the number of injured people has decreased from 2007 to 2012. AAG-data show that fatal accidents involving professional drivers at work have decreased by 17 % from 2005 to 2013. The indicated reduction in absolute numbers is not as large as it is for all types of road transport accidents (33 %). AAG-data show a contrasting trend for accidents involving non-professional drivers at work. Accidents involving these do not appear to have decreased from 2005 to 2013, despite clear downward trends in other types of accident.

5. Lower use of protective equipment among professional drivers. AAG-data show that 55 % of professional drivers involved in fatal accidents did not use a seatbelt at the time of the accident, according to those cases registered, while 39 % of the non-professional drivers at work did not use a seatbelt at the time of the accidents. SN-data based on police reports show that the reported seat belt/airbag use is lowest for bus drivers involved in accidents, followed by HGV drivers and cab drivers. People driving for leisure have a reported seat belt use that is nearly twice as high as it is for those driving at work.

6. Lower injury severity for professional drivers at work (as they generally drive heavy vehicles). SN-data based on police reports show that driver injury severity is lower for people driving at work than for people driving for other purposes, and the traditional professional drivers (cab, bus, HGV) have the highest shares of unharmed drivers, perhaps because they are more protected in their vehicles. AAG-data also shows a relatively low serious injury rates for professional drivers, partly because 90 % of those involved drive heavy vehicles. 65 professional drivers have been killed in the period from 2005 to 2013. This is a relatively low share of those involved (12 %), and only 2.8 % are seriously injured. AAG-data show a contrasting tendency for non-professional drivers at work. Although relatively low numbers of these driver types are involved in fatal accidents (117 in study period), 41 % of those involved are killed.

7. (Professional) Drivers at work trigger fewer accidents than other drivers. AAG-data indicate that the chances are that professional drivers involved in fatal road accidents do not drive the triggering vehicle, but become involved in head-on collisions with counterpart drivers who drive into the path of oncoming traffic because they are tired, stressed, ill, influenced by drugs or alcohol, speeding or intending to take their own lives. 39 % of involved professional drivers trigger the fatal accidents. These are mostly head-on collisions, road exits or collisions with bicyclists or pedestrians.

8. Fatigue and stress are important risk factors of the triggering drivers at work. Of those professional drivers triggering accidents, 19 % are fatigued or stressed. However, 75 % are not registered as having in an abnormal condition at the time of the accident. The most commonly recorded contributors to fatal accidents triggered by professional drivers are lack of information gathering, surplus speed, mistaken decisions, and driver fatigue. Obstructed driver view is important in accidents involving pedestrians or cyclists that are triggered by professionals. Of the non-professional drivers at work who triggered fatal accidents, 28 per cent were registered as being in an abnormal condition, half of whom were stressed at the time of the accident. One in three non-professional drivers at work who triggered a fatal road accident were over 54 years old. If the are are few drivers at this age in this group, their accident risk is high.

9. The SN-database and AAG-database do not include work-related risk factors. We may however infer some work-related risk factors from the *AAG-reports*, e.g. related to fatigue and stress, indicating the importance of several work-related risk factors and framework conditions for safety.

10. The AIBN-reports focus on work-related risk factors. In the reports studied, AIBN usually assign vital importance to the work-related factors in the causal chain prior to the accident and risk factors related to driver and vehicle are usually linked to these.

4 Work accidents in the maritime sector

4.1 Personal injuries per year

The Maritime Authority's database of maritime accidents discerns between ship accidents and work accidents. An accident is recorded as either a ship accident or a work accident, depending on whether the accident involves damage to the vessel or not. As noted, we focus on all *personal injuries*, i.e. injuries caused by both ship accidents and work accidents in this study, and we only focus on personal injuries involving crew members.[6] The database includes information on all accidents between 1981 and 2013, the accident types causing the injuries and the severity of the injuries. It should, however, be noted that reporting routines and reporting rates have changed substantially in the period, and that this may limit or negatively influence comparisons of reporting tendencies and accident development over time.

A total of 23 446 personal injuries have been registered in Norwegian waters with Norwegian (NIS/NOR) and foreign ships, and in foreign waters with Norwegian ships (NIS) in the period 1981-2013. Injuries on vessels in canals, lakes and rivers are excluded. Injuries involving passengers and people external to the vessels are also excluded, as well as injuries on leisure vessels and mobile offshore units. The number of personal injuries per year is given in figure 4.1.

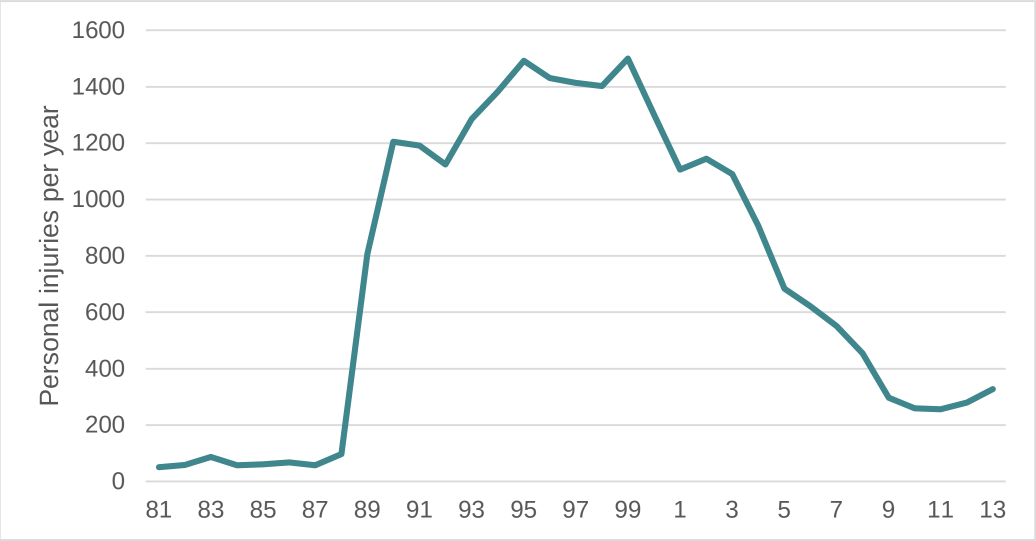


Figure 4.1 Crew members injuries on ships with Norwegian (NIS/NOR) and foreign flags in Norwegian waters, and ships with Norwegian flags (NIS) in foreign waters in the period 1981-2013. All injury severities and all ship types. Based on The Maritime Authority's database of maritime accidents.

[6] As the NMA's database also include personal injuries to people on ships who are not crew members, i.e. passengers and visitors, personnel accidents may be a more suitable term than work accidents. We choose to use the term work accidents, however, as we only focus on crew members' injuries in this report.

Figure 4.1 shows a dramatic increase in registered injuries from 1988 to 1989, which was caused by a change in reporting requirements, i.e. that the NMA started to register all kinds of injury severities, and not just fatal accidents and serious injuries. We also see that the number of registered injuries have decreased regularly from 1999 to 2009, but that there was a slight increase from 2009 to 2013. The statistics include personal injuries caused both by ship- and work accidents.

A total of 4 % of the reported injuries were caused by different ship accidents. These were: groundings (N=244), fire/explosion (N=262), collisions (N=103), capsizes (N=148), contact damage (N=108) (e.g. dock, bridge).

Figure 4.2 shows the number of crew member injuries per year for different ship types. Most of the registered injuries were for cargo ships. Thus, perhaps the injury risk of cargo ships to some extent could explain the dramatic increase in injuries from 1988-89 that are reported above, in addition to changes in reporting practice. The figure also shows a steady decrease in injuries for cargo ships, fishing ships and passenger ships in recent years. There were on average 177 personal injuries per year for fishing vessels, 350 for cargo ships and 184 for passenger ships in the period 1981-2013.

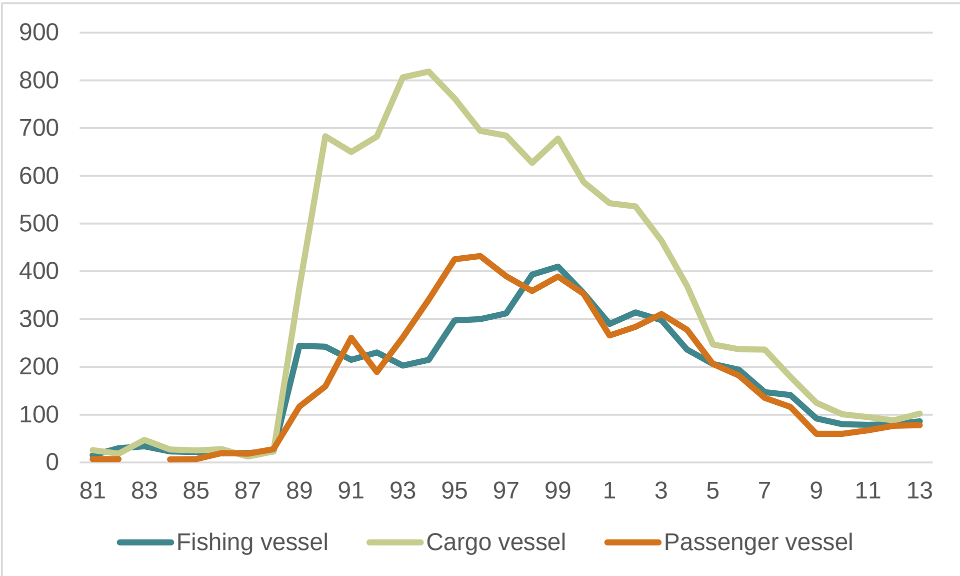


Figure 4.2 Crew member injuries for different ship types with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 1981-2013. All injury severities. Based on The Maritime Authority's database of maritime accidents.

4.1 Severity of personal injuries

Table 4.1 shows the severity of personal injuries per year from 2004 to 2013, for fishing vessels, cargo ships and passenger ships. In this table, missing people are presumed dead.

Table 4.1 Dead and injured crew members for three ship types with Norwegian (NIS/NOR) and foreign flags in Norwegian waters, and ships with Norwegian flags (NIS) in foreign waters in the period 2004-2013. Distinguishing between injuries involving work absence for more and less than 72 hours. Based on NMA's database of maritime accidents.

Vessel group	Severity	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	AVG
Fishing vessels	Dead	4	5	7	4	0	10	8	6	8	3	55	6
	Injured (<72hrs)	79	38	44	27	36	25	13	16	18	19	315	32
	Injured (>72 hrs)	153	163	143	116	105	57	59	57	54	64	971	97
	Total (F.V.)	236	206	194	147	141	92	80	79	80	86	1341	134
Cargo ships	Dead	27	5	3	12	5	11	5	3	4	2	77	8
	Injured (<72hrs)	178	107	85	82	71	43	30	25	32	33	686	69
	Injured (>72 hrs)	165	135	149	142	103	71	66	67	52	67	1017	101
	Total (C.S.)	370	247	237	236	179	125	101	95	88	102	1780	178
Passenger ships	Dead	1	1	1	1	0	0	0	2	0	1	7	1
	Injured (<72hrs)	153	90	89	41	46	21	14	16	31	29	530	53
	Injured (>72 hrs)	124	115	92	93	70	39	46	49	46	48	722	72
	Total (P.S.)	278	206	182	135	116	60	60	67	77	78	1259	126
Unregistered	Injured	16	0	0	0	0	0	0	0	0	0	16	
	Total	884	659	613	518	436	277	241	241	245	266	4396	439.6

The table shows that all three vessel types have had considerable decreases in the number of crew member injuries in the last ten years. The number of deaths each year has been fairly stable with some exceptional years with many deaths caused by ship accidents.[7] For instance, the cargo ship Rockness grounded and sank in 2004, causing a total of 19 deaths. We see that cargo ships had the highest average number of dead and injured per year, while passenger ships had the lowest numbers.

Figure 4.3 shows the distribution of severity for personal injuries for different ship types. We see that the share of severe injuries (>72 hrs) is 15 % points higher for fishing vessels than other vessel types.

[7] The NMA made us aware of the fact that some of the deaths in the database were suicides, and that accidents previously could be recorded as "suicide" in the database. This category is not used today. Per August 2015 some of these deaths were removed by the NMA, but they were still in the process of considering the removal of other deaths in the database. All in all, it was estimated that about 20 of 900 deaths in the period 1981-2013 could be suicides. As the status of these incidents were unclear by the time of publication, we did not remove these from our data. This may lead to minor differences in our presentations of deaths, compared to the NMA statistics where these deaths have been removed.

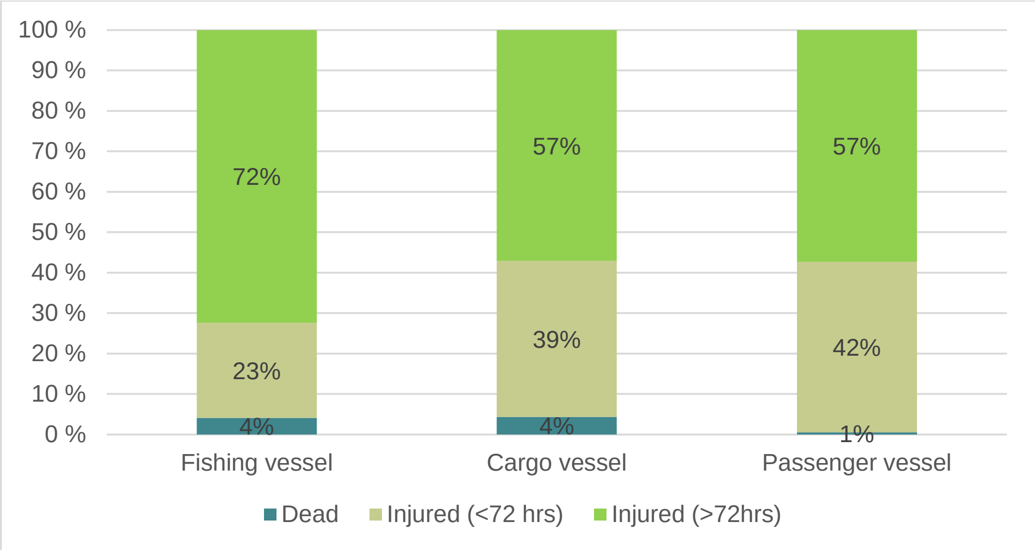


Figure 4.3 Severity of crew member injuries for different ship types with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. Dead, injured and injured with a work absence of more than 72 hours. Based on NMA's database of maritime accidents.

4.2 Personal injuries on ship types

In the period 2004-2013 there were on average 97 personal injuries involving work absence of at least 72 hours per year for fishing vessels, 101 for cargo ships and 72 for passenger ships. The total average per year for the three groups in the period was 271 personal injuries involving work absence of at least 72 hours.

Figure 4.4 shows an index of personal injuries involving work absence of at least 72 hours per year with the number of personal injuries in 2004 as 100 %. We focus on personal injuries involving work absence of at least 72 hours in order to reduce the effect of reporting changes in the period.

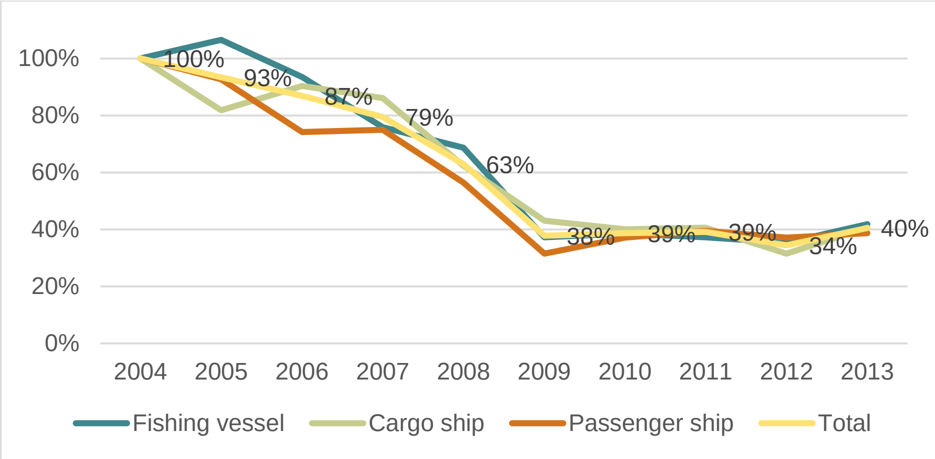


Figure 4.4 Index of crew member injuries involving work absence of at least 72 hours per year for different types of vessels from 2004 to 2013, with 2004 as 100 % (N=2710). Ships with Norwegian (NIS/NOR) and foreign flags in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters. Based on NMA's database of maritime accidents.

The figure shows that for all ship types, personal injuries involving work absence of at least 72 hours have declined substantially in the last ten years. Since 2009, the number of personal injuries involving 72 hours work absence has been stable below about 40 % of what it was in 2004, i.e. a 60 % reduction in the period. It is important to note, however, that these numbers are contingent on: 1) the number of ships each year, 2) the number of crew on the ships, and 3) the number of hours worked by the crew members on the different ship types each year.

Figure 4.5 takes the number of ships into account, and shows the distribution of severity for personal injuries per 1000 vessels per year for fishing vessels. The year 2004 is excluded as flag state was not sufficiently recorded in ship accidents and personal injuries until 2005. We only look at personal injuries on vessels with Norwegian flag (NIS/NOR).

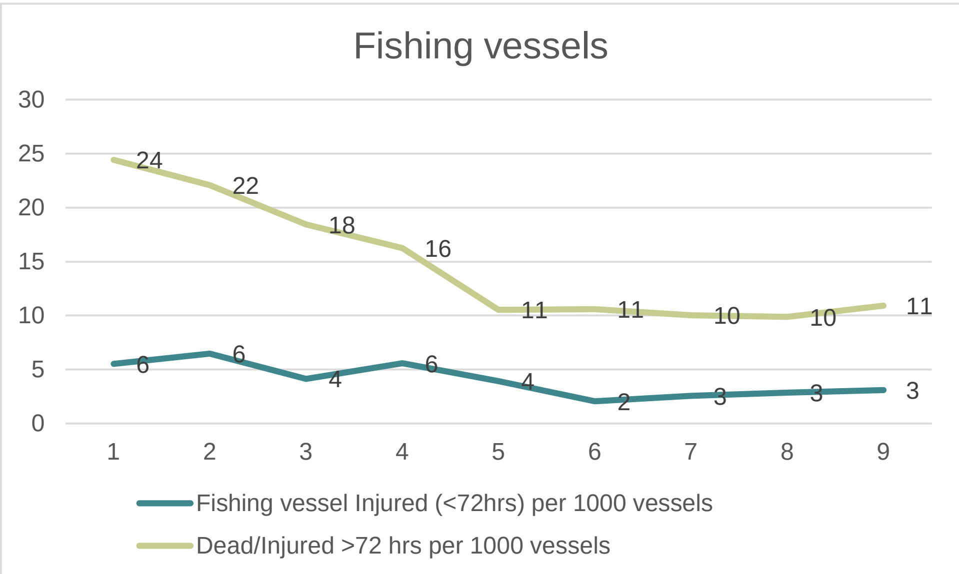


Figure 4.5 Severity of crew member injuries (more or less than 72 hours work absence) per 1000 vessels per year for fishing vessels. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

We see that the risks of both injury severities have been reduced substantially. The risk for the most severe injuries has been reduced by 54 % in the period. In the same period, the number of NIS/NOR fishing vessels have been reduced with 11 %, to 6145 vessels in 2013. This supports the impression of a risk reduction, as we measure risk as the number of injuries per thousand vessels each year. This is however a crude risk measure as it neither includes the number of crew on the ships, nor the hours worked do. Unfortunately, we do not know whether the number of crew members on these ships have increased or decreased.

Looking at all severities, there were 1341 personal injuries on fishing vessels in the period 2004-2013. Most of the personal injuries were on regular fishing vessels (74 %), followed by factory trawlers (15 %), regular trawlers (8 %) and other fishing vessels (3 %). The distribution of injuries on the different fishing vessel types have been fairly stable in the period 2004-2013, although the numbers of injuries have decreased each year.

Figure 4.6 shows the distribution of severity for personal injuries per 1000 vessels per year for cargo vessels.

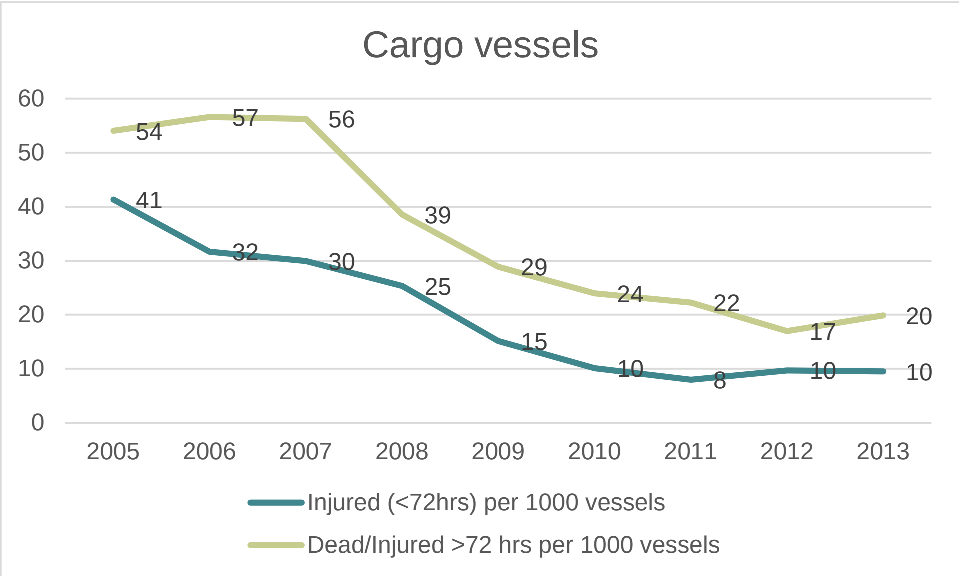


Figure 4.6 Severity of crew member injuries (more or less than 72 hours work absence) per 1000 vessels per year for cargo vessels. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

We see that the number of injuries per 1000 vessels have been reduced substantially for both injury severities in the period. The risk for the most severe injuries has been reduced by 63 % in the period. In the same period, the number of NIS/NOR cargo vessels have increased with 34 %, to 3470 ships in 2013. Thus, some of the risk reduction we have seen could be attributed to more vessels, given that these vessels have more automation, smaller crews and better technology. As noted, we measure risk as the number of injuries per thousand vessels each year. We do, however, not know whether the number of crew members on these ships have increases or decreased, so more research is warranted on this issue.

Looking at all severities, there were 1780 personal injuries on cargo vessels in the period 2004-2013 Most (29 %) of the personal injuries on cargo ships were on "other" cargo ships followed by service vessels for offshore petroleum units (28 %), oil/chemicals (13 %), LPG (10 %), Regular groupage cargo (9 %), Roll-on/Roll-off (4,5 %), well vessels (4 %), and regular bulk (4 %).

The shares for offshore service vessels increased in the period, from 22 % in 2005 to 40 % in 2013. The same did regular groupage cargo, from 5 % in 2005 to 13 % in 2013. The shares of personal injuries on ships carrying oil/chemicals and LPG decreased substantially in the period, from 30 % in 2004 to 4 % in 2013.

Figure 4.7 shows the distribution of severity for personal injuries per 1000 vessels per year for passenger vessels. We see that the number of injuries per 1000 vessels have been reduced substantially for both injury severities in the period. The risk for the most severe injuries has been reduced by 57 % in the period. The number of NIS/NOR passenger ships has been very stable in the period, with 1235 ships in 2015. Unfortunately, we do not know whether the number of crew members on these ships have increases or decreased.

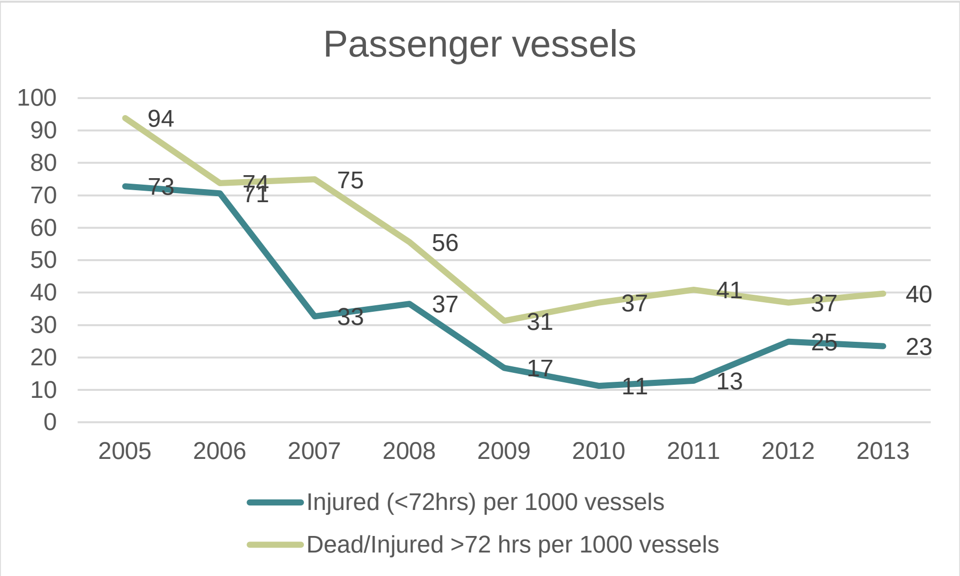


Figure 4.7 Severity of crew member injuries (more or less than 72 hours work absence) per 1000 vessels per year for passenger vessels. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

Looking at all severities, there were 1259 personal injuries on passenger vessels in the period 2004-2013 The highest share of these were on car ferries (38 %), followed by combined passenger/cargo vessels (26 %), Ro-ro/passenger ferries (15 %), passenger/cruise vessels (11 %) and other (10 %). It may seem that the shares of personal injuries aboard car ferries have decreased in the period, from 55 % in 2004 to 29 % in 2013.

4.3 Types of personal injuries

Above, we saw that the three vessel types had undergone a fairly comparable risk reduction of about 60 % in the period 2005-2013. Below, we will examine whether the reduction in personal injuries on ships in Norwegian waters can be explained by reduction in particular types of injuries.

Figure 4.8 shows the types of personal injuries per year per 1000 fishing vessels from 2005 to 2013. The figure shows a substantial reduction in all injury types in the period, although the risk of fall injuries and other injuries seem to have increased somewhat in recent years. It would be interesting to see what kind of injuries the category "other" encompasses. The most common personal injury types on fishing vessels are crushing injuries (43 %), fall on board (28 %), other injuries (15 %) and cut/stab injury (14 %).

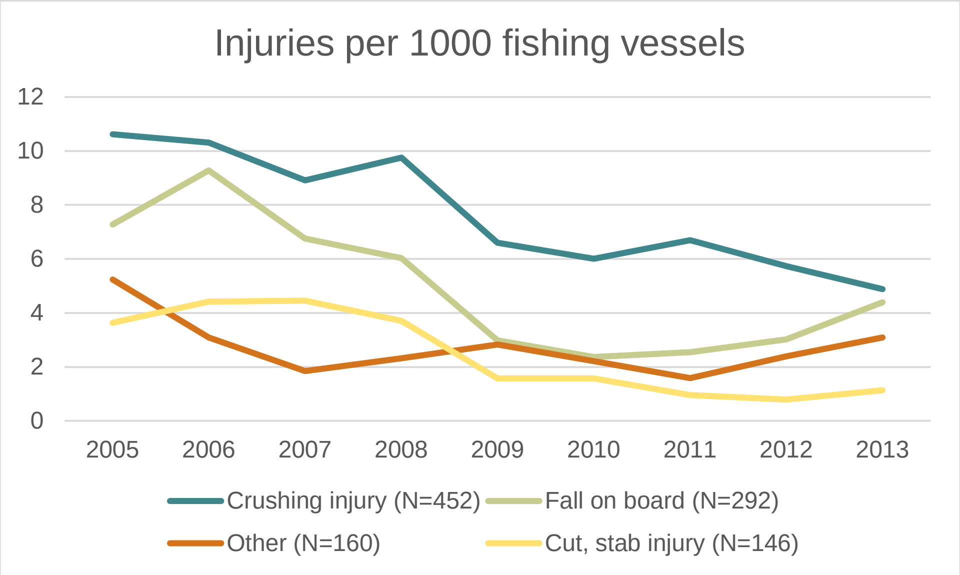


Figure 4.8 Types of crew member injuries per 1000 fishing vessels per year. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

Figure 4.9 shows the types of personal injuries per year per 1000 cargo vessels from 2005 to 2013. The figure shows a substantial reduction in all injury types in the period, and that the numbers have been fairly stable from 2009. The most common personal injury types on cargo vessels are crushing injuries (36 %), fall injuries (29 %) "other" injuries (24 %) and cut/stab injuries (10 %).

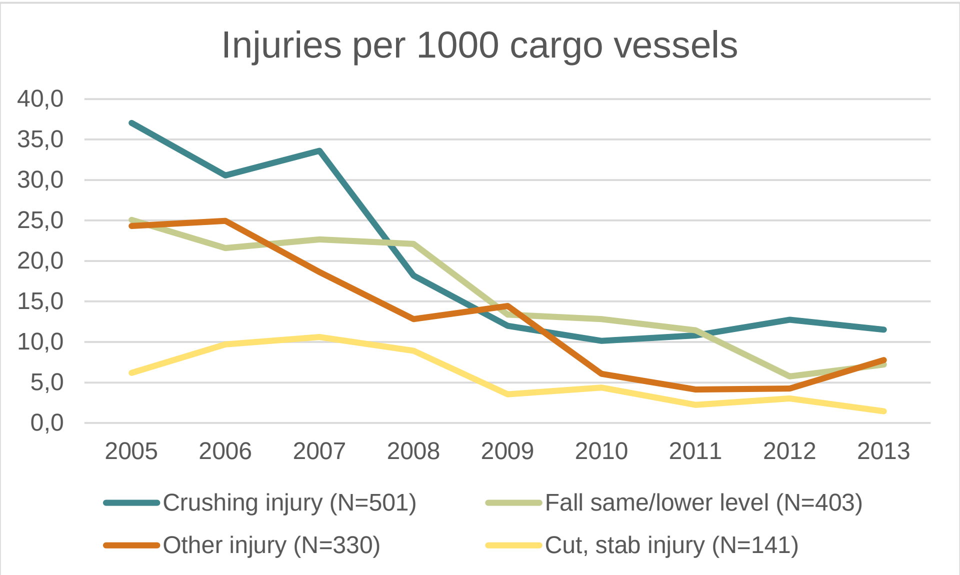


Figure 4.9 Types of crew member injuries per 1000 cargo vessels per year. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

Figure 4.10 shows the types of personal injuries per year for crew members per 1000 passenger vessels from 2005 to 2013. We see a substantial reduction in all injury types from 2005 to 2009, and that the injury risk has been stable, or increased slightly from 2010 to 2013. The most common personal injury types for crew members on passenger vessels are fall injuries (35 %), crushing injuries (31 %) "other" injuries (22 %) and cut/stab injuries (11 %).

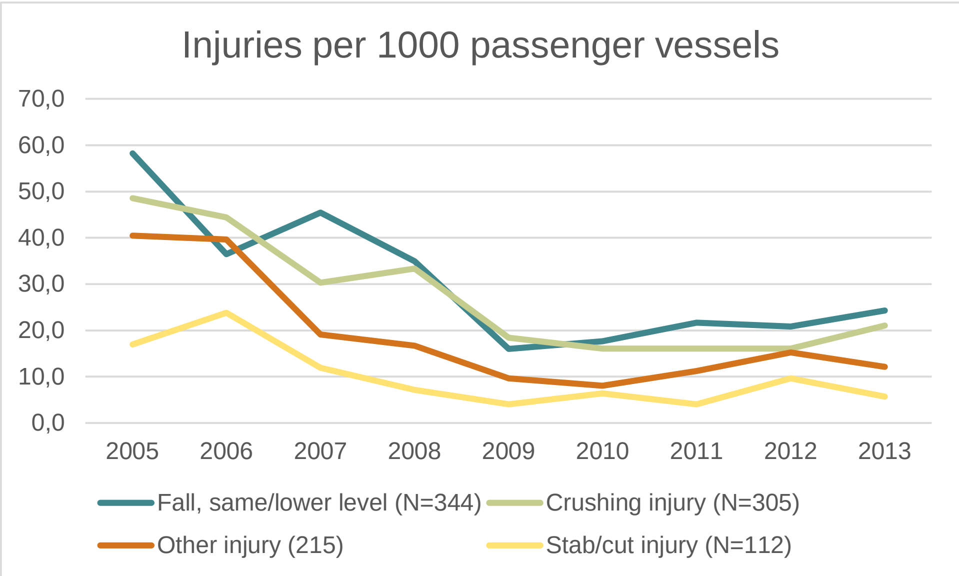


Figure 4.10 Types of crew member injuries per 1000 fishing passenger per year. Ships with Norwegian (NIS/NOR) flag only. Based on The Maritime Authority's database of maritime accidents.

We may conclude that the most prevalent injury types on all three ship types are fall, injuries and crushing injuries, and that safety measures should address these injury types. Fishing vessels have a higher share of crushing injuries than the two other ship types, probably because of rotating equipment. Passenger vessels have a somewhat higher share of fall injuries. We also see a slight increase in fall injuries on passenger- and fishing vessels in recent years, and more research should be devoted to examining this issue.

4.3.1 Operational phase

Figure 4.11 shows the operational phases in which the personal injuries occurred. Interestingly, the two operational phases with the highest share of personal injuries is "at dock" and "underway". Given the (presumably) fairly limited time spent at dock compared with the time spent at sea, future research should examine e.g. safety while loading/unloading. When we look at the work operations conducted "at dock" when people are injured, the "empty" category (unregistered) has the highest share with approximately 25 % for all ship types followed by "other work" (between 12-8 %) and loading/unloading (between 11-4 %).

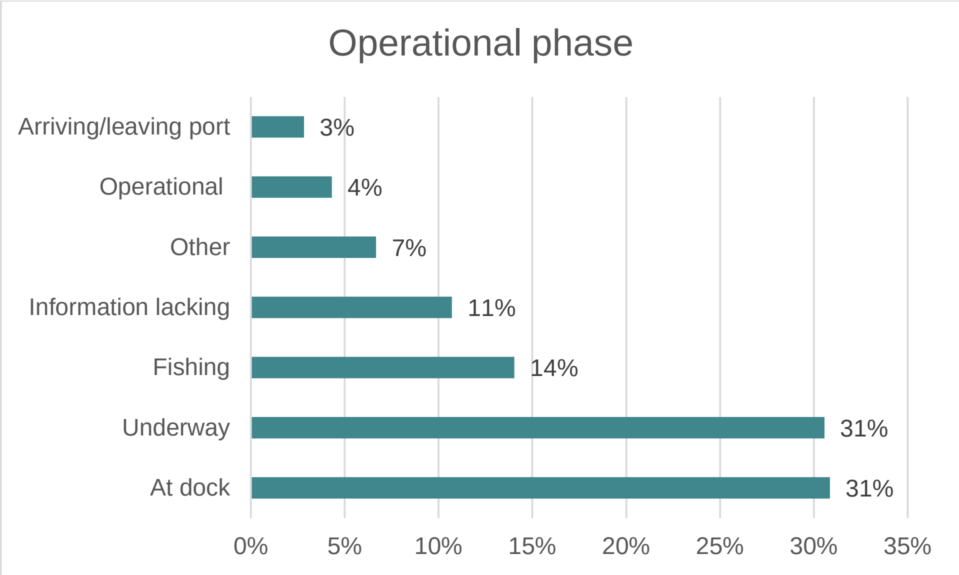


Figure 4.11 Crew member injuries per operational phase. Vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. All injury severities (N=4396). Based on The Maritime Authority's database of maritime accidents.

4.4 Who is injured?

4.4.1 Function

As noted, we have excluded passengers (N=155) and people outside the ship (N=21) in the 4396 injuries we include in this study. We look at all the people who were injured on Norwegian ships (NIS/NOR) in Norwegian waters or abroad, and foreign ships in Norwegian waters in the period 2004-2013.

Table 4.2 shows personal injuries per function from 2004 to 2013, for all injury severities, excluding passenger and people outside the ship, i.e. people who were not at work. Fishermen (19 %) had the highest share of injured people, followed by sailors/seamen (17 %) and engine room crew (16 %). Figure 4.13 shows personal injuries per year and function.

Table 4.2 Crew member injuries per function. Ships with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. Based on The Maritime Authority's database of maritime accidents

Function	Total	Percent
Fisherman	852	19 %
Sailor/seaman	769	17 %
Engine room crew	704	16 %
Unknown	590	13 %
Catering	552	13 %
Other	538	12 %
Bridge	391	9 %
Total	4396	100

Figure 4.12 shows the number of personal injuries per function and year. All functions except the category "Unknown" have had a steady decrease in injuries until 2009, and that the injury level for these has been stable below 50 personal injuries each year from 2009 to 2012. Future research should examine the functions that make up the category "unknown", as injuries have increased for this group.

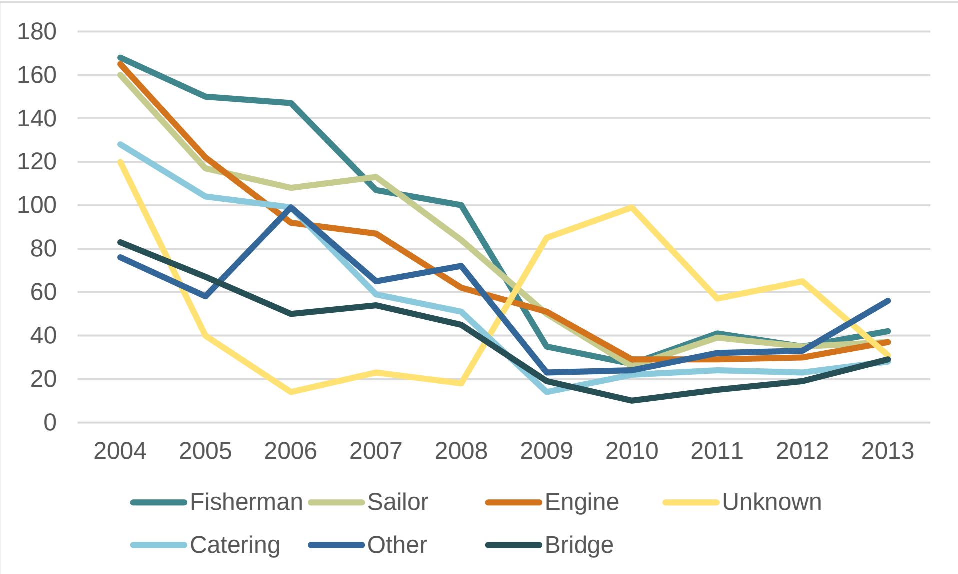


Figure 4.12 Crew member injuries per year and function. Vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. All injury severities (N=4396). Based on The Maritime Authority's database of maritime accidents.

4.4.2 Nationality of people injured

Table 4.3 shows that 77 % of the people injured were Norwegians, while 9 % were from the Philippines. The remaining 14 % were from other nations.

Table 4.3 Crew member injuries per nationality. Ships with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. Based on The Maritime Authority's database of maritime accidents.

Nationality	Total
Norway	3405
Phillipines	391
Other	238
EU	183
Unknown	111
Nordic (exc. Norw.)	68
Total	4396

Figure 4.13 shows the number of personal injuries per year for Norwegians. The number of personal injuries per year for Norwegians in 2013 is less than a third of the number in 2004. The share of injured Norwegians was the same in the beginning and in the end of the period (76 %). This share has fluctuated between 76 % and 83 % in the period. The latter share (83 % in 2010) was mostly due to a low absolute number (N=42) of foreigners injured this year and not a high number of Norwegians injured (N=199).

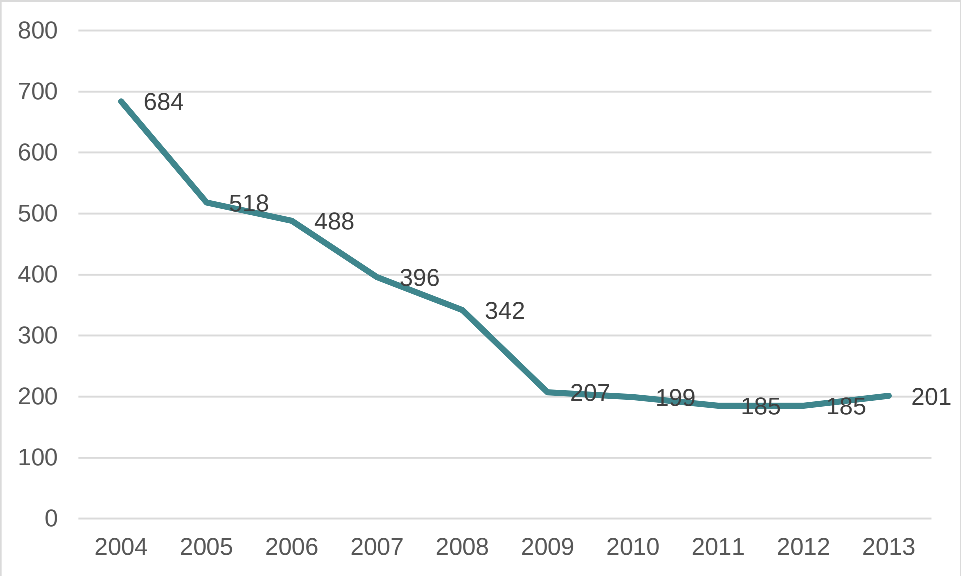


Figure 4.13 Crew member injuries per year for Norwegians. Vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. All injury severities (N=3405). Based on The Maritime Authority's database of maritime accidents.

Figure 4.14 shows the share of personal injuries per year for foreigners. The largest group of injured foreigners are people from the Philippines, followed by people from the EU.

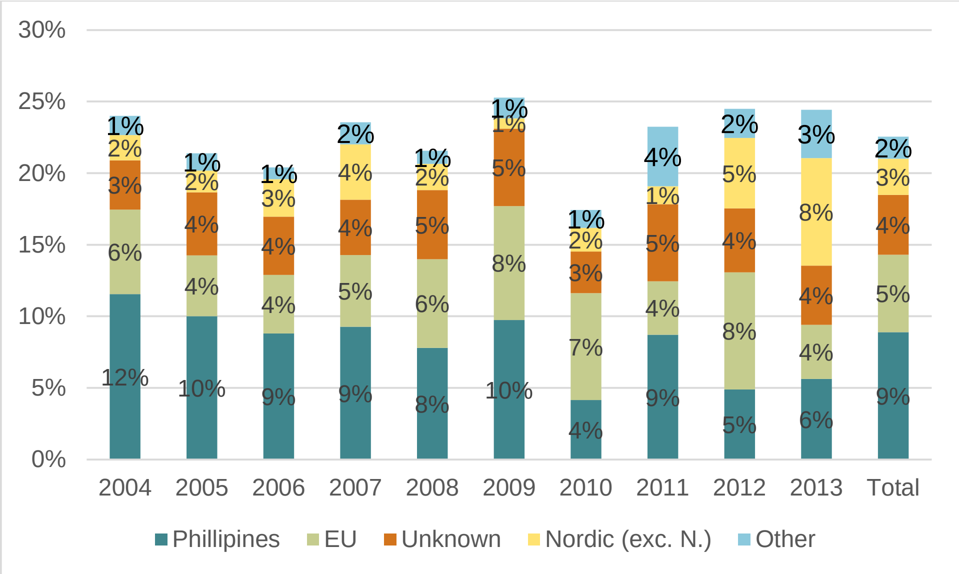


Figure 4.14 Crew member injuries per year for foreigners and unknown nationality. Vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2004-2013. All injury severities (N=991). Based on The Maritime Authority's database of maritime accidents.

4.4.3 Flag state of vessel

Table 4.4 shows personal injuries per flag state of ships in Norwegian waters from 2005 to 2013. The year 2004 is excluded, because the majority of ships lacked information on flag state in the years preceding 2005. This changed in 2005, probably as the Maritime Authority improved the database of maritime accidents.

Table 4.4 Crew member injuries per flag state. Vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in the period 2005-2013. All injury severities (N=3496). Based on The Maritime Authority's database of maritime accidents.

Flag state	Ships with injuries	Percent
Norway	3465	99 %
Nordic	2	0 %
EU	1	0 %
Flag of convenience	18	1 %
Other	4	0 %
Unknown	6	0 %
Total	3496	100 %

Table 4.4 shows that the flag state is Norwegian for 99 % of the ships with personal injuries, and that about 1 % of the ships with personal injuries were foreign, mainly from flags of convenience. We know, however, based on AIS-data[8] from the Norwegian Coastal Authority that 52 % of the cargo ships along the coast of Norway sailed under foreign flags in 2012 (Nævestad et al. 2014). Thus, it seems that foreign vessels underreport work accidents to the NMA.

[8] AIS: Automatic identification system.

4.5 Results from AIBN-reports

The review presented in the current report is based on published report from the AIBN maritime. All reports concerning accidents and incident taking place between 01.01.2009 and 01.01.2014 published by January 2015 have been included in the analysis. The number of accident reports from the period is 48 reports. All reports have been downloaded, and the AIBN-reports' discussions, conclusions, and recommendations have been studied and searched for work-related risk factors.

Table 4.5 Risk factors identified in the AIBN sea reports.

	Risk factors	2009	2010	2011	2012	2013	2014	Total
People	**Absence of, or lacking use of safety equipment**	1	2	2	6	4	3	18
	Other conscious risk taking				1	1	2	4
Vessel	**Technical design or lack of physical barriers**	1	3	2	3	4	2	15
Work-related factors	**Lack of (written) risk assessment**	3	2	3	2	5	5	20
	One person on board vessel	2	1	2	5	2	2	14
	Work practice violating procedures	1	1	1	3	4	2	12
	Lacking safety procedures		2			2	5	9
	SMS incomplete or not adapted	1	4			1	1	7
	Lack of safety training		2		2	1	2	7
	Communication problems		1		2	1	1	5
	Manning	1			1		1	3
	Time pressure	1						1
Framework conditions	**(Inter-)National rules/regulations**		1	1	2	1	1	6
	Inspection/audit/certification	1	3	2	1	1	1	7
	Quota system	1						1

4.5.1 Risk factors associated with people

Absence of, or lacking use of safety equipment. We may roughly divide maritime accidents described in the AIBN-reports into two kinds: accidents with small fishing vessels (frequently manned with only one person, who is typically the owner) and accidents with larger vessels, owned by a shipping company. For the first kind of accident, with small fishing vessels ("sjark" 19-42 feet), the typical sequence of events is that the sole person on board the vessel is trapped in the gear and/or falls overboard.

In these accidents, AIBN generally points to the benefits of safety equipment, e.g. properly installed emergency stops and safety vests. Safety equipment is the second most frequently mentioned risk factor. Report 2012/12 gives a typical description of how a fisherman was trapped in the gear and/or fell overboard.

> *"The investigation concludes that the fisherman was pulled overboard as a consequence of his ankle becoming entangled in a loop of the line/ string joining together the crab pots when setting a crab pot line. In the AIBN's opinion, the fundamental cause of the accident was that, for reasons unknown, the ground line was left in a position on the forward part of the deck, where the fisherman was moving around. This was a breach of his normal work procedure, which involved collecting all pots and ropes on the aft part of the deck so that he could stand forward of the gear when setting the line. There was no separate arrangement on deck with facilities for handling pots on board 'Sjøbjørn', and the available deck area for handling the pots was small."*

The AIBN suggests that the (correct) use of certain kinds of safety equipment, such as emergency stops, safety lines and inflatable vests might in many cases have increased the chance of survival, as illustrated in the above-cited report:

> *"For lone fishermen, there is also a requirement that a safety line should be used provided that such use is neither dangerous nor especially difficult. The AIBN believes that, had the fisherman on board 'Sjøbjørn' used a safety line, there is a possibility that he could have been held back so that he could free himself from the loop around his ankle. The fisherman had not conducted a written risk assessment of shipboard hazards, but his work procedures were based on sure knowledge of the dangers involved."*

Absence of, or lacking use of safety equipment is a risk factor that concerns both people at work and organisations, depending on whether the equipment was not used because of negligence, or because it was not available. However, most of these accidents involve one person who is self-employed. Thus the difference between individual and organisational factors becomes little in practice, as the organisation is made up by one fisherman, who is supposed to establish organisational and technical barriers in order to prevent his own errors from leading to severe accidents.

"Safety equipment" includes a number of different measures, from survival suits, to emergency lines and emergency stop systems. AIBN mentions the following safety equipment in the reports:

- Self- emergency stop system (2009/03, 2011/04)
- Faulty instalment of emergency stop system (2011/01)
- Survival suit (2012/05, 2012/14, 2014/02)
- Helmet unfastened (2014/10)
- Inflatable work vest (2010/09, 2012/05, 2014/04, 2013/06)
- Safety line (2010/07, 2012/12, 2012/11, 2013/06, 2013/07))
- E-stop (2010/07, 2012/11, 2014/02, 2013/06, 2013/07)
- Firefighter gear (2013/04)
- Rescue equipment (2013/01)
- Emergency beacon (2012/04, 2012/02)

4.5.2 Risk factors associated with vessels

Many of the reports, especially those with fishing vessels point to technical factors related to the vessels to describe how the accidents could happen and why they led to serious consequences. These reports often concern physical arrangements on fishing vessels, allowing for fishermen to get trapped in gear during fishing or leaving the fishermen vulnerable, and demanding a very high level of attention when fishing. Thus, these kind of work environments are unforgiving, in the sense that they do not allow the fishermen to make mistakes, e.g. because of inattention, without serious consequences. Thus reports conclude that technical barriers reducing the consequences of human error were not in place. Other reports concern the stability of vessels, stating that the vessels were not approved by relevant certification authorities, or that malfunctions were not detected in inspections.

4.5.3 Work-related risk factors

Lacking risk assessments. Lack of complete, written risk assessments is the most frequently occurring risk factor in the reports. Written risk assessments are required by the Norwegian HSE provision for people working aboard ships.[9] This factor is present both in the case of larger vessels, and in the case of small fishing vessels with sole proprietorship. In the first case, it can refer to several different work processes or modifications, in the latter case it by and large refers to lone fishermen that should have made better risk analyses of their work space (while fishing) in order for them to reduce their risk of getting trapped in their fishing gear while fishing.

The AIBN maritime defines risk assessments in a relatively broad sense (report 2013/03):

> *"Risk assessment is often used as a generic term for planning, risk analysis and risk evaluation. The objective of risk assessment is to uncover hazards and identify undesirable incidents, analyse and evaluate risk, establish an overview of all risks, assess them in relation to what is deemed to be acceptable (acceptance criteria), propose risk reduction measures and consider alternative solutions."*

The AIBN frequently finds risk assessments to be non-existent or underdeveloped, for instance through not taking local contexts sufficiently into account, as illustrated by the quote below (Report 2013/03):

> *"As mentioned, the vessel was built as a combined chemical and oil product tanker. The segregation of incompatible cargoes was only facilitated to a limited extent by the design solutions on board the Clipper Sund and it was therefore necessary to use operational solutions. In the AIBN's view, this increases the need for carrying out the vessel-specific risk assessments that should form the basis for the introduction of risk reduction measures, such as necessary plans, procedures and instructions for carrying out safe operations. The AIBN believes that the circumstances described in Chapter 2.3.2 can be linked to a lack of awareness on the part of both the shipping company and the vessel of incompatible cargoes and inadequate risk assessments of discharging operations."*

One person on board vessel. Several of the studied maritime accidents involve small fishing vessels manned with only one person, who is also the owner. In this kind of accident, the typical sequence of events is that the sole person on board the vessel is

[9] https://lovdata.no/dokument/SF/forskrift/2005-01-01-8

trapped in the gear and/or falls overboard. There are also cases in this category, however, where the vessel is surprised by severe weather, and capsizes.

The single occupancy of the boat is thus an important risk factor in itself, as mishaps which might be relatively easy to sort out with the help of one additional person, may have fatal consequences when no-one is able to come to the rescue. The AIBN emphasises the importance of risk assessments and physical barriers to risky areas on board vessels in order to prevent such accidents. However, in many cases it is also suggested that the (correct) use of certain kinds of safety equipment, such as emergency stops, safety lines and inflatable vests might in many cases have increased the chance of survival. Often the vessels are relatively old, small, modified and sometimes unapproved, increasing the chances of maritime accidents.

Work practice violating procedures. In many cases it is also found that although procedures, assessments or safety management systems (SMS) are in accordance with regulations, these are not adhered to in practice, a finding that might suggest that the safety culture on board the vessel or in the shipping company is not satisfactory. In some cases, vessels violate safety rules of the shipping company. In other cases, work groups (or individuals) may violate safety rules.

Research often discern between formal aspect of safety work, like procedures, roles and functions, what we may refer to as safety structure ("how we officially say we do things") and informal aspects of safety work, what we may refer to as safety culture ("how we actually do things") (e.g. Antonsen 2009; Reason 1997). Several of the AIBN sea reports find a considerable gap between these aspects, indicating "silent deviations", and poor safety culture.

Report 2013/04, for instance, concerns a case where a fisherman died while he was working alone in the freezer hold, packing blocks of frozen fish. The accident happened when the fisherman was about to sort out blocks that had jammed on the conveyor belt. His jacket had been pulled down with great force towards the inclined conveyor. The AIBN concludes that this had probably resulted in the fisherman being unable to breathe, and links this to the company's overall safety work:

> *"Verbal guidelines stated that the conveyor belts were to be stopped before attempts were made to sort out jammed blocks. The AIBN's investigation shows that this was not the practice on board, however. In this context, the AIBN believes that more active involvement on the part of the shipping company relating to the use of working environment committees, follow-up of the shipboard management's review and internal audits could have contributed to identifying and changing this unsafe work practice."*

In some instances, it is obviously the case that the shipping company moves in a grey area, and consciously breaks regulations. This, for instance, seems to be the case in report 2010/09, where a seaman drowned after falling into the water:

> *"No boatman was used to let the mooring lines go. There were several possible measures for reducing the risk of the operation, but these were not implemented. If the ordinary seaman had used an inflatable work vest, her survival time would have increased significantly. The time pressure to get to the next port caused stress and a lack of overview and coordination in the departure phase. A number of key factors related to the safe operation of the ship were missing. This primarily applies to a number of factors related to work, health and safety. The shipping company had not established the necessary preconditions for safe operation of the cargo ship."*

These are exceptions, however, and more frequently, the risks taken seem to be the results of oversights or unsafe practices that have developed as a result of convenience, and insufficient planning. The description below of a falling accident while a ship was at quay (Report 2014/02), thus exhibits a number of typical features:

> *"The ordinary course gangway could not be used because the quay was too short. The crew perceived access with ladder as cumbersome, and thus a practice had developed of using the pallet elevator for access. The AIBN considers that this was an unsafe working practice, and that this led to the fatal accident where the machinist perished. The pallet lift at the side gate was used for traffic to and from the quay without prior risk assessments or comparison to alternative means of access. This enabled the development of a working practice with irregular use of safety chains, and there lacked instructions for traffic in the danger zone during lifting work."*

Inadequate safety procedures: Some of the reports point to inadequate safety procedures as a risk factor, often linking it to lacking risk assessments, stating that as proper risk assessments of work processes never were done, there were no proper work descriptions to make workers aware of the risks that they were about to face in their work (e.g. 2011/04).

Lack of safety training: Lack of proper safety training is also listed as a risk factor in seven of the reports. This is a risk factor that it is natural to relate to risk assessments and procedures (e.g. 2014/03), as proper safety training of personnel is dependent on systematic risk assessments identifying risks and the development of safety procedures based on these risk assessments.

Safety management system incomplete/not adapted: Above we have stressed the importance that AIBN attributes to risk assessments, procedures and training. These three elements make up what we refer to as safety management systems (SMS). Report 2014/03 concludes for instance that the accident was a result of lacking competence on the part of the crew, because of lacking risk assessments, safety procedures and subsequently lacking safety training. SMS is probably the single most important work-related factor being referred to in the reports, as it is made up of three other frequently mentioned factors, especially risk assessments, which is the single most frequently mentioned risk factor. It should be noted, however, that one person aboard vessels also is a pivotal risk factor in the maritime sector, but risk analyses are also often evoked to explain these accidents.

4.5.4 Framework conditions

Inspection/audit/certification: As noted, many of the reports, especially those with fishing vessels point to technical factors related to the vessels to describe how the accidents could happen and why they led to serious consequences. These reports often refer to physical arrangements on fishing vessels, or the lacking stability of vessels, stating that the vessels were not approved by relevant certification authorities, or that malfunctions were not detected in inspections. The reports sometimes also point to general problems with the audit and certification systems, stressing that certain types of problems are not covered in audits or certifications. In these cases, the AIBN recommend new practices, new checklists for those conducting audits or certifications, or changes in international regulations.

(Inter-)national rules and regulations. Several AIBN-reports (2013/03) state that it is problematic that national and international rules lack proper and detailed procedures for risk assessment aboard small fishing vessels (below 15 metres).

This constitutes, as noted above, a considerable safety challenge. The following quote is from report 2013/11, which states that risk assessments should be applied already in the design phase.

> *"The current regulations contain few and unclear requirements to ensure the safety of fishermen when they use fishing gear and tools. The regulations contain no requirements for risk assessments relating to the operation of the vessel to be conducted already in the design phase. This can result in effective safety barriers not being built in and in the safety of the crew becoming overly dependent on organisational factors relating to the operation of the vessel. Both building regulations and occupational safety regulations should contribute more to ensuring operational safety than they do at present. An important lesson to be learnt from this accident is that the owners' safety work must be initiated already in the design phase. The owners must play an active role and involve the users, and they must use qualified HSE personnel to conduct a critical review of the design solutions, and thus ensure safer working conditions for the fishermen who are to operate the vessel."*

Frequent ownership changes due to quota system. AIBN report 2009/09 stresses that the Directorate of Fishing practices the regulations in a way that makes it difficult to get fishing quotas transferred from one vessel to another which is owned by a different shipping company without having to buy and sell vessels. This may lead to frequent, temporary ownership changes that may have negative impacts to maritime safety, as it for instance may disturb the daily operations and focus on HSE.

4.6 Summing up

1) Decrease in injuries. Both fishing, cargo and passenger vessels have had considerable decreases in the number of personal injuries in the period 2004-2013. There was a 60 % reduction of injuries on average from 2004 to 2013. When we look at the number of serious injuries per 1000 vessels, the number was reduced with 54 % in the period for fishing vessels, 63 % for cargo vessels and 57 % for passenger vessels in the period 2005-2013.

2) Higher share of severe injuries on fishing vessels. The share of severe injuries (work absence >72 hrs) was 15 percentage points higher for fishing vessels than other vessel types. This could be due to underreporting of less serious incidents. The NMA receives few reports from small fishing vessels. These vessels have small crews (e.g. one fisherman) and the perceived benefit from reporting may perhaps be little.

3) Higher injury risk on passenger vessels? Although fishing vessels have the highest average number of injuries per year, we see that passenger vessels have the highest number of personal injuries per 1000 vessels. This is probably due to bigger crews on passenger vessels. More research is needed on this issue.

4) Most prevalent injury types were: fall, crushing and cut/stab injuries. However, fishing vessels have a higher share of crushing injuries than the two other ship types, and passenger vessels have a somewhat higher share of fall injuries. The former is probably due to work in the factory facilities aboard or with fishing nets. Safety measures should be directed specifically to these working processes.

5) Nearly a third of the injuries occurred at dock. Given the (presumably) fairly limited time spent at dock compared with the time spent at sea, future research should examine e.g. safety while loading/unloading.

6) Fishermen, sailors/seamen and engine room crew. The highest share of the people injured were fishermen, followed by sailors and engines room crew. As noted, future research should look into the work processes of fishermen, e.g. work in the factory facilities aboard or with fishing nets, in order to develop appropriate safety measures.

7) Most of the injured were Norwegians. A total of 77 % of the injuries involved Norwegians, while 9 % involved crew from the Philippines. These shares are probably not representative to the population of Seafarers that the NMA accident database covers, due to national differences in reporting.

8) Nearly all reported injuries were on ships flying the Norwegian flag. Although we found that 99 % of the personal injuries were aboard ships flying the Norwegian flag, data show that 52 % of the cargo ships along the coast of Norway sailed under foreign flags in 2012, indicating that foreign vessels underreport work accidents, at least to the NMA.

9. Company size as a work-related risk factor? One person on board vessel is a frequently mentioned risk factor in the AIBN-reports, often involving accidents with small fishing vessels manned with one person, who is typically the owner.

10. Lack of risk assessments and safety equipment. The AIBN data show that the most frequently mentioned risk factors are lack of complete, written risk assessment and lack of or incomplete use of safety equipment. The latter goes especially for smaller fishing vessels with one person on board.

11. The NMA database does not include work-related risk factors. Our analyses indicate, however, the importance of several work-related risk factors and framework conditions for safety.

5 Work accidents in the aviation sector – inland helicopter

5.1 Introduction

In collaboration with Committee for Helicopter Safety - Inland Operations , the Civil Aviation Authority (CAA) and the Ministry of Transport and Communications, Safetec Nordic have assessed the reported events with personal injury in inland helicopter in the period from 2000 to 2012 (Bye et al. 2013a, Bye et al. 2013b). These analyses were part of a larger project on safety in inland helicopter transportation. Various forms of data were gathered and analyzed in different ways by using different methods. The study included analysis of incident and exposure data, surveys, interviews and expert group meetings. The data from inland helicopter transportation differ somewhat from the other sources of data in this report, as the design of the study was explicitly directed at describing work-related conditions.

The final report from the inland helicopter project report was published in 2013 with data from 2000-2011 (Bye et al. 2013a; Bye et al. 2013b). The analyses presented in the current chapter are based on the database from the inland helicopter project, but the database is updated to also include events from 2012.

5.1.1 Domestic helicopter operations

Domestic helicopter activities in Norway are run by 18 different operators with the approval of the Norwegian Civil Aviation Authority. Three of these operators perform primarily ambulance missions and police helicopter service. The rest are commercial companies performing aerial work (AW) and passenger transportation (PAX) related to a wide range of activities. In addition to these 15 Norwegian AW/PAX companies there are also some foreign companies operating in Norway (mainly Swedish).

The total Norwegian fleet in 2012 was 131 helicopters (Bye et al. 2013a). The most commonly used types of helicopter among AW/PAX companies are the Eurocopter AS 350 (51 %) and the Robinson R44 (20 %). Their different operations may be divided into the following 15 types;

1) Transportation of passengers from A to B
2) Transportation of passengers from A to A
3) Parachuting
4) Ambulance
5) Educational and training flights
6) Police missions
7) Line Inspection/thermography/top control/ radio noise measurement etc.
8) Reindeer herding/game counting/animal tagging etc.
9) Tower installation/power-line construction
10) Firefighting/lime treatments of waterways/ice crushing/avalanche protection /geophysical measurements (flying with external structures at low altitude)

11) Logging
12) Film photo
13) Advertising banner
14) Other flights with external load
15) Other flights (technical, transfer etc.).

Domestic helicopter operations are conducted with single pilots. With the exception of ambulance operations the flights are carried out without the use of instruments. The operations are regulated by a number of national regulatory requirements based on an adaptation of common European standards. Airworthiness and maintenance is regulated through common European requirements set out in EASA Part M and EASA Part 145 regulations. Commercial transport of passengers and goods by helicopter has been regulated by the common European requirements, JAR OPS 3.

Unwanted events are reported to the Norwegian Civil Aviation Authority (NCAA). The present analysis is based on incident reports related to civil inland helicopter traffic. Private- (i.e. not commercial), military-, and offshore operators are excluded from our main analyses although private operators are included in some figures for comparisons. Events with exclusively damage on materials and equipment are also excluded. The total amount of accidents with personal injury is relatively low, with 19 reported accidents between 2000 and 2012, excluding private flights.

5.2 Number of events and persons involved

5.2.1 Number of events

The number of reported events to the Civil Aviation Authority is presented in figure 5.1 and 5.2. It is important to note that when interpreting the figures in this section, we must remember that they are based on a low number of incidents. We should therefore be careful when it comes to drawing conclusion on differences and trends. Because of the low number of events, these are not necessarily statistically significant.

As expected, the difference between events with consequences and events without consequences is relatively high. We see that an exponential growth in reports regarding events without consequences started in 2007-2008. This increase coincides with the introduction of a new regulation. An attachment to the regulation included several examples of events that should be reported (Aasprang et al. 2013).

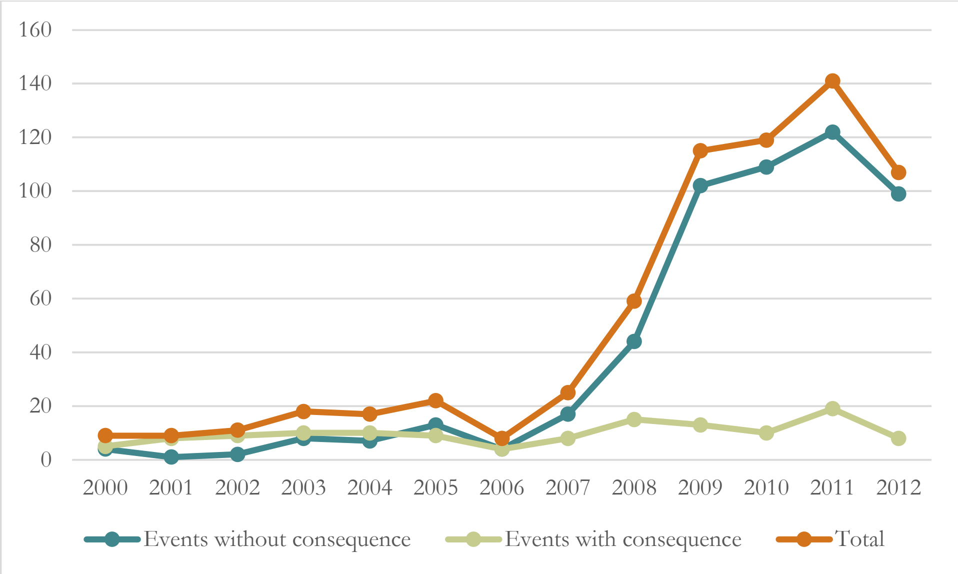


Figure 5.1 Development over time for number of reported events with (133) and without consequences (587). The graph also includes events with damage to materials only.

Figure 5.2 presents events that only involved material damage and events with injury to personnel. The number of reported events with personal injury is relatively stable compared with events with damage on equipment, which have been more fluctuating.

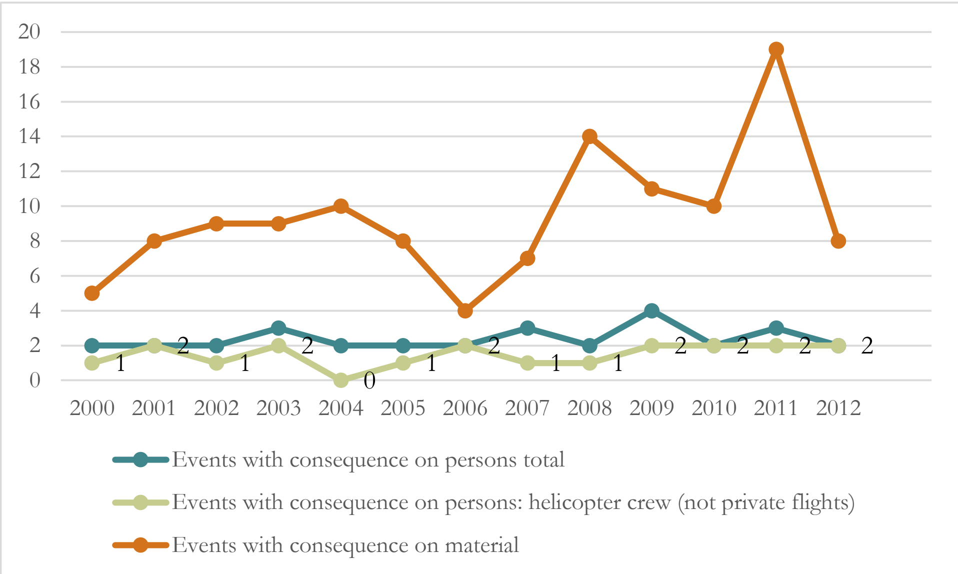


Figure 5.2 The events with consequences distributed by damage to material or persons in mutually exclusive categories.

5.3 Number of persons and severity of injury

From 2000-2012 there have been reported 31 helicopter accidents with personal injury, including private flights. 30 non-crew members have been injured, among these were 11 killed. Excluding private flights, 26 helicopter crew members have been injured from 2000-2012 as a result of 19 of the 31 accidents (see Figure 5.3). Eight of these 19 accidents have been fatal, killing 10 helicopter crew members.[10]

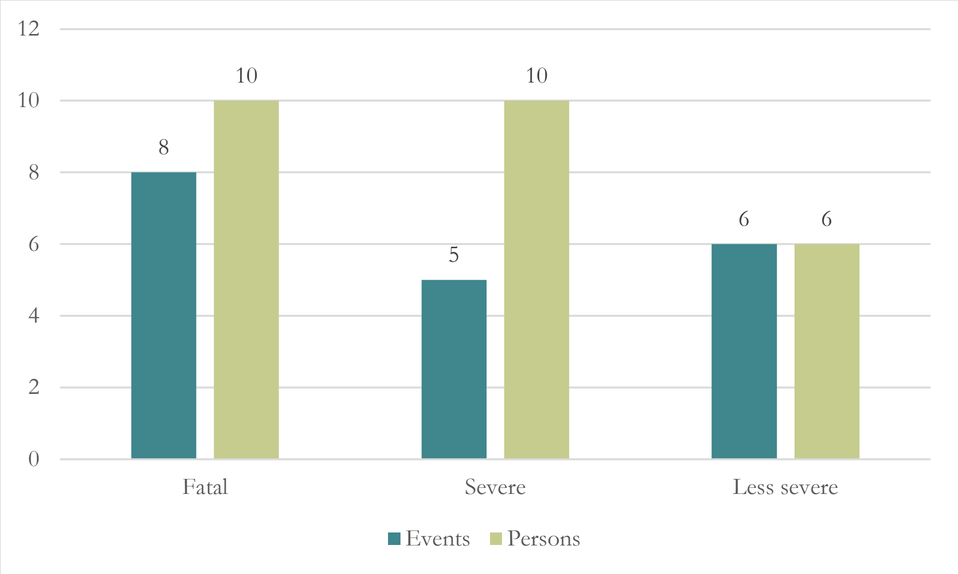


Figure 5.3 Persons injured (N=26) and number of events with person injury to helicopter crew (N=19) by severity.

5.4 Model of deviating events, loss events and landing types

In order to investigate the possible contributing causes of accidents, we have created a model (*Figure 5.4*) consisting of; (1) contributing factors, (2) deviating event (mutually exclusive categories), (3) landing types (mutually exclusive categories), and (4) consequences. First, we present the landing types, and then work our way backwards in an imagined causal chain.

[10] We have categorized the severity of personal injury into three groups. For accidents where members of the helicopter crew are killed, the accident is described as fatal. If the accidents caused severe injuries that requires extensive medical treatment or permanent harm, it is described as severe. The third category consists of personal injuries that not requires extensive medical treatment or represents permanent harm. Importantly, these categories are mutually exclusive. If a fatal accident also resulted in severe or less severe injuries, the accident will be categorized only according to the most severe category.

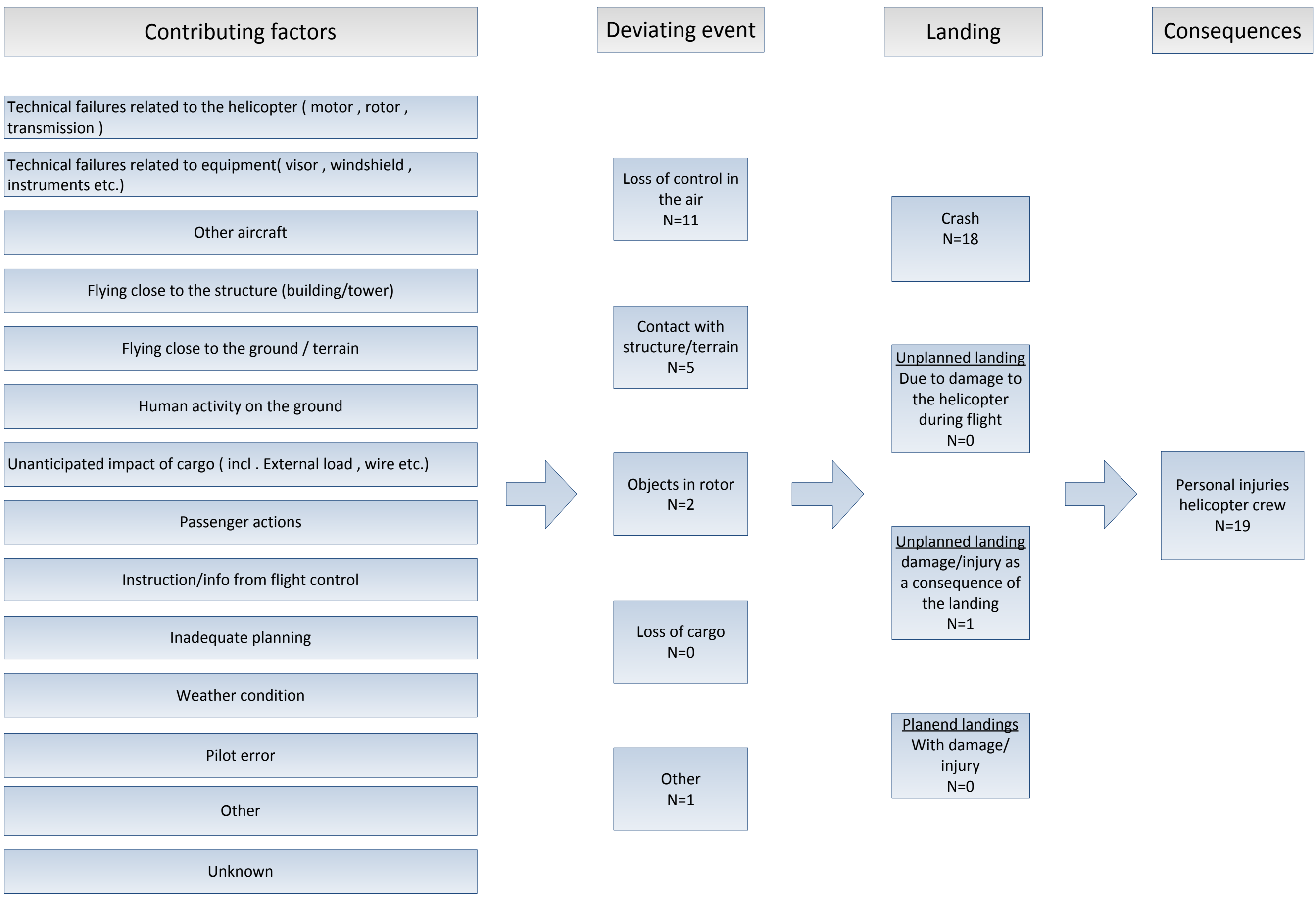


Figure 5.4 Model of the course of the events resulting in personal injuries.

5.4.1 Landing types

The following *landing types* have been used in our analysis; *Crashes*, *Unplanned landings,* and *Planned landings*. *Crashes* denote a situation where the helicopter collides with the ground or structure where the result is a totally wrecked helicopter, or situations where the helicopter is damaged during landing or takeoff. An example of a crash is a helicopter plunging into sea or ground.

Unplanned landings is a situation where the helicopter pilot performs a landing that was not planned initially. Unplanned landings could either be *emergency landings*, due to e.g. damage to the helicopter during flight, or it can be a so-called *precautionary landings* were damage/injuries occur as a consequence of the landing.

Planned landings denote situations where the pilots conduct a landing that was initially planned, but where injury occurs as a consequence of the landing.

The relationship between landing types and numbers of accidents with personal injury to helicopter crew is presented in figure 5.5. With one exception, the accidents with personal injuries occurs in relation to crashes.

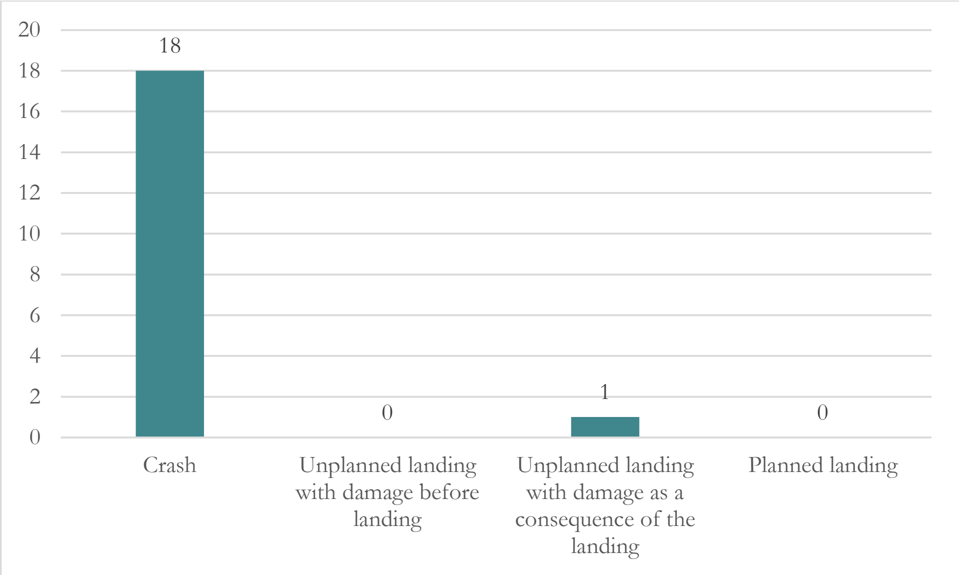


Figure 5.5 Distribution of landings types, accidents in the period 2000-2012 (N=19).

5.4.2 Deviating events

A deviating event is the first deviation from normal operation which can lead to an accident. In our analysis we have defined 5 different deviating events; *Loss of control in the air*, *Object in rotor*, *Contact with structure/terrain*, *Loss of cargo* and *Other*.

Loss of control in the air denotes situations where the pilot loses the control of the helicopter without any impact of external objects.[11] *Object in rotor* denotes situations where loose external objects originated from the helicopter (cargo, loose parts, cargo line etc.) come in contact with the rotary systems. *Contact with structure/terrain* represents situation where the helicopter conducts operation close to the terrain (i.e. ground, rock face etc.) or a structure (power line, overhead cables, buildings, poles etc.) and a contact occurs. *Loss of cargo* means that cargo (pendant cargo) falls down from the helicopter into the terrain. *Other* includes all other situations that may not be considered as part of the other categories of deviating events.

For crashes with personal injuries among crew members as an outcome, the dominating *deviating event* is loss of control in the air (Figure 5.6).

[11] Corresponds with the concept “loss of control in flight” (LOC-I) in the ADREP taxonomy (see http://www.icao.int/safety/airnavigation/AIG/Pages/ADREP-Taxonomies.aspx)

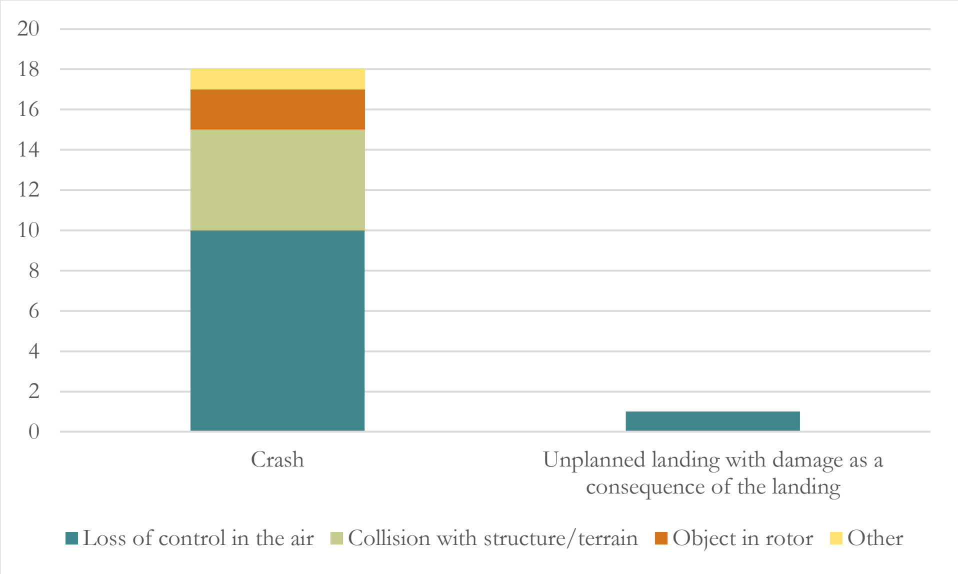


Figure 5.6 Distribution of deviating events and landing types for the accidents 2000-2012 (the category "loss of cargo" is not associated with these events) (N=19).

5.4.3 Contributing factors

A single accident is considered to have multiple contributing causes. In Figure 5.7, the frequencies of contributing factors for the 19 events with personal injury among helicopter crew are presented. Most accidents include some sort of flight pilot error.

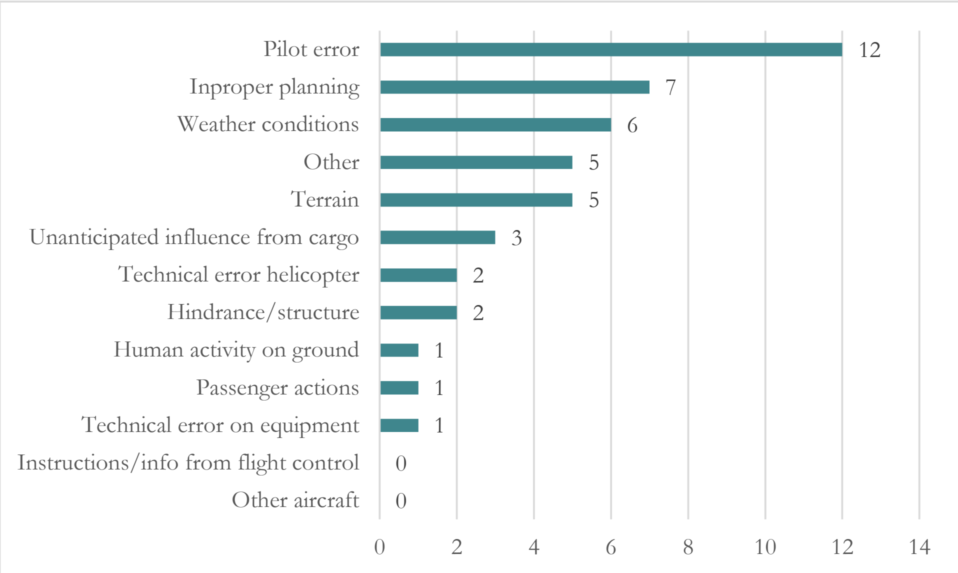


Figure 5.7 Frequencies of contributing factors in accidents with person injury 2000-2012 (N=19).

5.5 Accidents per 100 000 flight hour from 2005-2012

In this section, we present the number of hours flown by the helicopter operators, which in turn are used to normalize the accident data by calculating risk defined as the number of accidents per 100 000 flight hours. The calculation of accident risk makes it possible to find out whether some types of operators are more accident prone than others.

Figure 5.8 and Table 5.1 show the collected production data from the 18 Norwegian operators plus private flights. Production data is reported in by the operators themselves to CAA. The commercially driven aerial work (AW) / passenger transport (PAX) companies account for roughly one third of the total flight hours (i.e. the large, medium and small companies). Within this third, the large companies account for roughly the half of the hours. Private flights are relatively small in comparison. Ambulance/police flight hours are approximately the same as the total hours flown by medium aerial work/PAX companies. In total, a moderate positive linear trend in amount of hours flown is present.

Table 5.1 Total flight hours for operators of inland helicopter 2005-2012.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
Large companies	20 005	20 490	13 677	18 449	14 651	18 220	20 542	19 207	145 241
Medium companies	4186	6002	6678	7121	9087	10 001	11 042	11 727	65 844
Small companies	4526	5236	5385	7216	7111	6173	6483	6506	48 636
Ambulance/police	8061	11943	9381	10 430	10 468	9510	10 792	11 162	81 747
Private	2456	2687	2918	3149	3380	3611	3842	4073	26 116
Total	**39 234**	**46 358**	**38 039**	**46 365**	**44 697**	**47 515**	**52 701**	**52 675**	**367 584**

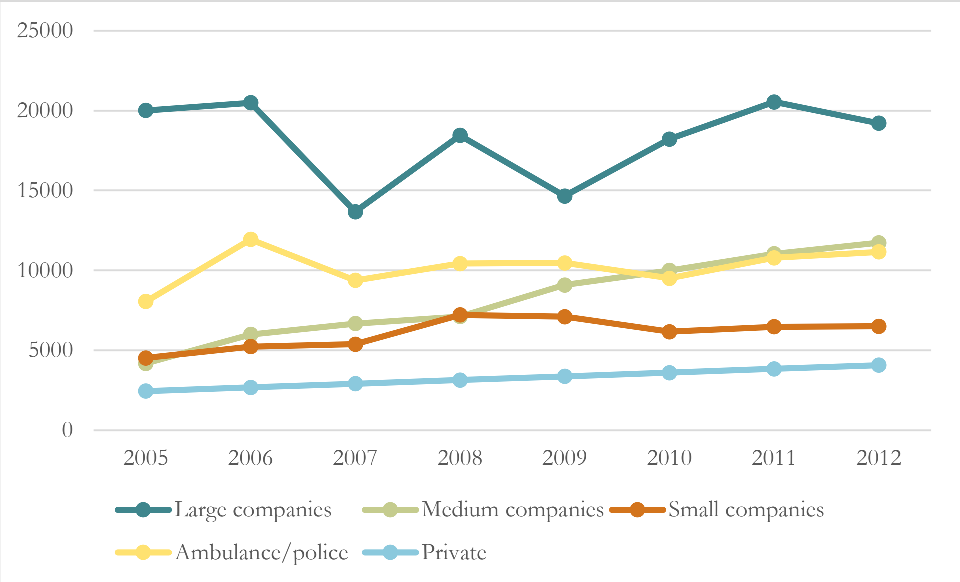


Figure 5.8 Number of flight hours for different types of operators per year 2005-2012.

The numbers of accidents with personal injuries among helicopter crew members per 100 000 flight hours for the years 2005-2012 are presented in Figure 5.9. The risk for the period is 2.9 accidents per 100 000 flight hours.

Figure 5.9 Number of accidents with personal injury among helicopter crew per 100 000 flight hours for all operators (excluding military, offshore, private and foreign operators) 2005-2012 (N=10 accidents).

The numbers of accidents and the belonging number of injured crew members per 100 000 flight hours for 2005-2012 are presented in Figure 5.10. There are only 10 accidents with personal injuries in this sample (since we exclude the years 2000-2004, and foreign, private and unknown operators).

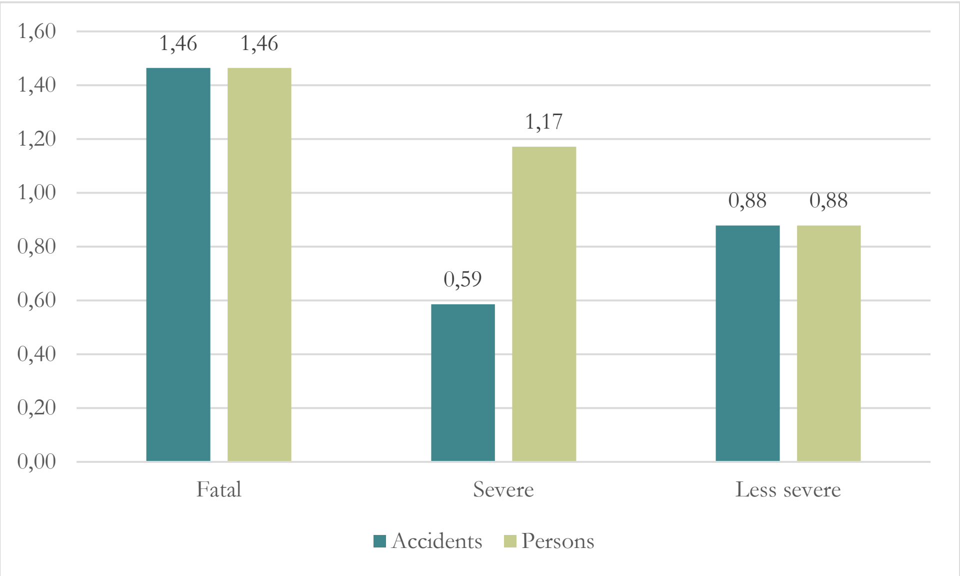


Figure 5.10 The accidents with personal injuries among helicopter crew by severity type of accident per 100 000 flight hours in the period 2005-2012 (N=10) and Number of persons killed, severely injured and less severely injured among helicopter crew per 100 000 flight hour 2005-2012 (N=12).

5.5.1 Comparing operations

Figure 5.11 shows the numbers of accidents with personal injuries among helicopter crew per 100 00 flight hour by operation type.

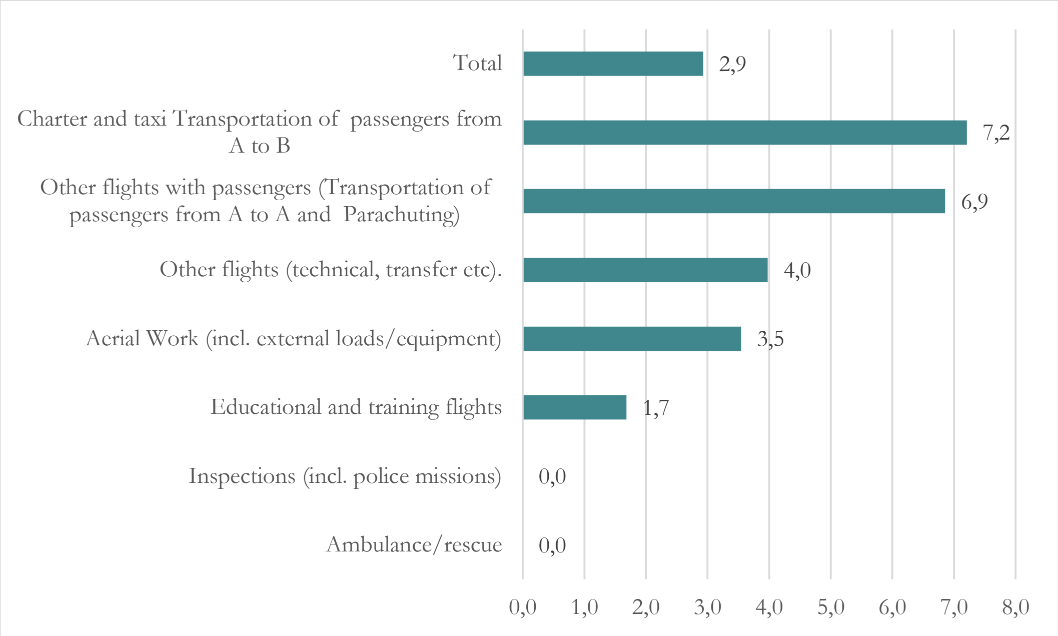


Figure 5.11 Number of accidents with personal injuries among helicopter crew per 100 000 flight hour by operation type (N=10).

The highest personal injury accident risks are associated with transportation of passengers from A to B (7.2) and other flights with passengers (6.9).

As we can see, there are no accidents in the operation type ambulance/rescue. However, there is one accident by an ambulance operator with person injury, as shown in chapter 5.5.3. This means that this accident did not occur during a regular ambulance mission.

5.5.2 Comparing seasons

The rather hash climatic and topographic conditions in Norway implies a wide range of natural hazards. Snow, low sunlight, lakes, fjords, glaciers and mountains represent hazards in terms of e.g. ice, degraded visibility, flat light and local turbulence. These conditions will vary by season. Due to the weather conditions most of the helicopter activity involving the AW/PAX operators is conducted from April throughout September. Figure 5.12 shows the number of flight hours among ambulance/police operators and Norwegian AW/PAX operators during summer (April-September) and winter (October-March) 2005-2012. As we can see, AW/PAX operators double their flight hours during the summer season. In comparison, the activity among the ambulance/police operators seems to be less affected by seasonal variation.

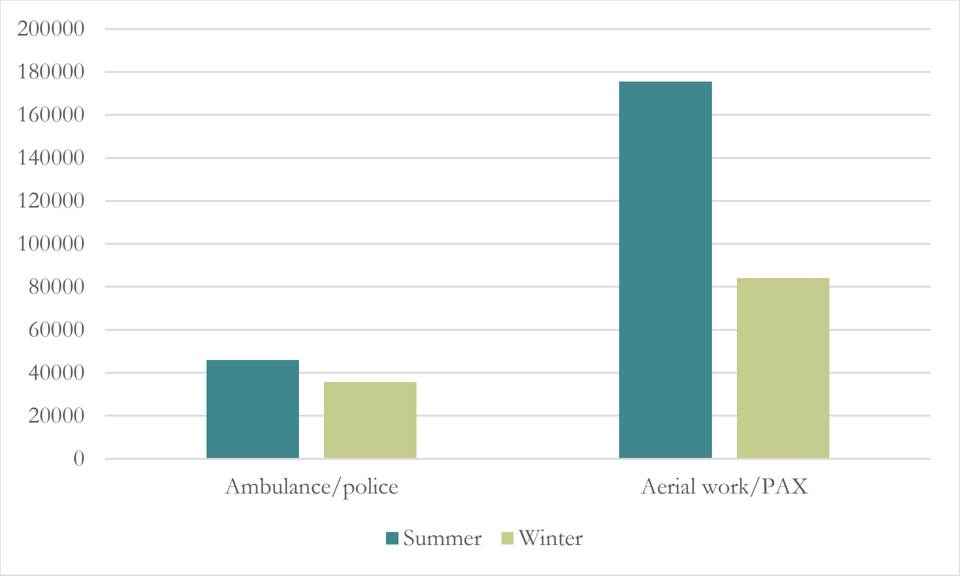


Figure 5.12 Flight hours among ambulance/police operators and Norwegian AW/PAX operators during summer (April-September) and winter (October-March) in 2005-2012.

Not surprisingly, the analyses of accident data show a higher number of accident with personal injuries per 100 000 flight hours during the winter months, compared to the summer, both among ambulance/police operators and AW/PAX operators (Figure 5.13).

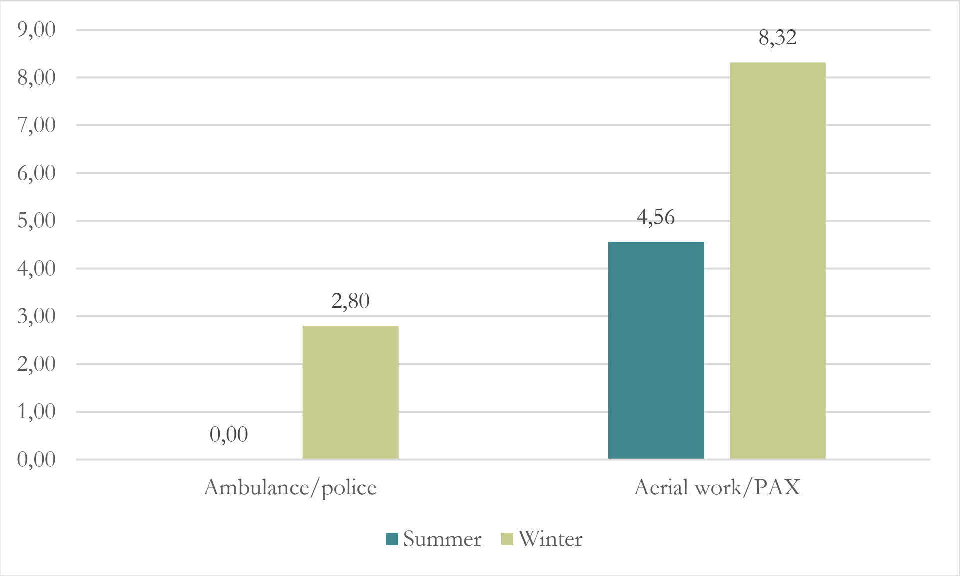


Figure 5.13 Number of accident with personal injuries per 100 000 flight hours among ambulance/police operators and Norwegian AW/PAX operators during summer (April-September) and winter (October-March) in 2005-2012 (N=10).

5.5.3 Comparing operators

Aerial work/PAX operators have almost three times more accidents with personal injuries per 100 000 flight hour (3.47) than ambulance/police operators (1.22). However, private pilots have a personal injury accident frequency of 7.66 per 100 000 flight hour (Figure 5.14).

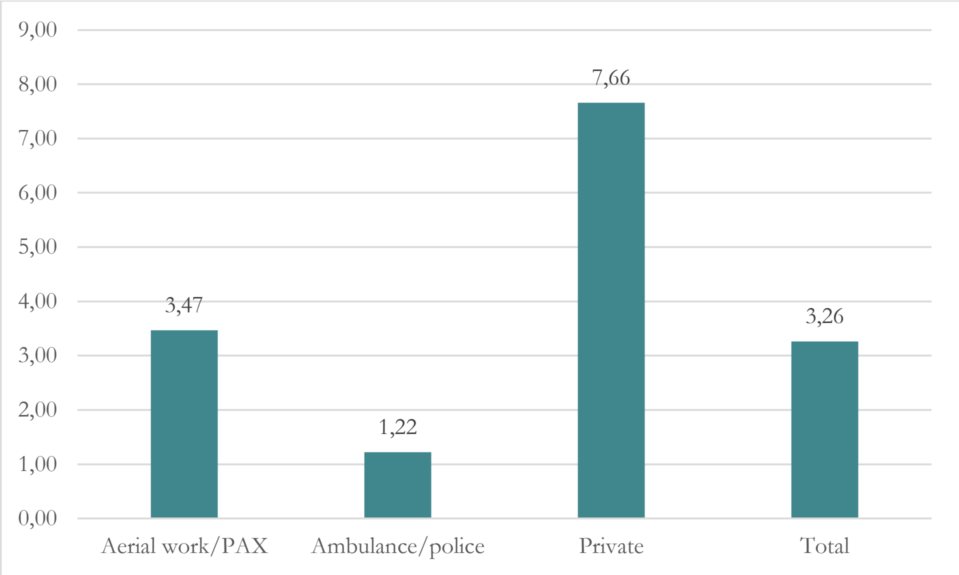


Figure 5.14 Number of accidents with personal injuries among crew members per 100 000 flight hour among AW/PAX operators, Ambulance/police operators and private pilots from 2005-2012 (N=12).

Figure 5.15 shows the numbers of accidents with personal injuries per 100 000 flight hours among aerial work/PAX operators of different company size. Small AW/PAX companies have twice as many accident with personal injuries per 100 000 flight hour (6.17), as medium AW/PAX operators (3.04). Large companies have the lowest injury accident frequency (2.75). This frequency is however twice as large as the corresponding value among ambulance/police operators (1.22).

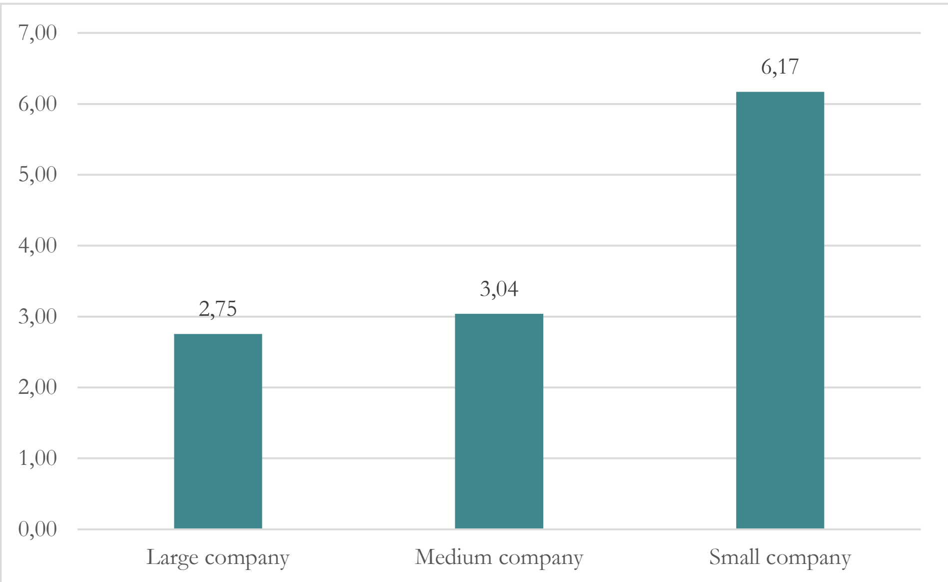


Figure 5.15 Number of accidents with personal injuries among crew members per 100 000 flight hours among aerial work/PAX operators of different company size, 2005-2012 (N=9).

5.5.4 Comparing engines

Figure 5.16 shows the estimated flight hours among Norwegian ambulance/police operators and AW/PAX operators, divided by type of engine and year, from 2005 throughout 2012. The majority of flight hours are conducted with single engine helicopters (71 %), primarily different types of Eurocopter 350. Flights conducted with helicopters with piston engines is estimated to represent only 9 % of the total number of flight hours.

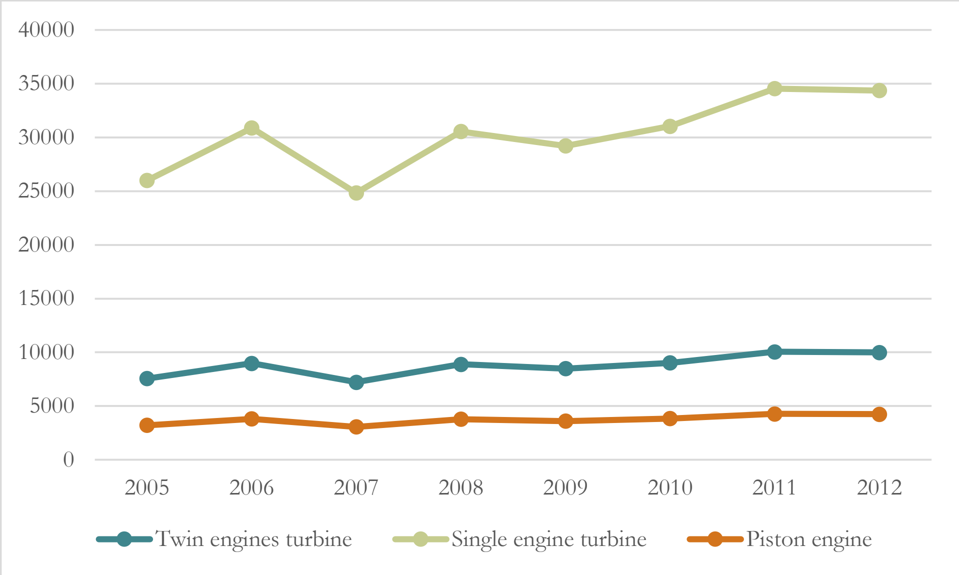


Figure 5.16 Estimated flight hours among Norwegian Ambulance/police operators and AW/PAX operators, divided by type of engine, 2005-2012.

The numbers of accidents with personal injuries among crew members per 100 000 flight hour divided by type of engine are presented in Figure 5.17. Helicopters with piston engines have the highest accident frequency (6.7), and twin engines have the lowest (1.4). These results reflects the fact that piston engines are primary used in operations involving transportation of passengers, especially transportations from A to A. This is also the operations that involves most AW/PAX operators (see 5.7.4). Helicopters with twin turbines are mainly used by ambulance/police operators.

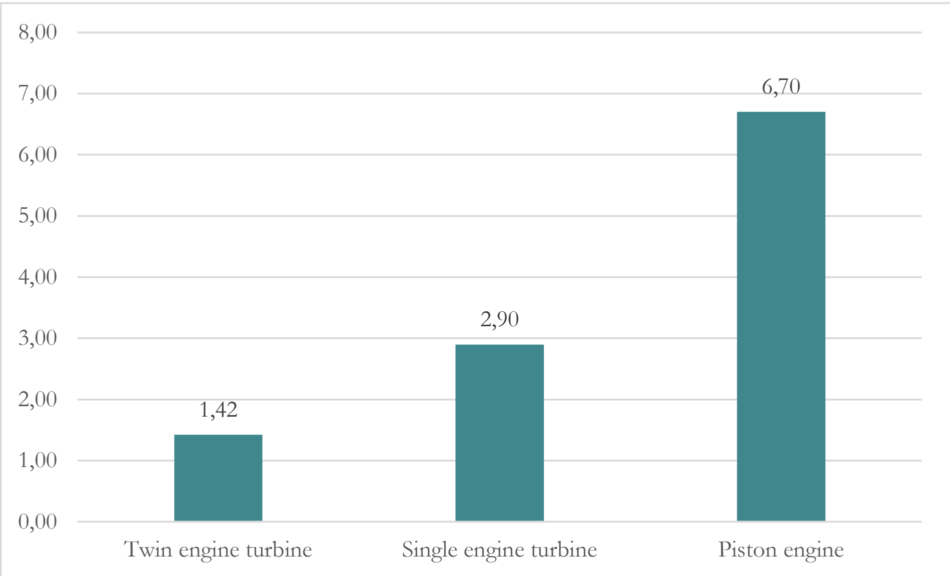


Figure 5.17 Accidents per 100 000 flight hour by motor type (excluding private flights), 2005-2012 (N=10).

5.6 Risk influencing factors

5.6.1 Regression analysis of incident data

As described in chapter 5.4.1, the majority of accidents with personal injuries are associated with helicopter crashes. All fatal accidents have occurred in crashes. In order to identify root causes of helicopter crashes, a binary logistic regression analysis of incident data was performed (Aasprang & Bye 2013a). The dependent variable was crash versus accidents associated with planned/unplanned landings. The following risk-influencing conditions were found to distinguish helicopter crashes from other unwanted events when conducting a binary logistic regression analysis of helicopter crashes (N=39) compared with accidents associated with planned and unplanned landings (N=83) (Aasprang & Bye 2013a):

- PAX operations
- Weather conditions
- Loss of control in the air
- Inadequate planning
- Pilot's age (younger pilots were more involved in crashes)
- Pilot's total number of flight hours (i.e. fewer than 1000 flight hours)
- Types of operators (small aerial work/PAX operators, foreign operators, and private pilots)

Thus, a typical helicopter crash, compared with other helicopter accidents, is associated with passenger transportation, young and inexperienced pilots, inadequate planning, bad weather, loss of control in the air and small aerial work/PAX operators, foreign operators, and private pilots.

Several factors related to operative context, pilot experience and safety management seem to be factors influencing the risk of a helicopter crash, and the probability of personal injuries.

5.7 Survey and interviews regarding operational and organisational conditions

In order to assess how operational and organisational conditions can constitute risk influencing factors, a questionnaire-based survey was conducted among personnel employed by the helicopter operators (Bye 2013; Aasprang & Seljelid 2013). In addition, information regarding the organisation was obtained from the 18 different operators by the use of a structured questionnaire (Aasprang & Bye 2013b). Further, 50 representatives from the industry was interviewed by the use of a semi structured interview guide (Bye et al. 2013c). The results are presented below and form an important context for understanding work-related accidents in helicopter transport.

5.7.1 Operational conditions and practice

As described in 5.5.2, the number of accidents with personal injuries is higher during the winter months, and helicopter crashes are associated with bad weather conditions. The survey results shows that 47 % of the AW/PAX pilots claim that they weekly or daily have to decide whether to fly into weather condition that may deteriorate below Visual Flight Rules minimum (Bye 2013). In comparison, a survey conducted in Alaska among commercial pilots (included fixed wing pilots) showed that 34 % of the pilots claimed the same (Conway et al. 2006). This indicates that weather conditions will trigger situations of safety-critical decision making.

Considering that weather conditions seem to be a major hazard during helicopter operations (5.5.2), only 31 % of the AW/PAX pilots claim that the company they work for have a standard procedure for handling IMC (bad weather conditions). In comparison 92 % of the ambulance/police pilots claim they have.

Questions regarding operational practice showed that only 25 % of the pilots employed by the AW/PAX operators claim that they always follow the procedures during flight. 45 % of the ambulance/police pilots claim the same. The dominating reasons for the violations were that (1) the procedures/guidelines do not work as intended (44 %), (2) the procedures has too detailed requirements (39 %), and (3) that the work goes faster (35 %) when procedures are violated.

As many as 42 % of the pilots employed by the AW/PAX operators claim that consideration regarding the mission means that they sometimes have to break safety routines. The corresponding percentage among ambulance/police pilots is 10 %.

A share of 28 % of pilots employed by the AW/PAX operators claimed that they have experienced a pressure to fly even though safety was jeopardized. None of the ambulance/police pilots claimed that they had experienced the same. A total of 57 % of the AW/PAX pilots claimed that they have experienced pressure to fly from customers, and 13 % claimed that they have experienced pressure from the flight operation manager in the company they work. Further, 75 % of the pilots employed by the AW/PAX operators stated that it has happened that they have wanted to reject a flight due to fatigue, but flew anyway. 14 % claimed that this happen monthly or more frequent. The corresponding percentages among ambulance/police pilots were 82 % and 6 %.

A comparison of AW/PAX operators of different size did not reveal any statistic significant differences in terms of operational practice.

5.7.2 Personnel

The average total flight time and the average number of years of experience are higher among the ambulance/police pilots than among AW/PAX pilots. In addition, 80 % of ambulance/police pilots have IR (instrument rating) certificate, i.e. for flying by means of instruments and not just visual references. The corresponding percentages among AW/PAX pilots were 27 %.

There are also some differences between AW/PAX operators and ambulance/police operators when it comes to the educational background of the pilots (table 5.2). The majority of the pilots employed by AW/PAX operators have civil education in Norway (64 %). The corresponding percentage among ambulance/police operators is 31 %.

Table 5.2 Educational background and type of helicopter operator (AW/PAX and Ambulance/police) (N=147).

	AW/PAX	Ambulance/Police
Military	1 %	28 %
Civil in Norway	64 %	30 %
Civil abroad	35 %	42 %
	100 %	100 %

5.7.3 Organisational conditions

The study indicates that there are big differences between operators with respect to how their activities are organized and how safety is taken care of. In particular, there are important differences between ambulance/police pilots, and AW/PAX pilots.

Information regarding employment, obtained from the companies, shows that 22 % of the pilots employed by the AW/PAX operators only work part time. In contrast, all pilots among the ambulance/police operators are full time employed. When we compare AW/PAX operators of different size, we observe that the proportion of part time employees is higher among the small operators.

Table 5.3 The proportion of part time employed pilots employed by respectively small, medium and large AW/PAX operators

AW/PAX operators	The proportion of part time employed pilots
Small	46 %
Medium	11 %
Large	2 %

The survey shows that 40 % of the pilots employed by AW/PAX have additional employment outside the helicopter company. The corresponding percentage among the pilots employed by the ambulance/police organisations were 12 %.

27 % of the pilots employed by AW/PAX have been temporary laid off once or several times by their present employer. The corresponding percentage among the pilots employed by the ambulance/police were 2 %.

The survey result shows statistically significant differences between AW/PAX pilots and ambulance/police pilots in their evaluation of organisational conditions. The significant differences included questions regarding the following themes:

- Safety management and safety priority
- Violation of procedures
- The quality of the interactions between crew members
- Manning
- Resting time

- Level of training
- The use of risk assessment
- Support from the management
- Production pressure
- Reporting system and practice

There are indications that there are considerable differences between different AW/PAX operators with regard to organisational factors that affect safety. In particular, there were marked differences related to safety management and safety priority, the level of training, manning, and production pressure:

- 65 % of the pilots employed by the AW/PAX operators agreed that safety is maintained in a good manner in the company they work for. In comparison 94 % of the ambulance/police pilots agreed.
- 48 % of the AW/PAX pilots agreed with a statement that they received retraining if they were going to conduct a type of mission they were not familiar with. In comparison, 91 % of the pilots employed by operators of ambulance/police operations agreed with the statement.
- 62 % of the AW/PAX pilots claimed that they have received sufficient training in handling critical situations. With the exception of one respondent, all ambulance/police pilots agreed that the training was sufficient.
- 94% of the ambulance/police pilots claimed that the manning situation was sufficient in order to maintain the safety in the organisation. The corresponding percentage among AW/PAX pilots is 63 %.
- 28 % of the AW/PAX pilots experience a pressure from the management to conduct a flight, even though they experience that the safety is in jeopardy. None of the ambulance/police pilots experienced such pressure.
- 57 % of the AW/PAX pilots experience a pressure from customers to complete a flight, even though they experience that the safety is in jeopardy. 11 % of the ambulance/police pilots experienced such pressure.

A comparison of AW/PAX operators of different size did not reveal any statistically significant differences.

5.7.4 Market conditions and regulations

In the survey, there were several indications that market conditions was a highly relevant risk influencing factor:

- The survey showed that 26 % of the pilots employed by the AW/PAX operators claim that the competition with other helicopter companies make it necessary to violate safety routines.
- 28 % claimed that the efficiency requirements set by the operating company make it sometimes necessary to violate procedures.

The customers of the ambulance/police operators is limited to Norwegian governmental organisations. The agreement is based on multiannual contracts, with rather extensive specification regarding the terms and quality of the services.

The customers of the AW/PAX operators are more numerous (ranging from 300 to 20 different customers) and more diverse, ranging from the companies within the construction industry to private persons. With the exception of major construction works, the contracts are usually limited to single assignments.

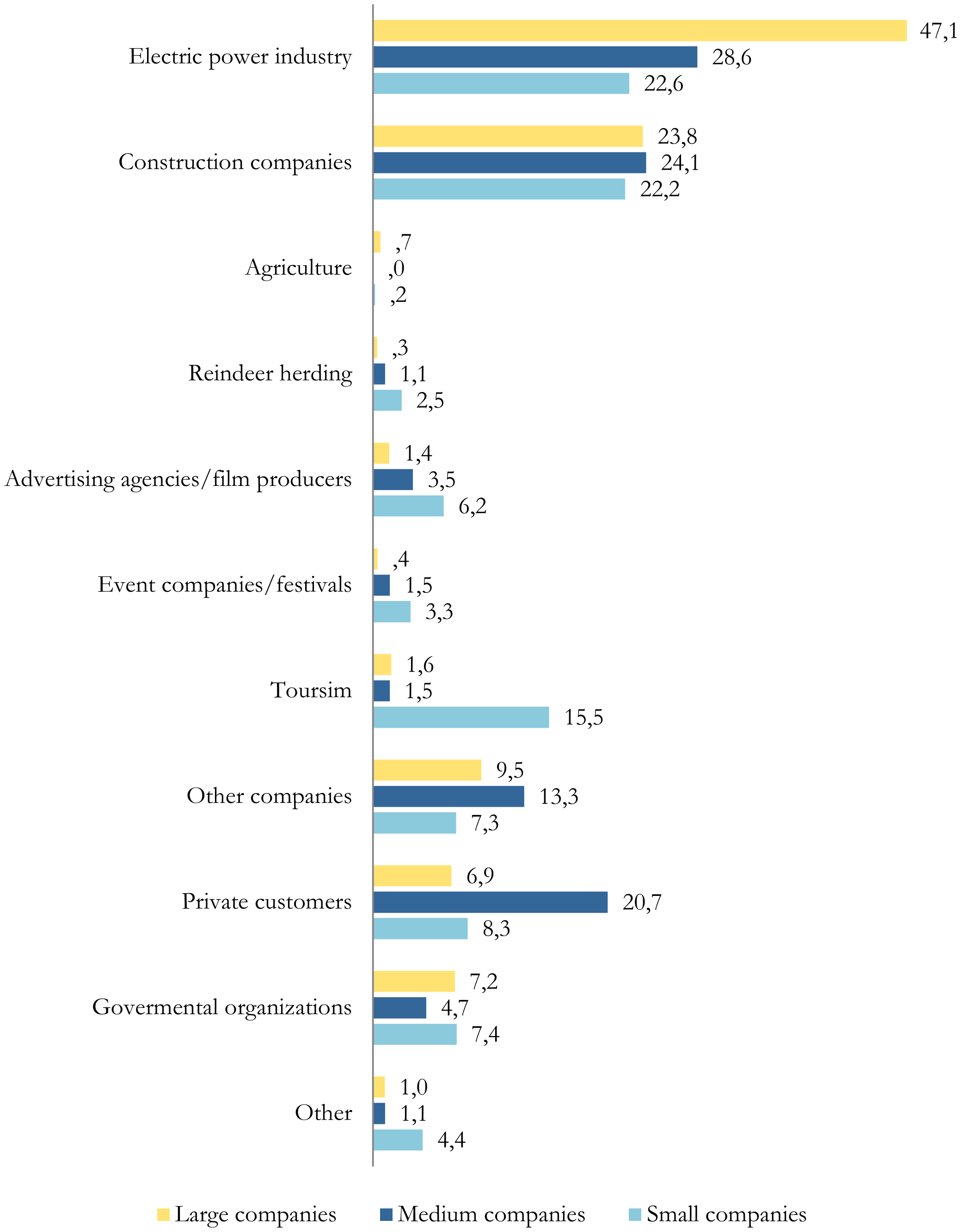


Figure 5.18 Percentage distribution of revenues of AW/PAX operations on different customer groups.

41 % of the revenue within the AW/PAX segment comes from companies within the electric power industry, and 24 % comes from construction companies. Private customers contribute with 10 % of the total revenue. The remaining 25 % of the revenue stems from e.g. governmental organisations (7 %) tourism, (3 %) and forestry/agriculture/reindeer herding (1 %).

There are differences between the small and the larger operators (medium and large) when it comes to the composition of the customer portfolios. Almost half of the revenue among the large AW/PAX operators stems from assignment from the electric power industry (see Figure 5.18). Small operators are more dependent on tourism, advertising agencies/film producers and reindeer herding (28 %) compared with the larger operators (12 %).

Compared with larger operators, small operators are relatively more dependent on operational types such as *PAX* (both transportation of passengers from A to B and A to A) and other flights with external load [12], reindeer herding and tourism. This is also the market segment where there are most competition (number of operators) and where the hourly rates are lowest (Figure 5.19).

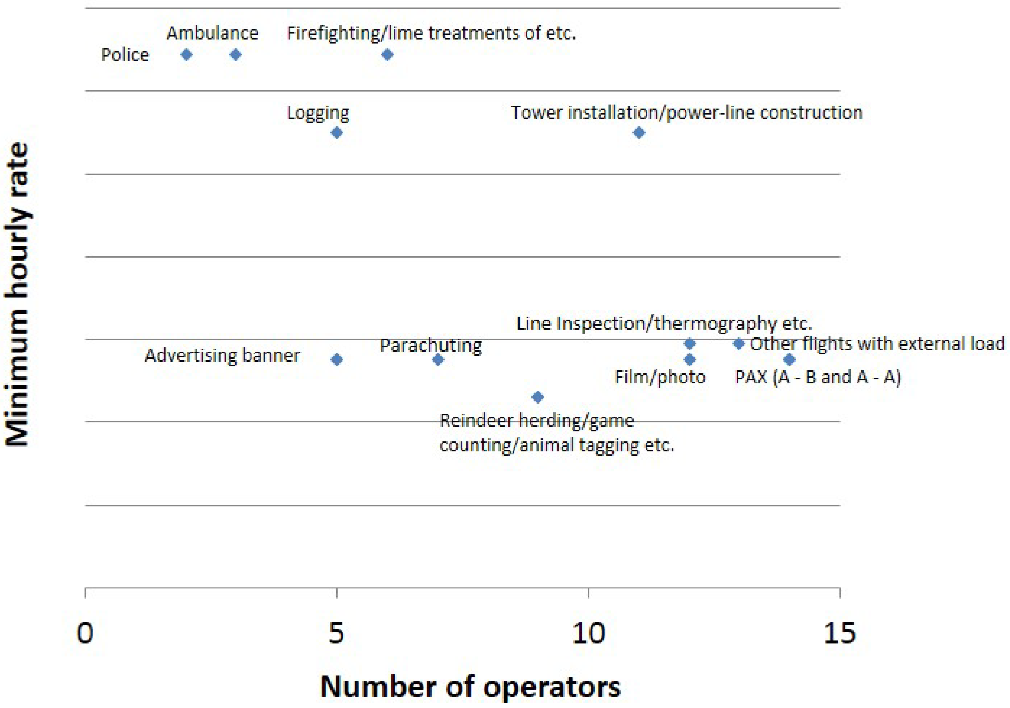


Figure 5.19 Inland helicopter operations, minimum hourly rates and numbers of suppliers in 2011.

Our analysis shows a higher increase in hourly rates from 2007 until 2011 within the ambulance/police segment, compared with the AW/PAX segment. For some of the AW/PAX operation, the hourly rates have actually decreased during the same period (Line Inspection/thermography/top control/ radio noise measurement etc., and Other flights with external load) (Aasprang & Bye 2013b).

The harsh market situation with small margins was a recurring theme among the informants in the interviews and in the responses to some of the open questions in the survey, both among pilots and managers. In the interviews this theme was introduced by the informants in relation to questions regarding possible causes of the helicopter accidents. There was a common notion among the informants that the economic situation among AW/PAX operators led to increased production pressure and cost reduction. The implication was more risk taking in order to actually accomplish an operation, and less money spent on maintenance, and on safety improving equipment (Bye et al 2013c, Aasprang & Seljelid 2013).

[12] Predominately in relation to constructions of private cabins.

Analysis of company data shows that the majority of the aerial work/PAX companies have had negative operating profit over the past five years (Aasprang & Bye 2013b). Several of the companies have operated with negative operating revenue over several years.

According to managers, the only thing that prevented these companies from bankruptcy was access to new capital from investors (Bye et al. 2013c). The access to new capital seems to stem from an expectation of future increase in demand for helicopter services, and the investors' involvement in a rather lucrative business for the purchase and sale of helicopters.

The results from the survey, the analysis of company data (e.g. type of customers, hourly rates, operating profit) and interviews indicate that the market/competitive situation between aerial work/PAX operators contributes to cost reduction strategies that results in a reduction of resources in terms of organisational frameworks, training, employment conditions, working time arrangements, and extent of procurement of safety-related equipment.

In addition, the industry is characterized by a relatively low number of effective regulatory stakeholders (regulatory authorities, certifying bodies, customers, trade unions, etc.) that ensure minimum standards for the organisational infrastructure. Supervisory activity of the NCAA has mainly been based on supervision of the companies' management systems, not on the actual operational practices on day to day basis. This has contributed to a situation where management systems do not necessarily reflect the actual work practice within the industry (Bye et al. 2013c; Aasprang & Seljelid 2013). Furthermore, the study shows that the use of price as the only criterion for tenders among the biggest buyers of helicopter services help to encourage companies to choose to cut costs and resources linked to organisational issues with safety-related implications. Cost cutting is also stimulated by competition from private pilots who fly commercially without permission, and Swedish operators with different regulatory frameworks and lower operating costs.

5.7.5 Model of risk influencing factors

As an attempt to model the link between different levels of risk influencing factors on the one hand, and the crash frequency on the other, a risk influencing factor model was constructed. This has been used both to estimate the risk contribution from different factors, and the expected effect of 41 proposed improvement measures (Bye et al. 2013a).

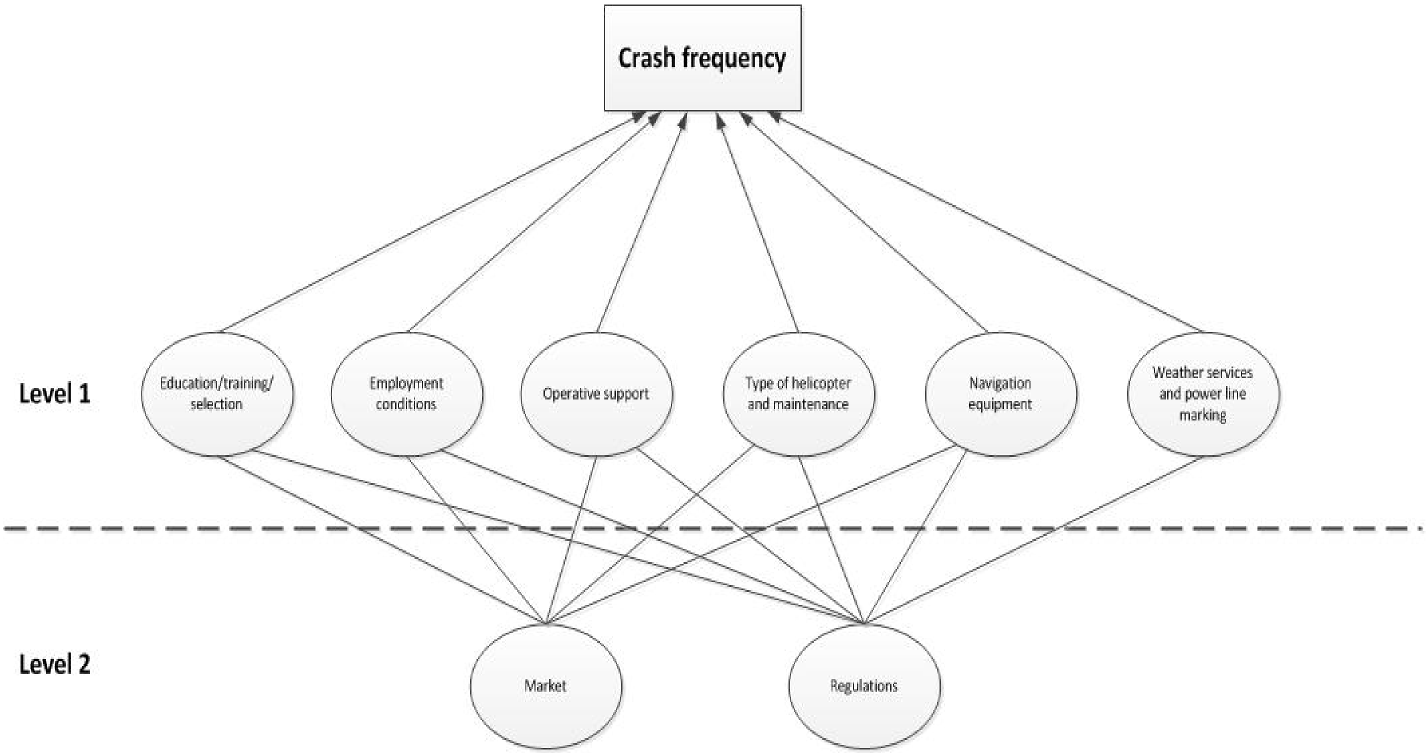


Figure 5.20 RIF model for predicting crash frequencies.

Having an underlying model of how the various sources of information fit together, was an important prerequisite of the study. As we will discuss in further detail in chapter 6, we argue that the reporting systems of other industries could benefit from establishing a similar logic.

5.8 Results from AIBN-reports

The review presented in the current chapter is based on published reports from AIBN. All reports concerning accidents and incident taking place between 01.01. 2009 and 01.01.2014 published by January 2015 have been included in the analysis. The discussions, conclusions, and recommendations of the reports have been studied and searched for work-related risk factors.

As of January 2015, AIBN had published twenty reports dealing with accidents and incidents with light inland helicopters in the period 2009-2013. However, ten of these reports were deemed to be irrelevant to the present analysis, as they uncovered no work-related factors (Many of these reports are extremely short, and only states the probable cause of the incident – thus further factors are not discussed). The ten irrelevant reports were excluded for the following reasons: five dealt with private flights, three were described incidents deemed to be triggered by technical malfunctions, while two were associated with operational risks that are difficult to avoid (e.g. an unsecured car trailer rolling onto the helicopter rotor after safe landing). The remaining ten reports contained some discussion of work-related factors.

	Risk factors	2009	2010	2011	2012	2013	2014	Total
Pilot	Lacking use of/ lack of safety equipment			2	1		2	5
	Risky behaviours				2	1	1	4
	Assignment completed in spite of unfavourable conditions			1		1	2	4
	Procedure violation				1	1	1	3
	Lack of experience					2		2
Helicopter	Insufficient engine power under the circumstances			1			1	2
Work-related factors	Deficient safety management system/procedures			2	1	2	1	6
	Underdeveloped organisational structure					2	1	3
	Stress/fatigue					2		2
	Communication problems				1	1		2
Framework conditions	Safety culture in the business					1	1	2
	Poor aviation authority follow up					1		1
	Insufficient rules			1				1
	Missing elements in helicopter pilot education			1				1
Situational factors	Reindeer herding				(1)	1	1	2
	Low altitude				1	2	2	5
	Wind/weather/darkness			1		1	2	5

5.8.1 Risk factors related to operators

Lacking use of / lack of safety equipment. In five of the reports, it is remarked that the use of various kinds of safety equipment might have prevented or mitigated the effects of accidents or incidents. This goes for traditional forms of safety equipment such as safety belts or helmets, but also technical devices such as flight recorders and radio altimeters:

- Radio altimeter lightweight recorder (2011/08)
- Flight recorders (2012/13, 2014/06)
- Helmets (2011/21)
- Shoulder belts (2014/06)

Risky behaviours. Since the number of cases is so limited, few of the factors are repeated between reports. Four different reports describing accidents involving some kind of risky pilot behaviours. This refers to voluntary risks taken by pilots, such as aggressive manoeuvring, flying too low or too close to physical obstacles.

Assignment completed in spite of unfavourable conditions. Another risk factor related to helicopter operators is "assignment completed in spite of unfavourable conditions" which is found in four separate reports. These refer to cases when, in the view of the AIBN, an assignment should have been cancelled as a safety precaution, but was still carried out. This risk factor is sometimes related to reindeer herding, which to some extent require continuous operations, or other forms of helicopter operations involving time pressure or certain expectations from customers, often in combination with bad weather.

Situational factors. "Unfavourable conditions" could for instance refer to bad weather or darkness and low visibility. This typically occurs during reindeer herding, which 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, increasing the risk of "white out". The AIBN states that reindeer herding is a high risk activity that should be closely followed up by authorities and operators both in Norway and Sweden (AIBN 2013/30).

Flying low also increases the risk of loss of control of the helicopter, because of variations in the terrain (e.g. hills) and surprising and unpredictable winds that may affect the stability of the helicopter. Additionally, when flying low, it may be difficult for the pilot to uphold a correct sense of the terrain and maintain reference points. Thus, safety margins are small when flying close to the terrain. Under these conditions, reports sometime conclude that under the manoeuvre that the pilot was undertaking, or a sudden wind, the power of the engine was insufficient to uphold control over the helicopter, given its mass.

Work-related risk factors are often invoked to explain why pilots complete assignments in spite of unfavourable conditions. Some reports note that pilots find it hard to negotiate the competing demands of business (as when taking risks to satisfy clients) and safety. For instance, in report 2013/30, it is suggested that work overload and knowing the client well might have led the pilot to take a risk. In report 2011/08, the AIBN similarly suggests that such a trade-off has taken place:

> *"The AIBN has not considered appropriate to try to identify the factors contributing to the pilot's choice to "push the weather." This could not produce definite answers. In general, the choices an individual pilot makes, often seem reasonable one the basis of the perceived situation. An unconscious or conscious desire to perform the task on schedule and in a manner that creates as little extra work as possible for oneself and others, is often a factor."*

A more developed organisational framework could make such trade-offs easier for the individual pilot. We expand on this below.

5.8.2 Work-related risk factors

Deficient safety management system/procedures. AIBN-reports repeatedly underline the negative safety implications of the fact that helicopter operators are not obliged by law to carry out risk assessments of their operations, stating however, that such a requirement will come in new EASA rules. As a consequence, several of the AIBN-reports indicate how proper risk assessments could have prevented accidents.

Moreover, risk assessments could have informed relevant and precise work descriptions with clear guidelines and limits for helicopter operations. Vague or missing procedures/guidelines are an important factor related to safety management systems that are referred to as a risk factor in several of the reports. For instance, clear - and clearly enforced – guidelines specifying when assignments should be aborted for safety reasons, could counteract the tendency to "push the weather", and complete assignments in spite of unfavourable conditions. Report 2013/30 suggests the establishment of such procedures to regulate reindeer driving, while report 2012/13 suggests clear procedures regulating flying altitude and limits for banking below certain altitudes. Report 2014/10 recommends clear procedures on how to choose places to land the helicopter. Many of the cases of "risky behaviour", for instance cases of aggressive manoeuvring or low flying for the enjoyment of passengers, seem to be reflecting such an underlying lack of strict organisational guidelines, and enforcement.

Additionally, there are also examples of lacking training of helicopter pilots in companies that have been involved in crashes. This is especially the case with "freelance pilots" with a weak relationship with the company.

Underdeveloped organisational structure. The organisation of the business in question is mentioned as a possible risk factor in three of the investigations. For two of the cases, the problem is perceived to be the lack of a proper organisational structure. For instance, in report 2013/30, the relationship between the pilot and the company is described as tenuous:

> *"The commander was stationed at the company's base in Laisholm, Hemavan-Tärnaby. Regardless of which forms of contact the company uses, there is reason to believe that the commander's association with the company's operational management was looser than for corresponding personnel working at the main base in Östersund. The commander also had a lot of experience from reindeer driving and had worked in two other helicopter companies earlier. He had accordingly established routines and a customer following before becoming an employee of Jämtlands Flyg. Overall, this may have resulted in the commander being given too much freedom and trust in the company. The large physical distance and large trust may have created challenges as regards operational control, which in turn can lead to safety-related challenges.*[13]

In two of the reports, the safety risk concerns the distribution of roles and responsibilities; in one case, an owner is also a pilot, which might complicate lines of command:

> *"Based on findings in other cases, the AIBN holds that in general, it is unfortunate that a pilot is also the owner because this could undermine flight commander's authority and make it difficult to reprimand such a pilot."*

In this case, the pilot's manoeuvring was characterised by the AIBN as "irresponsible", and "worrisome", and suggests that this behaviour may conform to a pattern in the company:

> *"After the accident, one of the passengers has explained to the police that he had previously experienced such manoeuvers where the helicopter has risen by a very sharp angle with this pilot and other pilots."*

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[13] It is important to note that the mentioned example concerns a Swedish pilot in a Swedish company, which is the responsibility of Swedish authorities. We include it, however, as the company operates in Norway.

In some cases, the pilots' association with the organisation is so tenuous, that it cannot be expected that enforcement is really a possibility. Several of the pilots involved in the accidents and incidents were not directly employed in the companies responsible for the flights, and some worked at different locations from the management.

5.8.3 Framework conditions

Safety culture in the business. Several reports recommend flight recorders to be installed in the helicopters, to monitor helicopter operations and "discipline pilots". In one of the cases, the helicopter had such equipment to monitor helicopter operations. The pilot nevertheless continued the operations as it got dark, although this serious procedure violation would be visible to the company's management.

> *«The commander must have been aware that the flying with SE-JPZ could at all times be monitored by the company's operational management. The fact that he, in spite of this, continued to fly in darkness, may indicate that he was willing to push the limits far. It can also indicate that his experience was that the company silently accepted such operations." (2013/30)* [14]

As the AIBN suggests, this could suggest that risky behaviours had been tacitly accepted by his employers in the past. Summing up, what these various risk influencing factors seem to suggest, is a business where the professional actors who were involved in accident not always seemed to work as systematically with safety as should be expected, given the relatively high level of risk of the operations. Some AIBN-reports comment on the general safety level of the business, when discussing recurring safety problems. In AIBN report 2013/20 for instance, it is noted that:

> *"The AIBN finds that the results in this investigation and the Safetec report shows that the business "inland helicopter" has a considerable way to go before it can be said to have reached a level of maturity where professional safety knowledge permeates the operations." (2013/20).*

Additionally, report 2014/06 states that safety culture is a general challenge in the inland helicopter business:

> *"It is the opinion of the AIBN that this accident is a reminder of how challenging it can be for inland helicopter companies to create a safety culture that influences pilots to avoid risky behaviour when they are alone on an assignment, and "nobody" see what they do. The AIBN find that these challenges previously have been treated thoroughly in our reports…."(2014/06).*

> *"It is the opinion of the AIBN that the many helicopter operators can attain considerable safety benefits by implementing measures that not necessarily are complicated or expensive. This requires, however, a basic will and endurance to continuously work systematic with mapping the safety challenges that your own organisation face, and the ability to see which concrete solutions that will work best in practice. This applies both to the organisational and the individual level." (2014/06)*

In line with this, report 2011/14 complains that the reporting rate of inland helicopter pilots of incidents that they are not obviously required to report is too low

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[14] As noted, this example concerns a Swedish company operating in Norway.

to allow for a fruitful learning from dangerous incidents. If pilots would report more of the incidents and near misses that they experience, it could contribute to a common pool of knowledge and a possibility to detect and correct potential problems before they lead to accidents (AIBN 2011/14).

Other framework conditions mentioned in the reports are missing elements in helicopter pilot education, related to how pilots should avoid pilot induced oscillation (PIO) (2011/14). Report 2013/20 points to poor aviation authority follow up of an operator. The CAA had several times found weaknesses in the operators' safety management system and in the competence of the pilots, but failed to ensure that these weaknesses were corrected. Reports also point to insufficient (inter)-national rules regulating the business, for instance the above mentioned fact that there were no rules requiring operators to conduct risk assessments of operations.

5.9 Summing up

1. Ten crew members killed and sixteen injured in nineteen light inland helicopter accidents in the period 2000-2012. 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, e.g. offshore helicopter transport. The risk of fatal accidents for light inland helicopters during the period 2005-2011 was more than 10 times higher than that of offshore helicopters operating to and from installations on the continental shelf. 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.

2. Ambulance operators have the lowest accident risk. Generally, ambulance operators have relatively few accidents, and the lowest accident risk, with 1.22 accidents per 100 000 flight hours. The average accident risk for all inland helicopter operators are 3.26 accidents per 100 000 flight hours. The accident risk of private operators are 7.66 accidents per 100 000 flight hours.

3. Characteristics of light inland helicopter crashes. Historically, all helicopter fatalities have been the result of crashes, i.e. that the vessel collides with structures/terrain, or overturns during take-off or landing. A typical helicopter crash, compared with other helicopter accidents, is associated with passenger transportation, young and inexperienced pilots, inadequate planning, bad weather, loss of control in the air and small aerial work/PAX operators, foreign operators, and private pilots.

4. *The fatal accidents are most likely to occur during animal censuses/animal tagging/reindeer herding*; followed by (named in decreasing order of probability) scenic flights/ sightseeing/inspection flights/etc. (A to A); private flights (with privately owned helicopters); PAX (A to B), and technical flights/ferrying/transfers/etc. Reindeer herding is time critical work, dependent on how the herd moves in the terrain. Under these conditions, pilots fly close to the ground, sometimes under bad weather. The AIBN states that reindeer herding is a high risk activity.

5. Assignment completed in spite of unfavourable conditions and risky behaviours are the most typical forms of pilot behaviour mentioned in the AIBN-reports. Risky behaviours refer to voluntary risks taken by pilots, such as aggressive manoeuvring, flying too low or too close to physical obstacles. "Assignment completed in spite of unfavourable conditions" refer to cases when, in the view of the AIBN, an assignment should have been cancelled as a safety precaution, but was still carried out. Unfavourable conditions could for instance refer to bad weather or darkness and low visibility. Flying low also increases the risk of loss of control of the helicopter, because of variations in the terrain (e.g. hills) and surprising and unpredictable winds that may affect the stability of the helicopter.

6. *Vague organisational guidelines for dealing with competing demands.* Our data indicate that some pilots find it hard to negotiate the competing demands of safety versus efficiency. Pressure from customers and flight managers can sometimes be invoked to explain why pilots complete assignments in spite of unfavourable conditions. Thus, clear - and clearly enforced – guidelines specifying when assignments should be aborted for safety reasons, could counteract the tendency to "push the weather", and complete assignments in spite of unfavourable conditions. As noted, our data show that 47 % of the AW/PAX pilots claim that they weekly or daily have to decide whether to fly into weather condition that may deteriorate below Visual Flight Rules minimum, and only 31 % of the AW/PAX pilots claim that the company they work for have a standard procedure for handling bad weather conditions.

7. Pressure to fly, fatigue and safety procedure violations. Compared with ambulance and police pilots, who have considerably lower accident risk, AW/PAX pilots experience more pressure to fly from customers and flight operations managers, they break safety violations more often, fly more often in spite of being fatigued and in spite of poor weather conditions. This could explain some of the risk differences between the groups.

8. Company size as a work-related risk factor. There were significant differences between the companies' accident risk, depending on their size. The smallest companies experienced the highest accidents per hour ratio (6.17), followed by medium companies (3.04) and large companies (2.75). Small operators own five or less helicopters, medium operators own between six and 14 helicopters, while large operators own more than 14 helicopters.

9. *Insufficient safety management systems.* This is the most recurring theme in the AIBN-reports, indicating insufficient risk assessments, procedures and training in operators involved in accidents. Our data also show differences between AW/PAX pilots and ambulance/police pilots in their evaluation of organisational conditions like safety management and safety priority, violation of procedures, quality of the interactions between crew members, manning, resting time, level of training, use of risk assessment, support from the management, production pressure, and reporting system and practice.

10. Safety culture of the light helicopter inland business. The AIBN states that safety culture is a general challenge in the inland helicopter business and that it is challenging for inland helicopter companies to create a safety culture that influences pilots to avoid risky behaviour when they are alone on an assignment, and "nobody" sees what they do. It is also stated that inland helicopter has a considerable way to go before it can be said to have reached a level of maturity where professional safety knowledge permeates the operations.

11. Market/competition/contracts. A fourth of the pilots employed by the AW/PAX operators claim that the competition with other helicopter companies makes it necessary to violate safety routines. The customers of the ambulance/police operators are limited to Norwegian governmental organisations. They have multiannual contracts, with rather extensive specification regarding the terms and quality of the services. The customers of the AW/PAX operators are more numerous and diverse, and generally the contracts are limited to single assignments. Thus, market conditions and financial instability constitute a challenge for safety management and the prioritization of safety. There are also differences between the small and the larger AW and PAX operators (medium and large) when it comes to the composition of the customer portfolios.

6 Concluding discussion

The main aims of the study were to map the prevalence of work-related accidents in Norwegian road, sea and air (light helicopter inland) transport, and examine risk factors associated with them. We focused especially on work-related risk factors.

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.

6.1 Prevalence of work-related injuries

6.1.1 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. Work trips are trips done by people driving in their work, either employed or self employed. An average of 1500 people is injured in these accidents each year. Thus, we see that most of the injured road users in accidents with 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. Data from SN shows that a total of 44 % of the trips involving police-reported personal injury accidents and known trip purpose had work (27 %), or to/from work (commuting accidents) (17 %) as purpose. AG-data show that 31 % of all fatal road accidents in Norway involved professional drivers at work, while 7 % involved drivers at work who were not professional drivers.

This supports an assertion found in the EU-PRAISE reports, that 40 % of traffic accidents generally involve driving in or to or from work (SafetyNet, 2009). However, the share of road accidents that are work-related in Norway appears to be higher than those found by studies in certain other countries. For instance, one French study suggests that only 10 % of traffic accidents are thought to involve drivers at work, although the share of accidents involving drivers on their way to or from work was similar to Norway (18 % in France vs. 17 % in Norway) (Charbotel, Martin, & Chiron, 2010). Indeed, the abundance of accidents involving commuting drivers relative to those involving working drivers has also been found in Australia (Boufous & Williamson 2006). A comparison of the methods used in these and our studies may be merited.

SN-data based on police reports 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 in the AAG-data drove heavy vehicles, and that most (65 %) of the non-professional drivers at work drove light cars or vans at the time of the accident. A thematic report by NPRA for 2010 found that HGVs were involved in 36 % of fatal road accidents. In addition to the annual variation, the higher share may be due to the inclusion of a small share HGVs that were on the way to or from work at the time of the accident. UK data show that 23 % of serious road accidents involve commercial vehicles "at work" and 7 % involve light or private vehicles "at work". Comparisons with Norwegian and EU-data are more difficult. Of all fatal road accident among EU-23 countries in 2008, 14.2 % were accidents with HGVs and 2.6 % accidents with buses (DaCoTa 2010). Assuming that these heavy vehicle drivers were at work at the time of the incident, we can say that about 16-17 % of fatal accidents involved professional drivers at work driving heavy vehicles. A report from Volvo Trucks on EU-27 countries for 2009 concludes similarly that heavy vehicles were involved in 17 % of fatal accidents (Volvotrucks 2013).

Given our finding that 90 % of drivers at work at the time of a fatal accident drove HGVs, and 31 % of fatal accidents involving drivers at work, it is interesting to note that the share of fatal accidents involving HGVs appears to be higher in Norway than in the EU generally. However, in a previous report we have shown that the risk of serious road accidents involving HGVs is lower in Norway than in most other EU countries (Nævestad et al. 2014). Thus the lower share of HGV accidents in other countries compared to Norway is probably due to the higher prevalence of non-work-related traffic accidents in many other EU countries.

6.1.2 15 killed and 424 injured annually on Norwegian ships

We have examined the number of dead and injured people at work for fishing vessels, cargo ships and passenger ships with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign waters in 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 per year injured for passenger ships in the period. This gives a total average of 15 killed and 424 injured annually on Norwegian ships. In comparison, over 30 people are killed in leisure boat accidents each year. Although it is difficult to compare directly, the following European statistics from the European Maritime Safety Agency (EMSA, 2014) make for an interesting comparison.

- In 2013 there were 74 fatalities and 754 people injured across EMSA member nations.
- In 2013, 12 ships capsized, there were 2580 collisions, 371 contact incidents, 200 incidents with damage to the ship or equipment, 164 incidents of fire or explosion and 318 groundings.
- Between 2011 and 2013 there were 4015 ship casualites and 1801 occupational accidents reported. Most incidents occurred on cargo ships, (944 ship casualties and 241 occupational accidents); followed by passenger ships (425 ship casualties and 228 occupational accidents), service ships (306

ship casualities and 220 occupational accidents) and fishing vessels (235 ship casualties and 132 occupational accidents).
- Estimated level of underreporting of occurrences (casualties and incidents) is 30 %, although underreporting is more serious for less serious accidents.

6.1.3 Low numbers but high risk for light inland helicopters

Two crew members are injured/killed at work each year on inland helicopters. Ten crew members were killed and sixteen injured in nineteen light inland helicopter accidents the period 2000-2012. Although these absolute numbers are low compared with corresponding numbers in other transport sectors, they reflect an accident risk which is high compared with other forms of air transport, e.g. that of offshore helicopters. The fatal accident frequency among aerial work/PAX operators are more than 10 times higher than the fatal accident frequency within the offshore helicopter transportation on the Norwegian continental shelf (Bye et al. 2012). How can the difference between the two helicopter types be explained? The differences in the risk level between domestic and offshore helicopter have not yet been systematically studied. However, a comparison of identified relevant risk influencing factors in the different safety studies of respectively inland helicopters (Bye et al. 2012) and offshore helicopters (Hokstad et al. 1999; Herrera et al. 2010), shows that there are 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.

6.2 Risk development in the sectors

6.2.1 Decreased risk in road and maritime sector, but no clear reduction of helicopter injuries

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, inland helicopter has not experienced the same strong and stable reduction in work accidents and injuries in recent years, as figure 6.1 illustrates.

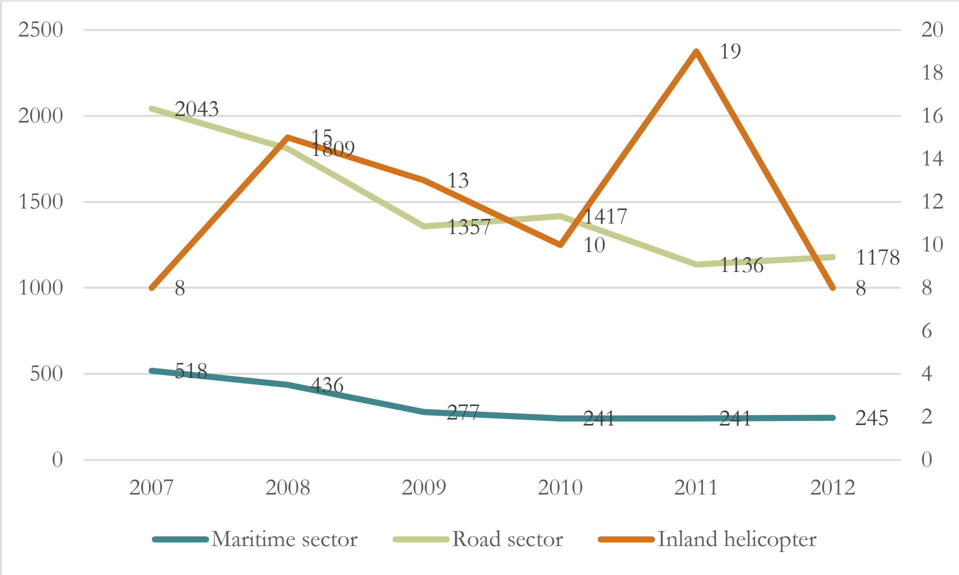

Figure 6.1. Primary axis: number of people injured in police reported traffic accidents in Norway 2007-2012, with work as the purpose of the trips and personal injuries per year for on vessels with Norwegian (NIS/NOR) and foreign flag in Norwegian waters, and ships with Norwegian flag (NIS) in foreign 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 6.1 shows tendencies in *absolute numbers* of injuries and events. As there were only ten events involving personal injuries to helicopter crew between 2007-2002, the secondary axis of the figure includes all events with personal injury and/or material damage in Norwegian inland helicopter flights per year 2007-2012. The tendency revealed by the graph indicates that light helicopter inland transport has not undergone a gradual decrease in work-related accidents and injuries in recent years, as the other studied transport sectors have.

In contrast, both SN-data based on police reports and AAG-data indicate that the number of drivers in work-related road transport accidents per year decreased substantially over the study period. AAG-data show, for instance, that fatal road accidents involving professional drivers at work have decreased by 17 % from 2005 to 2013. It is important to note, however, that the indicated reduction is not as large as it is for all types of road transport accidents (33 %). Moreover, AAG-data show a contrasting trend for accidents involving non-professional drivers at work, whose accidents do not appear to have decreased.

When it comes to the maritime sector, both fishing, cargo and passenger vessels have had considerable decreases in the number personal injuries in the period 2004-2013. There was an average 60 % reduction in the number of injuries from 2004 to 2013. When we look at the number of serious injuries per 1000 vessels, the number was reduced with 54 % in the period for fishing vessels, 63 % for cargo vessels and 57 % for passenger vessels in the period 2005-2013.

It should however be noted that different events in different sectors are studied in this report, as we compare one small sub-sector in aviation with two large sectors in this study. We would perhaps also 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. We expand more on this below in section "6.7 methodological limitations".

6.3 Do the developments reflect changes in risk or exposure?

The absolute numbers indicating a considerable decrease of injuries and accidents in the road and the maritime sectors do not necessarily imply a decrease in the accident risk of transport operators at work. Accident risk is estimated on the basis of an exposure measure, e.g. the number of accidents per million km driven, or the number of accidents per 100 000 hours at work. Thus, changes in absolute numbers of accidents and injuries may be the result of changes in exposure.

6.3.1 Decreasing risk for HGVs in the road sector

It is difficult to obtain exposure measures for all the groups that we study, e.g. "other drivers at work" but we know from a previous study, where we obtained and analysed exposure data for heavy goods vehicles (Nævestad et al. 2014), that their risk on Norwegian roads has decreased in recent years, as figure 6.2 shows.

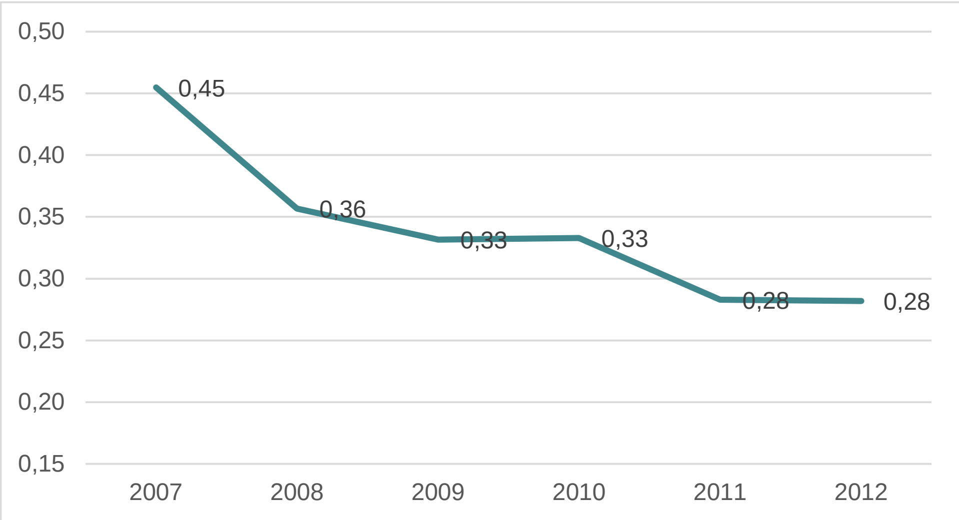

Figure 6.2 Number of heavy goods vehicles in police-reported traffic accidents with personal injuries per million HGV kilometres in Norway per year from 2007 to 2012. Based on numbers from Nævestad et al. 2014.

In accordance with the steady drop in the absolute numbers of injuries and accidents per year for drivers at work, we see that the accident risk for HGVs on Norwegian roads has decreased. As noted, HGVs are the most prevalent vehicle used by drivers at work, followed by private/estate cars, bus/minibus, van, cab and emergency vehicle. If we assume that the tendency for HGVs is representative for these other types of vehicles used by drivers at work, we may conclude that the accident risk for drivers at work has been reduced recent years. We have however, seen that this does not seem to apply to non-professional drivers at work, and this is an issue requiring more research.

6.3.2 Decreasing risk for all vessel types in the maritime sector

In the maritime sector, we see that the number of work injuries has decreased substantially, when we look at the number of injuries per 1000 ships.

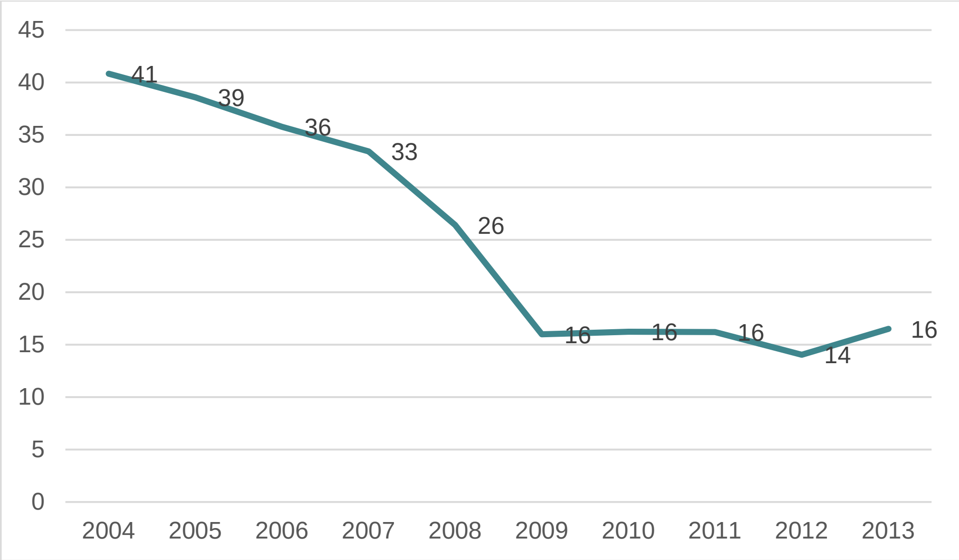

Figure 6.3 Personal injuries with more than 72 hours work absence per 1000 vessels per year for fishing/cargo/passenger vessels. Ships with Norwegian (NIS/NOR) flag only. Based on NMA's database of maritime accidents.

This estimate, is however based on a very crude risk measure: the number of 1000 ships per year. Although it is a better estimate of actual risk than absolute numbers, this estimate is still somewhat imprecise, as it neither includes the number of crew on the ships, nor the numbers of hours worked by the crew. With numbers of crew and hours worked, we could have calculated the number of work injuries per million hours worked at the ships in the different categories. Without these numbers, we may get a false impression of the risk reduction, e.g. if the number of ships increase and/or manning on board decreases. Given the reduced manning afforded by increasing use of technology on board in recent years, more research is needed on this issue.

6.3.3 Small numbers and unstable risk development for inland helicopter

In the previous chapter, we saw that the accident risk for light inland helicopters in the period 2005-2012 indicated a downward trend in the years 2009-2012, but that the trend was not as clear and stable as in the other sectors (see figure 5.9). Risk was measured as the number of accidents with personal injury per 100 000 flight hours. It is important to note that the estimates are based on low absolute numbers of accidents that are vulnerable to coincidental changes from year to year; changes that not necessarily are statistically significant.

6.4 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. We expand more on this below in section "6.7 methodological limitations".

6.4.1 Risk factors in the road sector

Figure 6.5 below illustrates the hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to people and vessels. The hypothesized relationships are based on our analyses of quantitative and qualitative data: AAG-data, SN-data based on police reports and AIBN-reports.

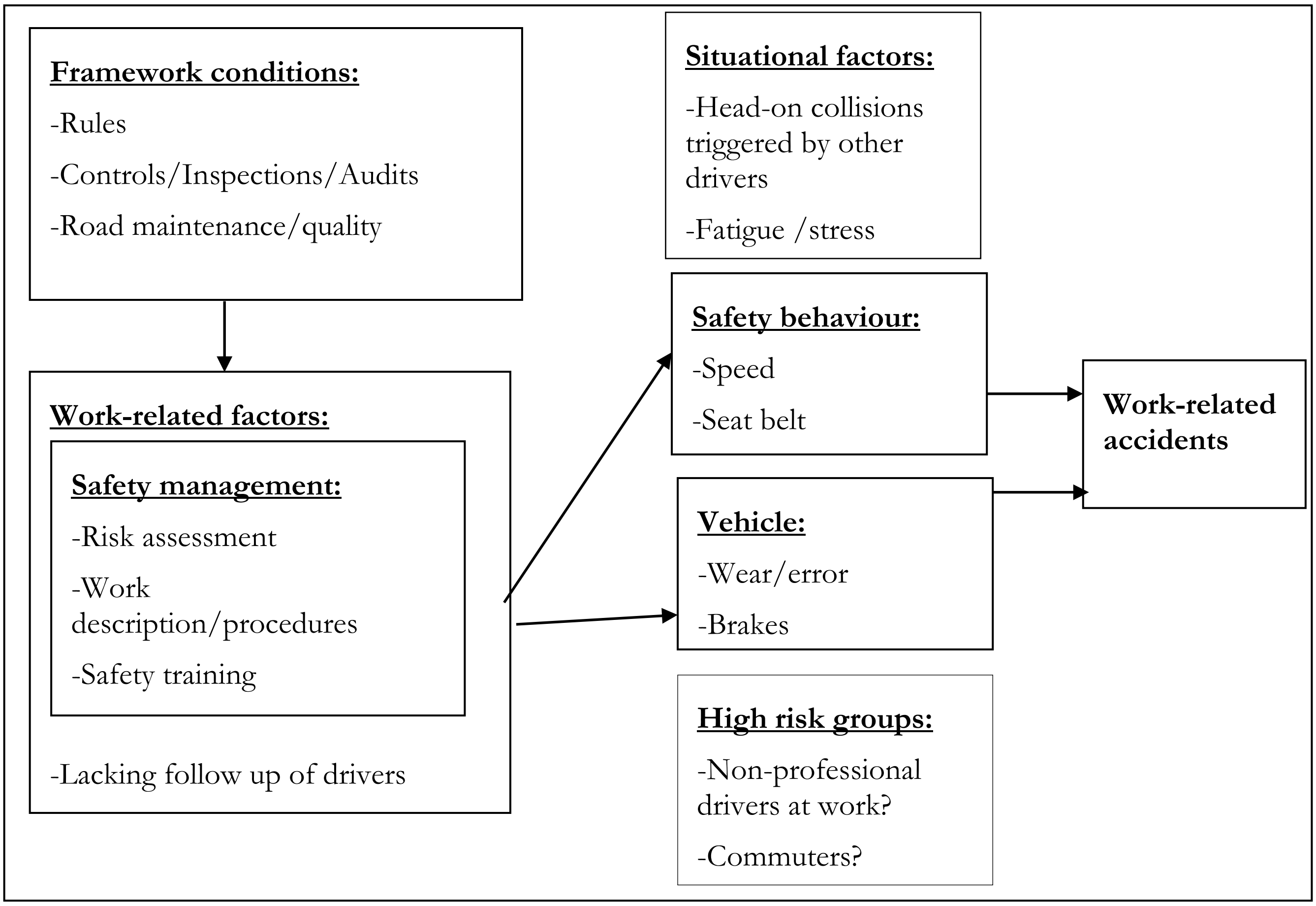

Figure 6.5 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to operators and vehicles in work-related accidents in the road sector. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and qualitative data.

Results show that speeding and lack of seat belt use were the most frequent risk factors related to drivers in these accidents. AIBN-reports show that these risk factors often can be related to work-related factors like follow up of drivers by employers (e.g. speed, seat belt use, driving style), and companies' safety management systems (risk assessments, procedures, training). Additionally, AIBN-reports show that work-related factors often can be understood in light of companies' framework conditions such as rules and safety requirements, controls, inspections, audits and road maintenance and quality.

Non-professional drivers at work are a high risk group. The analysis of the AAG-data show that accidents involving non-professional drivers at work do not appear to have decreased from 2005 to 2013, despite clear downward trends in other types of accidents. These were involved in 7 % of all fatal road accidents. Although relatively low numbers of these driver types are involved in fatal accidents (117 in study period), 41 % of those involved were killed. Little is known about non-professional drivers at work. As their workplace does not have transport as its primary objective, less attention is perhaps paid to traffic safety by their managers. More research should focus on this group in order to evaluate safety level, safety challenges and potential safety measures, in order to decrease their accident risk. We do however know, from AAG-data that one in three non-professional drivers at work who triggered a fatal road accident were over 54 years old, and that most (65 %) drove light cars or vans at the time of the accident. Of those who triggered fatal accidents within this group, 28 % were registered as being in an abnormal condition, half of whom were stressed at the time of the accident. If there are few drivers above 54 years old in this group, their accident risk is high. Interestingly international research shows that there is a "company car" effect, where company car drivers tend to drive not just faster than drivers of private cars, but also when they are more tired (Husband 2011; Symmons & Haworth 2005; Newnam, Watson & Murray 2004). Driver behaviour among company car drivers is clearly something that companies can tackle through risk management (Wills, Watson & Biggs 2009).

Commuting accidents. Our results show a considerable share of commuting accidents. SN-data show that 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 other drivers, e.g. drivers on their way to/from work. The same tendency was found in the AAG-data. However, 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 the exposure data of the two groups, in order to compare their risk of personal injury accidents.Although commuters are not included in the focus of Norwegian work life authorities, for instance ILO and WHO include these in a general occupational safety perspective. Commuting accidents are probably influenced by work schedules, and it is likely that driving home after e.g. a night shift is an accident prone trip. Our analyses suggest that fatigue is a challenge for a considerable share of commuter drivers.

Professional drivers are more at risk for head-on collisions. Our analyses indicate that professional drivers are less likely than other road users to trigger accidents. On the other hand, they are more likely to become involved in head-on collisions with counterpart drivers who drive into them because they are tired, stressed, ill, influenced by drugs or alcohol, speeding or intending to take their own lives.

6.4.2 Risk factors in the maritime sector

Figure 6.6 below illustrates the hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to people and vessels. The hypothesized relationships are based on our analyses of quantitative and qualitative data.

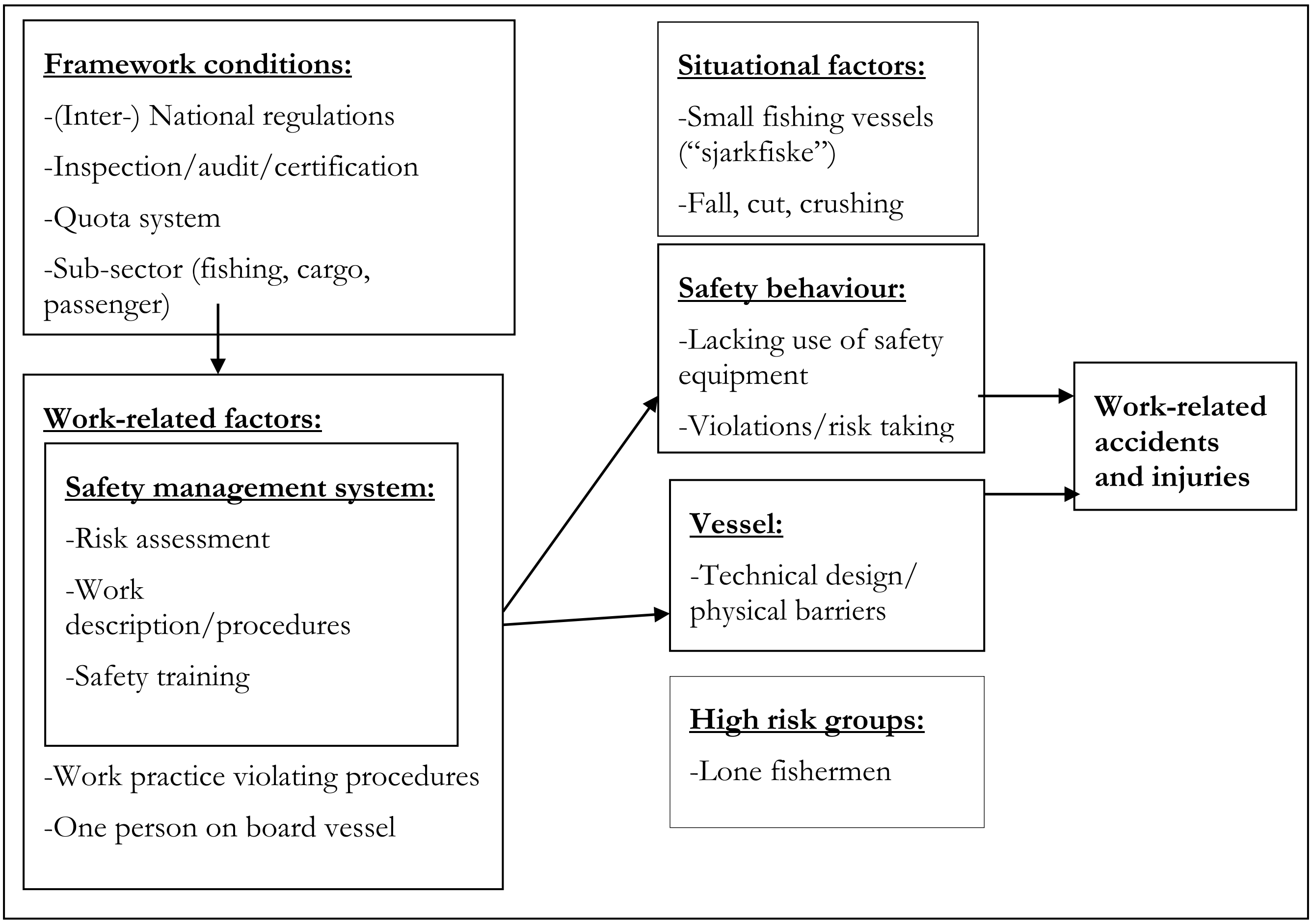

Figure 6.6 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to safety behaviour and vessels. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative & qualitative data.

Our analyses of the maritime accidents involving people working aboard Norwegian and foreign vessels in Norwegian waters and Norwegian vessels in foreign waters are based on two data sources: NMA-data and AIBN-reports. These show that (lack of and) lacking use of safety equipment was the most common behavioural risk factor. 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. AIBN-reports indicate that with proper safety management systems, relevant risks can be identified in risk assessments, informing safety procedures and safety training. AIBN-reports also show that work-related factors often can be understood in light of shipping companies' and vessels' framework conditions, like (inter-) national regulations, inspection/audit/certification, and sub-sectors.

The share of severe injuries (>72 hrs work absence) was 15 percentage points higher for fishing vessels than other vessel types. This may perhaps partly be due to the fact that many of these are self employed and do not see the benefits of reporting minor incidents. 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 to the population of Seafarers that the NMA accident database covers, due to national differences in reporting.

Lone fishermen on fishing vessels are a high risk group. AIBN-reports indicate that lone fishermen make up a specific high risk group in the maritime industry. Several of the studied maritime accidents involve small fishing vessels ("sjark" 19-42 feet) manned with only one person, who is also the owner. In this kind of accident, the typical sequence of events is that the sole person on board the vessel is trapped in the gear and/or falls overboard. The single occupancy of the boat is an important risk factor in itself in these accidents, as well as lack of risk assessments, physical barriers to risky areas and safety equipment. AIBN-reports indicate the need for clear national rules (and governmental regulation) applying to fishing vessels below 15 meters, e.g. rules requiring risk assessments and specifications of how to conduct them.

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 a board 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 underway on fishing, cargo and passenger vessels were: fall, crushing and cut/stab injuries.

6.4.3 Risk factors in light inland helicopter accidents

Figure 6.7 illustrates the hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to pilots and helicopters. The hypothesized relationships are 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 that small helicopter operators have significantly higher accident risk than large operators. Small operators (<5 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".

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, AW/PAX pilots experience more pressure to fly from customers and flight operations managers, they break safety violations 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.

Our data also show differences between AW/PAX pilots and ambulance/police pilots in their evaluation of organisational conditions like safety management and safety priority, violation of procedures, quality of the interactions between crew members, manning, resting time, level of training, use of risk assessment, support from the management, production pressure, and reporting system and practice.

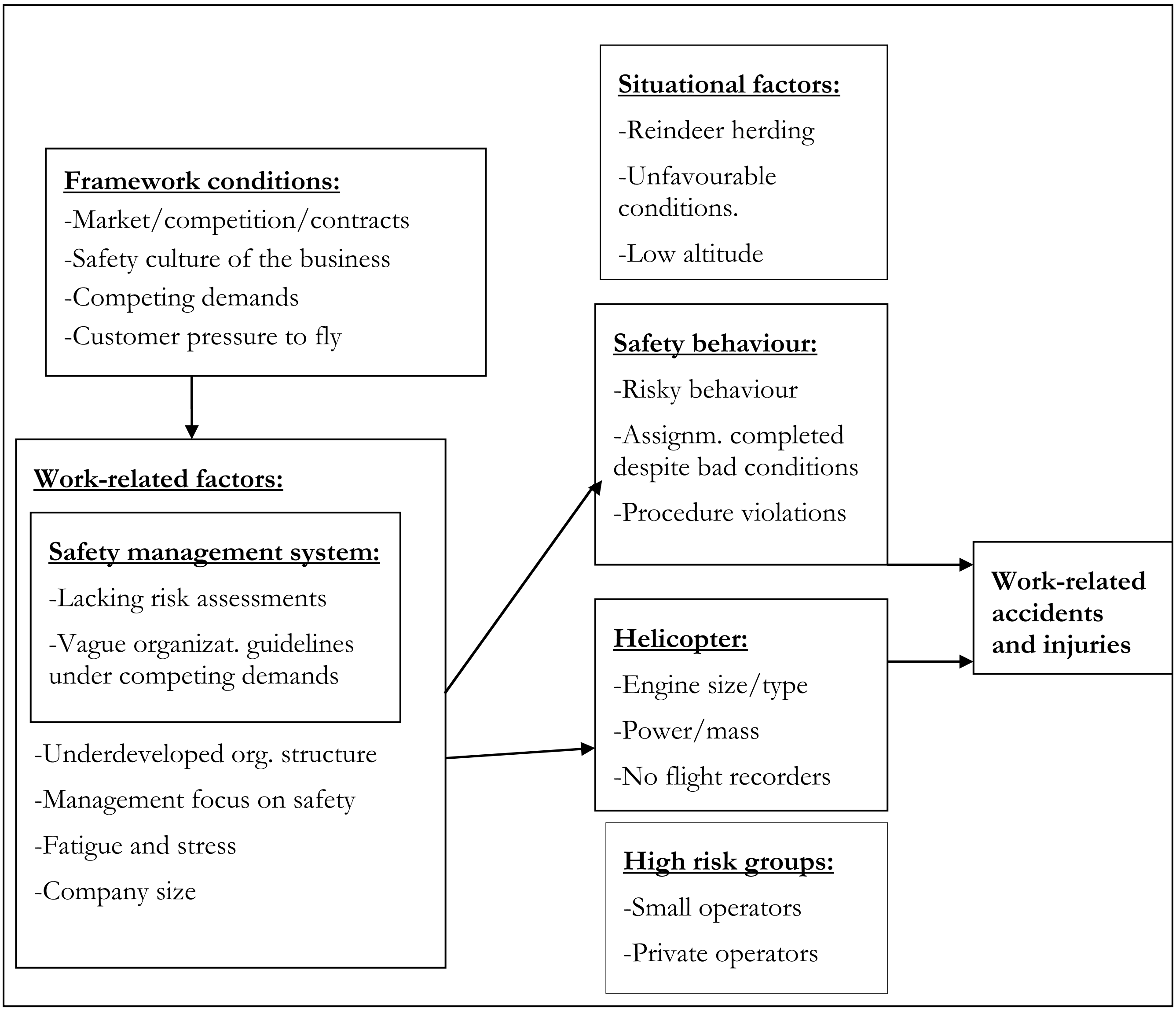

Figure 6.7 Illustration of hypothesized relationships between typical risk factors related to framework conditions, work-related factors, and risk factors related to pilots and helicopters. Situational factors and potential high risk groups are also mentioned. Based on our analyses of quantitative and qualitative data.

Inland helicopter safety is also influenced by framework conditions. 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, competition and contracts also influence helicopter safety. Large operators have long (governmental) contracts with detailed safety requirements, while small operators often have contracts limited to single assignments. A fourth of the pilots employed by the AW/PAX operators claim that the competition with other helicopter companies makes it necessary to violate safety routines.

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 and unpredictable 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. The AIBN states that reindeer herding is a high risk activity that should be closely followed up by authorities and operators both in Norway and Sweden (AIBN 2013/30).

A literature search conducted in 2012 (Bye et al. 2013) shows that there are not many international publications on helicopter safety[15]. Most of the articles deal with patient safety in connection with helicopter transport. Only 30 Articles were considered to be relevant.[16] Identified risk influencing factors related to helicopter crashes in international published articles corresponds partly with our findings. Several studies shows that the age of the pilot, experience, perception of production pressure due to economic constraints, cultural factors associated with communication, terrain type, rapid shifts in weather conditions and landing site represents factors that influence the probability of helicopter crashes (Lubner 1997, Lubner 2005, Thomas et al. 2000, Nakagawara 2004). Other identified risk influencing factors are reduced situation awareness, skill level, helicopter type[17] (Iseler & De Mayo 2001). Manwaring et al. (1998) has studied accidents associated with helicopter operations with external loads in terms of causes. According to their analysis mechanical error, error associated with maintenance and pilot error the most common causal explanations. Studies examining the causes of pilot error in general indicate that insufficient experience, cultural differences between actors involved in the operations, terrain type, weather conditions, standard of the landing place and experienced production pressure are factors contributing to human errors.

6.5 Common risk factors in work-related transport accidents

6.5.1 Risky operator behaviour

The data show that risky operator behaviour was a common factor among transport operators in all three transport sectors studied here. In the road sector, we saw that driving at speeds too high for the conditions was one of the most important risk factors, explaining both why work-related accidents happen and the scale of the accidents.

The NMA-data do not include information on risky behaviours of injured ship crew members, but information on operator behaviour is included in the AIBN-reports, e.g. lacking compliance with safety procedures and lacking use of safety equipment.

"Risky behaviours" is the most frequently mentioned factor in the AIBN-reports on light helicopter inland accidents, referring to voluntary risks taken by pilots, such as aggressive manoeuvring, flying too low or too close to physical obstacles and "assignment completed in spite of unfavourable conditions".

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[15] The literature search was conducted by the use of search engines Google Scholar and Science-direct. The following combinations of keywords have been used:
- "helicopter Accidents"
- "helicopter Accidents" Canada
- "helicopter Accidents" Switzerland
- "helicopter Accidents" statistics risk
- "helicopter transport" + risk + Accidents + safety

[16] The search resulted in a total of 1268 hits, but most of the articles dealt with patient safety in connection with helicopter transport.

[17] I.e. thar cheaper helicopter types are more prone to breakdowns than more costly types

6.5.2 Lacking use of safety equipment

Another risk factor common to transport operators in all the three sectors was lack of and lacking use 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, SN-data based on police reports show that people who drove for leisure had a reported seat belt use that was nearly twice as high as those driving at work. Nevertheless, SN and AAG-data show that professional drivers are less severely injured than other drivers in accidents, probably because they are more protected in their heavy vehicles. Lacking use of safety equipment was also noted in the AIBN-reports from the maritime- and the aviation sector.

6.5.3 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 (SMS)*, consisting of three elements. Taken together, these three processes summarize an ideal of how transport operators should relate to risk and how they should work with safety management. We formulate these normatively in the following:

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.

In the accidents described in the AIBN-reports, it is often concluded that one or several of these processes have failed. This ideal of HSE requirements in accordance with the Working Environment Act (WEA) and the Internal Control provision and the principles behind the safety management system seems to underlie many of the AIBN's conclusions. As noted, the WEA does not apply to the maritime sector. In this sector, safety management systems are. required by the HSE regulations applying for people working aboard ships (e.g. the Ship Safety Act), but as noted the AIBN identifies a need for clearer rules applying to small vessels (<15 metres). Thus, the legal requirements for SMS are to some extent different and sector-specific.

Moreover, the regulation of safety are different in the sectors. It may perhaps seem that the aviation sector has a stronger tradition for self regulation on the part of the involved companies. The Committee for Helicopter Safety - Inland Operations represents an important framework condition for the business. The committee was established in 2009 by the Civil Aviation Authority (and with political support by the Ministry of Transport) reflecting the fact that Inland helicopter safety has been given priority by the Civil Aviation Authorithy in recent years. All the inland helicopter operators are represented in the Committee and meet a minimum of 4 times anually. The purpose of the committee is to be a driving force in relation to authorities, customer groups and operators in order to increase inland helicopter safety. The committte works according to a zero vision, suggests and follows up safety measures and cooperates with international partners. Interestingly, in a sub-sector that to some extent lacks procedures establishing precise limits for several actitivites that may pose risks, one of the roles of the committee is to discuss and establish commonly accepted operational limits and safety standards. The committee also discusses relevant accidents and safety problems, and may thus serve as a promising example of sectorial safety work. Offshore helicopter operations have a similar committee with the same purpose (Committee for Helicopter Safety on the Norwegian Continental Shelf).

Compared with aviation, the road sector has fairly detailed set of regulations, clearly defining limits for transport operator behaviour and rules of conduct. In contrast to the Ship safety act, "Vegtrafikkloven" does not focus on the responsibility of the transport companies when it comes to setting the premises for transport safety. "Vegtrafikkloven" primarily focuses on the legal responsibility of the individual driver; applying both to private and professional drivers. Finally, AIBN-reports as noted indicate the need for clear national rules (and governmental regulation) applying to fishing vessels below 15 meters, e.g. requiring risk assessments.

6.5.4 Fatigue and stress

Analyses of the AAG-data show that fatigue and stress are important risk factors of the triggering drivers at work. Of the professional drivers triggering accidents, 19 % were fatigued or stressed. Fatigue and stress are risk factors that often are explained by referring to work-related risk factors like pressure from customers and managers, work schedules etc..

We have also seen that AW/PAX helicopter pilots experience more pressure to fly from customers and flight operations managers than police/ambulance helicopter do. Additionally, the former break safety violations more often, fly more often in spite of being fatigued and in spite of poor weather conditions. This could explain some of the risk differences between the groups, and it illustrates the negative consequences of pressure and stress for transport safety.

Fatigue was only to a limitied extent identified as a risk factor in the maritime data material that we have studied in the present report. Nevertheless, there are many reasons why human operators performing safety-sensitive tasks are exposed to high levels of fatigue in shipping. The demands for safe operation 24-hours a day are greater in shipping than in any other transport sector. All rest must be obtained in the workplace, which can cross time zones and is exposed to varying degrees of motion, temperature and noise (Phillips 2000). In many branches of shipping there are long work weeks, nonstandard work days, extensive night operations, and periods of intense effort alternating with periods of monotony. Pressure to improve productivity and the introduction of technology have resulted in reduced manning, reduced port turnaround times and decreased layovers (Wadsworth et al. 2008). Examining fatigue as a safety problem in shipping, Phillips (2014) sums up its main causes as: minimal manning, port calls at different times of day, poor organisation, high demands on board, in addition to suboptimal watch systems contributing to unpredictable, fragmented and irregular sleep, and regular working through circadian lows.

6.5.5 Framework conditions

Results indicate that the different framework conditions of transport companies influence safety. Typical framework conditions are national/international rules, regulation/inspection/controls and market/competition. Several maritime AIBN-reports state that it is problematic that national and international rules lack proper and detailed procedures for risk assessment aboard small fishing vessels, and that procedures and checklists for certification and inspection of vessels sometimes come short of detecting safety problems. We have also seen that helicopter pilots employed by AW/PAX operators claim that the competition with other helicopter companies make it necessary to violate safety routines. Finally, it has been noted that safety requirements in contracts differ substantially between helicopter operators of different size.

6.6 What are the consequences of company size for safety?

The AIBN-reports often seem to find that small companies have underdeveloped and/or unclear organisational structures, for instance with one person filling several perhaps contradictory roles (e.g. owner/transport operator). We do, however, not know the prevalence of such organisational structures in organisations that have not been involved in accidents. Nevertheless, the importance of company size has also been indicated in some of the other data sources that we rely on in this study. The analysis of helicopter accident data for instance showed significant differences between the companies' accident risk, depending on their size. The analysis of maritime AIBN data shows that accidents with small fishing vessels manned with one person were a recurring safety topic.

Future research should examine whether the implementation of safety management systems require a certain company size, as several AIBN aviation and AIBN maritime reports point to underdeveloped safety management systems in small transport organisations. Do small companies have poorer administrative resources for managing risk than larger companies, and what are the consequences of this for safety?

Finally, it should be noted that from a societal perspective it is interesting to ask whether authorities regulating transport safety should pay most attention to small companies with high risk or big companies with low risk. It is not always given where the highest potential for prevention of work-related transport accidents is. However, given that most companies in Norway are small or intermediate, special attention should probably be devoted to safety measures in smaller companies. In the Norwegian road sector, it is for instance currently discussed whether it is (too) difficult for small transport companies to apply the ISO Standard 39001 for transport safety. Interestingly, road transport employer organisations (e.g. Norges Lastebileierforbund, Norges Taxiforbund) have started to facilitate the implementation of the standard for its members, and this seems to make it easier for smaller companies to implement this fairly comprehensive safety management system. Although investigations stress the importance of documented risk assessments, it is reasonable to ask whether formalized risk assessments are likely to be used by small companies and one-man companies. This indicates the importance of facilitating and simplifying such systems, and the mentioned initiative of employer organisations providing ready -made solutions through mobile phone applications is therefore positive.

6.7 Methodological limitiations

6.7.1 Different events in different sectors are studied

Above, we compared the development of accidents and risk over time in the three studied sectors. It should, however, be noted that we compare one small sub-sector 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 see in figure 6.4. It is also important to note that we study different kinds of events from different accident databases. In the road sector, we focus on accidents involving personal injuries, i.e. fatal accidents from the AAG-data and police-reported personal injury accident data from the database of Statistics Norway. It is important to note that in the road sector, we only focus on road accidents, and not accidents related to (un)loading. This is a limitiation of the report, as research shows that several accidents and injuries among drivers at work occur while (un)loading (Shibuya et al. 2008). We will therefore follow this up in future research. In the maritime sector, we focus on personal injuries caused by either work accidents or ship accidents. Some ship accidents and all work accidents contain one (or more) injury to people. In the maritime analyses, we do include injuries related to (un)loading. Moreover, because of changes in reporting, we distinguish between maritime injuries involving work absence of more and less than 72 hours. In the aviation sector (i.e. light helicopter inland), we primarily focus on fatal accidents and serious injury accidents, but also serious incidents in some cases (e.g. near misses). It is important to remember that the total amount of accidents with personal injury to helicopter crew is relatively low, with 19 reported accidents between 2000 and 2012.

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

As noted, the identification of the risk factors are firslyt 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. Secondly, we have 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. Thirdly, we also present our hypotheses on relationships between the risk factors. This are, as we underline, only hypotheses, and should therefore be treated as suggestions for future research.

6.7.3 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 common risk factors linked to framework conditions, work-related factors, and operators and vehicles within each transport sector. These hypothesized relationships are based on our analyses of quantitative and qualitative data. 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. Induced exposure methods could for instance be applied to examine this issue.

We have actually assessed this in previous research on fatal road accidents, where we have compared professional drivers in fatal accidents who triggered and who not triggered the accidents (Nævestad & Phillips 2013). In this research, we found that the identified risk factors (e.g. fatigue, stress, press) to a greater extent were present among the triggering drivers. In this research, we only focused on a few risk factors, however, and it is important to conduct a more thorough examination of this.

As noted, future research should assess the importance of formal and documented risk assessments. Although accident investigations often conclude that proper risk assessments would have identified the relevant risks, it is not given that the accident-struck organisations would have been able to conduct a proper risk assessment that would have identified the risk. Thus, would a poor, but formally documtented risk assessment have been helpful? More research is needed on this issue, for instance examining the existence and use of formal risk assessments in organisations with a good safety level. Are formal documented risk assessments as crucial as the accident investigations suggest?

Perhaps the most important risk factors are located at a more basic level, for instance related to the companies' day-to-day focus on safety and the actual attention given to safety by managers and employees? This is often referred to as "lacking focus on HSE in the company" or "poor safety culture", which is very difficult to assess the importance of in accident investigations. Nevertheless, future research could relate the risk factors that we have suggested in this study to safety culture, and perhaps try to assess how these are related, i.e. the interplay between framework conditions, SMS and safety culture, how this relationship facilitiates different safety levels in transport sectors and how these factors can be influenced in order to improve transport safety.

6.7.4 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 and may hide confounding factors. When interpreting these results, we must remember that the bivariate relationships may be a result of confounding factors that we have not controlled for in the present study. This does not apply to helicopter results, which are based on a much broader set of data. A confounding factor is a more basic, underlying variables causing two factors and thus giving us the impression of a relationship between two factors. 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 sometimeshave few resources for safety management; and thus lack safety management systems.

6.7.5 Underreporting of work-related transport accidents

Road. The accident database of Statistics Norway shows that the number of HGVs, with work as the purpose of the trip, in police-reported injury accidents is 2241 in the period 2007-2012. However, if we only look at HGVs involved in accidents in the period, we see that the actual number of HGVs in accidents in the period is 4150 (Nævestad et al. 2014). Only 2241 of these are ascribed work as purpose of the trip. A total of 1348 of the HGVs do not have a value on the "purpose of trip" variable (missing). In general, we found that about 30 % of the accident involved vehicles which usually are driven by people at work (i.e. professional drivers) had a "missing" trip purpose in the accident database of Statistics Norway. In the case of buses (29.5 %), cabs (28.5 %) and HGVs (32.5 %) about 30 % of the vehicles were not ascribed a purpose of trips in the accident database of Statistics Norway. Although we would assume that the vehicles that are defined as missing for HGVs, buses and cabs by and large were driven in work, we only focus on the vehicles that are ascribed "work" as the explicitly defined purpose in the database. We do not know whether the missing units were not ascribed a purpose because of an oversight or uncertainty. Neither do we know the shares of missing purpose among drivers at work who do not drive vehicles that usually are driven by people at work (e.g. HGVs, buses, taxis).In conclusion, this 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.

Sea. In this report, we look at injuries on cargo, passenger and fishing vessels. Although we found that 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. This indicates a considerable amount of underreporting of personal injuries from foreign ships in Norwegian waters. We have received feedback suggesting that the NMA largely receives reports on certain serious incidents (i.e. deaths, serious injuries) from vessels sailing under foreign flag in Norwegian waters.

Aviation. AIBN-report 2011/14 complains that the reporting rate of inland helicopter pilots, of incidents that they are not obviously required to report, is too low to allow for positive learning from dangerous incidents. If pilots would report more incidents and near misses that they experience, it could contribute to a common pool of knowledge and a possibility to detect and correct potential problems before they lead to accidents (AIBN 2011/14). The data from inland helicopter transportation differ, however somewhat from the other sources of data in this report (i.e. road and maritime), as the design of the study was explicitly directed at describing work-related conditions.

6.7.6 Missing information on work-related risk factors in the accident statistics

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 improved in order to include work-related risk factors. Knowledge on work-related risk factors is key to informing preventive measures and improving transport safety.

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Institute of Transport Economics (TØI)

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