TØI report 1440/2015

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Institute of Transport Economics
Norwegian Centre for Transport Research

Fatigue in operators of land- and sea-based transport forms in Norway. Risk Profiles

Fatigue in Transport Report IV

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Summary:

Relatively little is known about fatigue in human transport operators in Norway, even though it might explain substantial shares of dangerous incidents and accidents. This report surveys fatigue and fatigue risks among operators of different road, rail and sea transport forms in Norway. Analysis of the combined results for all operators (n=1776) shows that 29 per cent have slept or dropped off while operating, at least once during the three months preceding the survey. 14 per cent report getting less than 12 hours sleep in the 48 hours preceding their last operating period. Mapping of fatigue risks using the Fatigue Risk Trajectory shows that different operators face unique and contrasting sets of challenges, depending on which sectors and subsectors they work in. Comparative analyses show that fatigue during the final operating hour is highest for operators in the rail sector, followed by maritime watch officers, and professional drivers in road transport. On interpreting our findings, one should account for demographic differences among respondent groups, as well as the fact that they probably resemble to varying extents the operator populations they are supposed to represent.

Tittel: Trøtthet blant operatører i land- og sjøbaserte transportformer i Norge. Risikoprofiler. Trøtthet i Transport Rapport IV

Forfattere: Ross Owen Phillips
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Sammendrag:

Vi vet relativt lite om trøtthet blant transportoperatører i Norge, til tross for at den antas å bidra til en substansiell andel av ulykker og kritiske hendelser. Denne rapporten er basert på spørreundersøkelser som er brukt å kartlegge hvordan trøtthet og risiko for trøtthet varierer mellom norske transportoperatører i veg, sjø og bane. Analyser av resultatene for alle typer operatør samlet (n=1776) viste blant annet at 29 prosent har sovnet eller duppet av mens de opererte minst en gang i løpet av en tre-måneders periode. 14 prosent rapporterte at de fikk mindre enn 12 timers søvn de siste 48 timene før forrige driftsperiode. Kartlegging av risiko ved hjelp av en trøtthetsmodell (Fatigue Risk Trajectory) viser at hvilke trøtthetsrelaterte utfordringer transportoperatørene står ovenfor varierer ifølge de ulike (subs)sektorene de arbeider i. En sammenligning av ulike operatører viser at omfanget av trøtthet den siste timen av driftsperioden er høyest blant operatører i jernbanesektoren, fulgt av maritime vaktoffiserer og deretter yrkessjåfører på veg. I tolkningen av resultatene bør man ta høyde for forskjeller i respondentenes demografi i tillegg til at de representerer forskjellige populasjoner av transportoperatører i Norge.

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Preface

This is the fourth report from the Work Package 1 of the project Fatigue in Transport (FiT), carried out within the TRANSIKK programme (*Transportsikkerhet*) of the Research Council of Norway. The main objective of this Work Package is to increase what we know about fatigue in human transport operators in the road, maritime and rail sectors in Norway.

Report I was issued as TØI Report 1351/2014, with the title "What is fatigue and how does it affect the safety performance of human transport operators?". This was an account of how fatigue can be operationalised in order to study its prevalence and effects in human operators of land and sea transport. Report II was issued as TØI Report 1354/2014, with the title "An assessment of studies of human fatigue in land and sea transport". This report reviewed international studies of fatigue in transport operators, and evaluated the studies according to their operationalization of fatigue.

Reports III and IV from the FiT project focus on fatigue in Norwegian transport. Report III reviewed relevant literature and interviewed experts on prevalence, causes, consequences, management and regulation of fatigue in operators of land- and sea-based transport forms in Norway. The present report – Report IV – presents the results of a survey of operators working in Norway.

The project manager was Ross Owen Phillips, who also conducted the research and wrote the report. Trude Rømming edited the report and prepared it for publication. Fridulv Sagberg wrote the Norwegian version of the surveys used in the project. Torkel Bjørnskau was involved in advising on and help in recruiting for the project. Ingeborg Storesund Hesjevoll translated the summary from English to Norwegian.

We especially wish to thank the following for the help and time they gave to us: Morten Kveim, *Norges sjøoffisersforbund*, Hilde Brubakk, *Norges sjøoffisersforbund*, Steinar Nordemoen, *Norsk lokomotivmannsforbund*, Alejandro Decap and Ida Langdalen Kristiansen, *Yrkestrafikkforbundet*, Geir Kvam, *Norsk transportarbeiderforbund* and Jon-Kristian Hovland, *Norges Taxiforbund.*

Oslo, November2015
Institute of Transport Economics (TØI)

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Norwegian Centre for Transport Research

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Fatigue in operators of land- and sea-based transport forms in Norway. Risk Profiles

Fatigue in Transport Report IV.

TØI Report 1440/2015
Authors: Ross Owen Phillips, Fridulv Sagberg, Torkel Bjørnskau
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29 per cent of a sample of Norwegian transport operators report at least one episode of sleeping or nodding off while operating in the course of a three-month period. Based on retrospective ratings of the most recent operating period, alertness is found to decrease rapidly towards the final hour of operation, for most types of operator. Levels of sleepiness for the final hour of operating are highest for rail operators, followed by maritime watch officers and then professional drivers of road vehicles. Profiling risks using a fatigue-risk trajectory, it is clear that operators face different sets of fatigue-related challenges, depending on the transport branch in which they work.

Professional operator fatigue is thought to contribute to substantial shares of accidents and dangerous incidents. In Norway, however, we know relatively little about the causes, prevalence and effects of fatigue in transport operators. This report is the last in a series of four reports attempting to address this problem. By surveying transport operators, this final report aims to build a profile of comparative fatigue risks in the Norwegian road, rail and sea transport sectors.

There is increasing recognition that an effective way for organisations to control fatigue is to manage it as a risk alongside other major risks within a safety management system. To encourage this practice, fatigue risks can be mapped along a Fatigue Risk Trajectory (FRT) using the following hazard levels:

0. Framework conditions and fatigue-awareness culture
1. Work characteristics
2. Recovery from work
3. Fatigue-related symptoms
4. Fatigue-related errors
5. Fatigue-related accidents and incidents

Transport safety management systems should include the monitoring and mitigation of fatigue risks at each of these hazard levels if they are to be effective.

This report profiles mainly at Hazard Levels 0, 1, 2 and 3 for land- and sea-based operators. With the help of different transport unions, we used two internet survey waves to ask operators about the various fatigue risks. The first survey wave included questions about framework conditions and culture, general work characteristics, recovery from work, and fatigue levels for the preceding three months. The first survey included standard measures of workload (NASA Task Load Index), job demands/resources and fatigue (Epworth Sleepiness Scale, Checklist Individual Strength). The second survey wave asked operators to report on sleep and fatigue for their most recent operating period, and included ratings on the Swedish Occupational Fatigue Index (SOFI), Samn-Perelli and Karolinska Sleepiness (KSS) scales. We received a total of 1776 valid responses to the first survey wave, from the following: maritime watch officers working on a range of vessel types (n=794); train operators (n=155); and professional drivers of trucks, buses and taxis (n=917). About one third of operators participating in the first wave also participated in the second wave.

Analysis of survey responses resulted in the following findings for all transport operators.

- 29 per cent had slept or nodded off in the 3-months preceding the first survey.
- 4 per cent reported getting less than five hours sleep in the 24 hours preceding their most recent operating period.
- 14 per cent reported getting less than 12 hours sleep in the 48 hours preceding their most recent operating period.
- One in four of all transport operators report excessive daytime sleepiness (score over 10 on Epworth Sleepiness Scale).
- Over 70 per cent of transport operators reported being overweight (BMI > 25), compared to an average for Norwegian adults of 44 per cent.

Structuring fatigue risks using the FRT, we found the following on comparing operators in road, rail and maritime sectors.

Hazard Level 4. Fatigue-related errors

Falling asleep while operating was used as a proxy for fatigue-related errors. Rail operators reported the highest prevalence of sleeping while operating, with 63 per cent of cargo and 52 per cent of passenger train operators having nodded off or slept at least once in the three months preceding the survey. The corresponding share for maritime watch officers was 29 per cent, and for bus and truck drivers 26 per cent.

Hazard Level 3. Fatigue-related symptoms

Rail operators reported the highest retrospective ratings of fatigue for their most recent operating period. Average sleepiness for the final hour of operating was 5.7 on a 9-point scale (Karolinska Sleepiness Scale, KSS), versus 5.1 for watch officers and 4.3 for road operators. Prevalence of severe sleepiness (KSS 8 or 9) for the final operating hour was 16 per cent for rail operators, ten per cent for watch officers and 4 per cent for road operators. Differences in acute fatigue levels were not found to generalise to life beyond the working period, although there were some indications of broader fatigue in rail operators.

Hazard Level 2. Recovery from work

Rail operators report an average of 1.23 hours of sleep debt on a work day, road operators report 1.16 hours and watch officers 1.04 hours. Rail operators report poorer sleep quality (12.96 out of 20) than road operators (13.92 out of 20), especially in the cargo branch. Relative to other road operators, truck drivers have the highest sleep debt (1.47 h) and report the poorest sleep quality. Maritime watch officers are least able to detach psychologically from work during non-work time.

Hazard Level 1. Work characteristics

Almost all rail operators work irregular hours (rosters), and high shares report that they work shifts known to be associated with elevated levels of fatigue. However, rail operators work the least in terms of working hours, with an average work day of 8.9 hours, of which 6.5 hours is spent operating the train. The work of a rail operator is characterised by a high level of mental demand (NASA Task Load Index) corresponding with a highly dominant sustained vigilance task. There is little control over how the work is done. Relative to other operators, rail operators report that they most frequently experience physical discomfort from poor air or temperature, and cargo operators report the most frequent discomfort from noise and vibrations.

Road operators drive for 6.8 hours on a typical work day lasting on average 9.4 hours. Truck drivers work the most, reporting an average work day lasting 10.6 hours. Many truck drivers spend considerable time on physical tasks in addition to driving. The dominant secondary activity of taxi owner-driver is waiting. Taxi owner-drivers report working the most hours per week, with half of them working six or seven days a week, but the length of the average working day was still reported as 9.9 hours. The main challenges for local bus drivers are high shares working early starts and split shifts, high psychological demands, and low job support with little say about how their work is done.

Bridge watch is the main activity for watch officers, and paperwork appears to be a dominant secondary activity for many. At least one in two officers in several branches say they are often alone on the bridge during a watch. While there is variation according to branch, overall job demands (cognitive demands, goal conflicts) are higher than for operators in land-based sectors. Officers report spending an average of 11.1 hours on watch and working 12.6 hours on a normal working day. The 6-on/6-off watch system is the most prevalent, even though researchers regard it as one of the more fatiguing systems.

Hazard Level 0. Framework conditions and fatigue-awareness culture.

A higher share of watch officers (23 per cent) than land-based officers say they have to work even though they are too exhausted to do so. Framework conditions, measured using items assessing pay, violations, training and planning, are also rated worse. Between 20 and 38 per cent of watch officers report violating working time regulations at least once a week, depending on branch (excludes ferry officers). In comparison 11 per cent of truck drivers report exceeding the driving and resting regulations at least once a week. Very few of the rail operators report working time violations.

Despite the poorer framework conditions, the culture for fatigue-awareness is rated positively by maritime watch officers relative to land-based operators. Relatively higher shares of maritime watch officers tell someone should they become fatigued, and between 30 and 51 per cent of those who tell anyone tell a line manager. A culture of fatigue-awareness is less prevalent in the rail sector, where cargo operators agree less than any other type of operator that their employer treats fatigue as a serious risk. Despite this, fewer rail operators report that they often have to work when they feel too exhausted to do so.

We have profiled the following main operator fatigue risks, according to sector, based on a comparison of sectors.

Rail

- Culture in which there is relatively low awareness of fatigue as a risk, but framework conditions are positive and shares reporting that they often have to drive when too exhausted are relatively low.
- Work is dominated by a sustained vigilance task, little task variety, low levels of control. The time of day of the work task and sleep opportunity is more problematic than the amount of work.

- Relatively high sleep debt and poor sleep quality may impede recovery from work, and may be associated with signs of slightly elevated general fatigue.
- Levels of acute sleepiness towards the end of an operating period are higher than for other operators.
- Highest reported prevalence of sleeping while operating.
- Highest acute fatigue levels while operating even though fewer say they have to operate when exhausted – this implies that acute fatigue experienced by rail operators is sudden and unpredictable.

Road

- Framework conditions rated less positively than in the rail sector. Greater shares in the road than rail sector need to drive even though they are too exhausted to do so, and there are more violations of laws designed to limit time spent driving and working.
- The nature of fatigue-related work challenges and the extent to which irregular hours and challenging shifts are worked varies widely according to branch. Job support is low overall.
- Truck drivers report the highest levels of sleep debt and poorest sleep quality, and more drivers sleep away from home when working.
- Fatigue in truck drivers is more physical in nature. More bus drivers report that they lack energy after work.
- Relative to the maritime and rail operators in this study the reported incidence of sleep while operating is low, but no less concerning in terms of absolute levels and since the chance of having an accident due to drowsy operating is higher.

Sea

- Framework conditions, including working time violations and having to work while exhausted, are worse than they are for land-based operators.
- Operators work the longest hours day after day (although most have extended periods to recover from tours at sea). Many often work alone on the bridge and many work at night. Many watch systems curtail sleep lengths, and mean that operators must sleep at times of day when it is difficult. Cognitive job demands are high.
- Acute sleepiness towards end of a watch can approach that of rail operators in some branches. Officers score higher on concentration fatigue and burnout than road operators overall.
- Relative to road operators, incidence of falling asleep while operating (on watch) is high.

The study has not attempted to assess the relative contribution of the different risk factors to fatigue, nor controlled for the fact that operators have rated fatigue for recent work periods at different times of day. When considering these results, we also should consider the varying demographics of operators responding, as well as the extent to which they represent the different populations of transport operators in Norway. The results presented here will nevertheless be useful, both for researchers wishing to compare fatigue and risk factor levels among different samples, and for managers wishing to measure and mitigate fatigue as part of a Safety Management System.

Sammendrag:

Trøtthet blant operatører i land- og sjøbaserte transportformer i Norge. Risikoprofiler

Trøtthet i Transport Rapport IV

TØI Rapport 1440/2015
Forfattere: Ross Owen Phillips, Fridulv Sagberg, Torkel Bjørnskau
Oslo 2015, 144 sider

29 prosent av et utvalg av norske transportoperatører rapporterer å ha sovnet eller duppet av mens de opererte minst én gang i løpet av en periode på tre måneder. Egenrapporterte vurderinger av trøtthet i siste driftsperiode viser at årvåkenheten brått avtar mot den siste timen for de fleste typer operatør. Omfanget av trøtthet den siste timen av driftsperioden er høyest blant operatører i jernbanesektoren, fulgt av maritime vaktoffiserer og deretter yrkessjåfører på veg. Kartlegging av risiko ved hjelp av en trøtthetsmodell viser at hvilke trøtthetsrelaterte utfordringer transportoperatørene står ovenfor varierer ut fra hvilke sektorer og subsektorer de arbeider i.

Trøtthet og utmattelse blant profesjonelle transportoperatører antas å bidra til en substansiell andel av ulykker og kritiske hendelser. Likevel vet man relativt lite om årsaker, utbredelse og effekter av trøtthet blant transportoperatører i Norge. Den foreliggende rapporten er den siste i en serie på fire rapporter som håndterer dette problemet. På grunnlag av spørreundersøkelser tar rapporten sikte på å kartlegge hvordan trøtthet og risiko for trøtthet varierer mellom transportoperatører i veg, sjø og bane.

Forståelsen for at organisasjoner kan håndtere trøtthet som en risiko på linje med andre risikoforhold i et sikkerhetsstyringssystem er økende. For å tilrettelegge for en slik praksis kan trøtthetsrisiko kartlegges ved hjelp av en trøtthetsmodell (Fatigue Risk Trajectory, FRT) med de følgende farenivåene:

0. Rammebetingelser og fokus på trøtthet i bedriften
1. Karakteristika ved arbeidet
2. Restitusjon etter arbeid
3. Trøtthetsrelaterte symptomer
4. Trøtthetsrelaterte feil
5. Trøtthetsrelaterte ulykker og hendelser

Styringssystemer for transportsikkerhet bør inkludere overvåkning og håndtering av trøtthetsrisiko på hvert av disse nivåene.

Denne rapporten kartlegger hovedsakelig risiko på nivåene 0, 1, 2 og 3 for land- og sjøbaserte operatører. Grunnlaget er en nettundersøkelse som ble distribuert til transportoperatører i samarbeid med flere fagforeninger. Spørreundersøkelsen ble gjennomført i to runder. Den første runden inneholdt spørsmål om blant annet rammebetingelser og kultur, generelle arbeidskarakteristika og om hvordan man henter seg inn etter arbeid. Den inneholdt blant annet standardmål på arbeidsbelastning (*NASA Task Load Index*) og trøtthet (Epworth søvnighetsskala, *Checklist Individual Strength*). I den andre runden ble respondentene bedt om å rapportere om sin egen søvn og trøtthet for sin siste driftsperiode ved hjelp av *Swedish Occupational Fatigue Index (SOFI)*, Samn-Perelli indeks og Karolinska søvnighetsskala (KSS). Vi mottok totalt 1776 valide svar på den første runden av spørreundersøkelsen. Respondentene var maritime vaktoffiserer på mange typer fartøy (n=794), jernbaneoperatører (n=155), og yrkessjåfører som arbeider med lastebil, buss og drosje (n=917). Omtrent en tredjedel av respondentene som svarte i den første runden svarte også i den andre.

Analyser av resultatene samlet for alle typer operatør viste følgende:

- 29 prosent av alle transportoperatører har sovnet eller duppet av mens de opererte minst en gang i løpet av en tre-måneders periode.
- 4 prosent av operatørene oppgav at de fikk mindre enn fem timers søvn det siste døgnet før forrige driftsperiode.
- 14 prosent rapporterte at de fikk mindre enn 12 timers søvn de siste 48 timene før forrige driftsperiode.
- Blant alle transportoperatører rapporterer én av fire forhøyet trøtthet på dagtid (dvs. at de skårer over 10 på Epworth søvnighetsskala).
- Over 70 prosent av transportoperatører var overvektige (BMI >25). Det tilsvarende tallet for den norske befolkningen er 44 prosent.

Ved å kartlegge risikoforhold for trøtthet og utmattelse ved bruk av FRT, og å sammenligne operatører på veg, sjø og bane, fant vi det følgende:

Farenivå 4. Trøtthetsrelaterte feil

Å sovne under betjening ble brukt som indikator på trøtthetsrelaterte feil, og dette var mest utbredt blant jernbaneoperatører: 63 prosent av gods- og 52 prosent av passasjertogoperatører hadde duppet av eller sovnet minst én gang de tre siste månedene. 29 prosent av maritime vaktoffiserer oppgav å ha sovnet mens de betjente fartøyet, og det tilsvarende tallet for buss- og lastebilsjåfører var 26 prosent.

Farenivå 3. Trøtthetsrelaterte symptomer

Jernbaneoperatører rapporterte de høyeste nivåene av trøtthet i forrige driftsperiode. Gjennomsnittlig søvnighet den siste timen av driftsperioden var 5,7 på en 9-punkt skala (Karolinska Søvnighets Skala, KSS), mot 5,1 for vaktoffiserer og 4,3 for yrkessjåfører. Omfanget av alvorlig søvnighet (KSS 8 eller 9) i den siste timen av driftsperioden var 16 prosent for jernbaneoperatører, 10 prosent for vaktoffiserer og 4 prosent for yrkessjåfører. Til tross for noen indikasjoner på mer omfattende trøtthet og utmattelse blant jernbaneoperatører, var det ikke nivåforskjeller i akutt trøtthet utover arbeidsperioden.

Farenivå 2. Restitusjon etter arbeid

Jernbaneoperatører rapporterer gjennomsnittlig 1,23 timers søvnmangel på en arbeidsdag eller -døgn. Det tilsvarende tallet for yrkessjåfører er 1,16 timers søvnmangel, mens vaktoffiserer har 1,04 timers søvnmangel. Jernbaneoperatører oppgir dårligere søvnkvalitet (12,96 av 20) enn yrkessjåfører (13,92 av 20), og denne tendensen er særlig sterk i godsbransjen. Sammenlignet med andre yrkessjåfører har lastebilsjåfører størst søvnmangel (1,47 timer) og rapporterer den dårligste søvnkvaliteten. Maritime transportoperatører har størst problemer med å mentalt koble av fra arbeidet utenom arbeidstiden.

Farenivå 1. Karakteristika ved arbeidet

Nesten alle jernbaneoperatører har uregelmessige arbeidstider, og høye andeler oppgir at de jobber skift som generelt er forbundet med forhøyede nivåer av trøtthet og utmattelse. På den andre siden jobber jernbaneoperatører minst når man tar utgangspunkt i antall arbeidstimer; den gjennomsnittlige arbeidsdagen er 8,9 timer, hvorav 6,5 timer brukes til å betjene toget. Jernbaneoperatørenes arbeid er mentalt krevende (høy skåre på *NASA Task Load Index*), noe som er i tråd med et stort behov for vedvarende årvåkenhet når de opererer. De har lite kontroll over hvordan arbeidet utføres. Sammenlignet med andre typer operatør er de som jobber på jernbanen oftest plaget av fysisk ubehag på grunn av dårlig luft eller temperatur, og operatører i godsbransjen er den typen operatør som oftest plages av støy og vibrasjoner.

Yrkessjåførers arbeidsdag varer gjennomsnittlig 9,4 timer, og gjennomsnittlig 6,8 av disse brukes til kjøring. Lastebilsjåførene har de lengste arbeidsdagene, gjennomsnittlig 10,6 timer, og mange av dem bruker mye tid på fysiske oppgaver i tillegg til kjøring. Den aktiviteten drosjesjåfører/eiere bruker nest mest tid på i arbeidsdagen er venting. Drosjesjåfører oppgir det høyeste antallet arbeidstimer i uken, og halvparten jobber seks eller sju dager i uken selv om den gjennomsnittlige arbeidsdagen er 9,9 timer lang. De største utfordringene for rutebussjåfører er delte skift og skift som starter tidlig, psykologisk krevende arbeid og liten mulighet til å påvirke hvordan arbeidet deres utføres.

Vaktoffiserers hovedaktivitet er å ha vakt på broen, og mange bruker store deler av arbeidstiden sin på papirarbeid. Minst en av to offiserer i flere bransjer sier at de ofte er alene på broen når de har vakt. Den totale arbeidsbelastningen (kognitive krav, målkonflikter) er høyere for sjø- enn for landbaserte operatører selv om det er variasjon mellom bransjer. Sjøbaserte operatører oppgir å jobbe gjennomsnittlig 12,6 timer hvorav 11,1 er på vakt en vanlig arbeidsdag. Den mest utbredte vaktordningen er 6 timer av og 6 timer på.

Farenivå 0. Rammebetingelser og fokus på trøtthet i bedriften

Sammenlignet med operatører som jobber på land oppgir en høyere andel vaktoffiserer (23 prosent) at de må jobbe også når de er svært trøtte og utmattede. Rammebetingelser, målt ved spørsmål om lønn, overtredelser, opplæring og planlegging, er også dårligere. Avhengig av bransje oppgir mellom 20 og 38 prosent av vaktoffiserer (eksklusive fergekapteiner) at de bryter arbeidstidsbestemmelsene minst en gang i uken. Til sammenligning rapporterte kun 11 prosent av lastebilsjåførene at de bryter regelverket for kjøre- og hviletid minst en gang i uken. Svært få jernbaneoperatører oppgav å bryte arbeidstidsreglementet.

Til tross for dårligere rammebetingelser er kulturen for bevissthet rundt trøtthet positiv blant operatører i sjø. Relativt høye andeler sier ifra om at de er trøtte, og mellom 30 og 51 prosent av dem som sier ifra til noen når de er trøtte (inklusive kolleger, venner og familie) rapporterer trøtthet til en linjeleder. En slik bevissthet om trøtthet er mindre fremtredende i jernbanesektoren, og særlig godsoperatører er uenige i at arbeidsgiveren behandler trøtthet som en alvorlig risiko. Likevel oppgir færre jernbaneoperatører at de ofte må jobbe selv om de føler seg for utmattede til å arbeide.

Basert på sammenligninger av sektorene har vi kartlagt følgende sentrale risikomomenter for transportoperatørers trøtthet:

Jernbane

- En kultur med relativt lav bevissthet rundt trøtthet og utmattelse som en risikofaktor, men andelen som rapporterer at de ofte må kjøre når de er trøtte og utmattede er relativt lav.
- Arbeidet krever vedvarende årvåkenhet og er lite variert, og operatørene har lite kontroll over utførelse av arbeidsoppgaver. Arbeidstider og mulighet for søvn er mer problematisk enn arbeidsmengden.
- Relativt høy søvnmangel og dårlig søvnkvalitet kan gjøre det vanskelig å hente seg inn igjen etter jobb, og dette henger sammen med forhøyede nivåer av generalisert trøtthet.
- Høyere grad av akutt søvnighet mot slutten av driftsperioden enn andre operatører.
- Høyeste rapporterte forekomst av sovning under betjening.
- Størst omfang av akutt trøtthet under drift selv om færre oppgir at de må operere selv om de er utslitte. Dette indikerer at den akutte trøttheten jernbaneoperatører opplever er plutselig og uforutsigbar.

Veg

- Rammebetingelser vurderes mindre positivt enn i jernbanesektoren. Sammenlignet med jernbanesektoren må en større andel i vegsektoren kjøre også når de er utmattede, og det er flere brudd på lovverket som skal regulere kjøre- og arbeidstiden.
- Hvilke trøtthetsrelaterte problemer og utfordringer som er sentrale varierer mellom bransjene. Det samme gjør utbredelsen av uregelmessige og utfordrende skift og arbeidstider. Graden av støtte i arbeidet er generelt lav.
- Lastebilsjåfører rapporterer høyest grad av søvnmangel og dårligst søvnkvalitet. Flere lastebilsjåfører enn andre sover et annet sted enn hjemme når de arbeider.
- For lastebilsjåfører er trøtthet og utmattelse av en mer fysisk natur. Flere bussjåfører oppgir at de mangler energi etter jobb.
- Sammenlignet med operatører på bane og sjø er forekomsten av å sovne under drift relativt lav, men det må huskes at det er en forholdsvis stor risiko for en ulykke når man sovner bak rattet i vegtransport.

Sjø

- Rammebetingelser, inklusive brudd på arbeidstidsreglementet og å måtte jobbe når man er utslitt, er dårligere enn for landbaserte operatører.
- Gruppen har de lengste arbeidsdagene og flere sammenhengende arbeidsdager, selv om de fleste har fri i lengre perioder for å hente seg inn etter reiser. Flere arbeider ofte alene, og det er vanlig å arbeide om natten. Mange vaktsystemer begrenser muligheten for sammenhengende søvn, og gjør at operatørene må sove på mindre gunstige tidspunkter på dagen. Den kognitive arbeidsbelastningen er høy.
- Forekomsten av akutt søvnighet mot slutten av vakten er i noen bransjer tilnærmet forekomsten blant jernbaneoperatører.
- Sammenlignet med vegoperatører er det mange som sovner på vakt.

Den foreliggende studien har ikke forsøkt å ta for seg de forskjellige risikofaktorenes relative bidrag til trøtthet, og ei heller kontrollert for at de arbeidsperiodene som transportarbeiderne vurderte trøtthet for var på forskjellige tidspunkter av døgnet. I tolkningen av resultatene bør man ta høyde for forskjeller i respondentenes demografi i tillegg til at de representerer forskjellige populasjoner av transportoperatører i Norge.

1 Introduction

1.1 Fatigue is a risk for different types of operator

Fatigue has been found to contribute to a substantial share of accidents involving professional drivers in road transport, navigational officers at sea and train operators, and its detrimental effect on vigilance is a potential threat to security operations (Dawson and Reid 1997, Williamson and Feyer 2000, Raby and Lee 2001, Sagberg, Jackson et al. 2004, Gertler, DiFiore et al. 2013). Despite this, we know relatively little about the causes, prevalence and effects of transport operator fatigue in Norway (Phillips and Nævestad 2012).

This report begins addressing this problem by measuring fatigue risks for safety-relevant operator roles in the road, rail and sea transport sectors. Rather than investigate the relationship between causes and consequences of fatigue, its aim is to improve knowledge by providing a comparative "fatigue risk profile" for different types of operator in Norway. By doing this we hope to understand more about particular issues that need to be addressed in specific transport branches[1], and for particular types of operator, in order for fatigue to be reduced as a risk.

1.1.1 The need to consider fatigue as a broad concept

The current report is informed by three recent reports, which together with this report form one of the work packages of the project *Fatigue in Transport* (www.toi.no/fit). The first report considered what fatigue actually is, and how it poses a threat to safe transport operations (Phillips 2014). In this report, we concluded that:

- In order to understand implications for transport safety, operator fatigue is best operationalised as a broad concept that can capture not only the effects that being sleepy has on safe operation, but the effects that (non-sleepy) exhaustion has.
- While the effects of acute sleep loss on safety are established, we should also consider the longer term and interactive implications for health and performance, of fatigue caused by chronic partial sleep loss or sustained work demands.
- To understand the full safety implications of fatigue, we must capture its multidimensional nature, using a battery of standard measures with robust psychometric properties. This would allow valid comparisons of:
    - different types of operators in the same transport sector;
    - operators in different transport sectors;
    - transport operators and workers/operators in other industries;
    - transport operators in different countries.

[1] Throughout this report "sector" will be used to describe the main transport industries, i.e. rail, road and sea transport, while the term "branch" will be used for sub-sectors, e.g. truck industry, rail cargo transport and so on.

In the second *Fatigue in Transport* report we assessed 86 international studies of human fatigue in land and sea transport (Phillips 2014). In this report it was difficult to draw conclusions about the relative prevalence of fatigue in different transport operators, because of disagreement in the literature about what fatigue is, and the use of a variety of different measures. Due to the narrow operationalization of fatigue, we argued that researchers have neglected important contributors to fatigue, as well important outcomes such as the safety effects of operator burnout.

1.1.2 Need for more knowledge on fatigue in Norwegian transport

In the third *Fatigue in Transport* report we focused on existing studies of fatigue in Norwegian transport, supplementing them with qualitative findings from expert interviews on the causes, prevalence and outcomes of fatigue (Phillips, Nævestad et al. 2015). We found data confirming that fatigue is an important safety risk in the road, rail and maritime sectors in Norway. We also found that the causes of operator fatigue in Norway are rooted in framework, organisational and working conditions, as well as individual characteristics and life outside of work. Experts thought that the following were particularly susceptible to the effects of fatigue:

- Drivers working in coach, goods and taxi transport (road sector);
- Train operators working for smaller rail cargo companies; and
- Watchkeepers working on smaller coastal freight transporters and fishing vessels.

While experts from the rail sector did not think severe fatigue was as prevalent among train operators as it was for other types of transport operators, they conceded that there are still important areas to address, e.g. unknown fatigue effects of discrepancies between planned and actual shifts worked. Most maritime experts thought fatigue and sleepiness were common at sea. Mental exhaustion might be more prevalent on busy vessels with many port calls operated around the clock, while sleepiness may be more prevalent on well-equipped, larger vessels on long voyages. Fatigue levels were expected to vary a lot, depending on the nature of the voyage, vessel and with the particular phase of the ship's operation. There was little evidence in any sector of systematic programs for the management of fatigue in Norwegian transport, and no evidence that transport companies in any sector actually attempted to measure operator fatigue.

1.1.3 Aim of the current report

The aim of this current report is to develop the findings from these previous reports with quantitative survey data on fatigue in Norwegian transport. Ultimately, we want to inform managers and regulators about the fatigue risks that they need to address in order to improve transport safety. With this aim in mind, a good way to proceed is to structure the charting of fatigue risks using Dawson and McCulloch's (2005) fatigue risk trajectory, as the following two sections explain.

1.2 Fatigue risk management

One particularly promising way to reduce fatigue risks is for regulatory authorities to encourage the systemic management of fatigue and sleepiness by individual transport organisations, which are well placed to effectively design, implement and monitor measures to tackle fatigue according to the specific needs of its operators (Dawson 2005, Gander 2005, Gander, Hartley et al. 2011). In the Australian road and international air sectors, regulatory opt-outs have been offered to companies shown to demonstrate effective Fatigue Management Programmes (FMPs), which combine complementary measures to tackle fatigue, such as training, schedule management or health monitoring (NTC Australia 2008, Jackson, Holmes et al. 2009, Phillips and Sagberg 2010, Jackson, Hilditch et al. 2011). Some regulators, especially in the air sector, are promoting the management of fatigue within the framework of existing occupational health and safety legislation, where fatigue is treated as any other risk factor to be controlled within an ongoing Safety Risk Management System (Moore-Ede 2010, Stewart, Holmes et al. 2010). Attempts to do this are also increasingly evident in rail and maritime sectors (Starren, van Hooff et al. 2008), and more recently in the road sector (Wallington, Murray et al. 2014).

A Safety Management System (SMS) is a systematic approach to risk management that recognises that workplaces are complex, dynamic systems and that the causes of safety-related incidents derive from a broad range of interacting factors, from all levels of the organisation, and from outside of the organisation (Williamson and Friswell 2013). Lerman, Eskin et al. (2012) describe six elements of an SMS:

1. Safety management policy, documentation of roles and responsibilities.
2. Risk management (assessment, hazard controls, action plans).
3. Reporting.
4. Incident investigation.
5. Training and education.
6. Internal and external auditing for ongoing review and improvement.

Importantly, an SMS links each of these elements to a formal structure involving people and resources aimed at achieving safety. Management commitment and an informed, just and open reporting culture are also important to the success of the SMS.

In previous studies on goods transport by road in Norway, our group has concluded that there is a need for greater uptake of SMS as a way to structure and systematize risk assessment and mitigation (Nævestad, Phillips et al. 2015). Most of the accident investigation reports studied by Nævestad, Phillips et al. (2014) conclude that the companies employing drivers who precipitate accidents often fail to conduct (and document) risk assessments of safety-critical operations. They thus also failed to use risk assessment as a basis for work descriptions/procedures that the drivers could have consulted prior to work operations, or as a basis for training drivers to make them prepared for the risks of their work operations. Regulatory steps to promote SMS uptake would ensure adequate risk assessment and mitigation in transport branches in a way that is consistent with contemporary thinking on how transport companies should approach safety management. SMS implementation is also encouraged by the recent introduction, promotion and increasing uptake in Norway of ISO-39001 on safety management in organisations (Standard Norge 2012).

Accounting for these developments, our aim in this report is to structure our mapping of fatigue risks in a way that is consistent with the management of fatigue as part of SMS. Dawson and McCulloch (2005)'s Fatigue Risk Trajectory was designed to help do this.

1.3 Fatigue Risk Trajectory (Dawson and McCulloch 2005)

One way to assess the extent to which knowledge has been gathered in areas corresponding to different levels of fatigue risk management is to structure knowledge according to a so-called fatigue-risk trajectory (FRT) given in figure 1 (Dawson and McCulloch 2005).

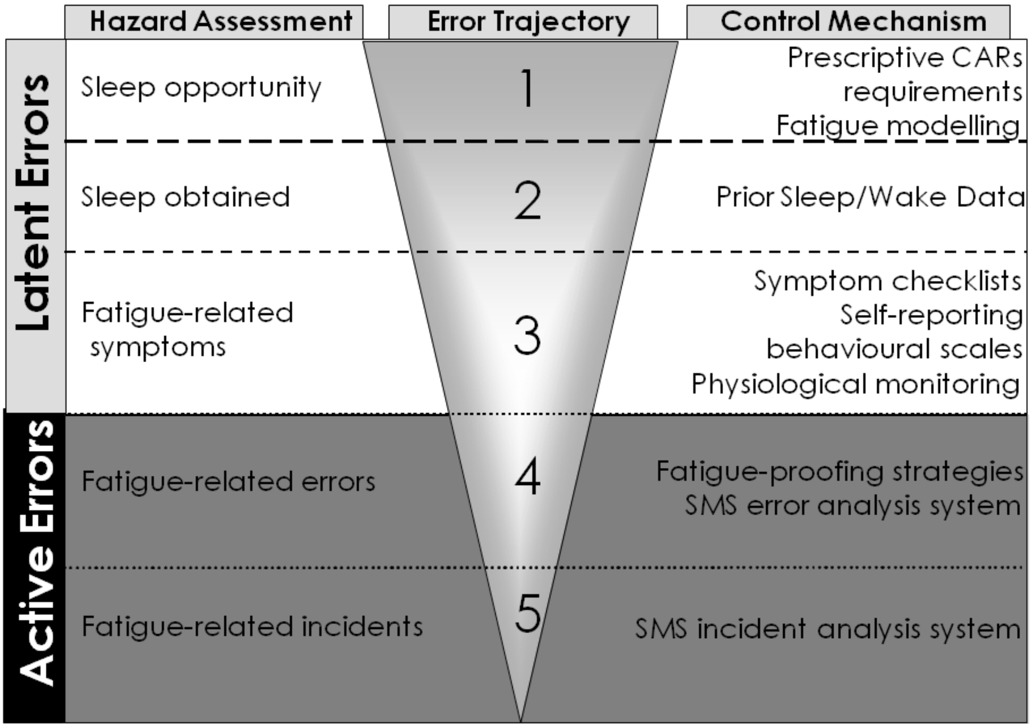

Figure 1. An illustration of the Fatigue Risk Trajectory, where five levels of defence reduce the possibility of a fatigue-related accident. Taken from Transport Canada web page (https://www.tc.gc.ca/eng/civilaviation/standards/standards-3921.htm).

The FRT is influenced by Reason's ideas about latent (removed) and active (frontline) errors (Reason 1990). Fatigue is best mitigated by measuring, monitoring and controlling for risks at all levels of the trajectory. At the first level, work can cause fatigue risks by limiting sleep opportunity, implying that we should control the risk by measuring the time a schedule realistically allows for sleep, and adjust the schedule accordingly. Just because an operator has a given opportunity for sleep does not mean that he or she will take it, so we should also measure and control the actual sleep obtained (Level 2). Operators can display fatigue symptoms even though they have had enough sleep (e.g. in circadian lows), so we should also monitor for fatigue while the operator is operating (Level 3). Any fatigue-related errors that still manifest themselves should also be assessed (Level 4), and we should try to monitor and learn from fatigue-related incidents that may still occur (Level 5). Thus by monitoring and controlling fatigue risks at all levels of the trajectory, we have a robust, multilayered defence against fatigue-related accidents.

1.4 Expansion of the Fatigue Risk Trajectory

The FRT is designed to focus solely on sleep-related fatigue. This was very much the intention of its authors, who rightly point out that sleepiness is the main fatigue-related threat to safe transport operations (Dawson and McCulloch 2005). However, this treatment of fatigue is not consistent with conclusions from our previous *Fatigue* *in Transport* reports, that broader, multidimensional aspects of fatigue (e.g. physical exhaustion, burnout) should also be considered in order to fully account for its safety effects. To account for this, we modified the Fatigue Risk Trajectory in a previous report, as shown in table 1 (Phillips 2014).

Table 1. Modification of Dawson and McCulloch (2005) fatigue-risk trajectory to account for hazards indicative of broader fatigue. The first two risk levels are expanded, while levels 3 to 5 remain the same as in Dawson and McCulloch's model. For explanation see text.

Hazard assessment levels
1. Work characteristics
2. Recovery from work
3. Fatigue-related symptoms
4. Fatigue-related errors
5. Fatigue-related incidents/accidents

The first level in the trajectory now describes not just the sleep opportunity afforded by work, but all factors that together determine the level of fatigue an operator is exposed to by doing the work that they do. Work characteristics comprise the quality of work and the timing of work. The quality of work describes the psychosocial and physical characteristics of work, including effects of the surrounding work environment. We consider that these factors are important in determining operator fatigue levels. The timing of work describes the formal length and timing of work periods, breaks and rosters, and time available for life outside work (non-work time), including the length and timing of sleep opportunity. The second level in the expanded trajectory describes the actual recovery from work, which may be physiological or psychological. Total recovery is described not only by actual sleep quantity and quality, but also by actual breaks taken while at work, and work recovery during non-work wake time. One way to assess total work recovery is by monitoring over time the need for recovery after work and before the next work period (van Veldhoven and Broersen 2003). Levels 3, 4 and 5 of the expanded FRT are as described originally by Dawson and McCulloch (2005).

Accounting for risks related to branch conditions and culture: further expansion of the Fatigue Risk Trajectory (expanded FRT)

In our last report, industry experts emphasised the importance of framework conditions and branch and organisational culture in operator fatigue (Phillips, Nævestad et al. 2015). Indeed our group has observed the importance of these factors as underlying causes in several studies when studying other safety risks in transport (Bjørnskau and Longva 2009, Nævestad, Phillips et al. 2014, Nævestad and Bjørnskau 2014). Other studies also provide support for links between branch and organisational conditions and fatigue risks, both internationally and in Norway (Enehaug and Gamperiene 2010, Williamson, Feyer et al. 1996).

One way that framework conditions influence safety is by affecting the cultural norms that prevail within a branch. Schein regards culture as the "foundation of the social order that we [work] in and the rules we abide by" (Schein 2004), and it is influenced by leaders, colleagues and other actors in our work environment (transport purchasers, customers, authorities etc.). Cultural conditions will influence operator attitudes and behaviour in terms of factors such as the planning of sleep, violations of operating time regulations or reporting of fatigue-related symptoms or incidents. It may also influence the extent to which managers account for fatigue as a safety threat in schedule planning, or the extent to which rest facilities provided for recovery (Phillips, Nævestad et al. 2015). This "fatigue-awareness culture" can be considered at the level of the organization, branch or sector.

In this report we wish to account for the importance of framework conditions and culture by adding a base level to the FRT. This is because we consider that factors described by framework and branch cultural conditions can influence fatigue risks related at any of the other five levels of the trajectory. At branch level, for instance, contracts awarded to organisations offering transport services may or may not contain requirements on fatigue risk assessment.

Table 2 shows the final expanded FRT.

Table 2. Final expanded Fatigue Risk Trajectory (expanded FRT).

Hazard assessment levels
0. Framework conditions & fatigue-awareness culture
1. Work characteristics
2. Recovery from work
3. Fatigue-related symptoms
4. Fatigue-related errors
5. Fatigue-related incidents/accidents

1.5 Profiling the fatigue risks for transport operators

In this report, we aim to use standard measures with proven validity and reliability to compare risks among Norwegian transport operators along the expanded FRT. This will not only allow comparison among operators within and across sectors domestically and internationally, but also structure the risks in a way that promotes thinking in terms of fatigue risk management. Below we outline the major risks associated with each level of the expanded FRT.

1.5.1 Level 0. Framework conditions and fatigue-awareness culture

Competition conditions, extent of driver organisation, power of supply chain actors to set demands, aspects of transport infrastructure (especially resting places in road transport sector), individual's freedom to choose schedule worked are just some examples of factors shared by a branch in which the operators work, that can influence operator fatigue levels in that branch.

A poor fatigue-awareness culture may be evident through occupational pride, a get-the-job-done-whatever-the-costs attitude. It may be assessed by addressing the following questions:

- How much do operators feel they need to carry on when severely tired?
- Is open reporting of fatigue encouraged? Is there a culture for catching fatigue early?
- Do operators understand the risks and what is the attitude to fatigue as a risk factor?
- Do they feel that others around them take fatigue seriously?

Long-distance truck drivers spending more time at work on non-driving tasks (e.g. queuing and waiting) have been found to be more fatigued, and because drivers are often not paid for this work there is no attempt to reduce it (Williamson and Friswell 2013). Incentive payments have been associated with greater hours, longer distances and higher driver fatigue. Economic pressures will have direct effects on scheduling and resources available to all transport operators, and influence fatigue indirectly (Crum and Morrow 2002). While they may not always be able to influence such conditions, organisations need to be aware of them as a source of fatigue risk that cannot be controlled. Moreover, once they have recorded particular fatigue risks related to branch conditions, they will be in a better position to convince others in their branch of the need for change.

1.5.2 Level 1. Work characteristics

The sort of work one does and when and how long one does it for together determine work-related fatigue.

Quality of work

Authors highlight the need to regard the operating task in the context of other tasks, which may themselves exacerbate fatigue or promote recovery (Feyer and Williamson 1995). Relatively little has been done to compare differences in work content on fatigue using generic occupational measures of work content (Phillips 2014). We should also consider that noise, vibration, sitting position and air quality can exacerbate the fatiguing nature of work (Phillips et al., 2015, Parker, Hubinger et al.

1997, Mitler, Miller et al. 1998, Smith, Allen et al. 2007, Enehaug and Gamperiene 2010, Darwent, Roach et al. 2012, Friswell and Williamson 2013).

Workload

Workload is often conceptualised as the type and intensity of demands and the operator's cognitive, emotional and physical responses to those demands (Hart 2006) (Kaillard 2000). Fatigue is more likely when workload is either very high or very low (Hancock and Desmond 2000). High workload and monotonous tasks are both present in transport work environments, and are therefore more likely to be linked to fatigue.

Workload is often measured using the highly validated NASA Task Load Index (NASA-TLX), which measures workload along six subscales covering mental, physical and temporal demands, frustration, effort and performance (Hart and Staveland 1988). Each workload dimension is thought to vary independently from task to task, but also co-vary to some extent due to an overarching workload dimension (Hart 2006). Workload ratings of transport operator tasks measured using the NASA-TLX suggest that the instrument is useful to help dimensionalise the varying workloads experienced by operators in different branches. For instance, cognitive rather than physical demands can be high for air pilots and rail employees, but we would expect physical demands are higher for truck drivers (Mackie and Miller 1978, Adams-Guppy and Guppy 2003, Shibuya, Cleal et al. 2010, Dorrian, Baulk et al. 2011). Furthermore, workload dimensions may be a useful way to link specific demands of work to specific dimensions of fatigue, such as cognitive, emotional or physical fatigue (Phillips 2014).

Psychosocial job demands and resources

Excessive job demands threaten safety performance in several ways. Firstly, too many job demands at one time may cause distraction from safety-central work tasks. Secondly, high daytime work demands can also threaten safety by causing acute fatigue and daytime sleepiness, partly because they predict a later bedtime, with higher pre-sleep arousal, fewer hours of sleep and greater sleep difficulty (Takahashi, Nakata et al. 2006, Loft and Cameron 2014). Finally, excessive job demands may also cause fatigue in the longer term, also known as burnout, and this can also lead to chronic reductions in safety performance levels via reduced cognitive performance or increased daytime sleepiness (Phillips 2014).

According to the job demands-resources (JD-R) model, burnout comprises energetic (work-related exhaustion) and motivational (one becomes demotivated and disengaged from work) components (Demerouti, Bakker et al. 2001). The JD-R proposes that job demands relate primarily to the energetic/exhaustion component and job resources to the motivational/disengagement component, as illustrated by figure 2 (Demerouti, Bakker et al. 2001).

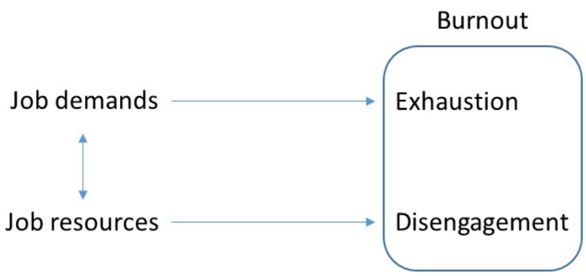

Figure 2. The Job Demands-Resources (JD-R) model of burnout (Demerouti, Bakker et al. 2001).

Thus independent of occupation, the JD-R classifies risk factors as one of two broad types, demands and resources.

Job demands are "those physical, psychological, social or organisational aspects of the job that require sustained physical and/or psychological effort and are therefore associated with certain psychological and/or physiological costs" (Schaufeli and Bakker 2004). Central job demands are work overload, emotional demands, physical demands and work-home interference (Bakker, Demerouti et al. 2005). Job demands lead to exhaustion via insufficient recovery from strain. Over the shorter term, job demands lead to attempts to maintain performance and cope[2], but as exhaustion and health decrements emerge (energy drops), there is downgrading of performance and disengagement, with serious safety implications (Schaufeli and Bakker 2004).

Job resources are: " those physical, psychological, social or organisational aspects of the job that either (i) are functional in achieving work goals, (ii) stimulate personal growth, learning and development, or (iii) reduce job demands and the associated physiological and psychological costs (Schaufeli and Bakker 2004). Central resources are social support, autonomy, feedback and supervisor relationship (Bakker, Demerouti et al. 2005). Resources may be described by organisational measures (e.g. salary, career opportunities, job security) or measures of interpersonal and social relations (supervisor and co-worker support, team climate), the way work is organised (e.g. role clarity, participation in decision-making) or the level of task (feedback, skill variety, task significance, task identity and autonomy)[3]. Lacking resources limits how much operators can deal effectively with high job demands, and fosters disengagement by the energetic mechanism described above. Motivational (rather than energetic) links between resources and disengagement are also explained by Demerouti et al (2001): "where resource lacks, withdrawal results, to prevent future frustrations of not obtaining work-related goals".

The JD-R accounts for the broad range of demands found in different jobs. It also says that different resources can buffer the effects of different demands. It can also help account for how work and home life mutually influence each other to cause fatigue. For instance, Bakker and Geurts (2004) find that job demands lead to exhaustion, with increased interference between work and home life, while higher job resources lead to engagement, which is positive for work-home life balance. Demerouti, Bakker et al. (2004) also find what they call a "loss spiral", where demands

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[2] in line with Hockey's Conceptual Control Model (Hockey, 1997. "Compensatory control in the regulation of human performance under stress and high workload: a cognitive-energetical framework." Biological Psychology **45**: 73-93).

[3] Hackman and Oldham's Job Charactersitics (Hackman, J. R., G. Oldham, R. Janson and K. Purdy (1975). A new strategy for job enrichment. Motivating individuals in organisational settings).

at work lead to exhaustion and poorer work-home life balance, but that exhaustion and poorer work-home life balance also leads to more work pressure over time. Thus **work-home interference** describes the mutually influential ways in which the work-home interface can cause fatigue, with possible implications for safety.

In summary, a large body of work on the JD-R strongly suggests that we should consider in addition to job content and workload, the relative level of different **job demands** and **resources** in transport operators. This is needed to understand the possible effects on chronic fatigue and burnout, which have implications for health, and in-role and extra-role safety performance, as well as the ability to concentrate at work (Demerouti, Taris et al. 2007).

Timing of work

Capturing the timing of work in order to study its health and safety implications is complex, and there is lack of consensus about how this should be done (Härmä, Ropponen et al. 2015). Weekly working hours can serve as a useful summative indicator of the fatigue risks that work poses, and there are useful comparative numbers for Norwegian day and shift workers available from Hordaland Health Study (Ursin, Baste et al. 2009). The way work is structured across a week (shift intensity) is clearly also important, however. In terms of acute sleepiness, time of day at which the work is carried out has a major influence on safety performance in its own right, with the main circadian low between 02:00 h and 06:00 h increasing fatigue levels and symptoms (Akerstedt and Folkard 1995, Folkard 1997).

The influence of time on task on fatigue has mainly been considered in terms of performance, and the effects depend on the task(s) being conducted. True sustained vigilance tasks, a large part of many transport operator jobs, are susceptible to effects after only one or two hours (Casagrande 2002), but well-rested operators appear to be quite good at sustaining daytime performance in real-world driving up to at least 8 h (Hanowski, Hickman et al. 2011). However, there is increasing pressure for sleep with time awake since last sleep, so increasing sleepiness can be expected where operators are expected to perform when they have not slept for a long time. In addition, even when a shift is short it may be timed such that sufficient sleep prior to shift start is difficult. This is partly due to social pressures (e.g. wish to spend time with family or friends who work normal day hours) and partly because it is physiologically more difficult to sleep at certain times of day, for instance between 08:00 and 14:00 h and 17:00 and 21:00 h (Borbély 1982).

Thus timing of the work period has important effects on fatigue outcomes because it determines the following factors, each of which is linked to fatigue:

- the time of day at which work must be carried out;
- length of time at work or time on task;
- time awake since last sleep; and
- the length of time and time of day for recovery from work, most importantly in terms of opportunity for sleep.

According to Spencer, Robertson et al. (2006), three main parameters predict the fatigue risks associated with work timing:

- A cumulative parameter assessing the way individual work periods, shifts or watches are put together to form a complete schedule (because the way work is timed over the course of several days or weeks has cumulative effects on fatigue).

- Duty / shift / watch timing, i.e. the effect of start time, shift length and the time of day throughout the shift.
- A job type / breaks component. This relates to the content of the shift, in terms of the activity being undertaken and the provision of breaks during the shift. Since we deal with work quality above, only breaks are considered under the timing of work.

Härmä, Ropponen et al. (2015) criticise the lack of robust, standard measures of work timing, and identify four working time patterns that influence fatigue and ensuing health problems:

- length of the working hours;
- time of the day;
- shift intensity; and
- social aspects of the working hours.

Comparative data

The US Sleep in America Poll from 2012 provides useful comparative data for pilots, truck drivers, train operators and "bus/taxi/limo" drivers, on the following measures:

- shift lengths
- shift start and end times
- hours off between shifts
- time to and from work
- hours spent working each week
- number of consecutive work periods
- shift regularity and predictability

In the maritime sector, work timing is of course importantly described by the different watch systems worked, which in many cases will be linked to the type of operation (Phillips 2014).

Challenging shifts

In addition to problems from sleep timings caused by **early shifts**, the following shifts cause fatigue-related problems:

Nightshifts. Like early shifts, causes people to sleep at unsocial and "unphysiological" times of the day, but also to work through the main circadian low. Some people can adapt to nights, but only if nights are worked routinely, i.e. not if nights are worked as part of a roster.

Backwardly-rotating shifts refer to shifts that start earlier the next day than the day before, and they are infamous for curtailing sleep opportunities.

Split shifts involve working two separate periods on the same day, with each period typically separated by several hours. Split shifts have received increasing attention recently. There is little evidence yet that people who work these shifts are more tired or have more accidents. Recently we used HSE's Fatigue Risk Index (Spencer, Robertson et al. 2006) to compare a split shift system to a two-shift system (a 5-day week of early shifts followed by a 5-day week of late shifts) and found that split shifts carried elevated fatigue and accident risks (unpublished).

The US Sleep in America Poll from 2012 contains data on shares of operators of different types working challenging shifts, i.e. split shifts, early shifts, evening shifts and night shifts.

In summary then, different aspects of work timing have compound and interacting effects on fatigue, and several aspects of work timing should be assessed as part of a fatigue risk trajectory.

1.5.3 Level 2. Recovery from work

Sleep

Sleep is essential to recovery from sleepiness and fatigue. Indeed the threat that fatigue poses to safe transport operations can often be mitigated by controlling for actual sleep obtained, and several researchers call for greater focus on sleep as a risk factor (Dawson and McCulloch 2005, Darwent, Dawson et al. 2015).

Length

Hours of sleep obtained is one of the most common measures in fatigue risk research. It is often expressed in terms of sleep debt, or the difference between an individual's actual average sleep length and their average optimal sleep length, often measured subjectively. Useful mean sleep duration for Norwegian day and shift workers are again available from Hordaland Health Study, where shiftworkers in general were found to get significantly less sleep (6.85 h) than day workers (7.1 h) (Ursin, Baste et al. 2009). Drivers working shifts were found to sleep on average 6.48 h versus 6.64 h for day drivers, and 1 in 4 drivers got less than 6 h sleep on a normal week night. Sleep debt for drivers working shifts was found to be 0.85 h.

Obtaining 5 h sleep in the 24 h preceding work, and obtaining 12 h in the 48 h preceding work, are useful thresholds, below which the risk of severe fatigue at work increases considerably (Dorrian, Baulk et al. 2011). An analysis of rail employees in Australia by Dorrian et al. (2011) showed that 13 per cent working shifts had slept less than 5 h in the prior 24 h (average 7.6 h), and 25 per cent had slept less than 12 h in prior 48 h (average 15 h). Sixteen per cent had been awake for 16 h or more (Dorrian et al., 2011).

Quality

Authors of US studies emphasise that rail personnel may get more sleep than normal workers, but it is the *quality* and *cause* of this extra sleep that is important (Gertler, DiFiore et al. 2013, Gertler and DiFiore 2009). For instance, Pilcher, Popkin et al. (2005)'s study of on-call cargo crews finds that due to napping the crews get more total sleep than crews on more regular schedules, but have shorter main sleep lengths, and that this leads to problems going to sleep, staying asleep, and feeling poorly rested on waking. In addition to whether or not sleep is continuous, a sleep quality index is often constructed from measures of difficulties respondents have getting to sleep (sleep efficiency), staying asleep (sleep disruption) or waking up (sleep intertia) (de Lange, Kompier et al. 2009, Akerstedt, Kecklund et al. 2010). The US Sleep in America Poll (2012) showed that the average time taken to get to sleep was statistically higher for train operators and pilots (25 minutes) than truck drivers bus/taxi drivers (both 19 minutes). However, a greater share of the truck and bus drivers than train operators said they did not wake up feeling refreshed before a work period.

Psychological detachment

The need for recovery is "the sense of urgency that people feel to take a break from their demands, when fatigue builds up" (Schaufeli and Taris, 2005 in Demerouti, Taris et al. (2007)). It can be viewed as an early stage of the long-term strain process leading to prolonged fatigue, physiological distress and cardiovascular complaints (Karasek and Theorell 1990). There is increasing research into the important role that recovery outside of work plays in fatigue at work (Fritz, Sonnentag et al. 2010, Sonnentag and Fritz 2007), but this is poorly reflected by research into transport operator fatigue (Phillips 2014).

Non-work time behaviours play a significant role in mediating maladaptive outcomes from work strain, and in particular have been found to mediate sleep quality (Winwood, Bakker et al. 2007). Diary research has shown that non-work hassles and low social activity predict strain. Employees who engage in work activities at home in non-duty time also report more strain when going to sleep, whereas those doing low-effort, social or physical activities report less strain (Sonnentag and Bayer 2005). The benefits of non-work activities may be negated if one still thinks a lot about work. Sonnentag and Fritz (2007) differentiate four recovery experiences: psychological detachment from work, relaxation, mastery (of life outside work) and control (outside work). Psychological detachment in particular is negatively related to workload or job demands, and associated with positive mood and low fatigue (Sonnentag and Bayer 2005). Recovery from work in non-work time can be measured by the Occupational Fatigue Exhaustion Recovery Scale (Winwood, Bakker et al. 2007) or the Recovery Experience Questionnaire (Sonnentag and Fritz 2007).

Work-home interference (WHI)

As well as causing fatigue in its own right, work-home interference can also be conceptualised as inhibiting recovery from work. Demerouti, Taris et al. (2007) investigated the negatively reciprocal relationships between need for recovery due to strain at work and strain at home (so-called work-home interference or WHI). The idea is that work-induced need for recovery will make people prone to reserve their free time for resting as a self-regulative strategy to increase their personal resources. As a result they will invest a limited amount of effort at home, leading to emotionally loaded situations and strain as friends and family members seek full participation of the individual in home life. The higher the need for recovery, the higher the strain experienced from demands in non-work time and, consequently, the higher the potential for strain at home to interfere with work.

This suggests that in addition to strain from work affecting home life, strain experienced in the home domain can intrude into and interfere with participation in the work domain. For the transport operator, the effects on safety performance may initially be subtle, but no less important. For instance, being unable to recover from strain at home and strain at work, they may seek to conserve performance at work by simplifying task complexity, e.g. by preferring successive simple yes-no decisions over attention-demanding decision processes (Hockey 1997). There may also be increasing reliance on mental schemas, which have been implicated as a risk for safe train operation (Phillips & Sagberg, 2014). As fatigue and sleep deficit increase, the duration and number of lapses of attention will increase as well, leading to concentration problems with more obvious implications for safety (Demerouti, Taris et al. 2007).

In longitudinal studies with 123 employees from different organisations, need for recovery and WHI have indeed been found to be reciprocal and negatively related over time (Demerouti, Taris et al. 2007). Thus these two states may create a negative spiral in the home domain that could easily intrude in the work domain. Moreover, high levels of need for recovery and WHI were found to impede concentration at work one month later, which in turn had knock-on effects for safety performance at work. These findings suggest that need for recovery and WHI should both be considered as major Level 2 risks in our expanded version of the FRT.

1.5.4 Level 3. Fatigue symptoms

Measuring fatigue in a population for comparison with other populations is complicated by the fact that there are several dimensions of fatigue to consider, and no agreed way to measure any single dimension (Phillips 2014, Phillips 2015). Nevertheless, use of some validated scales is common. Here we consider some validated scales that can be used to measure acute, generalised and chronic fatigue, as well as burnout.

Acute fatigue

Acute fatigue usually describes how fatigued a person is in the course of a working or operating period, or how fatigued they are due to a recent challenging work bout or poor sleep. Two main measures of acute fatigue can be distinguished, those measuring broader fatigue and exhaustion, and those measuring sleepiness.

Of those measuring broader acute fatigue, the Samn-Perelli or USAFSAM scale is popular (Samn and Perelli, 1982). A similar but different scale is employed by Gouin, Sagot et al. (2001), while a visual analog scale for momentary fatigue was employed by de Araújo Fernandes Jr, Stetner Antonietti et al. (2013). The Samn-Perelli scale appears to be a favoured by researchers in English-speaking countries, and is also suitable for diary use, where drivers can report their fatigue levels before, after and/or during a shift (McGuffog, Spencer et al. 2004, Jay, Dawson et al. 2005, Robertson, Spencer et al. 2010, Dorrian, Baulk et al. 2011, Paech, Ferguson et al. 2011, Paterson, Dorrian et al. 2012). It is a 7-point Likert-type scale, anchored with statements about general feelings of tiredness (see figure 3).

USAFSAM MENTAL FATIGUE SCALE

When you are asked to "Rate your **average** mental fatigue (1-7)," fill in the number that is your best estimate of your average mental fatigue across the work period. Use this scale:

1. Fully alert. Wide awake. Extremely peppy.
2. Very lively. Responsive, but not at peak.
3. Okay. Somewhat fresh.
4. A little tired. Less than fresh.
5. Moderately tired. Let down.
6. Extremely tired. Very difficult to concentrate.
7. Completely exhausted. Unable to function effectively. Ready to drop

Figure 3. The Samn-Perelli or USAFSAM scale (Miller 2012).

In addition to broader acute fatigue captured by the Samn-Perelli scale, sleepiness has also been studied widely in shift workers, as the main consequence of insufficient sleep (Åkerstedt, Anund et al. 2014). Sleepiness ratings in real-time can be obtained easily using scales such as the visual analog scale, where respondents indicate their sleepiness on a continuous scale (line) anchored by statements about sleepiness (very sleepy – very alert) (Monk 1989), or Likert-type scales like the Stanford Sleepiness Scale (Chang, Wu et al. 2011) or the Karolinska Sleepiness Scale (KSS) (Åkerstedt and Gillberg 1990). The KSS is the best validated (Åkerstedt, Anund et al. 2014). The KSS is a 9-point scale designed more specifically for measuring sleep propensity. The scale is given in figure 4. The bottom end of the scale (i.e. low sleepiness) is similar to the Samn-Perelli, and both KSS and Samn-Perelli have in fact been found to correlate well with sleep dose (Ferguson, Paech et al. 2012). We might therefore expect KSS ratings to be very similar to those on the Samn-Perelli. However, the top end of the Samn-Perelli scale refers to "tiredness", "exhaustion" and "concentration", and therefore may also tap into tiredness one feels when one is not sleepy.

1. Extremely alert
2. Very alert
3. Alert
4. Rather alert
5. Neither alert nor sleepy
6. Some signs of sleepiness
7. Sleepy, no great effort to stay awake
8. Sleepy, but some effort to keep awake
9. Very sleepy, great effort to keep awake, fighting sleep

Figure 4. Karolinska Sleepiness Scale (later version) (Åkerstedt, Anund et al. 2014).

The KSS has been used in several studies of real sleepy-driving and studies with other transport operators, e.g. Ingre, Kecklund et al. (2008), Sandberg, Anund et al. (2011). A recent review summarises findings with the KSS, and concludes that it is a sensitive and reliable indicator of insufficient sleep (Åkerstedt, Anund et al. 2014). Other conclusions are (Åkerstedt, Anund et al. 2014):

- There is a U-shaped pattern of sleepiness in the course of a normal day, with high KSS values in the morning and late evening. The dip is typically between 10:00 h and 15:00 h for normal day workers.
- KSS values increase sensitively during acute total (e.g. night without sleep) and partial sleep deprivation (e.g. 4 h sleep over several nights) and night work, including night driving.
- High KSS values (>6) are associated with impaired driving performance.
- KSS values are higher for individuals with burnout and sleep apnea.
- The context has a strong influence on KSS ratings e.g. physical activity and light exposure reduce ratings by 1-2 units.
- For those working nights there is typically a steep increase in KSS ratings over the course of the shift, often ending above 6. For those working mornings, there is a U-shaped tendency due to higher sleepiness in the first hours awake (sleep inertia). For afternoon shifts, there is typically a slight increase over the course of the shift.

The prevalence of severe sleepiness is measured as the share of operators with KSS greater or equal to 7 (Ingre, Kecklund et al. 2004). In Swedish train operators, the prevalence of severe sleepiness was found to be especially high during early shifts, when 82 per cent of subjects reported at least one event during a drive (Ingre, Kecklund et al. 2004). In a recent study, Belgian car drivers were asked to rate sleepiness of trips occurring within the preceding 24 hours. The study concluded that 4.8 per cent of car journeys in Belgium are made by a driver showing some signs of sleepiness (KSS>6) (Diependaele 2015). The study points out that it is far more informative to ask about specific journeys made, than whether drivers have been sleepy ever or during the last 12 months, in order to get an idea of the real frequency of sleepy driving.

Supporting the validity of this approach, people have been shown to be rather good at estimating variations in momentary sleepiness across the course of a recent period using retrospective ratings (Folkard, Spelten et al. 1995). According to Folkard, Spelten et al. (1995), "retrospective measures [of recent periods worked] are sensitive to both time of day and shift, have a high level of reliability, even for relatively small sample sizes (e.g. 10), and are valid predictors of more traditional concurrent measures of alertness".

In addition to the above measures of momentary sleepiness, the Swedish Occupational Fatigue Inventory, or SOFI (Åhsberg 1998), can also be considered as a measure of acute fatigue. The SOFI asks respondents to rate a work period they have just completed. It is the most well validated occupational fatigue scale, having been validated against other established psychometrics and blood pressure, heart rate, heart rate variability and muscle activity (Phillips 2014). SOFI has five subscales (lack of energy, physical exertion, physical discomfort, lack of motivation and sleepiness) mapping onto overarching scales for general, physical and mental fatigue (Åhsberg 2000). One of SOFI's strengths is in its ability to dimensionalise the fatigue experiences of different occupations. For instance, Åhsberg (2000) used SOFI to test the hypothesis that teachers, firemen, cashiers, bus drivers and shift workers (train operators) would all score highly on the overall "lack of energy" scale, but that the subscales would distinguish the different occupational groups. Firemen were expected to score high on "physical exertion", cashiers high on "physical discomfort", bus drivers high on "low motivation", and shift workers high on "sleepiness". The results fitted well with this hypothesis, suggesting that a unidimensional fatigue construct is insufficient to describe fatigue in different occupations. SOFI appears to be culturally robust, having been validated in the USA (Muller, Carter et al. 2007) and with Chinese VDU operators (Leung, Chan et al. 2004). A Spanish validation also proved successful, although here it was necessary to reduce the 25 items to 15, while maintain the original scale structure, i.e. several dimension of fatigue and one latent "lack of energy" factor (González Gutiérrez, Jiménez et al. 2005).

Generalised fatigue

Generalised fatigue describes fatigue that has accumulated due to cumulative sleep deficiency or excessive work demands that have pervaded over periods of several days or weeks. It takes longer to recover from generalised fatigue than acute fatigue, and a person may be less able to assess their level of fatigue when they have been fatigued for a while.

The most popular level of generalised fatigue is the Epworth Sleepiness Scale (ESS), which as its name suggests measures sleepiness. In a previous review we found that 15 out of 39 studies on road transport operators employed the ESS to measure fatigue (Johns 1991, Phillips 2014). The ESS measures sleep propensity in day to day life and asks respondents to report on how likely they are to fall asleep in various life situations, such as sitting in front of the television (no time period is defined on which operators should base their response). The total ESS score is the sum of 8 item-scores and can range between 0 and 24. The higher the score, the higher the person's level of daytime sleepiness. The ESS is widely used and validated, and thus allows researchers to compare results for their sample with those from other occupational samples (Johns 1992). Data from Australia show that "normal" adults with no evidence of chronic sleep disorder (including snoring) have a mean ESS score of 4.6±0.7 (95 per cent confidence interval) with a standard deviation of 2.8 and a range from 0-10 (www.epworthsleepinessscale.com). The normal range defined by the 2.5 and 97.5 percentiles is also zero to 10 (Johns and Hocking 1997). Maycock (1996) reports average Epworth Sleepiness Scale score for a sample of UK truck drivers of 5.7, but higher levels have been found among other truck driver samples, ranging from 6.1 to 7.8 (Baas, Charlton et al. 2000, Charlton and Baas 2006, Braeckman, Verpraet et al. 2011), with the higher end values being reported for Australian short- and long-haul drivers (Howard, Desai et al. 2004, Friswell, Williamson et al. 2006, Williamson and Friswell 2008). Carter, Ulfberg et al. (2003) found that professional drivers had a greater average ESS score (7.1) than a corresponding control group (6.7).

A systematic comparison of absolute scores, accounting for varying contexts and standard deviations, may be useful, but it may be more informative to report the percentage of drivers in the sample who score above 10, indicative of excessive daytime sleepiness (EDS) and increased risk of sleep disorder (Johns and Hocking 1997). In the US Sleep in America poll (2012), nine per cent of all respondents were classified as having EDS, and there were no significant differences among pilots, truck drivers, train operators and bus/taxi drivers, for which the range was 8-11 per cent. In a sample of Australian truck drivers, 18 per cent of drivers were found to have an Epworth Sleepiness Scale above 10, with other studies indicating that as many as 1 in 4 score over 10 (Williamson and Friswell, 2008). Comparative scores on ESS and EDS are also available for those with shiftwork disorder in the US (Drake, Roehrs et al. 2004).

The ESS appears to be appropriate when considering the general effects of work on sleepiness. According to our operationalization, sleepiness is a core aspect of the psychophysiological state of fatigue, but it does not capture all aspects of mental exhaustion that may affect performance, e.g. psychosocial factors may increase exertion and consequently work-related fatigue, without increasing sleepiness. In previous reports we have claimed that measures capturing broader aspects of general fatigue that have been validated for occupational samples should be used, such as SOFI (Åhsberg 2000), the Checklist Individual Strength (CIS) (Bültmann, Kant et al.

2002) or the Profile of Fatigue Related Symptoms (Ray, Weir et al. 1992, Phillips 2014). Of these, the 20-item CIS is more suited to measuring generalised fatigue. Respondents are asked to assess their fatigue over the preceding two weeks. The CIS been used to assess fatigue severity in workers for the Maastrich cohort study. Each item is scored on a 7-point Likert scale and fatigue rated if the total score for all items was greater than 76 (Kant, Bültmann et al. 2003). The CIS can distinguish between fatigued and non-fatigued persons in occupational groups (Beurskens, Bültmann et al. 2000). Although often used in connection with a health focus, the CIS is a robust measure of fatigue in working populations (Bültmann, Kant et al. 2002).

Burnout

The above measures are designed to assess levels of fatigue in the respondent's present or more recent past. As we have discussed, fatigue can also manifest itself over the longer term in the form of burnout. Burnout was originally measured by Maslach Burnout Inventory (MBI), designed for use in the human services sector (Maslach 2000). Schaufeli (1996) expanded the MBI for use in other sectors, by producing the MBI-GS, capturing burnout by measuring the same generic burnout dimensions of *exhaustion*, *depersonalisation* and *cynicism* (cited in Demerouti, Bakker et al. 2002). Some psychometric drawbacks of the MBI and MBI-GS were addressed by the introduction of the Oldenburg Burnout Inventory (OLBI), which also assimilated previous dimensions into two dimensions of *exhaustion* and *disengagement from work*, in line with the JD-R model (Demerouti, Mostert et al. 2010).

According to OLBI, exhaustion is defined as a "consequence of prolonged exposure to certain job demands with affective, physical and cognitive aspects" (Demerouti, Bakker et al. 2002, p.298). Disengagement is "distancing oneself from one's work and experiencing negative attitudes towards the work object, work content or one's work in general". Disengagement items on OLBI concern the relationship between employees and their job, particularly with respect to their engagement with work, identification with work, and willingness to continue in the same occupation. A thorough treatment of the psychometric properties of different measures of burnout is given by Demerouti, Mostert et al. (2010). Burnout dimensions measured by OLBI have been shown to diverge statistically from other aspects of fatigue, such as mental fatigue related to performance, and frustration at work (Demerouti, Bakker et al. 2002).

1.5.5 Level 4. Fatigue-related errors

An account of fatigue-related errors that different transport operators are prone to is given in Phillips (2014). The capturing of fatigue-related errors is probably the least established areas in terms of available measures for use in the management of fatigue risks in specific occupations. While some established operator error questionnaires, such as the driver behaviour questionnaire, have been adapted for fatigue (Matthews 2000), they do not consider occupational specifics.

Falling asleep while operating is a clear indicator of operator error. A self-report measure of how often drivers have fallen asleep in the preceding 12 months is most often used, but the reference time period can vary, and sometimes is not defined at all (Sabbagh-Ehrlich, Friedman et al. 2005). The share of professional drivers who say they have fallen asleep in the preceding 12 months varies from under ten per cent to almost 50 per cent (McCartt, Rohrbaugh et al. 2000, Williamson and Friswell

2008, Phillips and Sagberg 2013). A slightly different approach is taken by the US Sleep in America Poll (2012), which asks people how often sleepiness has impacted their performance at work (National Sleep Foundation 2012). More train operators (26 per cent) than truck or bus (15; 10 per cent) said sleepiness had affected their performance at work at least once a week.

1.5.6 Level 5. Fatigue-related incidents and accidents

Assigning fatigue as the cause of an accident or incident is notoriously difficult, unless the operator has clearly fallen asleep, or is able to recall that tiredness led to the accident. This situation is not helped by a lack of adequate, systematic reporting systems. Fatigue has been identified as a major transport accident risk in Norway and internationally, in spite of these problems (Phillips, Nævestad et al. 2015).

One of the strong points of the managing fatigue using an FRT approach, is that measures are available of various fatigue risks, so fatigue may be thoroughly investigated as a cause of incidents and accidents. Moreover these risks can be traced along a trajectory so that the organisation knows exactly what to do to minimise the risks of similar fatigue-related incidents occurring in the future. As long as the organisation captures hazardous events, incidents and accidents as part of the FRT, fatigue can be assessed thoroughly as possible cause. In other words, collection of information on incidents and accidents by organisations will be an essential part of a data-driven fatigue risk management system, and a reduction in the number of such events is the ultimate indication of the system's effectivity.

Direct questions about involvement in fatigue-related incidents and accidents can serve to consolidate this approach. For instance, the 2012 Sleep in America poll asks respondents about whether they have ever experienced an incident at work because of sleepiness; and whether they have ever been involved in a car accident to or from work due to sleepiness. Such an approach may be the most simple and effective, even though it is prone to reliability problems.

In addition to accidents and incidents, other outcomes of fatigue, such as poor health or muscular pain can also be considered as indicators that fatigue is prevailing, which the company needs to address. Strong relationships have been found, for instance, between fatigue and health complaints in train operators (Ku and Smith 2010). The health effects of shiftwork are also well established (Wagstaff and Lie 2011). In coach drivers, the need for recovery after work is an indicator of work-related health complaints, in addition to high job demands and low job control (Sluiter, van der Beek et al. 1999). Fatigue and fatigue-related health complaints also manifest themselves in or elevated levels of sickness absence or presenteeism (being at work and performing poorly due to fatigue or illness) (Kessler, Barber et al. 2003). These may therefore also be fatigue outcomes that the organisation wishes to monitor.

1.6 Aim and scope

The main aim of this study is to chart for the first time a fatigue risk profile for major operator role types in land- and sea-based transport in Norway, represented by various professional drivers (road), train operators and maritime watch officers. The fatigue risks are structured according to the expanded FRT described above, in line with a fatigue risk management approach. In this way we hope to inform organisations, unions and regulators about gaps in the defences against fatigue that need to be filled in order to limit fatigue-related transport accidents. The study is an assessment of the relative level of different fatigue risk factors in different types of transport operator groups. Since comparisons of fatigue-related accidents and incidents across sectors is difficult, the study focuses on profiling risks at Levels 0-4 of the FRT. The study does not aim to assign specific fatigue-related causes to accidents, and it does not aim to account for fatigue risks associated with individuals, such as illness or chronological type.

2 Survey

2.1 Sample, data collection and response rates

We sent e-mail invitations with a link to an internet survey to various operator populations. We used MIPro to design the surveys, which were sent out in two waves. In the first survey wave, a link to the main survey was sent out with an invitation to participate (unless indicated otherwise). A link to a smaller, second survey was sent out in a second survey wave about four weeks following the initial first wave. Only those who both responded to the first survey and consented to participate in the second survey were sent the second survey. In each survey wave, we sent a reminder e-mail out one week after the initial invitation. A prize draw was used as incentive for all participants in the first survey wave (a gift voucher to the value of 20,000 Norwegian Kroner). Those also participating in the second survey wave were given two entries to the same prize draw.

Some items on the main survey were adapted to maximise relevance for the following populations:

- Taxi owner-drivers
- Truck, bus and coach drivers
- Maritime watch officers
- Train operators

The wording of some of the standard measures did not vary according to survey type, while the wording of others varied slightly to account for different contexts of the target group e.g. the use of the words "watch" (sea officers), "shift" (train operators) or "work period" (road sector). Items assessing branch conditions, activities and transport forms were adapted extensively to the different populations. We explain how items varied below and in the results of the report.

2.1.1 Taxi owner-drivers

First wave invitations were sent by e-mail in November 2014 using a list of e-mail addresses for 2225 members of a taxi owner's union (*Norges taxiforbund*). We made clear that the survey was intended only for those owners who drove regularly. We received 523 undeliverable e-mail messages, and we do not know how many of the others were opened and read. We received 290 responses from owner-drivers, which is 17 per cent of the e-mails delivered. Since not all owners were eligible to respond, and not all will have read and opened their e-mail, the real response rate was probably higher[4]. 55 per cent of those answering the first survey consented to receiving the second survey, and 110 of these actually responded.

[4] Based on a meta-analysis (Manfreda, Bosnjak et al. 2008) of 45 studies examining differences in the response rate between web surveys and other survey modes, it is estimated that the response rate in the web survey on average is approximately 11 per cent lower than that of other survey modes, presumably because people do not engage with their e-mail as much as they do with invitations delivered by normal post.

2.1.2 Truck and bus drivers

The first survey wave took place in February 2015. Professional bus and truck drivers were accessed mainly by sending out an invitation via the e-mail list of the national union, *Yrkestrafikkforbundet*, who have ca. 5000 bus driver and 2000 truck driver members. The weblink was also publicised via a Facebook page for truck drivers, and a newsletter of the national truck driver's union *Norsk transportarbeiderforbund*. We received 627 eligible responses, 513 of which were from members of *Yrkestrafikkforbundet*, and 80 from *Norsk transportarbeiderforbund* (the remainder responded via social media). Of those drivers responding in the first survey wave, 470 consented to a second survey wave, which was sent out in March 2015. 151 of those 470 drivers actually responded to the second survey.

2.1.3 Sea officers[5]

E-mail invitations to participate in a web-based survey were distributed to 3901 sailing members of main Norwegian officer union (*Norsk sjøoffisersforbund*) in October/November 2014, via the union's internal administration. This union contains few engineer officers. We received 750 responses. We did not know how many e-mails were received and read, so the response rate of 19.2 per cent can be regarded as a minimum. Of those who responded, we excluded 46 responses from officers who were unlikely to be involved in bridge operations, i.e. security officers, engineers, electricians and land-based officers. Of those 704 respondents of interest, 575 (81.6 per cent) consented to take part in the second survey wave. Survey invitations were sent to these people directly by TØI in November/December 2014. Of the original 575, 314 actually responded to the second survey.

2.1.4 Train operators

The first survey wave was sent out in February 2015. Train operators were informed about the survey through several channels, with the cooperation of the main driver union, *Norsk lokomotivmannsforbund* (NLF), who in addition to helping us gain access to e-mail lists, published two articles about the survey with survey links in their publication *Lokomotivmands Tidende*. E-mail addresses of 168 *«Company X»* drivers were obtained via NLF and used to send out survey invitations directly from TØI; 61 survey responses were obtained. E-mail invitations were also sent out using internal e-mail systems to 102 drivers of *«Company Y»* and 30 drivers of *«Company Z»* by contact persons whose names were given to us by NLF. These resulted in 33 and 9 responses, respectively. We also sent out e-mail invitations directly to 22 drivers in *«Company A»*, of which 14 responded. Our contact in NLF also sent invitations to *«Company B»* and *«Company C»* drivers via their internal mailing lists, but out of a total of 964 drivers in *«Company B»* and *Company C»* only 50 drivers responded. A possible explanation for this is that there was a problem with distribution of e-mail invitations, and drivers responding from these companies may have been those who accessed the survey via *Lokomotivmands Tidende*. The average company response rate was 33 per cent. Of a total of 167 drivers responding to the first survey wave, 155 consented to the second survey wave, sent out in March 2015. Of these, 52 actually responded to the second survey. Cadets were excluded from the final analyses, such that the number of responding drivers for the first and second waves was 155 and 50, respectively.

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[5] Throughout this report we use the term officer to refer to officers and captains.

2.2 Survey measures

Standard survey measures were translated from English into Norwegian, and checked by back-translation, unless indicated otherwise. The survey measures were presented in two survey waves. In the first wave, operators were asked about aspects of their job and branch, and assessed on work characteristics, recovery, generalised and chronic fatigue, demographics and fatigue-related outcomes. Where possible, operators were asked about events over the preceding three months of work (excluding holiday periods). Where standard measures referred time periods other than three months, those time periods were used. In the second survey wave, consenting respondents from the first wave were asked to assess sleepiness and fatigue for a shift they had just completed.

We do not reproduce the actual surveys as seen by the respondents in this report, since publication would infringe terms of use of some of the survey measures. They may be available on request (rph@toi.no).

The following measures were assessed in the first survey wave, unless indicated otherwise.

2.2.1 Branch characteristics

To get an idea of the transport area in which responding operators worked, respondents were asked about the form of transport and type of operation in which they had been involved most over the preceding three months (first survey wave).

2.2.2 Branch conditions and fatigue-awareness culture

Eleven items were used to assess fatigue-awareness culture, organisational and branch conditions. Analysis of responses on these items by preliminary factor analysis suggested three overall factors: active fatigue-awareness culture (six items); framework conditions (three items); and operator attitude and understanding (two items).

Fatigue-awareness culture was captured by items assessing the extent to which employees talked about and reported fatigue formally and informally, and the extent to which they are encouraged to do so, e.g. “We are encouraged to talk openly about fatigue” and “If an incident happens that is due to fatigue, it is reported as such”. Items also assessed fatigue training and the extent to which fatigue is accounted for in the planning of work. Framework conditions were captured by items such as e.g. “We keep to the working time regulations” and “We are paid for all the hours we work”. Two items assessed understanding (“We understand working time regulations and what they mean for our work”) and attitude (“We take fatigue seriously”). In each case participants were asked how much they agreed that such statements applied for them and their colleagues. They responded on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree.

The reporting of fatigue was also captured by asking respondents who answered that they at least sometimes needed to operate at work when they were too exhausted, whether they told anyone about this and who that was.

2.2.3 Quality of work

Participants were asked to indicate how much of their time they used on operating, maintenance, safety checks, paper work and other aspects of an operator's job, as indicated in the results.

Workload (NASA-TLX)

Work nature was also assessed in terms of workload, using the NASA-TLX (Friswell and Williamson 2008). For example, participants responded to the question "how mentally demanding is your work?". Physical, temporal and performance demands were assessed in a similar way, as were effort and frustration. Answers were given on a 21-point scale ranging from 1 = very low to 21 = very high. Scores for responses to individual questions, corresponding to different aspects of workload, are given in the results.

Psychosocial job demands and resources

Job demands. Cognitive demands were assessed using four items from the Job Content Questionnaire (Karasek, Brisson et al. 1998), addressing the pace, intensity and quantity of work, e.g. "I must work faster than I would like to get the job done", and two items assessing hindrance demands e.g. "I often face interruptions in my work". Emotional demands were assessed using three items on emotional demands from Bakker, Demerouti et al. (2004), e.g. "I am often confronted by people who compain" / "My work puts me in emotional situations", and one on recipient contact from Demerouti, Bakker et al. (2001), e.g. "My contact with persons to whom I have to offer a service is demanding". Role conflict and ambiguity was assessed using three items from Rizzo, House et al. (1970), e.g. "I have to break the rules to get the job done", "Safety standards often come in the way of other goals".

Job resources. Six items were used to assess job control, comprising two on decision making authority from the Job Content Questionnaire (Karasek, Brisson et al. 1998), e.g. "I have a say about things that influence my work", and the following four items: "I can plan my own work" , "I can decide when to stop and take a break", "I can adjust my workload to suit how I feel", and "I can decide myself how to do my job", the last taken from Demerouti, Bakker et al. (2001). Three items assessing leader support, e.g. "My line manager listens to what I say", and four assessing colleague support e.g. "I can ask colleagues for help when I need it", were taken from the Job Content Questionnaire (Karasek, Brisson et al. 1998).

For each item assessing job demands and resources, respondents were asked to rate their average agreement on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree.

2.2.4 Timing of work

Due to the limited space available, summary measures were used to capture the fatigue risk presented by the way work was timed. For periods of work over the preceding three months, respondents were asked how many hours they normally worked during a week. They were also asked about the number of hours worked in a typical 24-hour period, as a measure of shift or watch intensity. The frequency of shifts that are known to be fatiguing were also assessed. These were shifts with early shift starts, nightshifts, backwardly rotating shifts and split shifts. Each shift type was defined for the respondent, as indicated in the results. The predictability and regularity of shifts was also assessed. Finally, the type of watch system worked was recorded in the case of sea officers.

2.2.5 Sleep quantity and quality

Respondents were asked to estimate the number of hours of sleep they had obtained during a typical 24 work period working day over the three months preceding the survey. Sleep debt was assessed by asking respondents about how much sleep they felt they needed, and subtracting this value from the typical sleep length during a work spell.

In the second survey wave, which assessed a particular work shift, respondents were asked whether they had gotten more or less than (i) 5 h sleep in the 24 h preceding shift/watch start, and (ii) 12 h sleep in the 48 h preceding shift / watch start.

Sleep quality was assessed in following way.

- A sleep index was constructed from scores on questions about sleep efficiency, sleep debt and sleep inertia taken from the Karolinska Sleep Questionnaire (Åkerstedt, Ingre et al. 2008), as explained in the results.
- Sleep location.
- Number of sleep bouts comprising a main sleep during a work spell.

2.2.6 Psychological detachment

Items on psychological detachment were taken from the Recovery Experience Questionnaire (Sonnentag and Fritz 2007). Psychological detachment was assessed both at home, for those who spent 20 or fewer nights away from home due to work in the course of a year; and away from the home, for those who spent more than 20 nights away from home due to work in the course of a year. Respondents were asked to rate on the 5-point scale their agreement with 5 items in response to the question "To what extent do you agree that the following applies for your free time at home?". Examples of items presented are "I don't think about work at all" and "I get a break from the demands of work".

2.2.7 Work-home interference

Based on questions from Demerouti, Taris et al. (2007), respondents were asked to rate on the 5-point scale their agreement with 5 items in response to the question "To what extent do you agree with the following statements?" Examples of items presented were "Life outside work can be so hectic that it can affect how much I can concentrate at work.", and "My work prevents me spending time with other people."

2.2.8 Fatigue symptoms

Karolinska Sleepiness Scale (KSS)

A Norwegian translation of Version A of the KSS was used (Åkerstedt, Anund et al. 2014), available from Haukeland University Hospital (http://www.helse-bergen.no/no/OmOss/Avdelinger/sovno/Documents/KSS1.pdf). Respondents were asked in the second survey wave to indicate on the scale which number best describes how they felt before and after operating, and during the first, middle and last hours of operating. The response scale ranged from 1 to 9 (see figure 4).

Samn-Perelli fatigue scale

The Samn-Perelli fatigue scale (Samn and Perelli 1982) was used to record subjective ratings in the same way as the KSS. The Samn-Perelli is a 7-point Likert scale (see figure 3). It was translated in Norwegian by the authors.

Epworth Sleepiness Scale (ESS)

We used a version of the ESS (Johns 1991) translated to Norwegian by Bjorvatn, Nordhus & Pallesen (available from www.helse-bergen.no) . Respondents were asked "How likely are you to doze off or fall asleep in the following situations, in contrast to just feeling tired?". There were eight situations such as watching television, reading or sitting and talking with somebody. The response scale was 1 = would never doze off /sleep, 2 = little chance of dozing off / sleeping, 3 = moderate chance of dozing off / sleeping, 4 = large chance of dozing off / sleeping. Average scores for each sector or branch were calculated. Excessive Daytime Sleepiness was calculated as the percentage of respondents with a ESS score over 10.

Checklist Individual Strength (CIS)

Recent severity of general fatigue was measured using a version of the CIS (Bültmann, Kant et al. 2002), shortened to include five items to measure fatigue severity e.g. "I feel fit", "I get tired easily", and two to measure concentration e.g. "It takes a lot of effort to concentrate on things". Respondents were asked to indicate on a 6-point scale (from 1 = yes, that is true to 6 = no, that is not true) how they had felt over the preceding two weeks. Average scores for each sector or branch are reported. The level of "caseness" used by (Bültmann, Kant et al. 2002) (above 76) corresponds roughly to a score of 3.25 or above on our scale. This is because we use 6-point instead of a 7-point scale, and because we take the average item score instead of adding item scores.

Oldenburg Burnout Inventory (OLBI)

Instructions for use of the OLBI burnout inventory was obtained and used with permission from Evangelia Demerouti (Demerouti, Bakker et al. 2002). It was translated into Norwegian by Fridulv Sagberg (native Norwegian speaker) and checked by back-translation by Ross Phillips (native English speaker). Respondents were asked to indicate on a 4-point scale, from strongly agree to strongly disagree, their agreement with 16 items, 8 measuring exhaustion, e.g. "There are days when I feel tired before I start work" or "After work, I tend to need more time than in the past in order to relax and feel better"; and 8 measuring disengagement, e.g. "It happens more and more often that I talk about my work in a negative way" or "Over time, one can become disconnected from this type of work". Relevant items were reverse coded and response scores on scale items averaged, according to the instructions.

Swedish Occupational Fatigue Index (SOFI)

Dimensions of the Swedish Occupational Fatigue Index were measured based on Åhsberg, Gamberale et al. (1997). Respondents were asked "How much do you think that the statements below describe how you felt after your work?", and given 25 items, each with a response scale ranging from 1 = not at all to 10 = to a very large degree. There were five items for each SOFI dimension (see Appendix 1 for individual items and dimensions). The average response for the five items formed the basis of each dimension score. The 25 items were translated from English into Norwegian and checked by back-translation by the authors, as for the OLBI. Three of the items did not back translate (Appendix 1).

2.2.9 Fatigue-related errors

Fatigue-related performance errors were assessed by proxy, namely by asking participants how often they had dozed off or slept while operating over the three months preceding the survey, and how often they had been so tired they had been afraid of dozing off.

2.2.10 Fatigue-related outcomes

We did not ask specifically about *fatigue-related* incidents and accidents, because these are difficult to operationalise, and we wished to see what extent fatigue outcomes are predicted by fatigue risks present in other levels of the expanded FRT (outside the scope of this report).

We asked respondents to rate their general health over the last three months, and in particular whether they had experienced muscular pain. Sickness absence was scored with a simple question about days missed in the last 3 months. Presenteeism was measured using the questions of the World Health Organisation's Health and Work Performance Questionnaire (HPQ) (Kessler, Barber et al. 2003), as explained in the results.

2.2.11 Demographics

Items were included on age and gender, mainly to inform others about the extent to which respondents are representative of populations of interest. Height and weight were used to calculate the basic metabolic index (weight in kg divided by the square of the height in meters), an indicator of sleep apnea.

2.3 Analysis

Analysis was performed to produce comparative risk scores at group level, where different operating groups are denoted either by main transport sector (e.g. sea vs. road vs. rail) or branch (e.g. cargo train vs. passenger train). When we analysed scores for sectors, we included respondents from minor groups excluded for branch analyses. Thus, for example, operators who had sailed on international passenger and RoRo ferries, rescue vessels and other diverse vessels were excluded from analyses of maritime operators at branch level, but included for analysis at main sector level.

Train operators are considered as a main group ("rail") and according to whether they work in passenger or goods transport. In the road sector, drivers were analysed according to whether they carried passengers or goods. Passenger drivers are also considered according to sub-branches of the industry in which they worked. When drivers working in the road sector are considered together, for comparison with rail and sea operators, "other" passenger drivers and goods drivers using vans are included. Otherwise these drivers are omitted.

In this report we do not attempt to relate fatigue risks to each other, but rather present comparative scores on fatigue risks for different operator groups. For this reason, statistical analysis are simple, involving frequencies and average scores.

Statistical differences are presented for average group scores by giving 95 per cent confidence intervals for each group score. This was obtained by multiplying the standard error of the mean by 1.96, and subtracting and adding this value from the mean score.

Data was exported from MIPro to SPSS, and analysed using SPSS.

3 Sample characteristics

The total sample comprises 1776 transport operators. Table 3 shows the main sectors in which they work.

Table 3. Distribution of respondents according to role and the main sector in which they work.

Sector	Operator type	n	per cent
Sea	Watch officer	704	39.6
Rail	Train operator	155	8.7
Road	Professional driver	917	51.7
	Total	1776	100.0

We now describe this sample further, according to specific sector characteristics and demographics.

3.1 Specific sector characteristics

3.1.1 Watch officers: position, branch and operating area

Table 4 gives the distribution of maritime respondents according to position.

Table 4. Maritime respondents, according to position.

Position	n	per cent
Captain	321	45.6
Chief officer	212	30.1
Officer	171	24.2
Total	704	100.0

Table 5 shows the different branches of the maritime sector in which the watch officer respondents work. It shows how we grouped some of these branches to provide sufficient group sizes for statistical analysis.

Table 5. Distribution of sea officers according to the branch in which they report working in the three months preceding the survey. The table shows how we grouped categories for analyses at branch level. Certain categories are excluded from analyses at branch level, e.g. rescue vessels.

Branch	n	per cent	Analysis group	n	per cent
Passenger / RoRo / domestic	136	19.0	Domestic ferry	174	25.8
High speed passenger ship	38	5.4			
Passenger / RoRo international	17	2.4	-	-	-
Oil / tanker	35	5.0	Oil, gas, chemical tanker	59	8.7
Chemical tanker	14	2.0			
Gas tanker	10	1.4			
Offshore service ship	300	43.0	Offshore service	300	44.4
Fishing vessel	16	2.3	Fishing, coastal freight	31	4.6
Coastal freight	15	2.1			
Tug / AHT / shuttle tanker / cable layer	24	3.4	Tug, AHT, survey ship	50	7.4
Research / survey / hotel	25	3.6			
Moveable drill platform	1	0.1			
Bulk ship	28	4.0	Bulk, container, reefer, fish carrier	61	9.0
Container, larger freight carrier	8	1.1			
Fish carrer / reefer	25	3.6			
Diverse ship	4	0.6	-	-	-
Rescue vessels	7	1.0			
Total	704	100		675	100

Over 90 per cent of respondents in each of the analysis groups in table 5 report having bridge watches, where they are key to safe navigation of the vessel. Exceptions are those working on oil, gas and chemical tankers, of which only 50.8 per cent have bridge watches, and those working in the group "tugs, anchor handling tugs (AHTs), shuttle tankers and survey ships", of which 76 per cent have bridge watch. Those not working formal bridge watches are in most cases captains, many of whom nevertheless often on the bridge and essential to navigation.

Those working on domestic ferries work across Norway, with 27.1 per cent working in Northern Norway, and 32.4 per cent each in Mid- and Southern Norway. The remaining 7.6 per cent reported working in varying locations within Norway. Most of the officers working on domestic ferries (56.9 per cent) report being on board for less than 24 h. In contrast, few of those working on other types of vessel report being on board for less than 24 h.

Of those working on oil, chemical and gas tankers, 18.6 per cent report working mainly in international waters, with offshore service working across domestic and international coastal, short and deep sea waters (Table 6). Most working on board bulk ships, containers, reefers and fish carriers report working in Norwegian waters.

Table 6. Distribution of maritime officer respondents included in the analyses, according to branch and type of operating environment reported for the three months preceding the survey.

Operating waters	Branch													
	Domestic ferry		Oil, gas, chemical tanker		Offshore service		Fishing, coastal freight		Tug, AHT, survey ship		Bulk, container, reefer, fish carrier		All	
	n	per cent	n	per cent	n	per cent	n	per cent	n	per cent	n	per cent	n	per cent
Fjords, Norwegian	111	64	-	-	-	-	2	6	3	6	4	7	120	18
Coastal, Norwegian	63	36	6	10	31	10	13	42	9	18	33	54	155	23
Coastal, international	-	-	11	18	49	16	4	13	10	20	9	15	83	12
Short seas, Norwegian	-	-	1	2	58	19	1	3	11	22	5	8	76	11
Short seas, international	-	-	16	27	46	15	1	3	-	-	6	10	69	10
Deep seas, international	-	-	23	39	100	33	6	19	14	28	3	5	146	22
Other	-	-	2	-	16	5	4	13	3	6	1	2	26	4
Total	174	100	59	100	300	100	31	100	50	100	61	100	675	100

3.1.2 Train operators: branch, company and operating area

Table 7 shows the distribution of train operators responding according to branch and company. Due to numbers required for statistical analyses, train operators are analysed at branch rather than company level in this report.

Table 7. Distribution of train operator respondents according to the branch and company in which they report working during the three months prior to the survey.

Branch	n	per cent	Company	n	per cent
Passenger	83	53.5	"Company B and C"	43	27.7
			«Company Z»	8	5.1
			«Company Y»	31	20.0
Goods	72	46.5	«Company X»	59	38.0
			«Company A»	14	9.0
Total	155	100	Total	155	100

Most train operators report that their trips occur mainly within Norway, with none of the passenger train operators and only 6.8 per cent of the cargo train operators reporting trips mainly to and from other countries during the three months prior to the survey. Most passenger train operators (63.4 per cent) report working mainly local transport trips, with 36.6 per cent operating on regional or intercity trips. In contrast, 90.4 per cent of cargo train operators report operating regional trips[6]. Train operators reported being based mostly in Eastern Norway, the most densely populated area in Norway (figure 5).

[6] Respondents were left to decide whether their trips were regional or local.

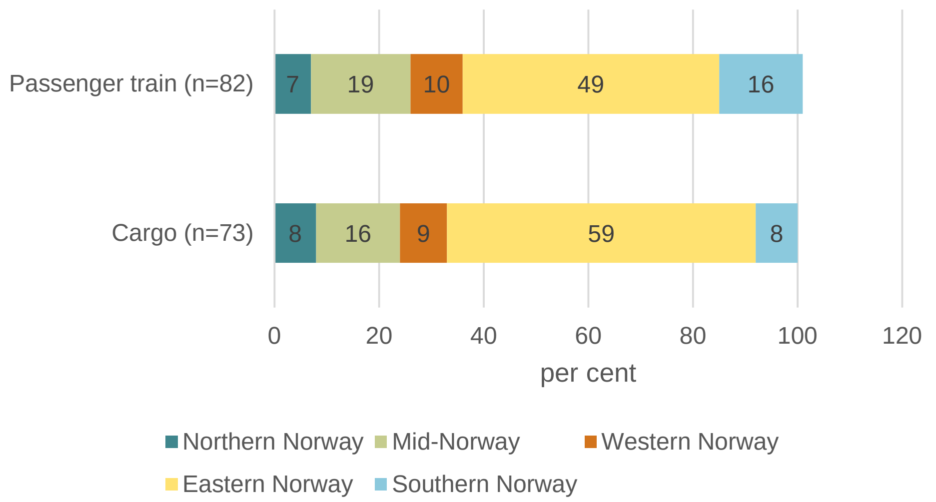


Figure 5. Shares of train operators answering the question "Where in Norway have you been based mostly during the last 3 months?".

3.1.3 Professional drivers: branch, operating area and employment

Three out of every four of the 917 professional drivers of road vehicles in our sample reported that they transported passengers (table 8), most of these driving scheduled or chartered buses and taxis. Table 8 shows how we grouped some branches in order to be able to analyse branch differences while providing sufficient numbers for analysis. Of the 219 goods drivers in our sample, 96.3 per cent report driving heavy goods vehicles. The goods carried by these drivers reflects the diversity of branches in which they operate (table 8).

Table 8. Distribution of professional drivers according to the branch in which they report working in the three months prior to the survey. The table shows how we grouped drivers working in different branches of passenger transport for analysis.

Subsector	n	per cent	Branch	n	per cent	Analysis group	n	per cent
Passenger	698	76.1	Scheduled bus	268	38.4	Local bus	312	34.6
			School bus	44	6.3			
			Coach	10	1.4	Express bus, coach	80	8.9
			Express bus	44	6.3			
			Airport bus	26	4.7			
			Taxi owner-driver	291	41.5	Taxi	296	32.7
			Maxi taxi owner-driver	5	0.7			
			Other	11	1.6	-	-	-
			Total	698	100	Total	688	100.0
Goods	219	23.9	Groceries	41	18.7	Goods	216	100,0
			Perishables	18	8.2			
			Dangerous goods	24	11.0			
			Industrial items	17	7.8			
			Building materials	31	14.2			
			Parcels/loose items	51	23.3			
			Diverse goods	34	15.5			
			Van drivers	3	1.4	-	-	-
Total	917	100	Total	219	100		216	100

Drivers in different branches worked in various different regions of Norway, with most being based in Eastern and Western Norway (figure 6).

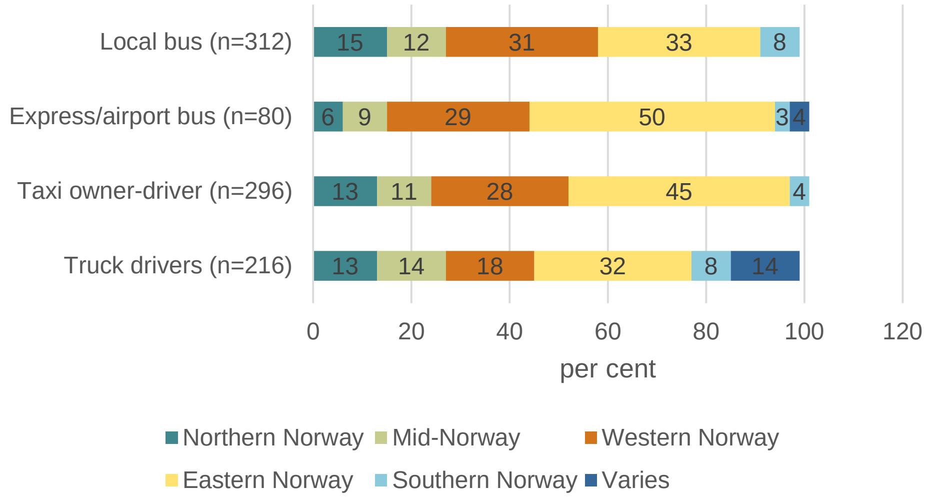


Figure 6. Shares of professional drivers answering the question "Where in Norway have you been based mostly during the last 3 months?". Per cent.

At least 94 per cent each of the goods and bus drivers report working for an employer. In contrast 97 per cent of the taxi drivers are independent operators, reflecting that most drivers were recruited from a union of taxi owners.

94 and 91 per cent of local and express bus / coach drivers, respectively, were permanent employees, while six per cent each were temporary. Almost all received a fixed wage, although four per cent of the express / coach drivers reported being paid by trip or distance driven. In contrast, only three per cent of taxi owner-drivers reported receiving a fixed wage, with most being paid depending on the number of trips and distance driven.

3.2 Demographics

3.2.1 Age and experience

Figure 7 shows the age distribution of the respondents according to the sector and branch in which they work. Over half (50.1 per cent) of those working in road transport are over 49 years old, with between 58 and 61 per cent of the bus drivers reporting that they are over 49 years old. In contrast only ten per cent of train operators are over 49 years old, and none are over 59 years old.

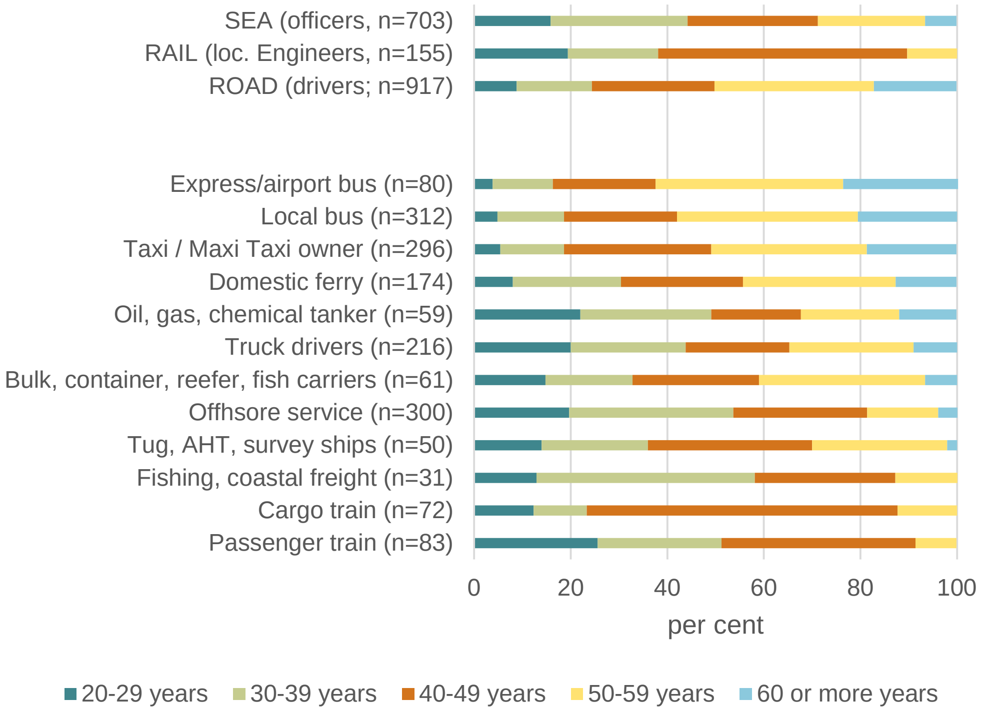


Figure 7. Age distribution of respondents, according to sector and branch. Branches are ranked in order of the share of respondents who are 60 years old or more. Per cent.

Although no cargo train operators were over 59, they reported the greatest number of years of experience as operators (average 26 years; figure 7). Passenger train operators reported relatively long experience (20 years on average), despite being relatively young. The shorter experience of bus and truck drivers may reflect later recruitment or higher turnover in these branches (figure 8).

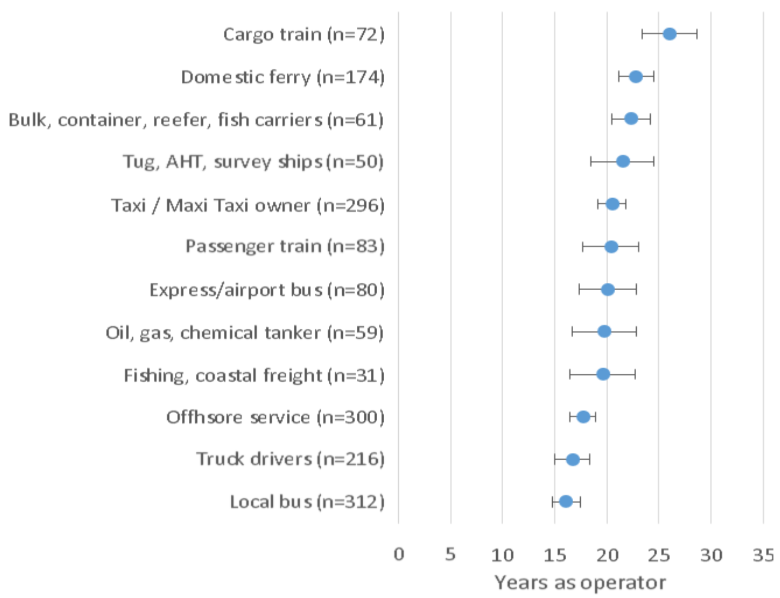


Figure 8. Average experience as operator, according to transport branch. Data was obtained in response to the question, "How long have you worked as professional driver / locomotive engineer / officer at sea?". Means with 95 per cent confidence intervals.

Most operators in the sample report being overweight, irrespective of branch, and the average BMI of all operators is above 25. On average, those working in the road sector are statistically more overweight than those in the maritime sector.

In the road sector the share of overweight drivers varied from 73.7 per cent (local bus) to 80.3 per cent (taxi drivers). 76.9 per cent of truck drivers were overweight. Between 26.9 per cent and 33.9 per cent of drivers responding from the road sector were classified as obese.

The shares of train operator respondents who were overweight were 62.2 per cent in the passenger branch and 78.1 per cent in the cargo branch. Notably, twice as many of the cargo as passenger train operators were classified as obese (34.2 and 17.1 per cent, respectively).

3.2.2 Body mass index

The body mass index, or BMI, is calculated by dividing the weight of a person (kg) by the square of their height (metres). It can be used as a rough indicator of whether or not a person is overweight. According to the World Health Organisation (WHO), a BMI over 25 indicates that a person is overweight. If BMI is over 30, the person is classified as obese. According to the WHO, 44 per cent of Norwegian adults are either overweight or obese[7]. Figure 9 gives the average BMI reported by respondents in the sample, according to branch.

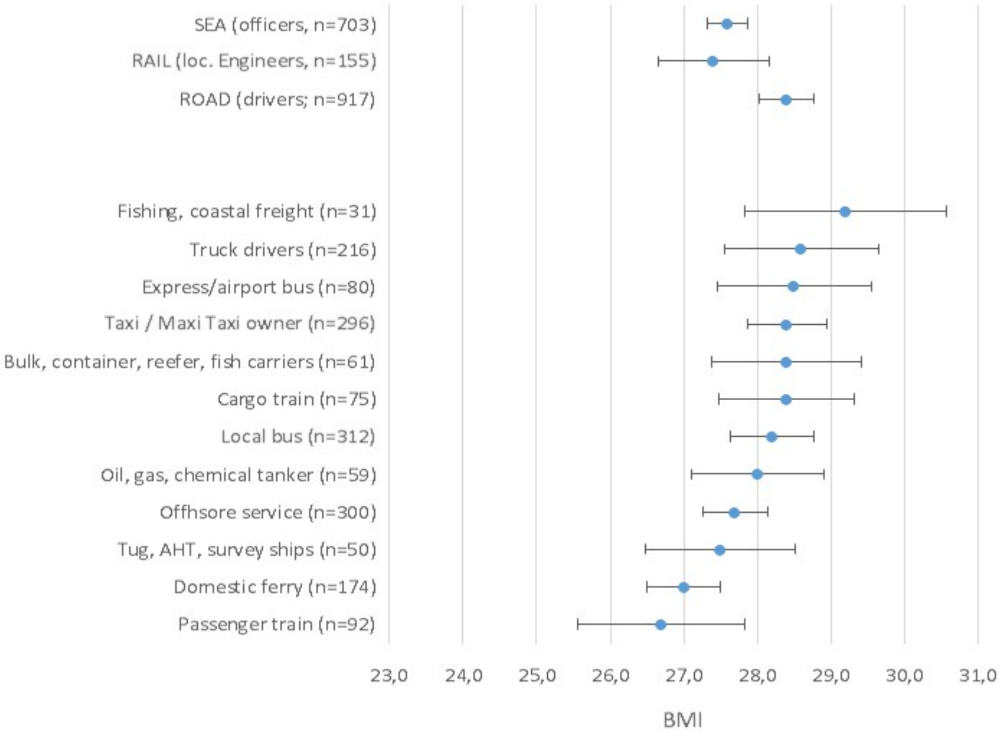


Figure 9. BMI of respondents, according to sector and branch. Branches are ranked in order of decreasing BMI. Blue dots indicate the mean BMI for each group, with 95 per cent confidence intervals.

[7] http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

3.2.3 Gender

Figure 10 gives the shares of female operators responding according to the branch in which they work. Apart from local bus drivers and taxi owner-drivers, females represent less than ten per cent of respondents in each branch.

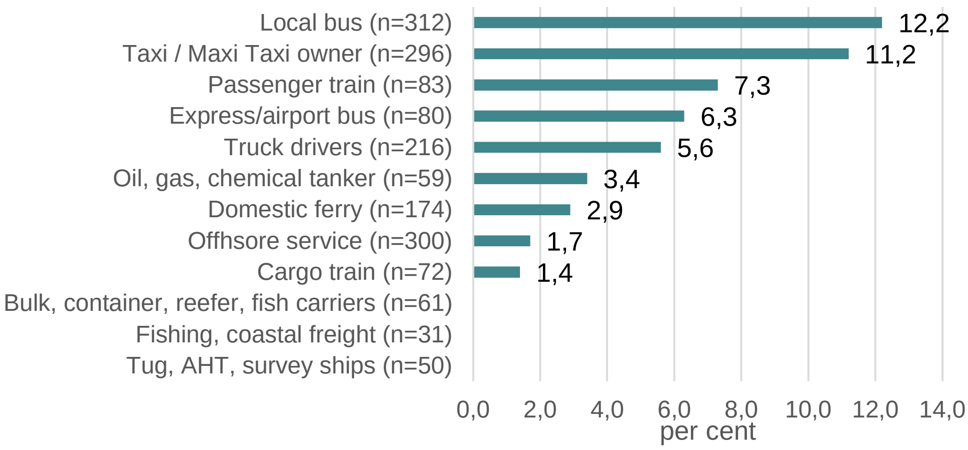


Figure 10. Share of female operators responding, according to branch. Branches are ranked in order of the share of females responding. Per cent.

4 Fatigue risk profiles

This chapter profiles fatigue risks for professional drivers, train operators and sea officers. In this chapter we categorise the risks within the hazard assessment levels described by the expanded fatigue risk trajectory (expanded FRT) in Section 1.4, which is reproduced below.

Hazard Assessment Levels
0. Framework conditions & fatigue-awareness culture
1. Work characteristics
2. Recovery from work
3. Fatigue-related symptoms
4. Fatigue-related errors
5. Fatigue-related incidents/accidents

Our goal is not examine links between risks, but to quantify the relative size of different risks for different groups of transport operators.

4.1 Framework conditions and fatigue-awareness culture (FRT Hazard Level 0)

According to our expanded FRT, above, we need to assess the fatigue-related risks inherent in general organisational and branch conditions that will influence exposure to fatiguing work, recovery from fatigue, and the handling and reporting of fatigue-related symptoms, errors, incidents and accidents. In this section we give survey responses on items assessing the following:

- Do operators **need to operate when** they feel too **exhausted** to do so?
- If they need to operate even though they feel too tired, do they **report** it, and if so **to whom**?
- Is there a positive "**fatigue-awareness culture**", i.e. one that actively promotes thinking about and tackling fatigue?
- Do **different actors take fatigue seriously**?

4.1.1 Do operators need to operate when they feel exhausted?

The answers to this question are summarised in figure 11. The need to work when too exhausted to do so is greatest in the maritime sector, where 65 per cent report that they work when exhausted at least sometimes, compared with 45 per cent of train operators and 47 per cent of road drivers.

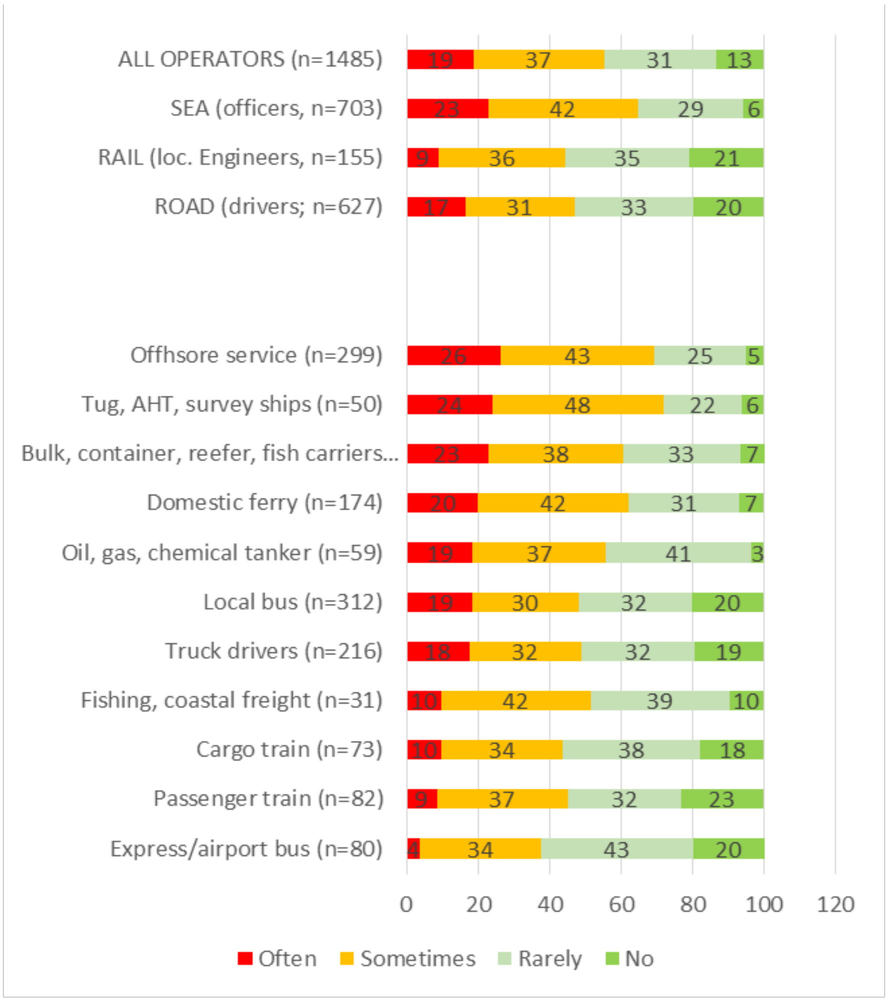


Figure 51. Shares of operator responses to "Do you ever need to drive / work (sea) even though you are too tired and exhausted to do so?" Per cent.

4.1.2 Reporting of fatigue

Although greater shares of maritime officers have to operate when too fatigued to do so, they have a greater tendency to tell someone about it figure 12). Between 56 and 70 per cent of maritime officers tell someone at least sometimes before beginning to operate (of those that have to operate while too fatigued). In contrast only 47 per cent of bus drivers tell someone at least sometimes before operating.

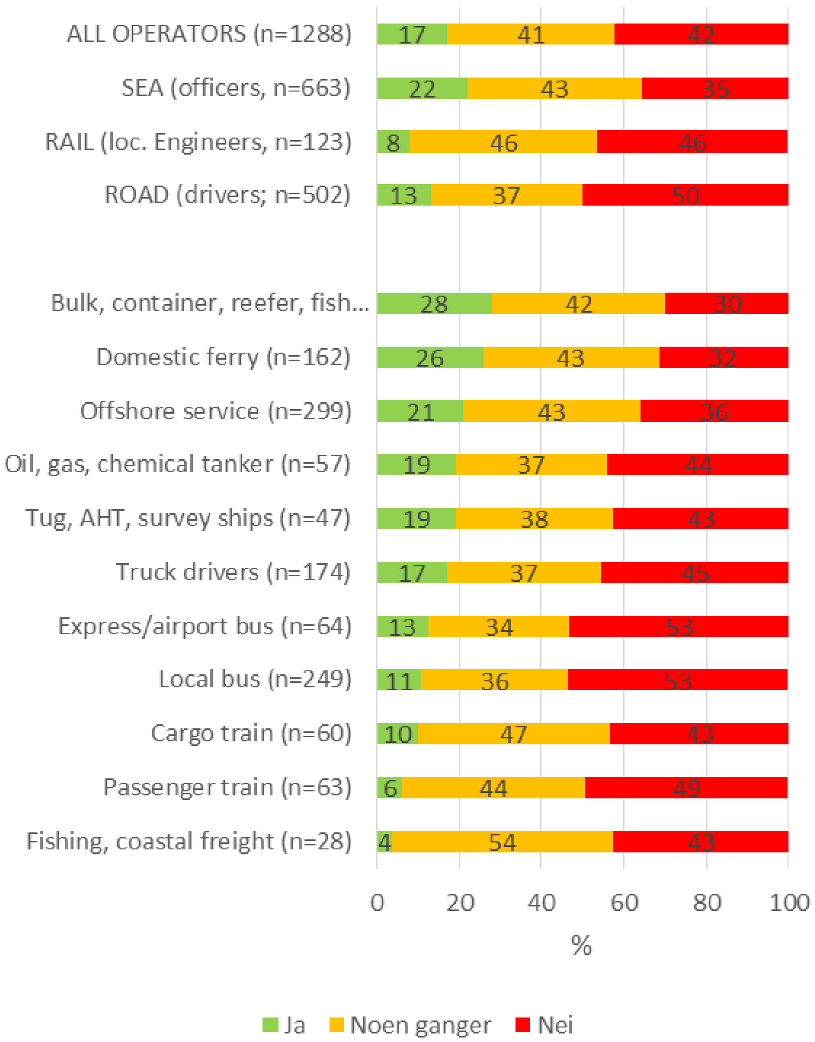


Figure 62. Shares of operators responding "If you feel too tired and exhausted to drive / work before you begin, do you usually tell anybody about this?", of those who report that they need to operate when too tired to do so. Per cent.

Generally, most operators tell colleagues when they feel too tired to operate (figure 13). Rail and road operators then tell friends and family, while sea officers report that they are next most likely to tell line managers. Train operators are more likely to report to operative centres when they are too tired, but more passenger drivers report that they do this than cargo drivers.

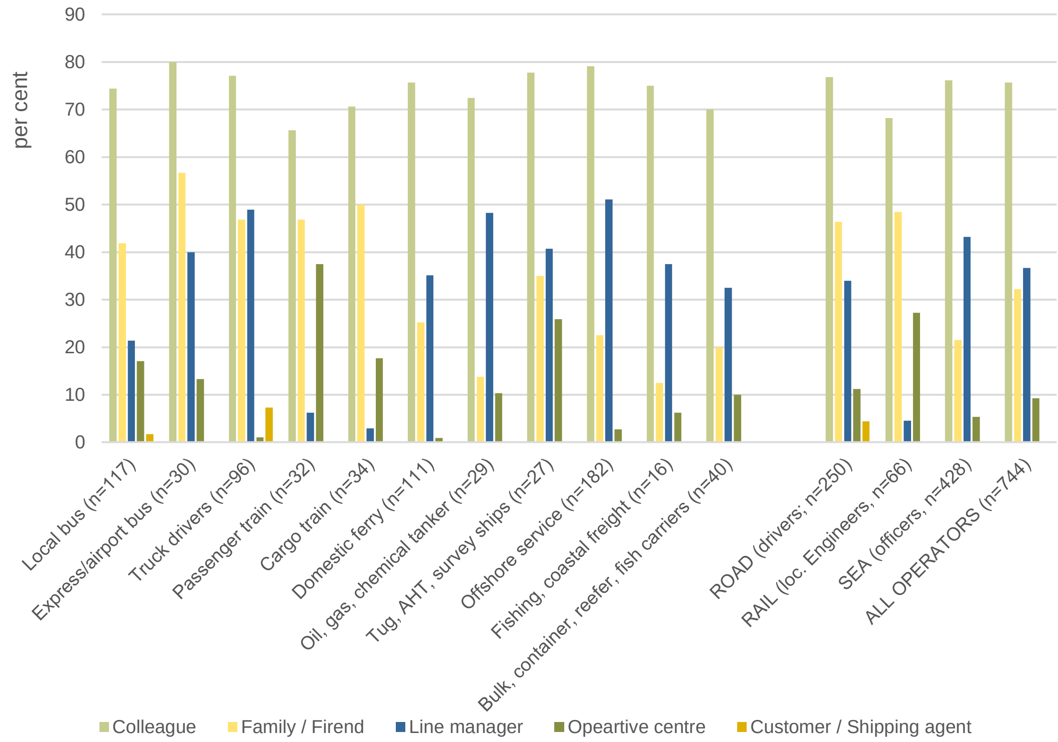


Figure 73. People operators tell when they are too tired to operate, of those who report that they need to operate when too tired to do so and that they tell someone about this sometimes or often. Respondents could tick one or more categories. Per cent.

4.1.3 Fatigue-awareness culture

A fatigue-awareness culture is one in which talking about and reporting of fatigue is encouraged informally and with informal procedures, and where fatigue is considered during planning and training. Scores on this measure are given in figure 14.

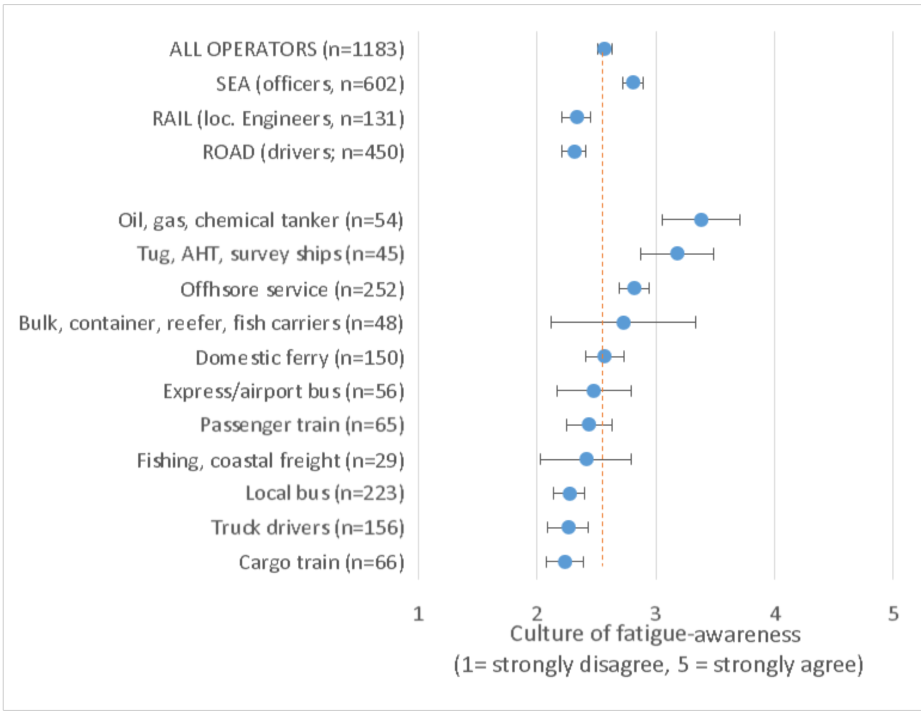


Figure 84. Agreement with six items assessing fatigue-awareness culture ("We are encouraged to talk openly about fatigue", "We have formal strategies for managing fatigue", "If an incident happens that is due to fatigue, it is reported as such", "[We] talk openly about fatigue", "[We] receive training on the risks of fatigue", "Fatigue is considered when our work is scheduled"). Participants were asked how much they agreed that such statements applied for them and their colleagues. They responded on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

A culture of fatigue awareness appears to be more present for maritime operators than for road or rail operators.

Framework conditions include the need to violate working time limitations, and pay conditions. Figure 15 shows that framework conditions are rated more favourably in the road and rail sectors.

Operator understanding of and attitude towards fatigue is rated more highly in the road and maritime sectors than in the rail sector (figure 15).

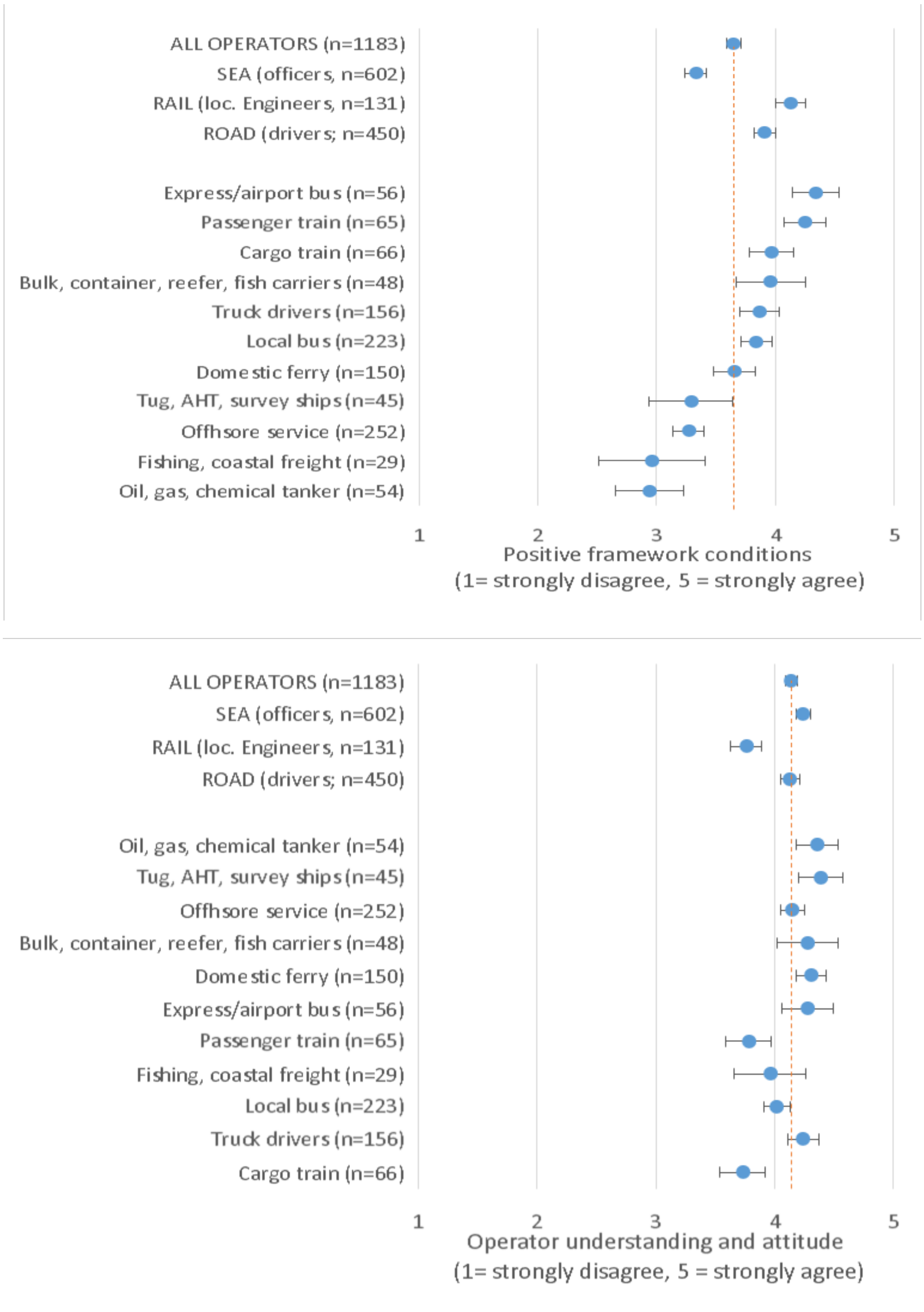
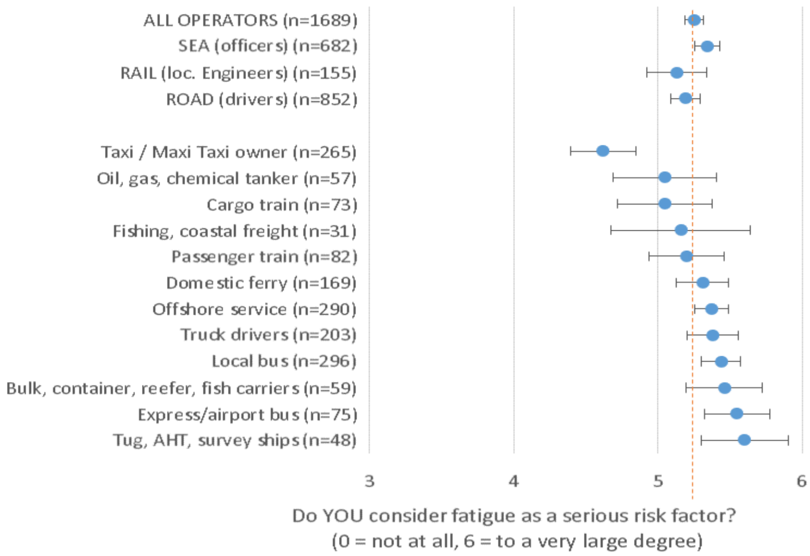


Figure 95. Agreement to three items assessing positive framework conditions ("[We] keep to the working time regulations", "[We] are paid for all the hours we work", "[We] are put under pressure to exceed driving hours regulations" [reverse coded]) and two assessing understanding ("We understand working time regulations and what they mean for our work") and attitude ("We take fatigue seriously"). Participants were asked how much they agreed that the statements presented applied to them and their colleagues. They responded on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

4.1.4 Taking fatigue seriously

We asked the operators how much different actors considered fatigue as a serious threat to operational safety (figure 16, 17 and 18). There are few statistical differences among sectors or branches when it comes to how much operators or colleagues consider fatigue as a serious risk factor. However, taxi owner-drivers rate the extent to which they and their colleagues consider fatigue as a serious threat as lower than operators in most other branches.



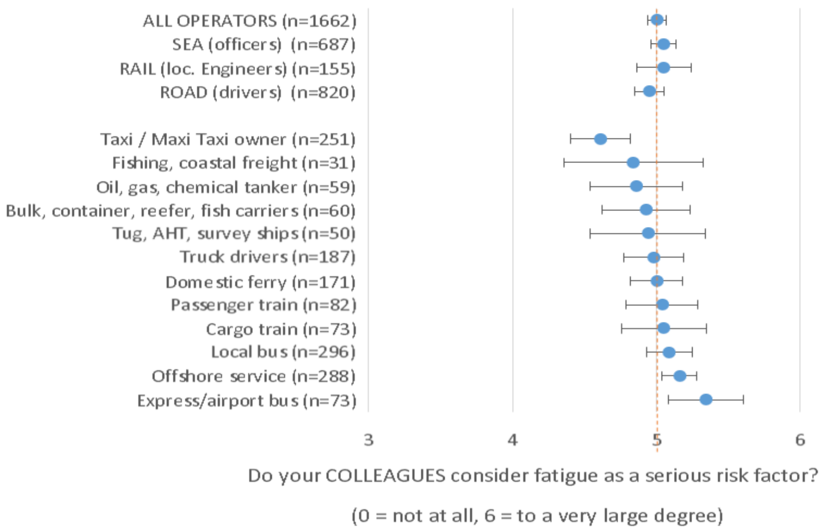
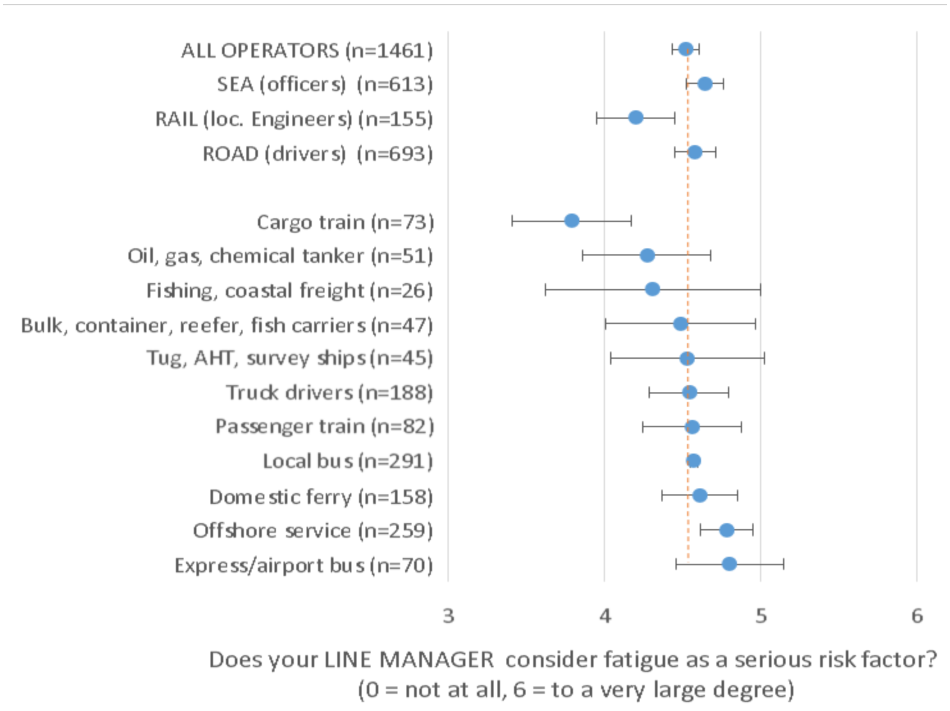


Figure 106. The extent to which respondents and colleagues (according to respondents themselves) regard fatigue as a serious threat to operational safety. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.



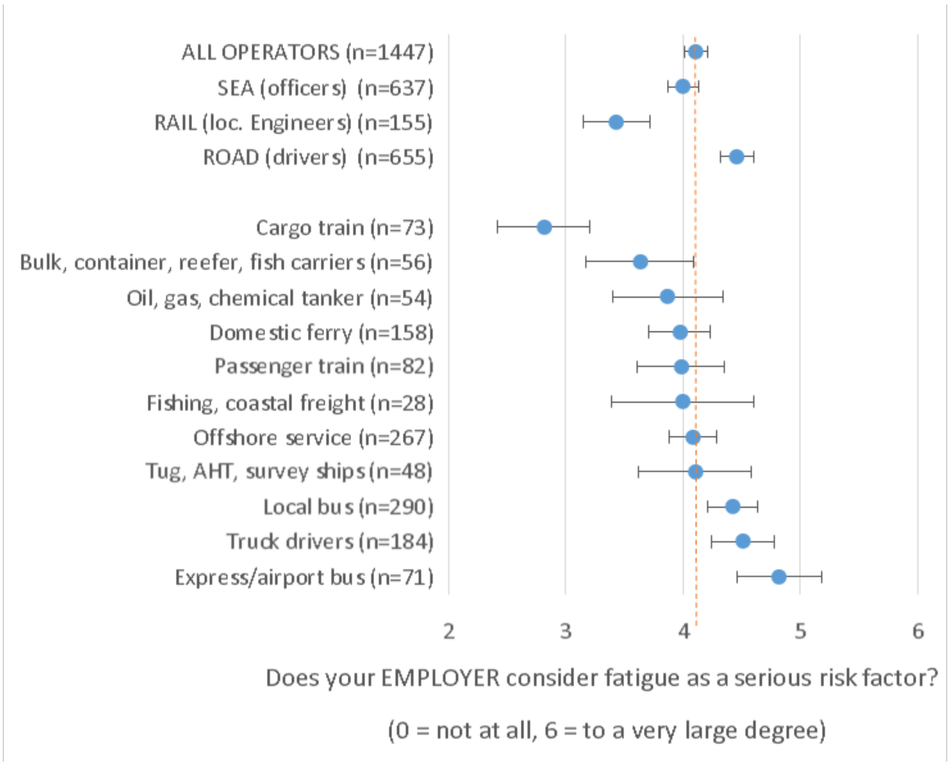


Figure 117. The extent to which line managers and employers (according to respondents) regard fatigue as a serious threat to operational safety. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Relative to passenger train operators, road vehicle operators and operators in several maritime branches, cargo train operators do not think that their line managers consider fatigue as a serious risk factor. Operators in the road sector rate their employers best in terms of accounting for fatigue as a risk factor, followed by those in the maritime sector, and then the rail sector. Cargo drivers rate their employers' regard for fatigue as low relative to those in other branches.

Finally, truck drivers rate the extent to which shipping agents consider fatigue as a serious risk as low (figure 18).

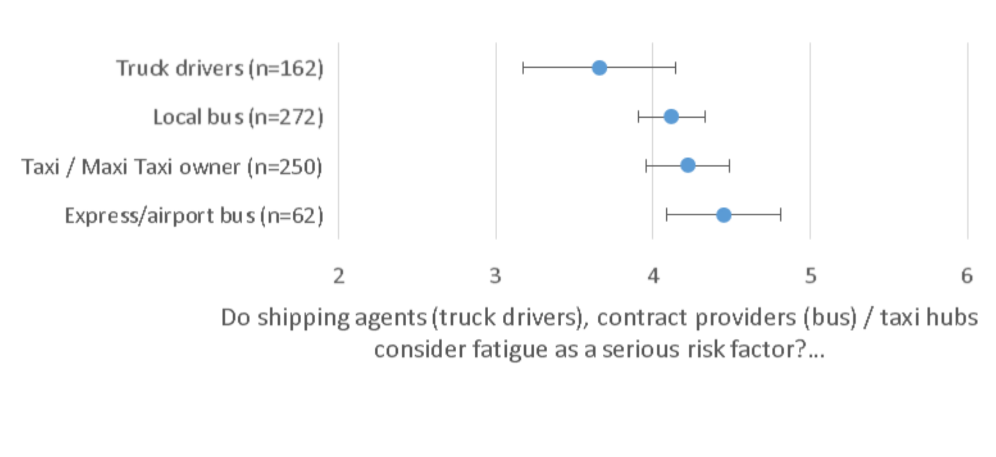


Figure 128. The extent to which shipping agents (according to truck drivers), contract providers (according to bus drivers) and taxi hubs (according to taxi driver-owners) regard fatigue as a serious threat to operational safety (0 = not at all, 6 = to a very large degree). Means with 95 per cent confidence intervals.

Violations

To consolidate the results on framework conditions we can consider how often working time limitations are violated. Figure 19 shows clearly that substantial shares of operators at sea violate the working time regulations. However, within branches of the maritime industry there is wide disparity about the frequency of violations. For instance, while 28 per cent of those in offshore service reported weekly violations, 27 per cent reported that they almost never exceeded working hours limitations.

Those subject to driving and resting time regulations were asked how often they exceeded these regulations (figure 20). Violations were more common among truck drivers, followed by local bus and then express/airport bus.

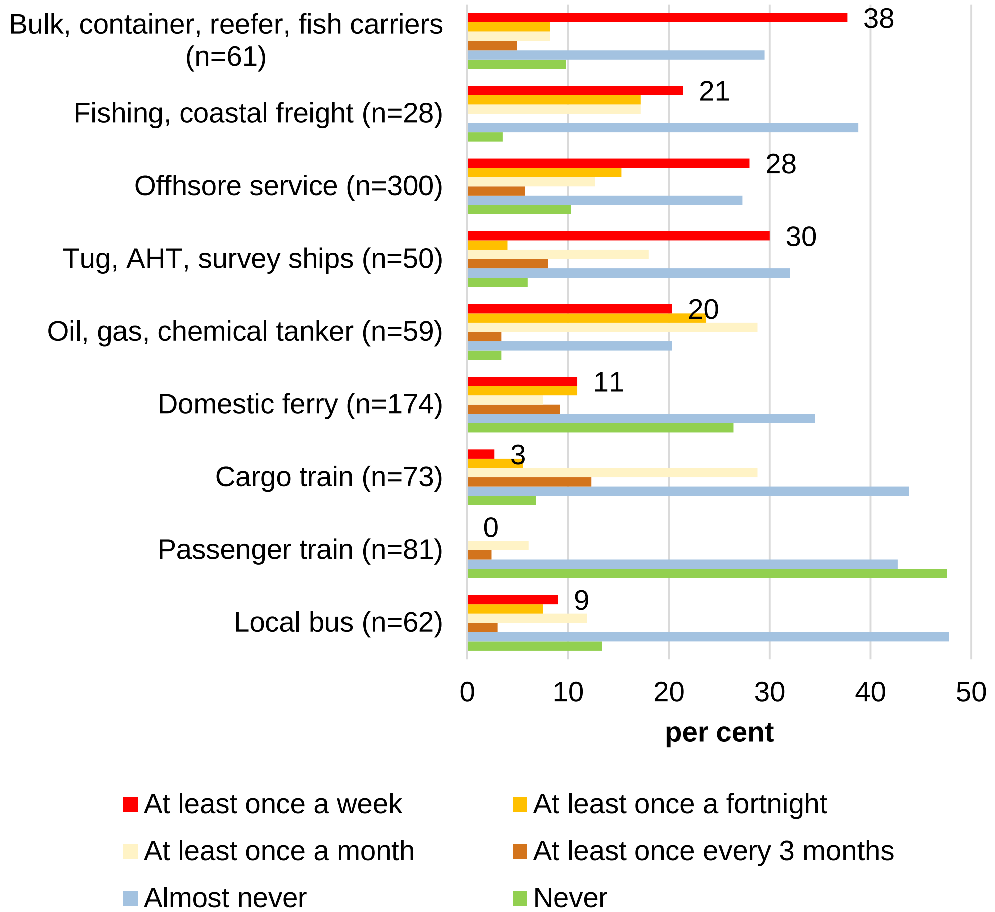


Figure 19. Those that answered that they were not subject to driving hours regulations were asked "How often does your working time exceed the working time regulations?". Per cent.

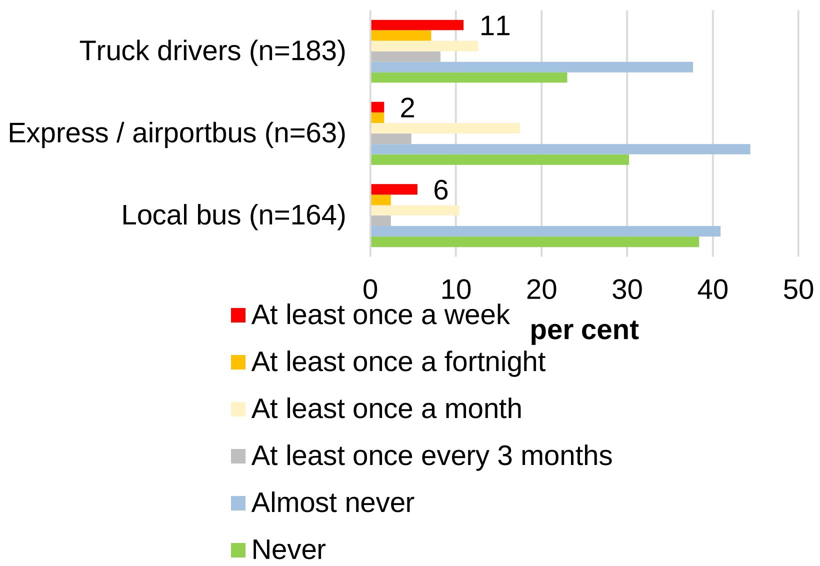


Figure 20. Those that answered that they were subject to driving and resting hours regulations were asked "How often do you exceed the driving time regulations in your job?". Per cent.

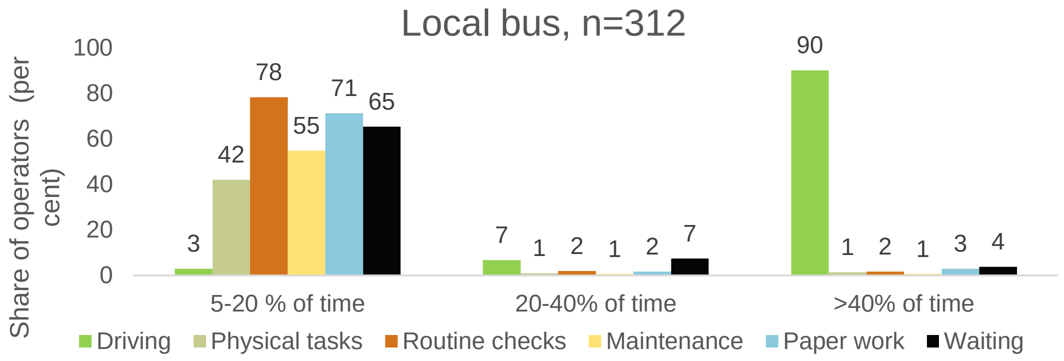
4.2 Work characteristics (FRT Hazard Level 1)

Risks at this level describe the nature and level of fatigue that work causes. The nature of work-related fatigue is be determined by the sort of work tasks that the operator needs to carry out, which can be described by a **job content** analysis. The level of work-related fatigue is determined by two main factors.

1. The intensity and level of work demands, which we assess here by measuring **workload**, psychosocial **job demands** and the **discomfort** of work.
2. The **timing of work**, which determines both the level of exposure to work and the time available for recovery from sleep and rest.

4.2.1 Job content

Respondents were asked about how much of their work time was spent on different sorts of work tasks, using the question "How much of your work time do you use on the following?" Figure 21 gives time use reports for bus drivers.



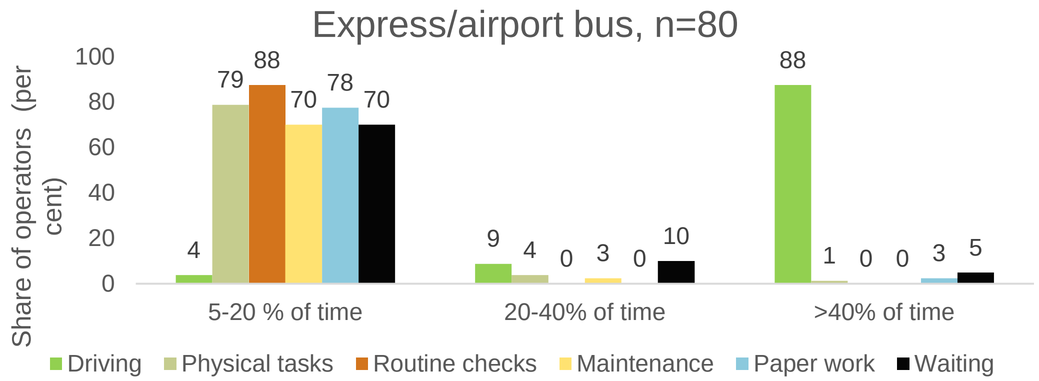


Figure 21. Responses of bus drivers to the question, "How much of your work time do you use on the following?", with the response categories as indicated. Per cent.

Ca. 90 per cent of both local bus and express / airport bus drivers spend most of their time at work driving, with a small share also spending substantial time waiting in depots or at termini. The share spending some time on physical work is notably larger for express / airport than for local bus drivers, as we would expect from their needing to help passengers with luggage.

Bus drivers also differ according to the type of road environment in which they drive (figure 22). Comparatively larger shares of local bus drivers drive in busy urban environments, compared with express / airport bus drivers who tend more to drive in rural environments.

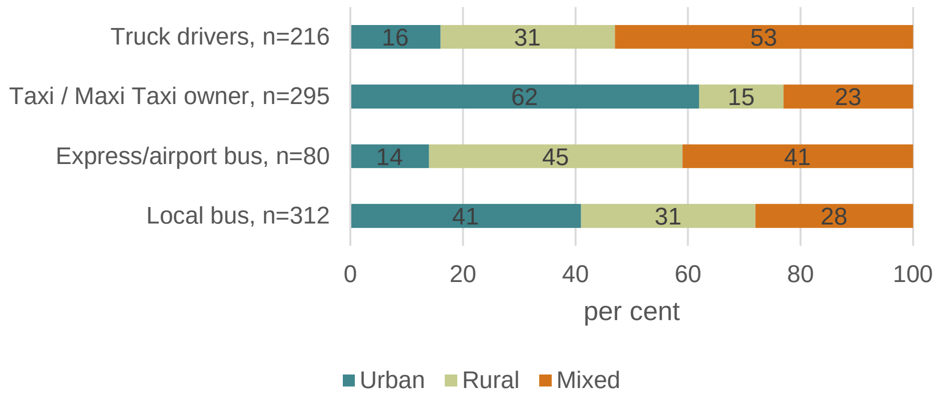


Figure 132. Shares of different types of driver responding to the question "Have you driven mainly in rural or urban areas during the last 3 months?", according to the branch in which they work. Per cent.

Time use reported by taxi owner-drivers and goods drivers is given in figure 23.

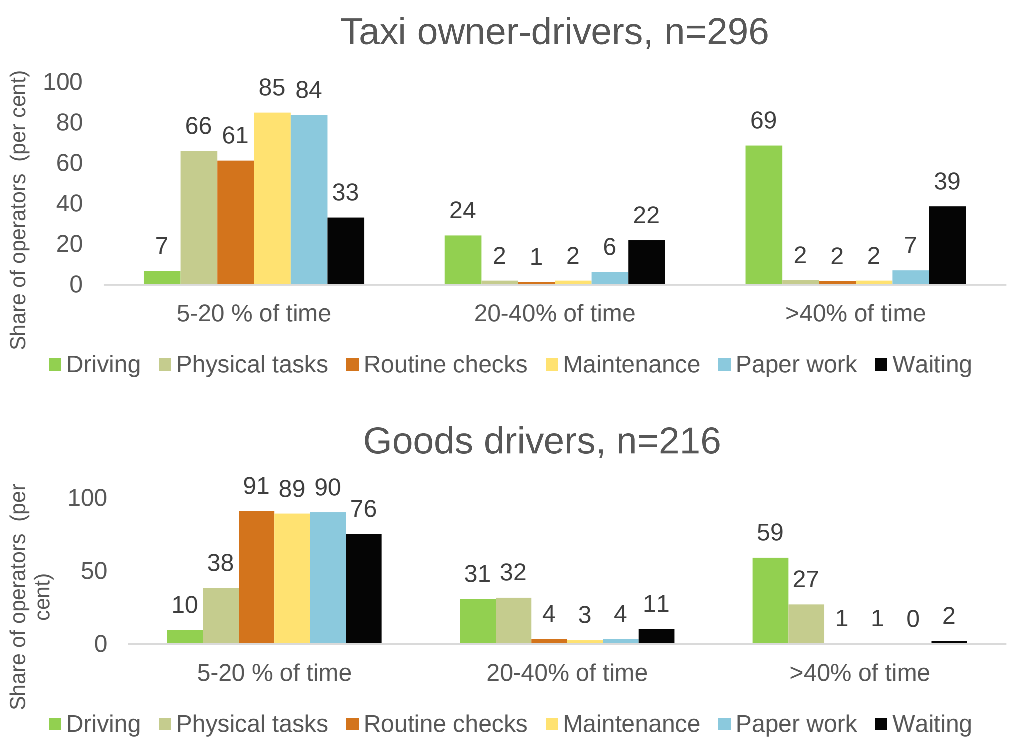
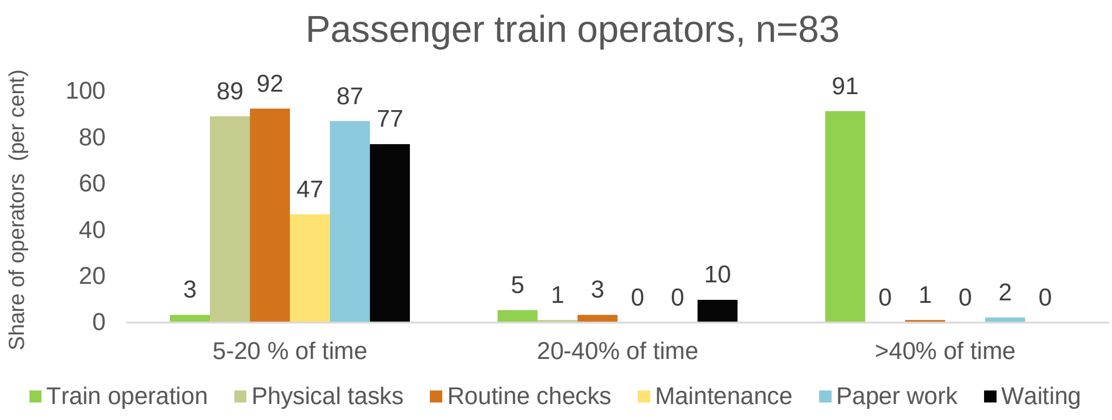


Figure 143. Responses of taxi owner-drivers and goods drivers to the question, "How much of your work time do you use on the following?". Response categories as indicated. Per cent.

Substantial shares of taxi owner-drivers and goods drivers report spending less than 40 per cent of their time at work driving. In addition to driving, a substantial share of taxi owner-drivers spend considerable amounts of time waiting, presumably time between jobs and waiting outside for passengers ("waiting" does not include time waiting at lights etc. while driving). The secondary activity for goods drivers, on the other hand, appears to be physical work, i.e. loading and unloading. Almost one in three goods drivers report spending over 40 per cent of their time at work doing physical tasks. For taxi and goods drivers, routine checks, maintenance and paper work are common supplementary activities. Most taxi drivers report driving mainly on urban roads, and most goods drivers report driving on mixed urban/rural roads (figure 23).

Time use reported by train operators in the goods and passenger branches was similar (figure 24).



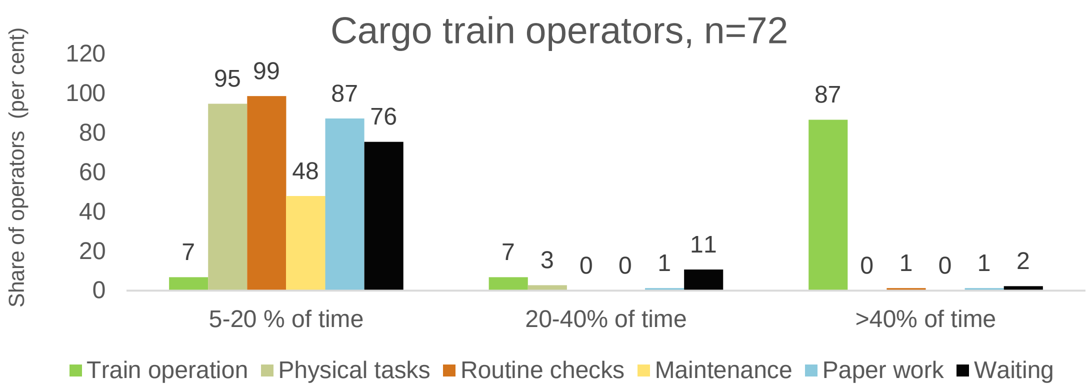


Figure 154. Responses of passenger and cargo train operators to the question, "How much of your work time do you use on the following?". Response categories as indicated. Per cent.

The data imply that most train operators spend at least 80 per cent of their time operating the train. Physical tasks (including walking between trains), routine checks and paper work are common supplementary activities. Over three-quarters of drivers also spend 5 to 20 per cent of the time waiting, presumably in station areas between or before trips ("waiting" does not include time waiting while operating).

Responses of watch officers and captains to the time use question is given in figure 25 and figure 26). They were not able to select "waiting" as an answer category, as we saw it as inappropriate.

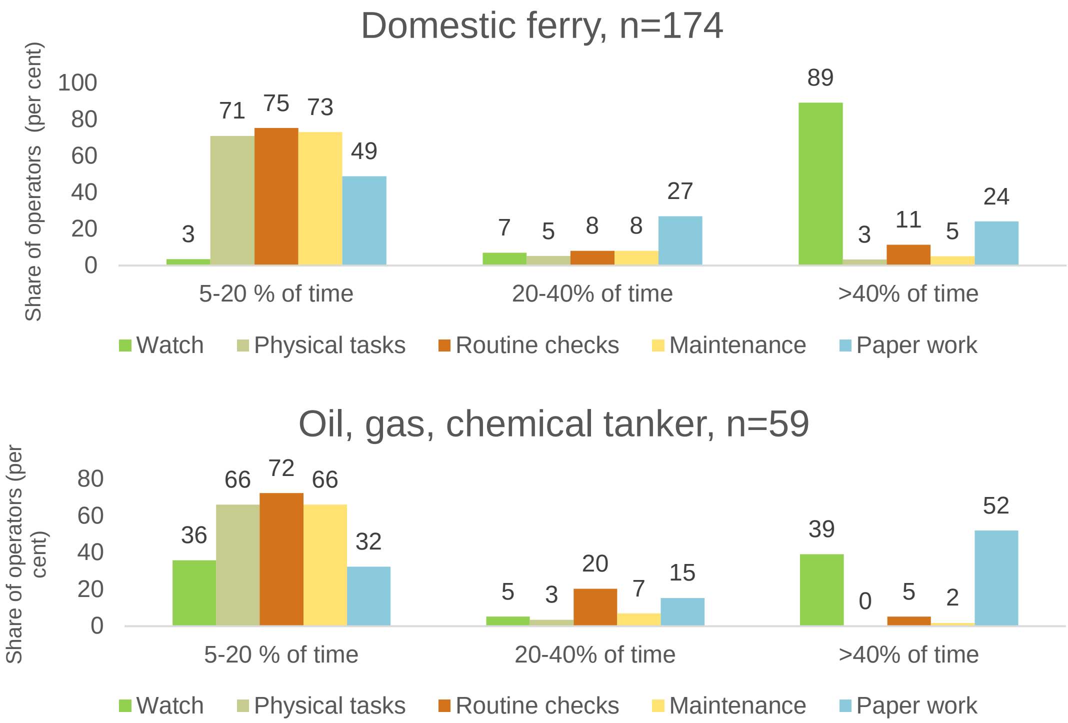


Figure 165. Responses of domestic ferry and tanker officers to the question, "How much of your work time do you use on the following?". Response categories as indicated. Per cent.

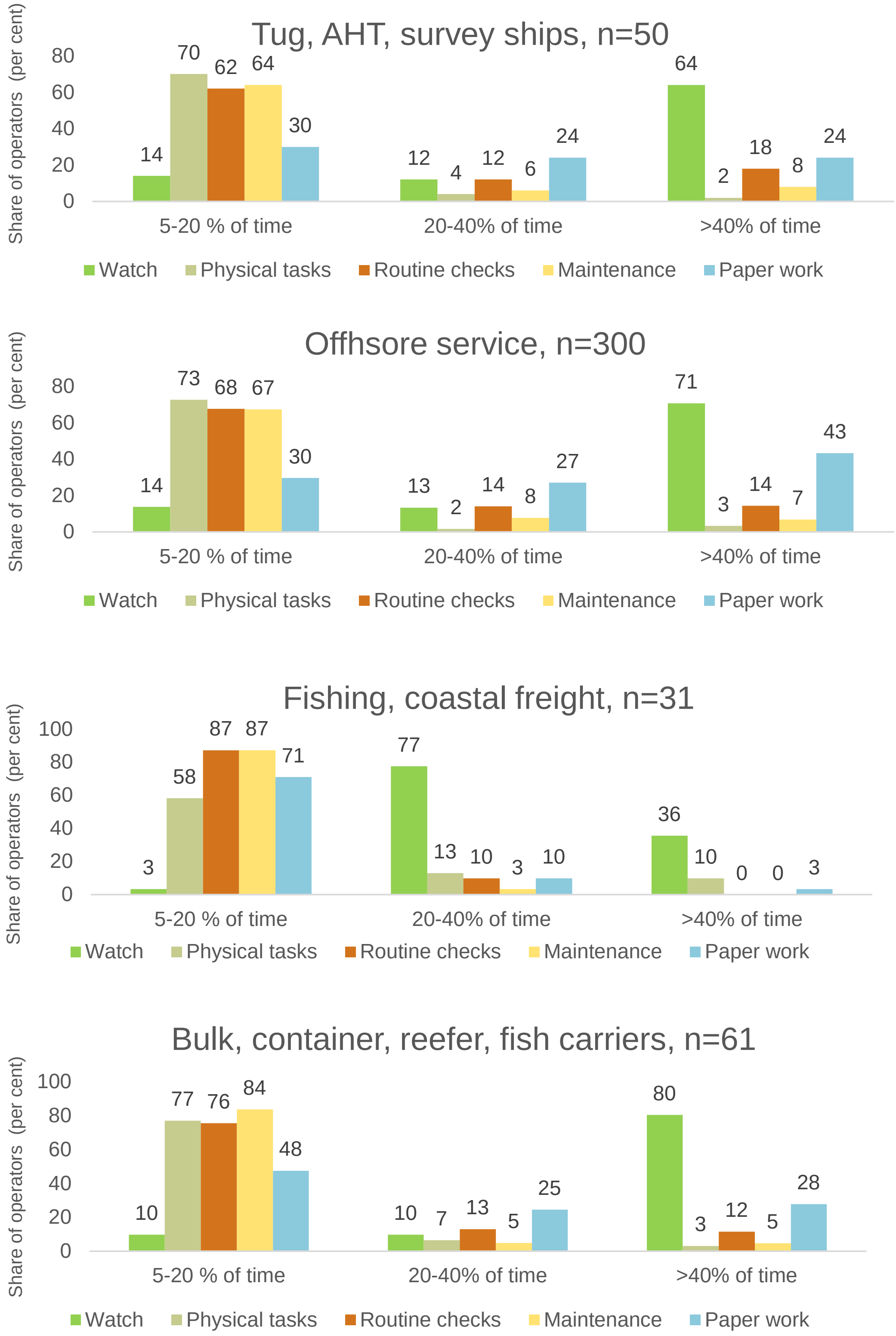


Figure 176. Responses of maritime officers in different branches to the question, "How much of your work time do you use on the following?". Response categories as indicated. Per cent.

It is clear that the job of watch officer and captain involves a greater amount of administration than other operator roles do. Notably, most tanker officers report spending more time doing paperwork than time on watch. However, officers in other maritime branches spend more time on watch than on any other task. Most of the maritime officers and captains work bridge watches (see Section 3.1.1), and substantial shares of these report that they are often alone on the bridge (figure 27).

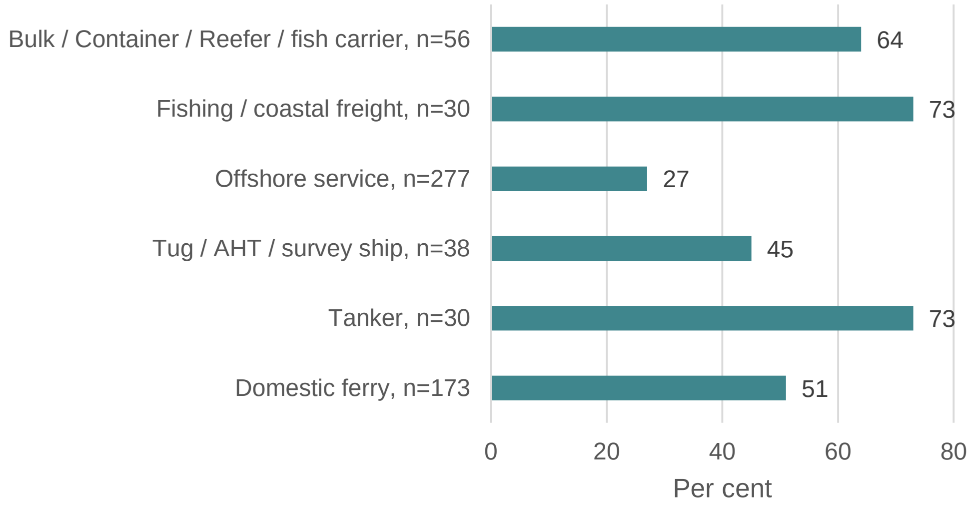


Figure 187. Shares of officers and captains reporting that they are "often" alone on the bridge, according to branch. Only those who report working bridge watches are included. Per cent.

Over 85 per cent of respondents in all branches report that they are alone on the bridge at least sometimes.

4.2.2 Workload

We measured workload by asking respondents to rate various demands experienced at work over the last three months, on a 21-point scale ranging from very low to very high, using the NASA-TLX. NASA-TLX assesses the following demands: **mental**, **physical** and **temporal** demands; the demand for **effort** in order to achieve performance; and demands in terms of **frustrations** encountered on the job. The degree to which **performance** is achieved is also measured.

Figur 28 shows that the level of **mental** demand reported by rail and maritime operators overall was statistically higher than that reported by road operators. All types of operator perceive that physical demands are low relative to mental (and other) demands, but physical demands are high for truck drivers relative to other types of operator. Those driving express/airport buses and officers on fishing and coastal freight vessels also experience relatively high physical demands (figure 26)

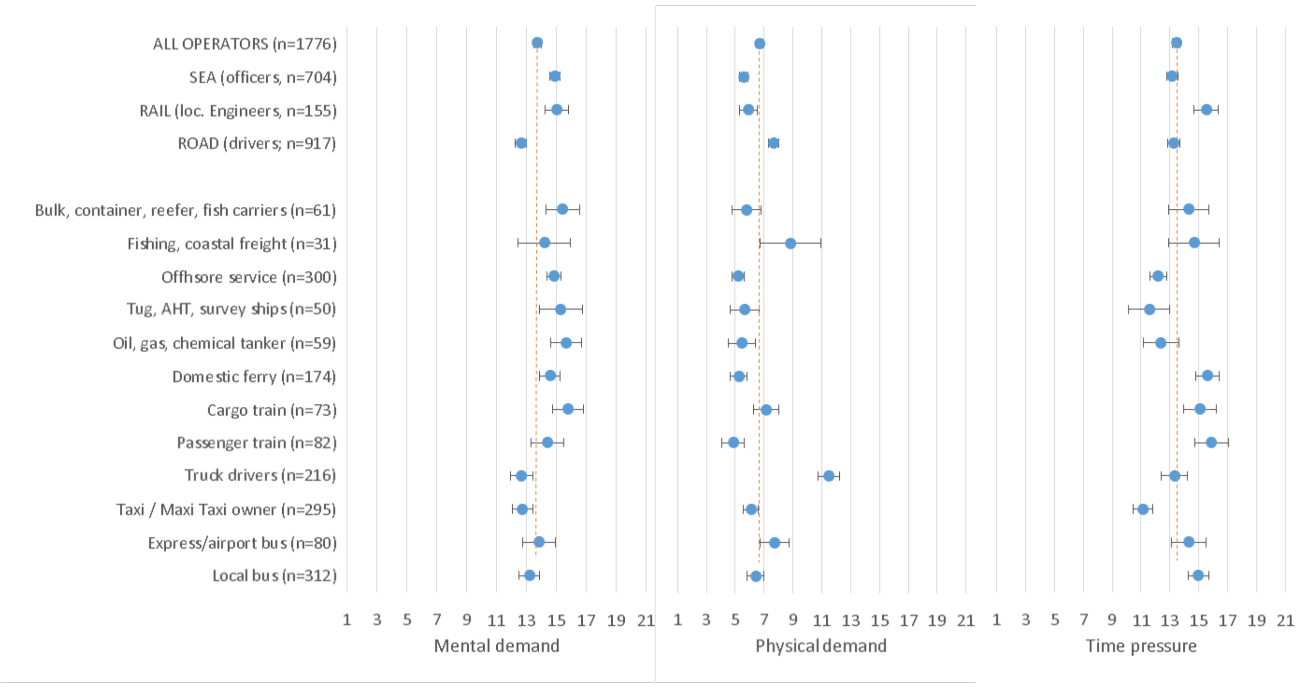


Figure 28. Response to the questions "How mentally demanding is your work?", "How physically demanding is your work?", and "How hurried or rushed is the pace of the work?". Participants responded on a 21-point scale ranging from 1 = very low to 21 = very high. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

All types of operator perceive that physical demands are low relative to mental (and other) demands, but physical demands are high for truck drivers relative to other types of operator. Those driving express/airport buses and officers on fishing and coastal freight vessels also experience relatively high physical demands (figure 26).

Cargo train operators also report statistically more physical demand than passenger train operators do.

Temporal demand (**time pressure**) is higher for rail operators, overall, than for road transport drivers and sea officers (figure 28). However, there are some branches within the road and maritime sectors who also experience relatively high time pressure levels. In particular, those operating on domestic ferries and local buses, where there may be fines for delays, report that time pressure is relatively high. Those operating on larger vessels at sea appear to face less time pressure, as do taxi owner-drivers.

Figure 29 shows that differences in perceived effort among operators in different sectors and branches are small.

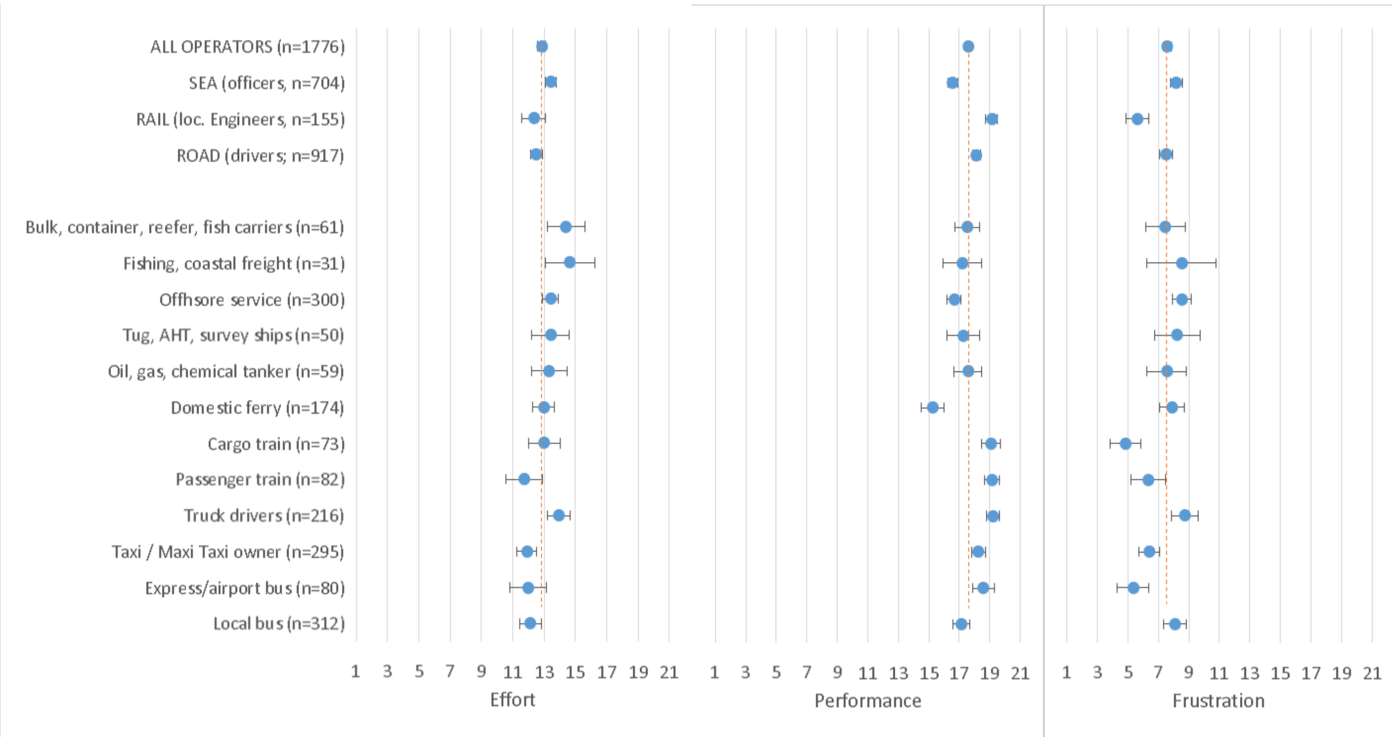


Figure 199. Response to the question "How hard do you have to work to accomplish your level of performance?" (Effort), "How successful are you in accomplishing what you are asked to do?" (Performance), "How insecure, discouraged, irritated, stressed and annoyed are you when you work?" (Frustration). Participants responded on a 21-point scale ranging from 1 = very low to 21 = very high. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Any operator who reports that they do not **perform** to the required standard is probably experiencing high performance demands. Relative to operators in most other branches, those working on domestic ferries report lower performance accomplishment, possibly in terms of keeping to a tight schedule. Truck drivers and rail operators report achieving the highest levels of performance.

However, those operators in the groups fishing and coastal freight vessels; bulk ships, container ships, reefers and fish carriers; and truck drivers, report that higher than average levels of effort are required in order to accomplish their performance. Despite the relative low performance accomplishment, ferry operators do not perceive that they work particularly harder than those in other branches in order to accomplish their level of performance. Levels of frustration are low relative to other demands (figure 29).

A subset of our sample also responded to the NASA-TLX measures in the second survey wave. Rather than measure workload over the preceding three months of work, the second survey was designed to assess workload over the preceding shift.

Although the results were more variable, due to the lower number responding, the important following trends were reproduced, suggesting that the above results are reliable.

- Overall operators rate mental demands and time pressure as greatest source of workload.
- Mental demands were greater for sea and rail than road operators.
- Physical demands were greater for truck drivers, cargo train operators and those working on fishing and coastal freight vessels.
- Temporal demands were greatest for rail operators, domestic ferry officers and local bus drivers.
- Relatively poor performance accomplishment was reported by sea operators in general, in particular ferry operators. Relatively high performance accomplishment was reported by rail and truck drivers.

4.2.3 Job demands and resources

As reviewed in Section 1.5.2, there are various job demands and resources that are particular to an operator's job, which we must account for in order to understand longer term fatigue.

Figure 30 gives **cognitive job demand** scores for operators in different branches.

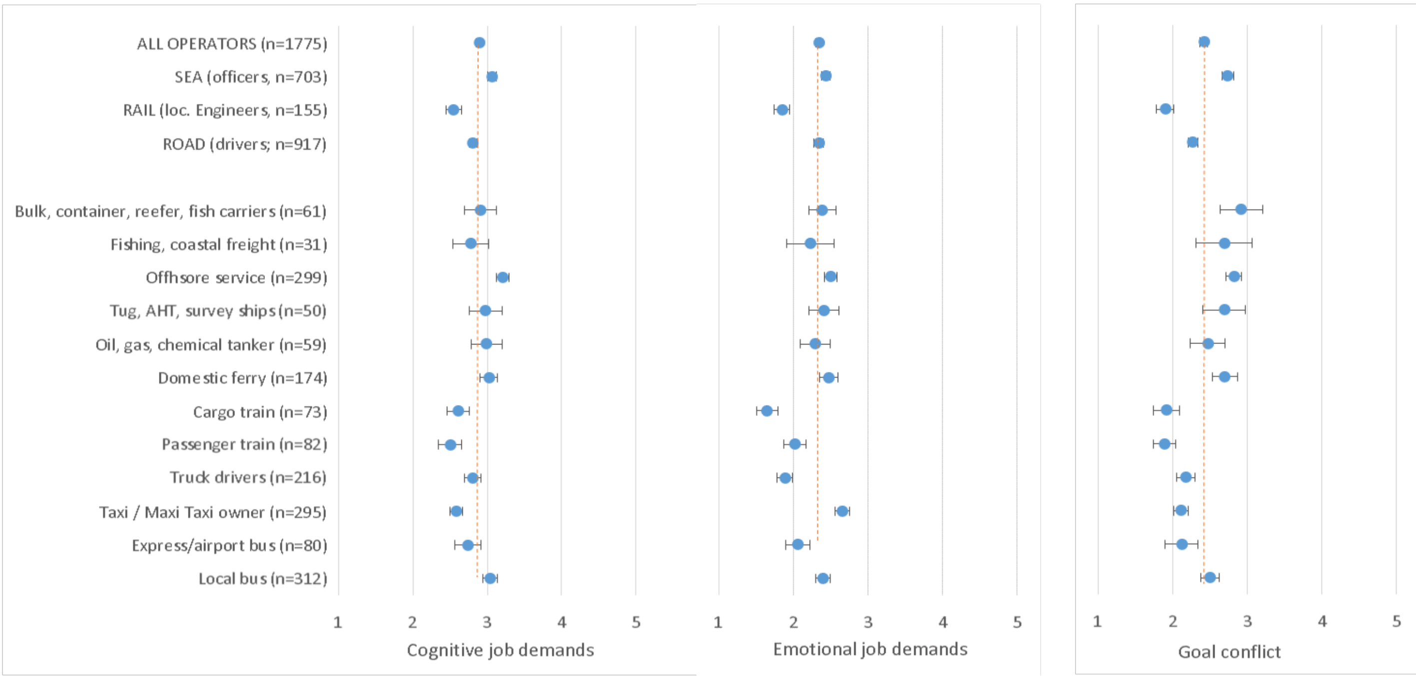


Figure 30. Average agreement to six items assessing cognitive job demands (e.g. "I must work faster than I would like to get the job done", "I often face interruptions in my work"), emotional job demands (e.g. "I am often confronted by people who complain", "My work sets me in emotional situations") and goal conflict (e.g. "I have to break the rules to get the job done", "Safety standards often come in the way of other goals"). Participants responded on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Whereas the NASA-TLX contains separate items for mental demand and time pressure, overall cognitive demand is assessed here in terms of multiple competing tasks, interruptions and distractions. Operators working at sea report greater levels of cognitive demand than professional drivers, who in turn experience greater cognitive demands than rail operators.

Figure 28 shows scores for various levels of **emotional job demands**. Compared with cognitive job demands, operators agree less that they face emotional demands. Taxi owner-drivers report higher emotional demands than any other driver group, and are in fact the only operator group who score higher on emotional demands than cognitive demands. Otherwise, offshore service and ferry operators also report higher than average levels of emotional demands.

Goal conflicts as measured in this study specifically indicate the extent to which safety and other goals are in conflict with other important operational priorities, such as punctuality or customer service. Figure 30 shows that sea officers report higher levels of goal conflict, followed by road and then rail operators. There is not much variation among maritime branches. Local bus operators report statistically greater agreement than truck or taxi drivers that they experience goal conflicts.

Decision latitude describes the extent to which operators can choose how to do their job using the skills that they have. Operators in our sample reported widely varying levels of decision latitude (figure 31). Taxi owner-drivers and sea officers in most branches generally tend to agree that they get to decide how to do their jobs. In contrast rail operators and bus drivers tended to disagree that they could do this, i.e. had a lower degree of decision latitude. Officers on fishing and coastal freight vessels also reported a low degree of decision latitude.

Scores for **leader** and **colleague support** are given in figure 31.

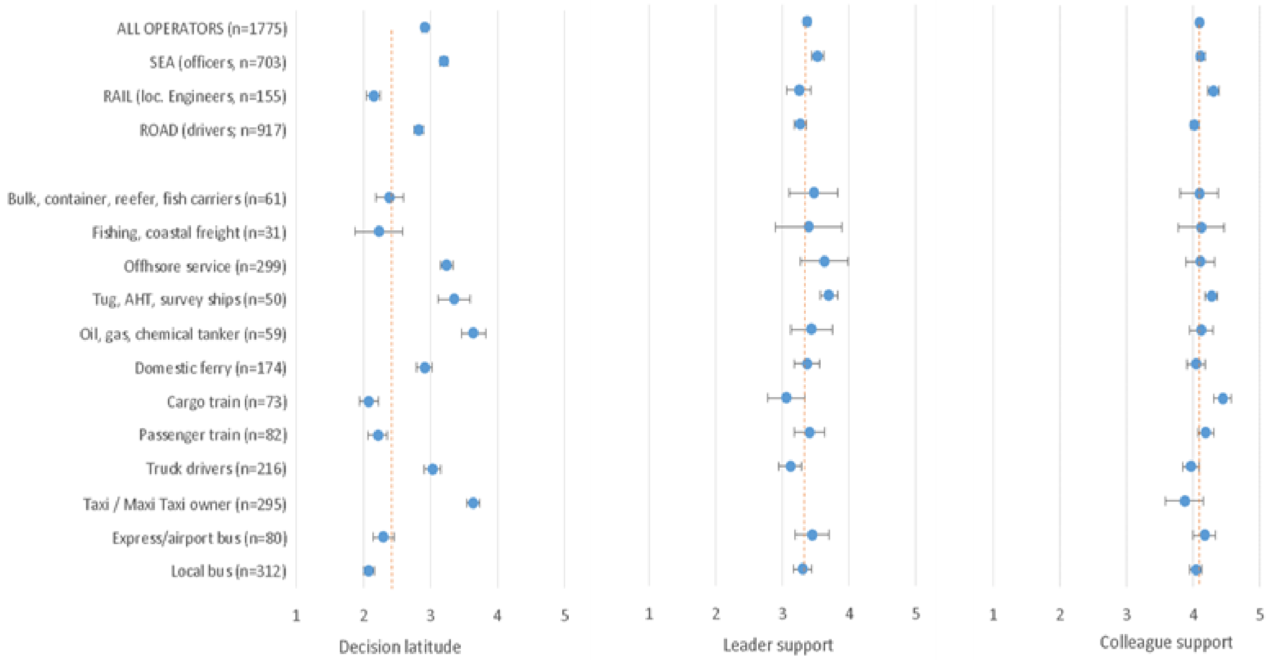


Figure 31. Average agreement to three items assessing decision latitude (e.g. "I can plan my own work", "I can decide how to do my work"), three items assessing leader support (e.g. "My line manager listens to what I say") and four assessing colleague support (e.g. "I can plan my own work", "I can ask colleagues for help when I need it"). Participants responded on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

All types of operator experience that support is greater from colleagues than leaders, but most tend to agree that their leader is supportive. Sea officers report statistically greater support from leaders than professional drivers (road), and colleague support is statistically higher in the rail sector, largely due to the ratings of cargo operators. Overall road branches appear to receive the lowest levels of support at work.

4.2.4 Causes of discomfort

Operators were asked how often the following caused discomfort at work: **boredom and monotony**; the physical work environment, in terms of **noise**; **vibration**; **air quality** and **temperature**; and their **operating position**.

Overall **boredom and monotony** caused more problems for maritime operators than professional drivers working in road transport (figure 32).

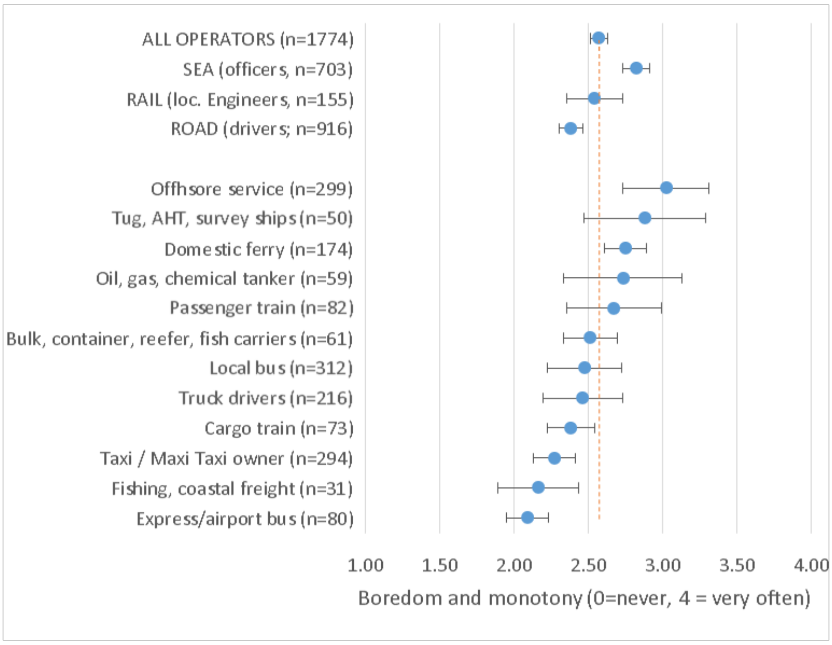


Figure 202. Response to the question "How often did the following cause discomfort at work?", for "boredom and monotony", by sector and branch. Participants responded on a 5-point scale ranging from 0 = never to 4 = very often. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Officers working on vessels travelling longer distances (tankers and survey ships), as well as those that may be exposed to some degree of routine (e.g. offshore service), tended more to report boredom as a problem. Between 35 per cent and 40 per cent of officers operating on these vessels indicated that boredom was a problem often or very often.

Those operating in sea and cargo rail transport reported experiencing discomfort from **noise** while operating more often than professional drivers in the road sector do (figure 33).

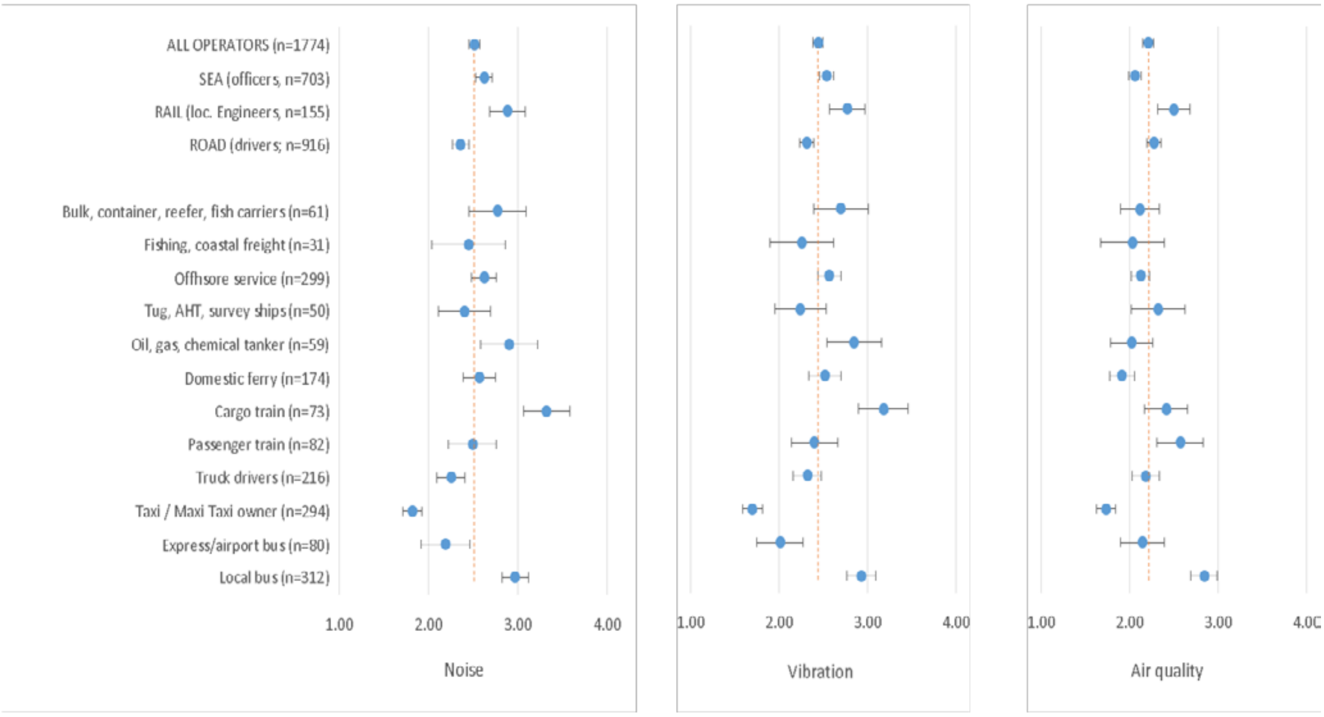


Figure 213. Response to the question "How often did the following cause discomfort at work?", for "noise", "vibration", "air quality / temperature", by sector and branch. Participants responded on a 5-point scale ranging from 0 = never to 4 = very often. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Rail operators in both main branches report that discomfort from **air quality** or temperature is more often a problem than for those in sea transport. Road operators also experienced discomfort more often than sea operators.

The picture is somewhat different as regards discomfort from **operating position,** which is the sitting or standing position that the driver or officers operates in) (figure 34).

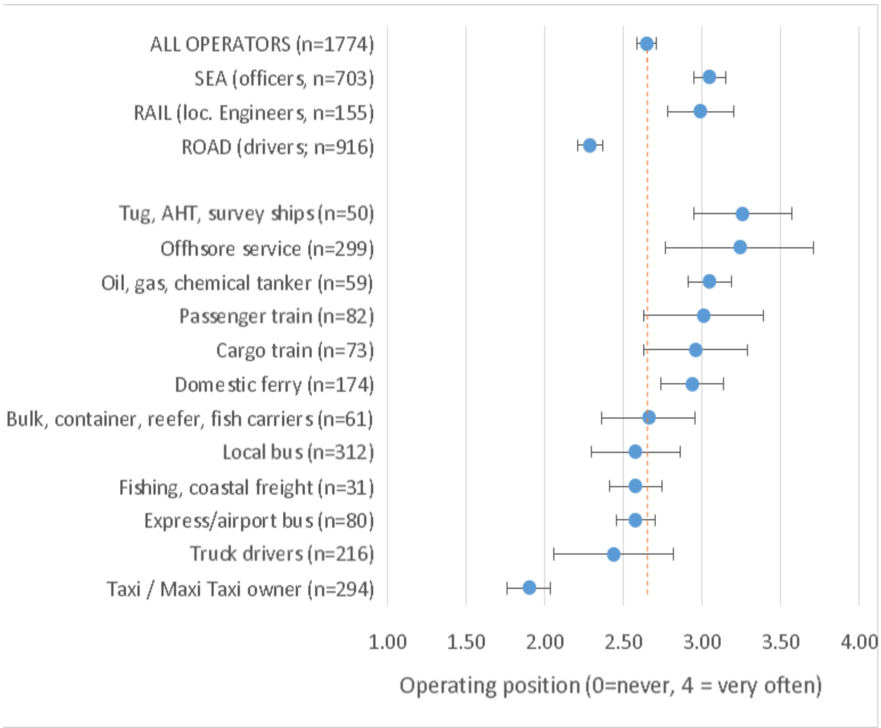


Figure 224. Response to the question "How often did the following cause discomfort at work?", for "operating position", by sector and branch. Participants responded on a 5-point scale ranging from 0 = never to 4 = very often. Means with 95 per cent confidence intervals. Dotted line indicates mean for all operators.

Operators in rail and sea transport report experiencing discomfort from their position markedly more often than drivers in the road sector. It is worth noting that discomfort from operating position is the most frequently reported type of discomfort, especially for those operators in sea and rail transport. 37.1 per cent and 39.4 per cent of rail and sea operators indicate that it is often or very often a problem for them.

4.2.5 Timing of work

As we have discussed, the way work is timed determines the length of exposure to fatiguing tasks at work, time available for recovery from fatigue and the time of day at which recovery occurs.

Here we assess work timing in terms of average hours spent operating while at work, whether work is timed regularly and predictably, and the extent to which shifts are worked that are known to be challenging in terms of being able to get sufficient recovery.

Length of work and operating hours

Figure 35 shows the number of days a week worked by operators in the road and rail industries.

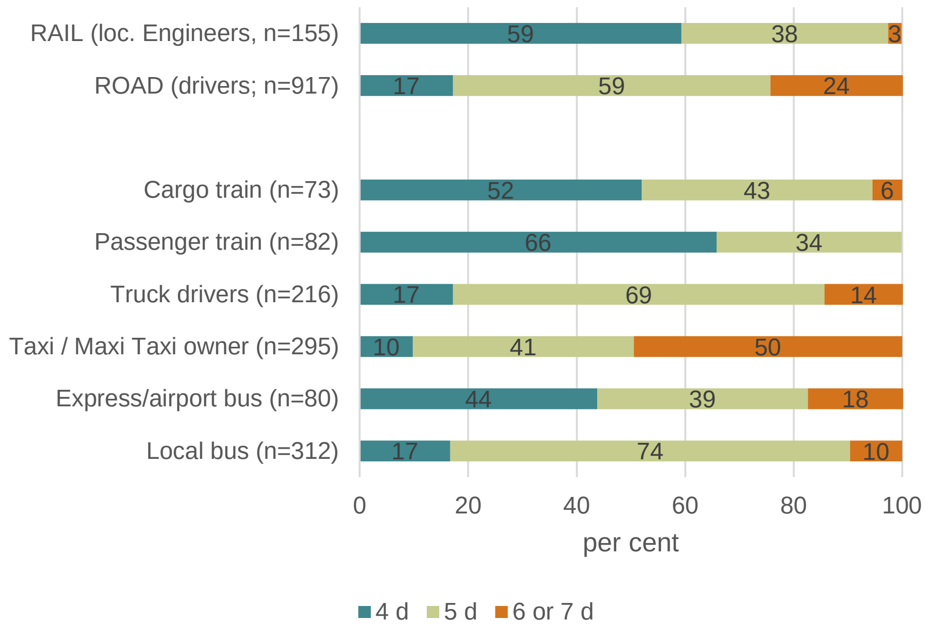


Figure 235. Shares of land-based operator responding to "How many days a week have you normally worked during the last three months?". Per cent.

Almost all train operators work 4 or 5 days, but 24 per cent of road operators work 6 or 7 days. In particular, over half of the taxi drivers report working 6 or 7 days a week. Sea officers were asked how many days they had worked over the last three months, and the answers are shown in Figure 36.

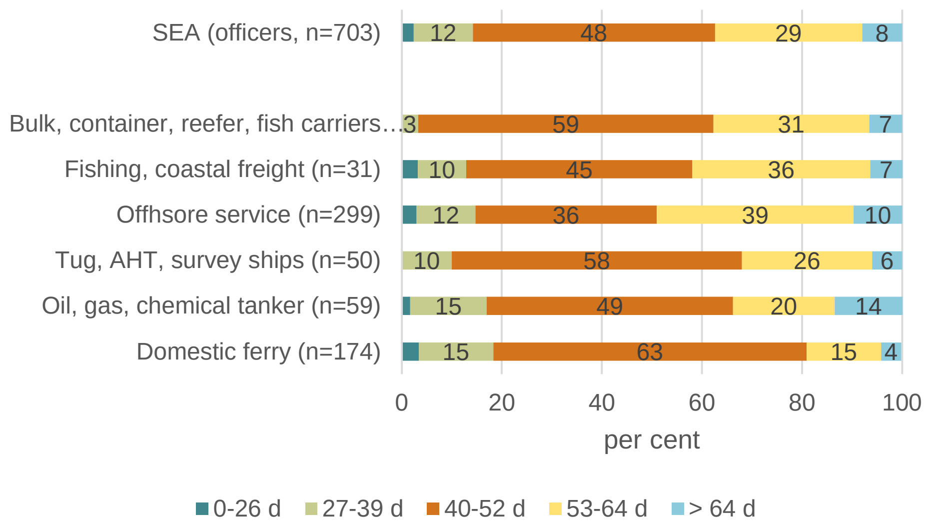


Figure 246. Shares of sea officers responding to "How many days have you worked during the last 90 days?".

Most sea officers spent between 40 and 64 days, or between 6 and 9 weeks, working over the preceding three months.

Figure 37 shows operating and working hours reported by operators in our survey.

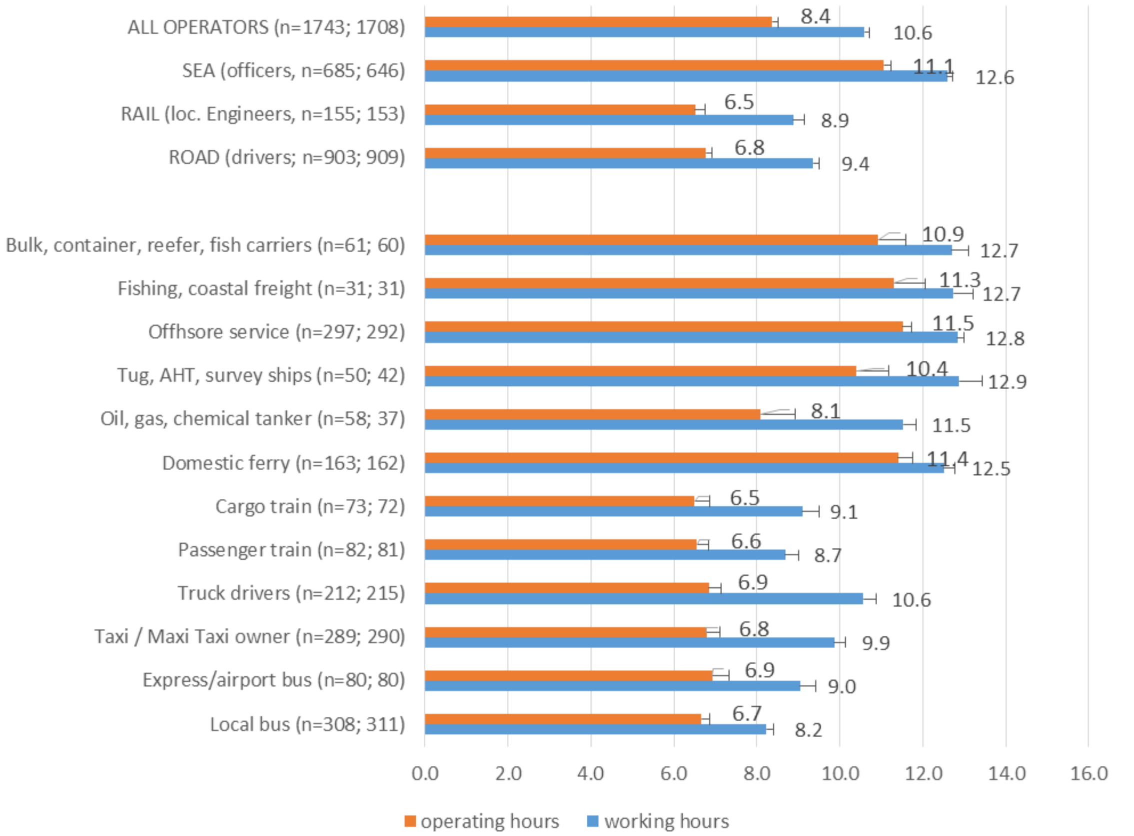


Figure 257. Working and operating hours for different types of operator. We used answers to "During a normal 24-hour period on a work day, how many hours do you work on average (both driving / watch and other work)?" to estimate working hours. We used answers to "For a normal working 24-hour period / 24-hour period at sea, how many hours do you spend driving / on watch (on average)?" to assess operating hours. Numbers of respondents answering in each sector or branch are given for working hours and operating hours, respectively. Means with 95 per cent confidence intervals.

On average transport operators report that they operate for 8.4 h during a typical working day, shift or watch, but spend an additional 2.2 h on other tasks at work. There is wide variation among sectors, particularly between sea officers on the one hand and road and rail operators on the other. Officers at sea report long hours at work, an average of 12.6 h on a typical day. Much of this is watch work (11.1 h per 24-hour period on average). Interestingly rail and road operators report that they typically drive between 6.5 and 6.8 h on a working day, irrespective of branch. However, truck drivers and taxi owner-drivers report longer working days due to time spent on non-driving tasks (addressed in Section 4.2.1).

Irregular working hours

It is easier for the body to recover from work by getting sleep of sufficient length and quality, if one always goes to bed at about the same time of day, preferably at night. If work is timed to start and end at different time of the day, it may interfere with the routineness of sleep and cause fatigue. Figure 38 shows the shares of respondents in each branch who answered that the timing of their work over the three months prior to the survey had been irregular. For rail and road operators, this can be thought of as the shares who work shifts.

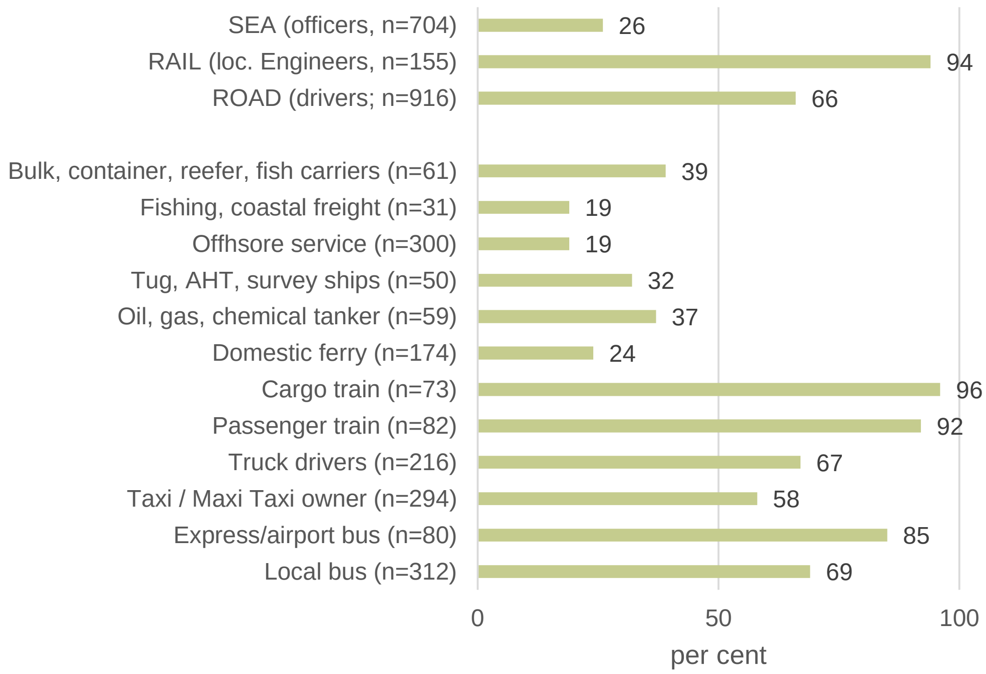


Figure 268. Shares of operators working irregular working hours. We asked respondents "How regular are your working hours?", and show here the shares of respondents answering "Irregular, my working hours tend to vary from day to day". Per cent.

Almost all of the train operators worked shifts, and irregular hours were also common among road operators. Although most of the sea officers work routine watches from day to day, substantial shares also work irregular hours. Moreover, the timing of sleep may still be irregular for sea operators in the sense that it may change between periods at sea and periods on shore.

Predictability

Predictable work hours allow operators to plan other life activities and maximise rest opportunities afforded to them. To assess how predictable work hours were for different types of operator, we asked those respondents who worked shifts and watches how long in advance they found out about what sort of working hours they would be working. Figure 39 gives the results, and indicates that challenges from unpredictable work hours are greatest for truck drivers.

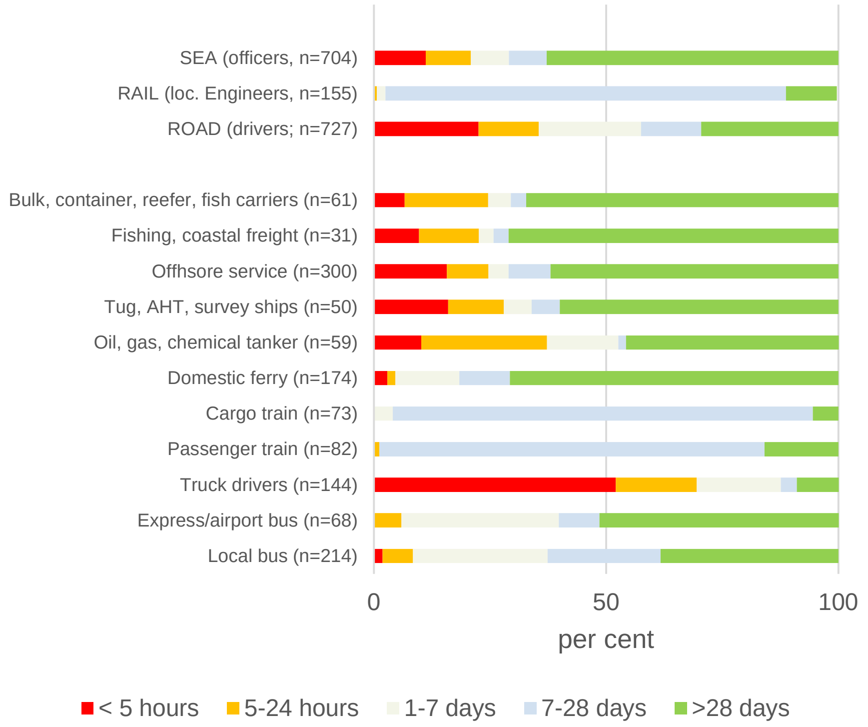


Figure 279. How long before operators find out about their working hours. Those with irregular working hours were asked how long beforehand they knew what sort of working hours or watch system they would be working. Taxi owner-drivers are omitted since the nature of their work makes comparisons difficult. Per cent.

There is also considerable unpredictability in sea transport, but less so on scheduled ferries that are not as prone to variations in operational demands as other vessels.

Challenging shift types

We asked the rail and road operators how often they had worked different types of shifts, each of which is associated with increasing fatigue risks.

- Backwardly rotating shifts, where a shift starts earlier than it did the day before.
- Split shifts, where the operator works two or three shifts on the same day with time off in between.
- Early shifts, defined here as starting between 02:00 and 06:00 in the morning.
- Night shifts, defined here as starting between 22:00 and 02:00 in the morning.

Figure 40 shows that considerable shares of operators in most road and rail branches work each of the above shifts at least once a week.

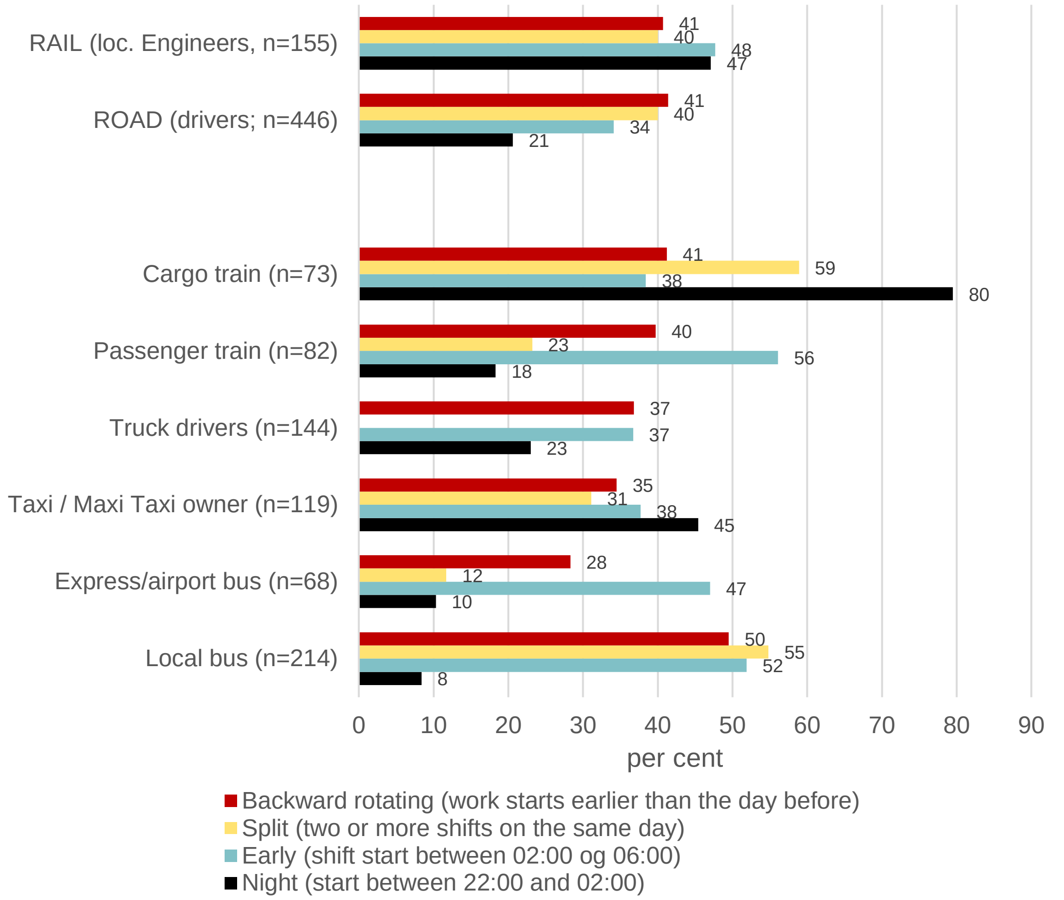


Figure 40. Challenging shifts. We asked the operators "How often have you worked the following types of shift?" for the shifts indicated in the key. Shares answering "at least once a week" are shown. Per cent.

Between 40 and 50 per cent of rail operators report working each of the four types of "fatiguing" shift regularly, although many more cargo than passenger train operators reported that they worked nights and split shifts. Early shift starts were more common among passenger train operators than cargo train operators.

Backwardly rotating and split shifts were the most common type of challenging shifts worked by professional drivers in road transport. More than half of the local bus drivers reported working split shifts, and almost a third of taxi owner-drivers. Early starts were also common across each branch in the road transport sector. Notably, almost half of taxi owner-drivers and almost a quarter of the truck drivers reported working nights at least once a week.

Watch systems

In order to provide 24 h-cover at sea, work hours are traditionally arranged in watch systems. In terms of challenging "shift systems", these watch systems mean that many operators at sea work each of the above "risky" shifts every day. The different watch systems officers reported that they had worked is given in table 9.

*Table 9. Shares of officers and captains responding to the survey working different types of watch system, according to maritime branch. The two most common watch systems in each category are in bold. For an explanation of watch systems see Phillips et al. (2015). Respondents were asked to indicate the most common shift system worked for the three months prior to the survey. Per cent. *The number of respondents in the "all" category is greater than the sum of the branch categories, because it includes those operating on rescue boats and international ferries.*

	6-6	4-4	4-4-8-8	4-8	12-12	7-7-5-5 / 7-5-5-7 / 7-5-7-5	24-hour watch / 14-10	Varies / not relevant	Total
Domestic ferry (n=162)	4.9	0	4.3	1.2	**19.1**	9.9	**42.0**	18.7	100.0
Oil, gas, chemical tanker (n=53)	9.4	0	1.9	**35.8**	0.0	0.0	**17.0**	35.8	100.0
Tug, AHT, survey ships (n=47)	**25.5**	6.4	8.5	8.5	**23.4**	0.0	12.8	14.9	100.0
Offshore service (n=292)	**56.5**	3.1	11	1	**18.8**	0.3	4.8	4.7	100.0
Fishing, coastal freight (n=31)	**77.4**	0.0	0.0	**16.4**	0.0	0.0	3.2	3.2	100.0
Bulk, container, reefer, fish carriers (n=59)	**66.1**	3.4	3.4	**10.2**	0.0	1.7	5.1	10.2	100.0
All (n=617)*	**41.7**	2.1	7.6	6.5	**16.0**	3.1	13.8	9.2	100.0

The most common watch system among our respondents was the traditional 6-6 two-watch system. On domestic ferries, however, other arrangements are more common, in which officers work long hours during the day in exchange for more frequent time off ashore. The 12-12 two-watch system was the second most common watch system, worked by substantial shares of officers on ferries, tankers and in offshore service. Around a third of the tanker officers worked the 4-8 three-watch system, which requires extra manning but which is favoured by fatigue researchers.

4.3 Recovery from work (FRT Hazard Level 2)

Level 2 risks describe threats to adequate recovery from the fatigue that work causes. Most researchers agree that the most important of these is insufficient sleep, usually assessed in terms of both the **quantity** and **quality of sleep** obtained. Failure to detach psychologically from work during non-work time (**psychological detachment)** can also threaten recovery and lead to fatigue over the longer term, as can high levels of **work-home interference**.

4.3.1 Sleep

Sleep quantity

Figure 41 shows the amount of sleep that operators report getting on typical work days over the three months prior to the survey.

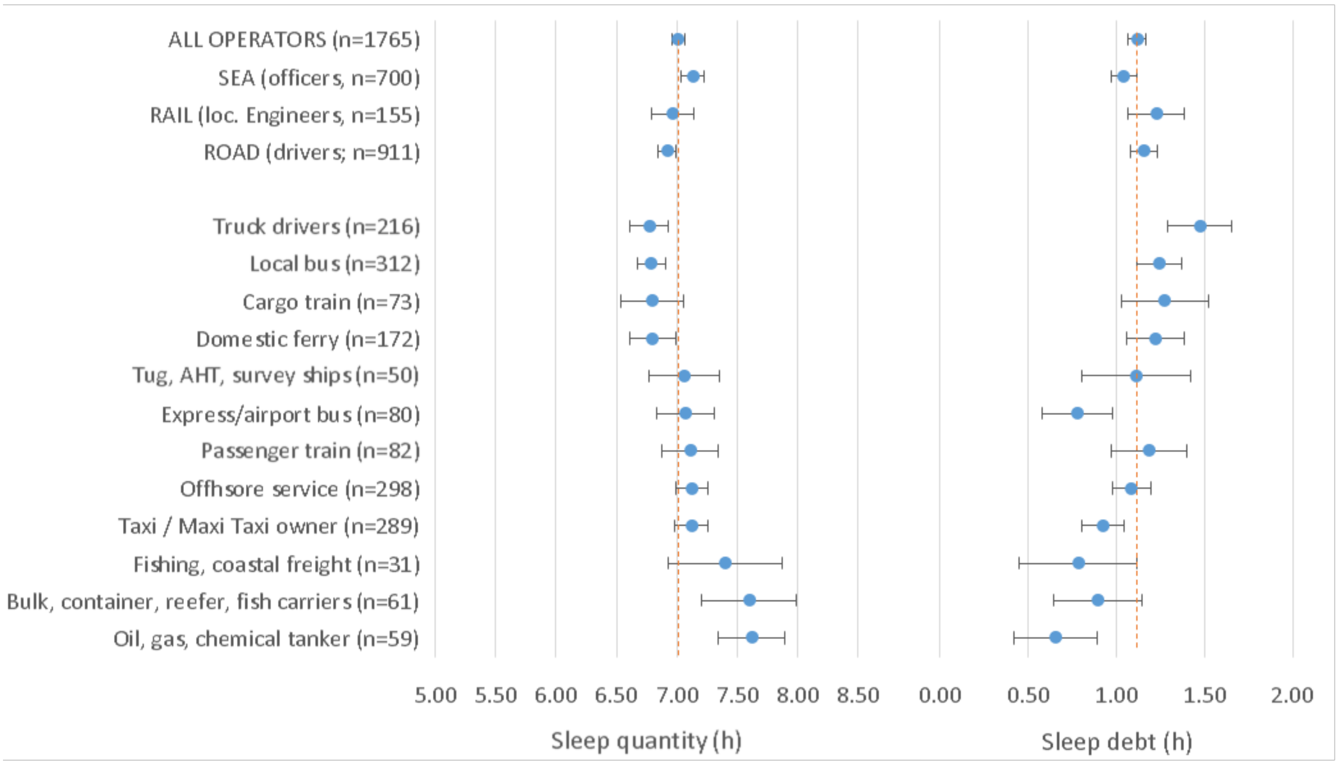


Figure 41. Sleep quantity and sleep debt on working days. Sleep quantity was obtained in answer to the question "How many hours of sleep do you normally get in a 24-h period on a working day?" Sleep debt was obtained by subtracting the answer for sleep quantity from the answer to the question "How many hours sleep do you need during a 24-h period (how many hours would you sleep for if you could sleep as long as you needed)?" The two questions were separated from each other on the survey. Means with 95 per cent confidence intervals. The dotted line indicates mean for all operators.

Operators obtained an average of 7.0 h sleep on work days, but there was considerable variation from sector to sector and from branch to branch. At sector level, sea officers obtain statistically more sleep on average (7.1 h) than professional drivers in road transport (6.9 h). At branch level, truck, local bus, cargo train operators and officers on domestic ferries obtain an average of only 6.8 h of sleep on working days, whereas tanker officers obtain 7.6 h on average. When considering these data it must be remembered that there is also considerable variation in sleep obtained across individuals.

An interesting question with fatigue in mind is how much sleep operators get in relation to how much they feel they need. This is indicated by sleep debt, which is the difference between needed and actual sleep. The average sleep debt for all operators in our sample was 1.1 h, which indicates that most operators get considerably less sleep than they feel they need (figure 42). The greatest sleep debt is felt by those who sleep less. This is not too surprising, but it is important because it confirms that those who work in branches where operators get less sleep are no different from operators in other branches in terms of the amount of sleep that they feel they need. Most operators report that they require around 8 h sleep, regardless of the branch in which they work. Of greatest concern are truck drivers, who report an average sleep debt of 1.5 h.

To obtain more information about the prevalence of recovery sleeps that are so short that they increase acute fatigue risks considerably, operators were asked in the second survey wave how much sleep they had gotten prior to the very last *operating* period. Figure 40 gives the shares of operators in each sector and branch obtaining less than 5 h in the preceding 24 h, and the shares obtaining less than 12 h in the preceding 48 h. These sleep lengths are useful thresholds, below which the risk of severe fatigue at work increases considerably (Dorrian, Baulk et al. 2011).

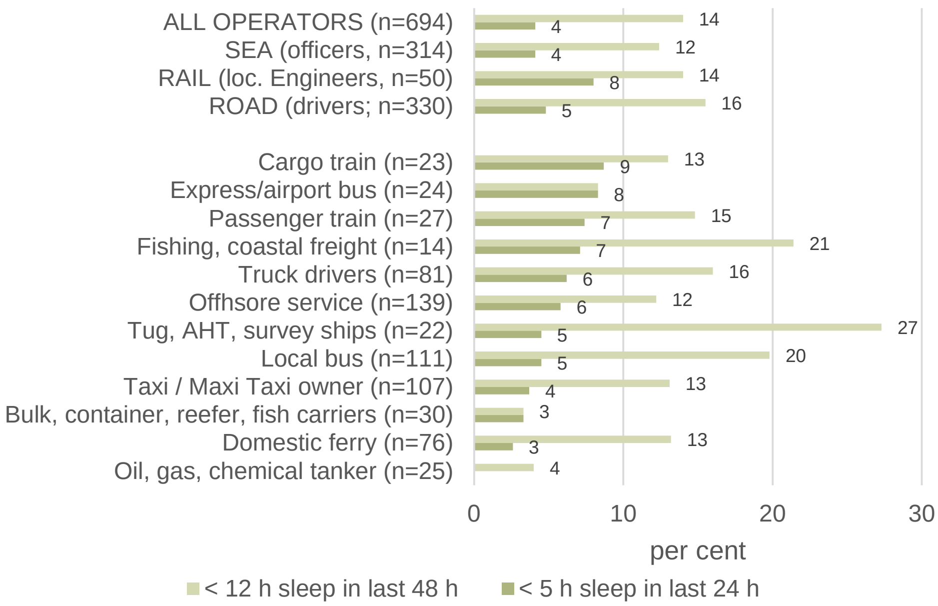


Figure 282. Risky sleeps. Operators responded to the question "About how long did you sleep during the 24-/48-hour period before beginning to drive / your watch?" Shares giving answers less than 5 and 12 hours, respectively are given. Branches are ranked in order of the share reporting less than 5 h sleep in the preceding 24 h period. Per cent.

A greater share of rail than road and sea operators report that they obtained less than 5 h sleep in the 24 h prior to operating. Shares reporting less than 12 h in the 48 h prior to operating are similar across sectors, but vary widely among branches. Considerable shares of truck and local bus drivers report getting less than 12 h in the previous 48 h. Among sea operators, large shares of those in the fishing/coastal freight and tug/AHT/survey ship groups reported less than 12 h in the previous 48 h, but the numbers on which these shares are based are small.

Sleep quality

Influences

Influences on sleep quality include the time of day at which sleep is obtained, the number of bouts in which it is obtained, and the extent to which the environment is conducive to sleep. The first point is not addressed directly in this report, but we can make some assumptions from the results on the timing of work (Section 4.2.5).

Figure 43 shows that most operators in sea and cargo rail transport report sleeping in more than one bout (split sleeps) on working days.

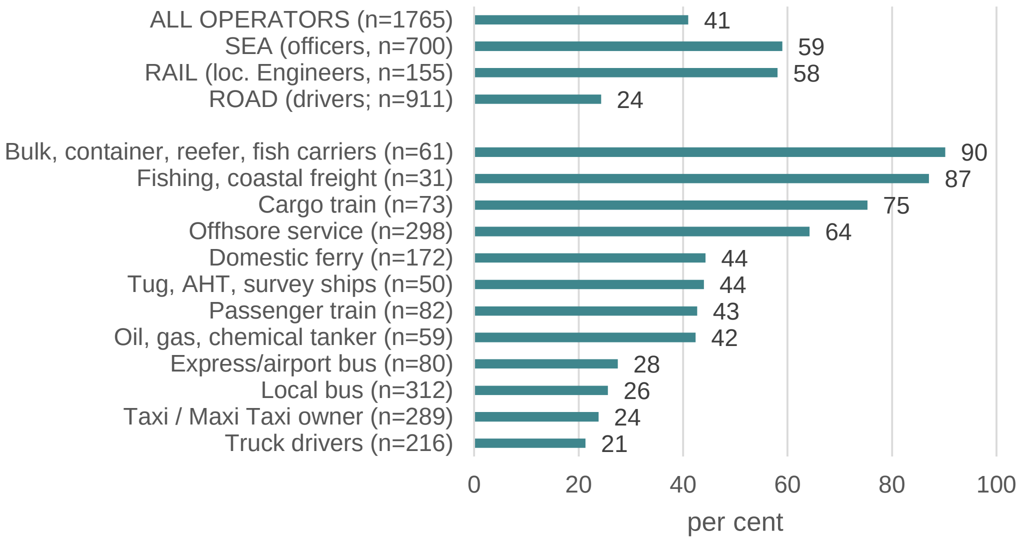


Figure 293. Shares of operators sleeping in more than one bout on working days. The question was "On such working days do you obtain your sleep in one continuous period (e.g. one night) or in two or more periods (e.g. shift work)?" Shares answering 2 or more periods are shown. Per cent.

In particular, nine out of ten of officers in the groups "bulk/container/reefer/fish carrier" and "fishing/coastal freight" report split sleeps, as do three out of four cargo train operators.

Figure 44 gives data on *where* the different operators normally slept when working, over the three months prior to the survey.

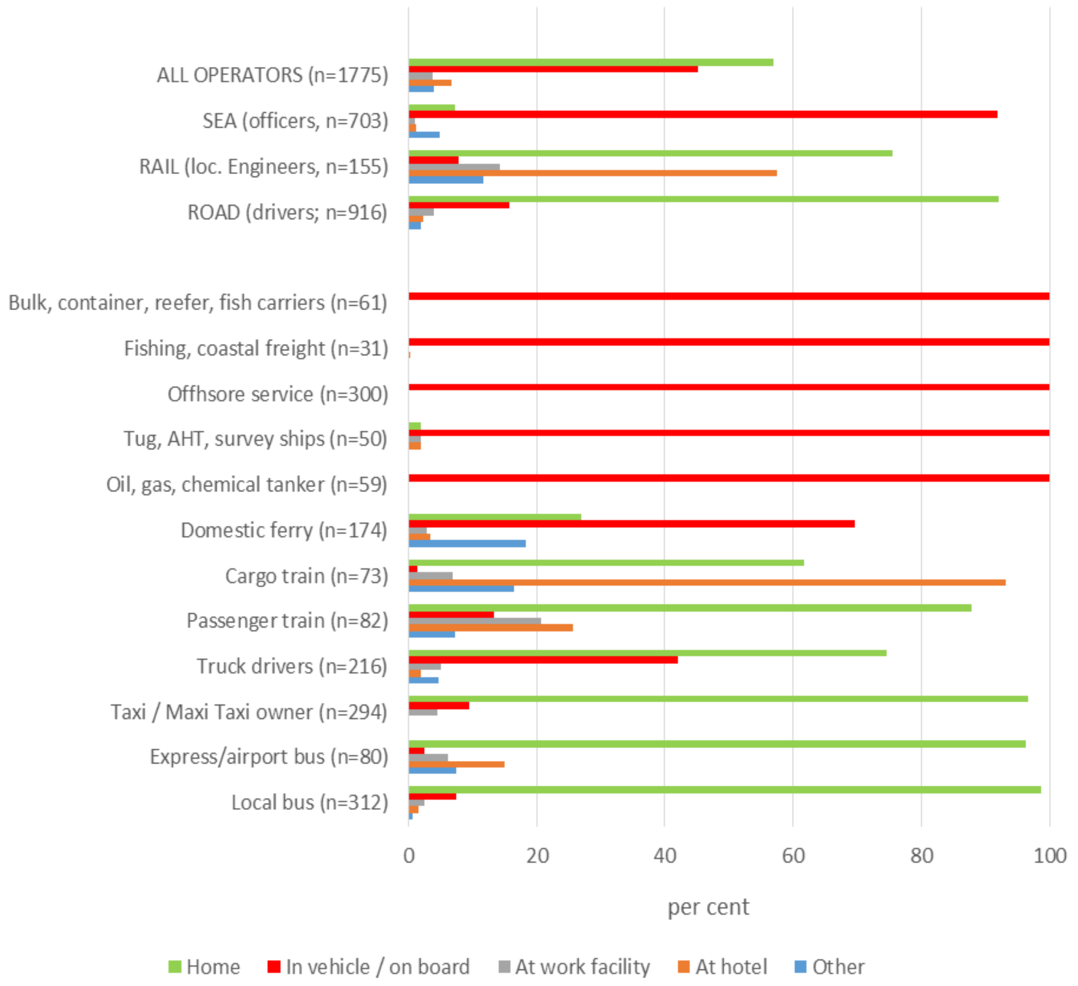


Figure 304. Shares of operators sleeping in various locations on working days. We asked, "Where do you normally sleep on working days?", and provided the answer categories indicated. Respondents could indicate more than one answer category, since operators can sleep in different places, depending on their location in relation to home. Per cent.

All of the sea officers slept on board when working, apart from those in the ferry branch, some of whom slept on shore at the end of the working day. It is normal for most passenger train operators, and taxi and bus drivers to sleep at home on work days. Notably, over 40 per cent of truck drivers report that as well as sleeping at home, it is also normal for them to sleep in their vehicles on working days. Likewise over 90 per cent of cargo train operators report that it is normal for them to sleep in hotels on work days.

Quality index

Operators were asked to rate the quality of sleep they had obtained over the last three months, using an index comprising measures of restitution (how awake and refreshed they were after sleeping), sleep inertia (ease of waking), sleep latency (ease of falling asleep) and a general rating of how well they had slept.

Figure 45 shows that sea and rail operators generally reported sleeping worse than road operators did. In particular, cargo train operators and offshore service officers reported the worst sleep quality. Within the road sector, truck and local bus drivers reported sleeping statistically worse than taxi owner-drivers.

Figure 45 also provides data for a sleep quality index for the preceding shift worked, which was obtained in a second survey wave.

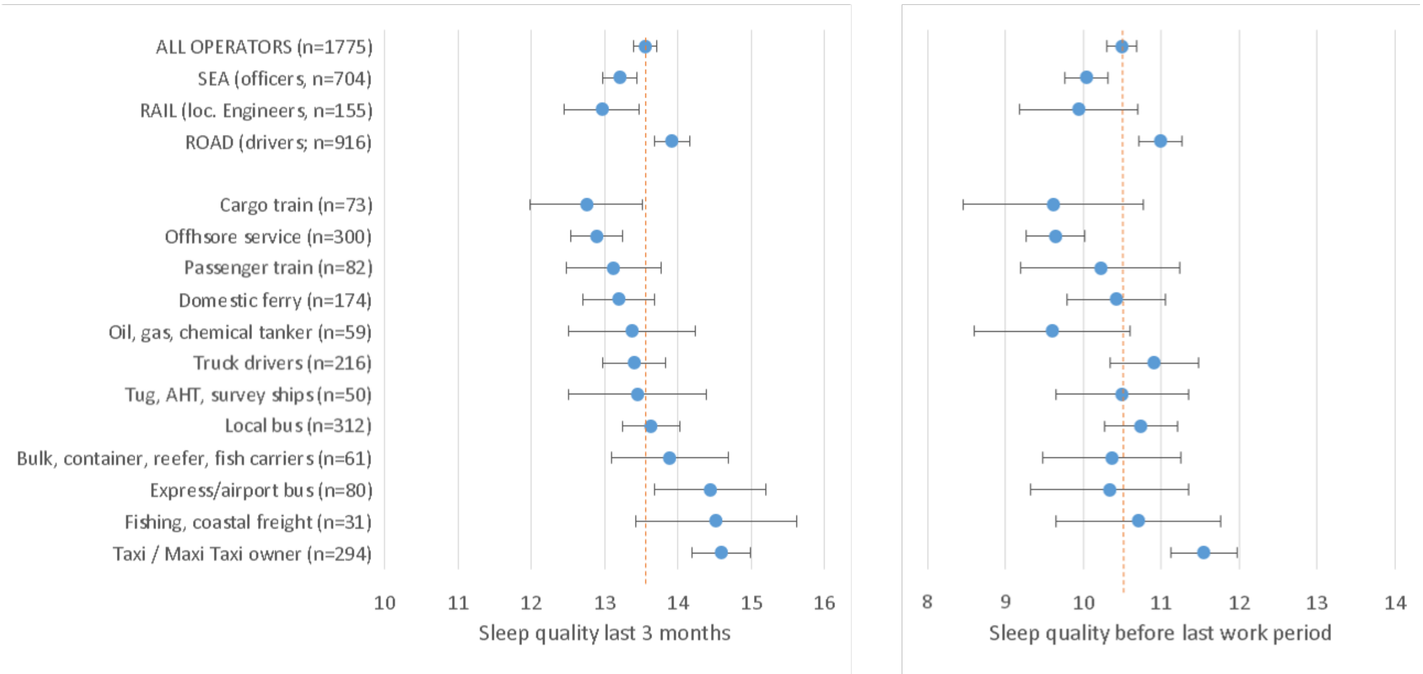


Figure 315. Sleep quality indices for preceding 3 months and last work period. Respondents were asked to rate on a 5-point scale (1 = very poorly / difficult and 5 = very easy / well) (i) how they had slept; (ii) how easy had it been to fall asleep; (iii) how easy had it been to wake up; (iv) how rested and refreshed they had felt after waking, for the last three months. <u>Preceding three months index</u>: Sum of scores for (i), (ii), (iii) and (iv). Scores out of a maximum 20. Questions posed in first survey wave. <u>Last work period index</u>: Sum of scores on (i), (ii) and (iii). Scores out of a maximum 15. Questions asked in second survey wave, and only some operators responded. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

Note that index used in the second survey wave comprises only three of the four items used to assess sleep quality in the first survey wave. Despite this, the sector data and general branch patterns in the first and second waves are similar, suggesting that the index is reliable.

4.3.2 Psychological detachment

In addition to sufficient restorative sleep, researchers have recently recognised the importance in being able to detach psychologically from work for recuperation. Psychological detachment is the ability to rest during non-work hours those mental and physical faculties that have become fatigued at work. Not thinking about work outside work is also an important part of psychological detachment (Section 1.5.3).

When considering psychological detachment we must recognise that there are two main types of transport operator: those who go home after work to recover, and those who must recover outside of work hours while they are still away from home (figure 44). The latter category includes most sea officers, many of whom recover on board ship, not far (physically and psychologically) from their working environment.

Figure 46 gives scores on the psychological detachment scale for those who spend 20 nights or fewer away from home due to work in the course of a year.

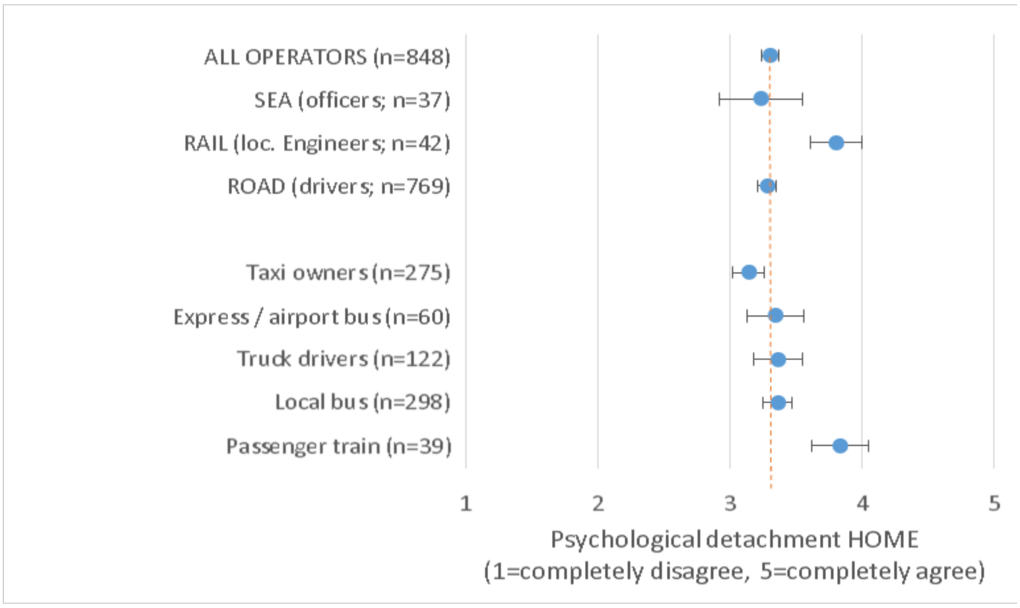


Figure 326. Psychological detachment outside work for those who spend 20 or fewer nights away from home due to work in the course of a year. Respondents were asked to rate on the 5-point scale their agreement with 5 items in response to the question "To what extent do you agree that the following applies for your free time at home." e.g. "I don't think about work at all", "I get a break from the demands of work". Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

We see that statistically, detachment is greater for train operators than for professional drivers working in road transport. These are mostly cargo train operators since only three cargo train operators spent 20 or fewer nights at home. So few of the sea officers sleep at home for most of the year that it is hard to draw conclusions about them.

Figure 47 gives corresponding scores on detachment while sleeping away from home, for those who report working away from home over 20 nights a year.

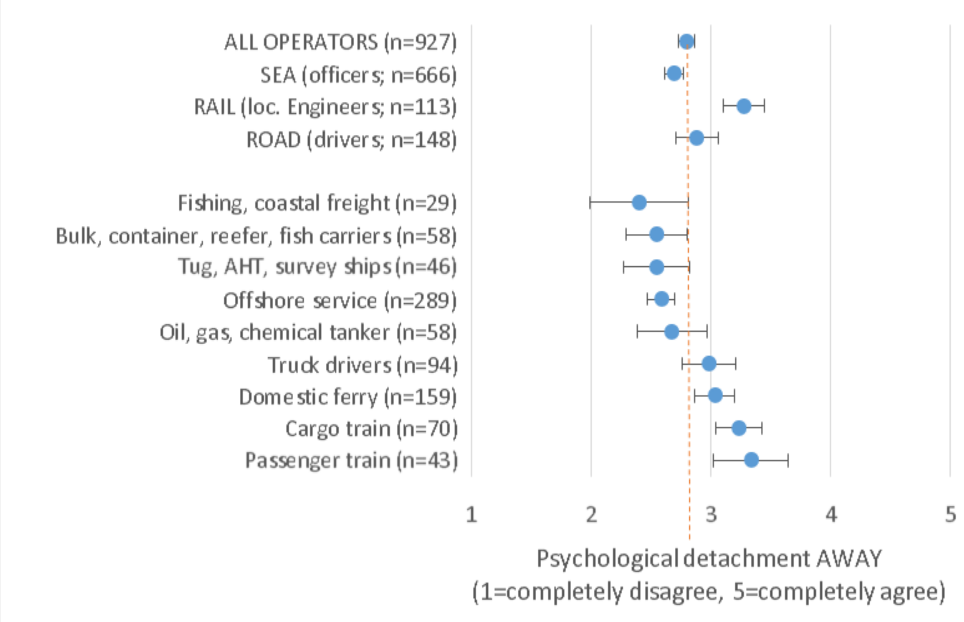


Figure 337. Psychological detachment outside work for those who spend 20 or more nights away from home due to work in the course of a year. Respondents were asked to rate on the 5-point scale indicated their agreement with 5 items in response to the question "To what extent do you agree that the following applies for your free time when you are away from home." e.g. "I don't think about work at all", "I get a break from the demands of work". Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

Scores are lower, such that there is disagreement on average that they are able to detach (i.e. scores < 3). In particular, detachment scores for passenger train operators for their free time away from home are statistically lower than corresponding detachment for free time at home. However, both cargo and passenger train operators still tend to agree that they can detach from work, even when they sleep away from home. Perhaps not surprisingly, officers in most sea transport branches report poorer detachment in free time outside work than those in rail and road sectors, who are at least able to get away from work during free time.

4.3.3 Work-home interference

Recovery from work can also be disrupted if there is extensive interference between work and life outside work. Work can interfere with things one needs or wants to do outside work – activities which may help one recover from work. Life outside work can also interfere with the job. Social activities can limit sleep opportunities, or major life events can cause distraction at work. When work is unpredictable and irregular, this two-way work-home interference can be expected to increase. Figure 48 gives work-home interference scores.

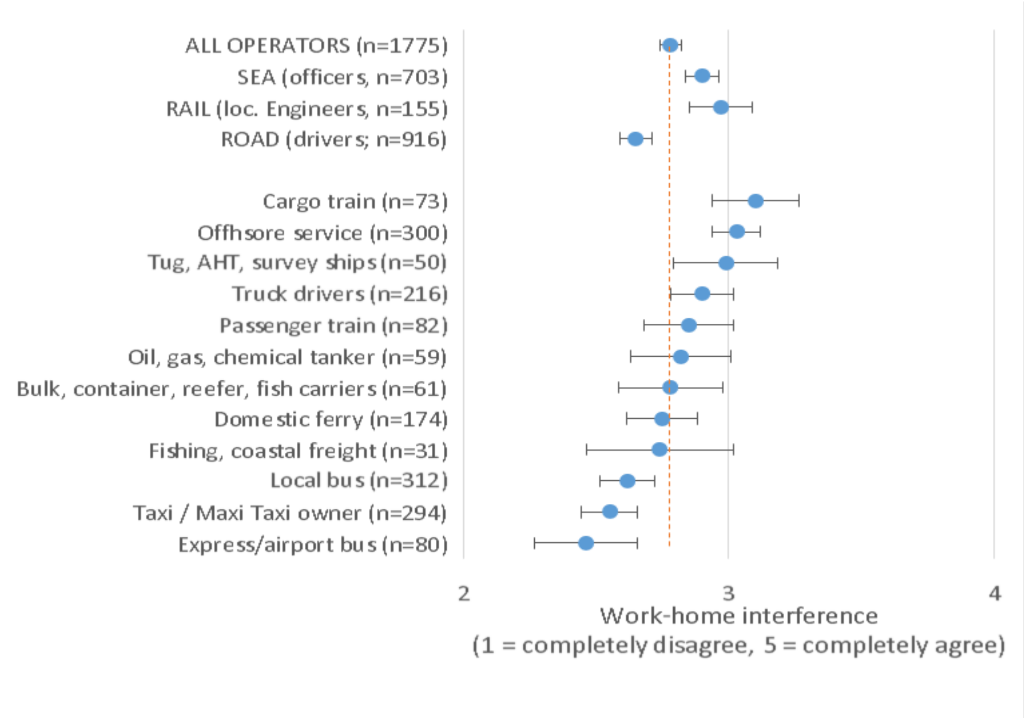


Figure 348. Work-home interference. Respondents were asked to rate on the 5-point scale indicated, their agreement with 5 items in response to the question "To what extent do you agree with the following statements?" e.g. "Life outside work can be so hectic that it can affect how much I can concentrate at work." Or "My work prevents me spending time with other people." Average scores for each sector or branch are given. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

Overall there is a tendency for operators to slightly disagree with items suggesting interference between work and home (indicated by average scores of less than 3). Rail and sea operators, most of whom work shifts and watches, report the highest degree of work-home interference. There is a tendency for cargo train operators to agree more than passenger train operators that there is interference between work and home.

4.4 Symptoms of fatigue (FRT Hazard Level 3)

Fatigue symptoms will result where there is exposure to fatiguing work with insufficient recovery. As discussed, fatigue manifests itself in several ways, all of which may be important in terms of operator health and safety. There may be sleepiness or cognitive exhaustion, which may be acute, such that caused by a one-off restricted sleep, or more chronic, such as the sort of fatigue conceptualised by burnout. In this section we use the following scales to measure the main different aspects of fatigue that work may cause:

- Epworth Sleepiness Scale (ESS) to measure **general sleepiness** which has become generalised in everyday life situations (no time scale).

- A shortened version of the Checklist Individual Strength (CIS) scale is used to measure **recent fatigue severity** and **concentration fatigue** over the preceding two weeks.
- The Oldenburg Burnout Inventory (OLBI) is used to measure **burnout** levels over the preceding three months.
- The Karolinska Sleepiness Scale (KSS) and the Samn Perelli index are used to measure **sleepiness** and **fatigue over a preceding shift**.

4.4.1 General sleepiness and fatigue

General sleepiness (ESS)

ESS results are reported as the average score for a group of respondents. The percentage of respondents with an ESS score above ten is also reported as a measure of excessive daytime sleepiness (EDS).

Figure 49 gives the ESS scores for different transport operator groups.

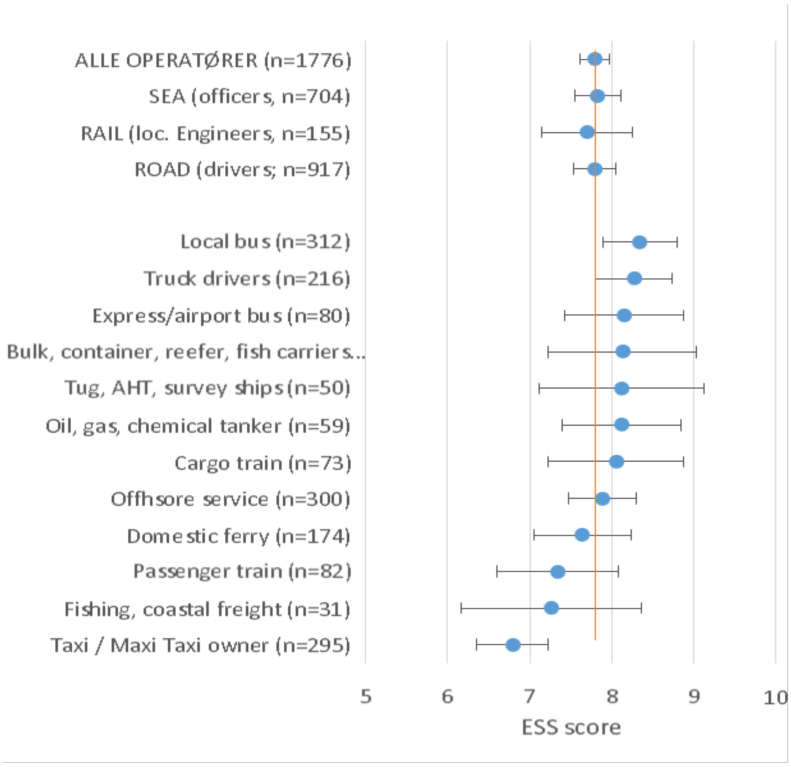


Figure 359. ESS scores. Respondents are asked "How likely are you to doze off or fall asleep in the following situations, in contrast to just feeling tired?". There are eight situations such as watching television, reading or sitting and talking with somebody. The response scale is 1 = would never doze off / sleep, 2 = little chance of dozing / sleeping, 3 = moderate chance, 4 = large chance. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

ESS scores vary widely within each operator group (i.e. at the individual level) such that we cannot say whether most average scores differ statistically by branch. Average ESS scores are statistically higher for bus and truck drivers and officers working in offshore service, than they are for taxi-owner drivers.

Figure 50 gives the share of respondents in different groups with excessive daytime sleepiness (EDS). Shares with EDS in each sector are similar overall, with large variation among branches.

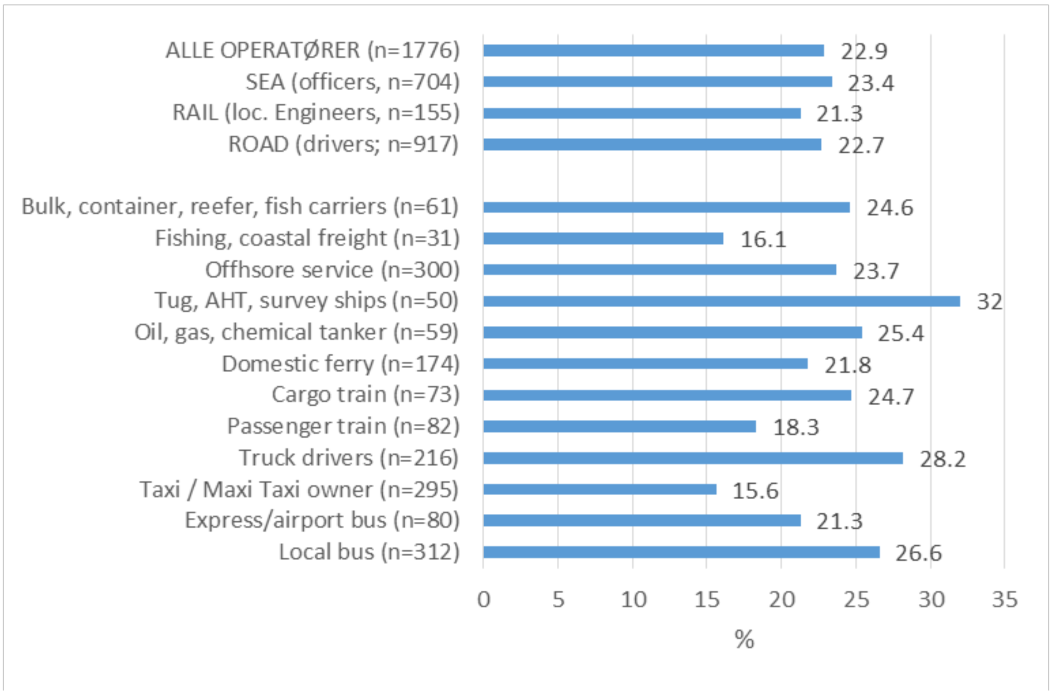
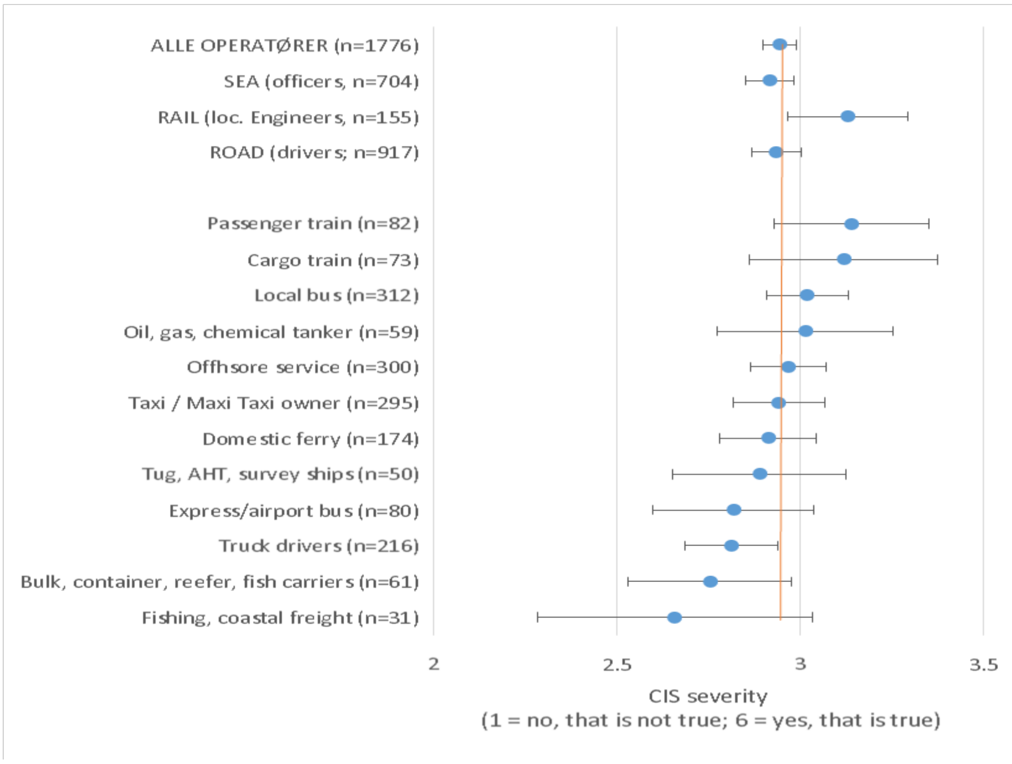


Figure 50. Shares of different operator groups reporting excessive daytime sleepiness (EDS), i.e. ESS scores over ten. Per cent.

Recent fatigue severity and concentration fatigue (CIS)

Work can cause operators to be exhausted without feeling sleepy. Therefore we measured aspects of fatigue other than sleepiness, using a shortened version of the CIS, which asks respondents about their experiences over the preceding two weeks. We measured the severity of fatigue experienced by operators (CIS severity; figure 51), as well as aspects of fatigue related to concentration (CIS concentration; figure 51).



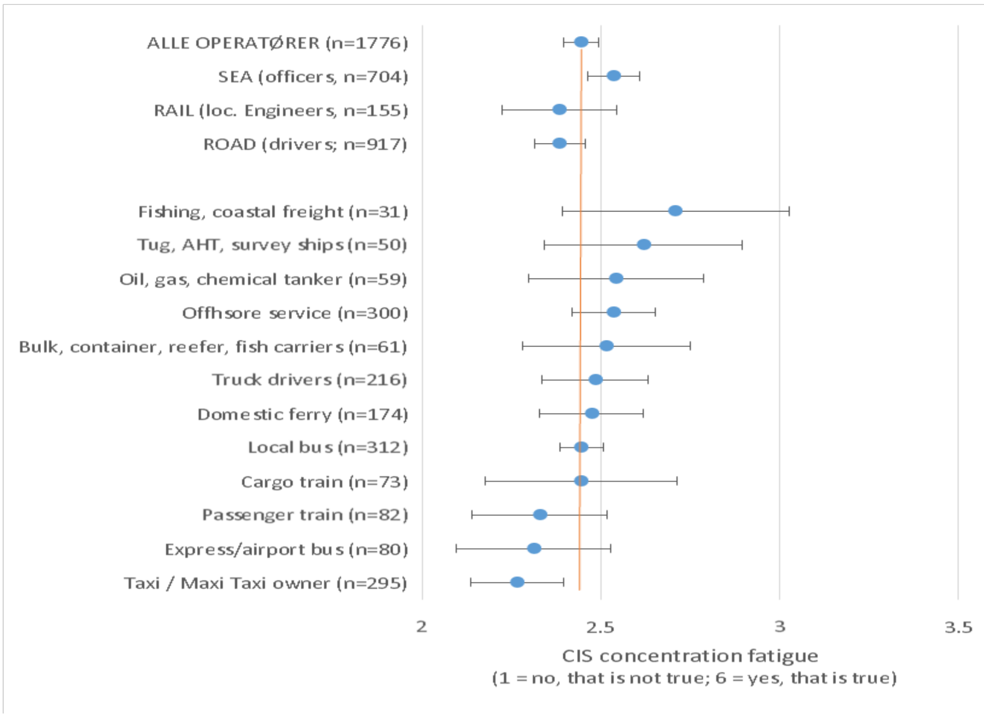


Figure 51. CIS scores. Respondents indicated on a 6-point scale (from 1 = yes, that is true to 6 = no, that is not true) about how they felt over the preceding two weeks. We used five items to measure CIS severity e.g. "I feel fit", "I get tired easily", taking the average score on the five items. We used two items to measure fatigue related to concentration e.g. "It takes a lot of effort to concentrate on things", taking the average response on the two items. Some items were reverse coded. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

The severity of general fatigue experienced over the two weeks preceding the survey varies widely among individuals, such that there are few statistical differences among the branches. There are also no statistical difference between sectors, but average scores for rail operators are notably high. The results are somewhat different for concentration fatigue (figure 49), supporting the notion that different operators experience different aspects of fatigue. Sea officers score statistically higher on concentration fatigue than road operators. This difference is primarily due to the relatively lower scores of bus drivers and taxi driver-owners.

Burnout (OLBI)

Scores on two main dimensions of burnout, exhaustion and disengagement from the job, are given in figure 52.

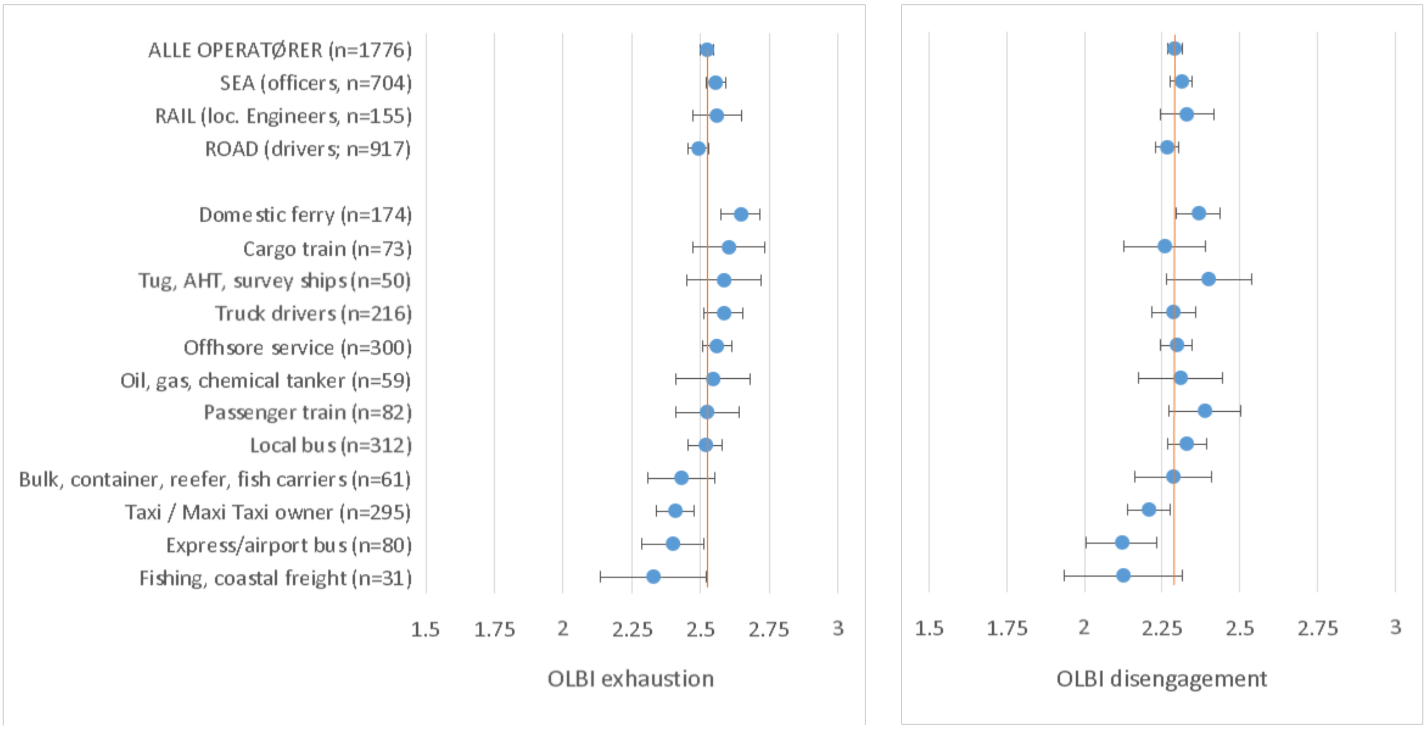


Figure 362. Scores on OBLI burnout scale. Respondents were asked to indicate on a 4-point scale agreement (1=strongly disagree; 4 = strongly agree) with 16 items, 8 measuring exhaustion ("There are days when I feel tired before I start work" or "After work, I tend to need more time than in the past in order to relax and feel better"); and 8 measuring disengagement (e.g. "It happens more and more often that I talk about my work in a negative way" or "Over time, one can become disconnected from this type of work"). Some items reverse coded. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

There are few statistical differences in burnout scores, either among sectors or branches, but domestic ferry officers are statistically more exhausted than operators in several other branches.

4.4.2 Sleepiness and fatigue on previous shift

To get an idea about the degree of sleepiness and fatigue experienced before, during and after a period of work, we asked respondents in the second survey to answer items on sleepiness and fatigue in relation to their last work period, as soon as possible after work. Figure 53 groups work periods assessed according to their starting times.

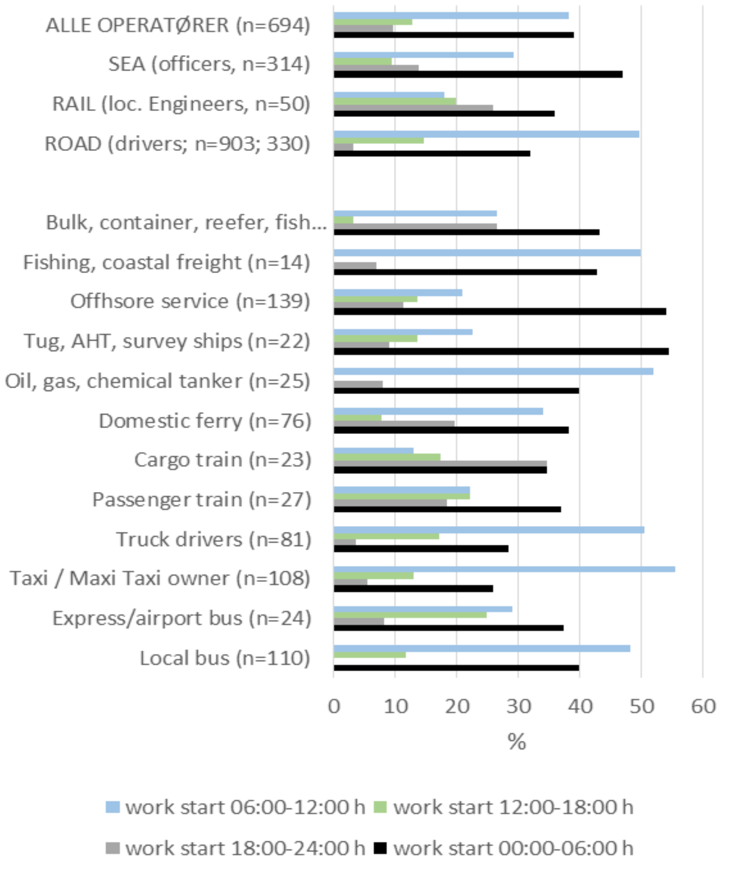


Figure 373. Share of work periods assessed for sleepiness fatigue by operators in different sectors and branches, according to time of day at which work period starts. Per cent.

Most assessed periods are those beginning in the early hours of the morning (between 0:00 and 6:00 h) or in the day, before noon. Note that cargo train operators responded mostly on shifts beginning in the evening or night.

To help interpret the results below on sleepiness and fatigue for a given work period, it is also useful to look at the reported lengths of the work periods assessed (for operating and other work) versus average working hours reported for the last three months (figure 37).

Figure 54 shows that for rail and road operators, the work hours for the periods assessed are similar to the number of hours worked in a typical 24-hour period on a working day for the three months preceding the survey.

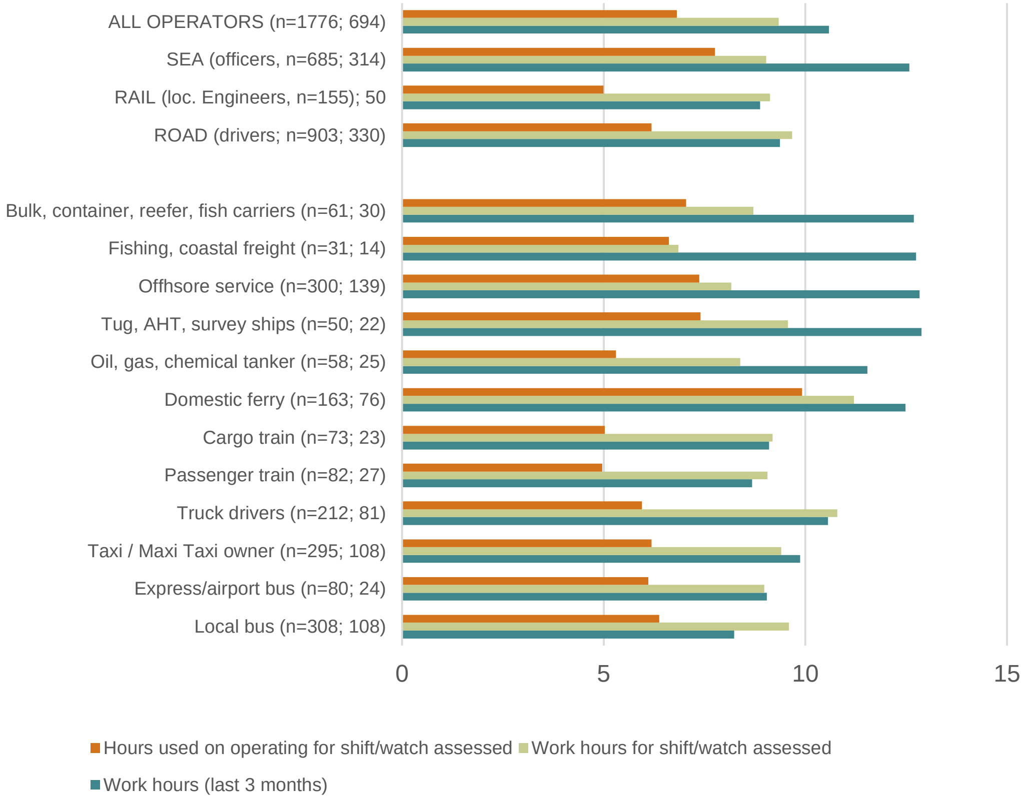


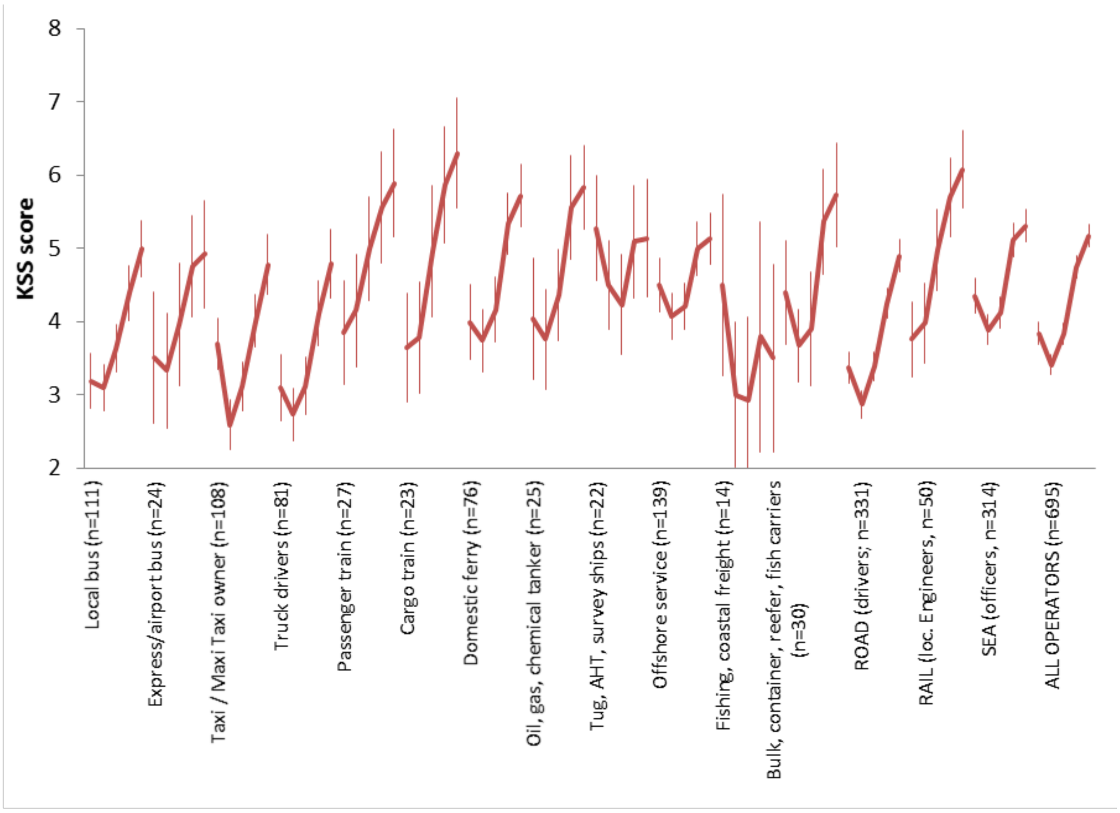
Figure 384. A comparison of work hours reported for an average work period over the last three months in the first survey wave, with work and operating hours reported for a shift worked by the same respondents ca. one month later. Per cent.

This supports the reliability of the answers given in the surveys, and suggests that the periods assessed for fatigue are representative, at least in terms of working and operating hours.

The lengths of the work periods assessed by seafarers is much lower than those reported for an average 24-hour period on a working day for the three months preceding the survey. This confirms that the many seafarers, who will have worked in two or more bouts within a 24-hour period, are reporting fatigue for only one of their work periods, as they were asked to do.

Sleepiness (KSS)

Figure 55 shows KSS scores for different operator groups before, during and after their most recent operating period. The first thing to note is that there is a distinct pattern, where sleepiness increases slightly from the first hour to the middle hour of driving or watch, with a greater increase towards the final hour. Sleepiness among rail operators seems to increase more from the first to the middle hour of operating than it does for other types of operator. All operators are most sleepy after operating.



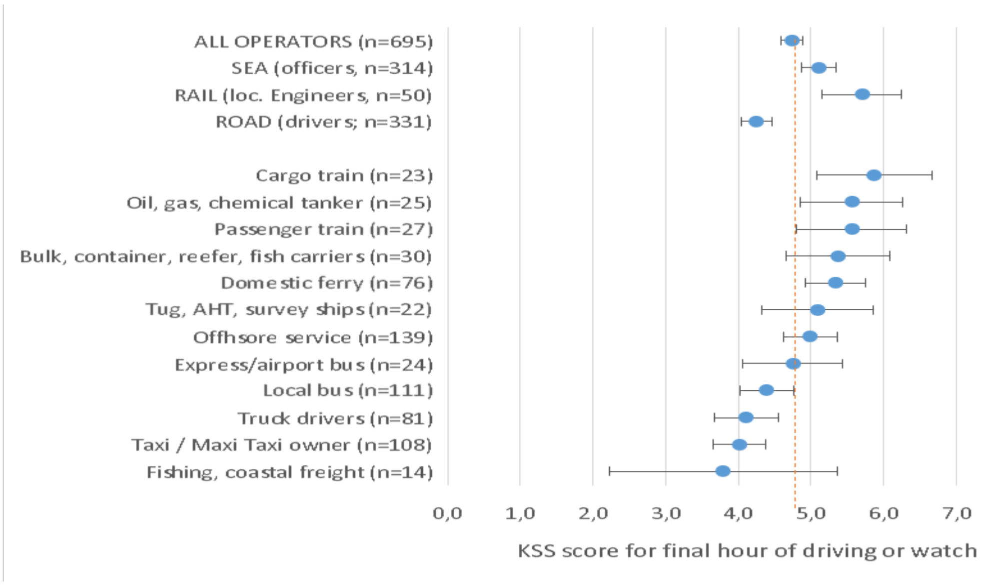


Figure 395. Top graph gives KSS scores across a recently completed operating period and the bottom graph ranks scores for the final hour of the same period. Respondents were asked to indicate on the scale how they felt "before", during the "first hour", "middle hour" and "last hour", and "after" their operating period. The KSS curve for each group is constructed from group average KSS scores on these five time points, respectively. We asked seafarers how they felt before, during and after their watch, and road and rail operators about how they felt before they began driving, and during and after their driving. Response scale ranges from 1 to 9, where 1 = extremely alert, 3 = alert, 5 = neither alert nor sleepy, 7 = sleepy but no effort to stay awake, 9 = very sleepy, great effort to stay awake, fighting sleep. With 95 per cent confidence intervals.

We have ranked KSS scores for the final hour in figure 54.

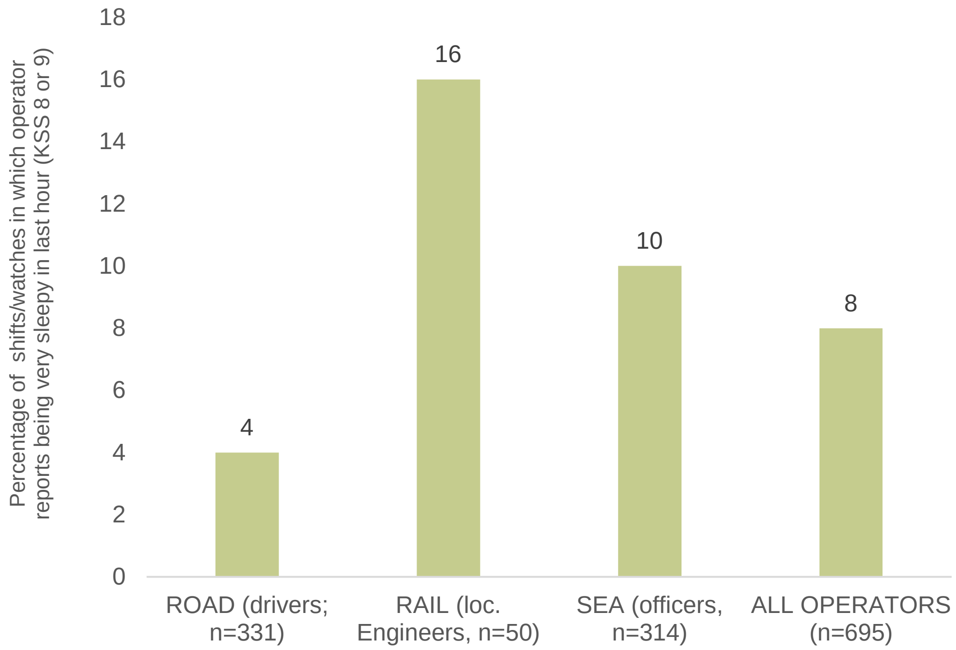


Figure 406. Percentage of respondents scoring KSS 8 or 9 for the last hour of operating. For explanation see figure 55. Per cent.

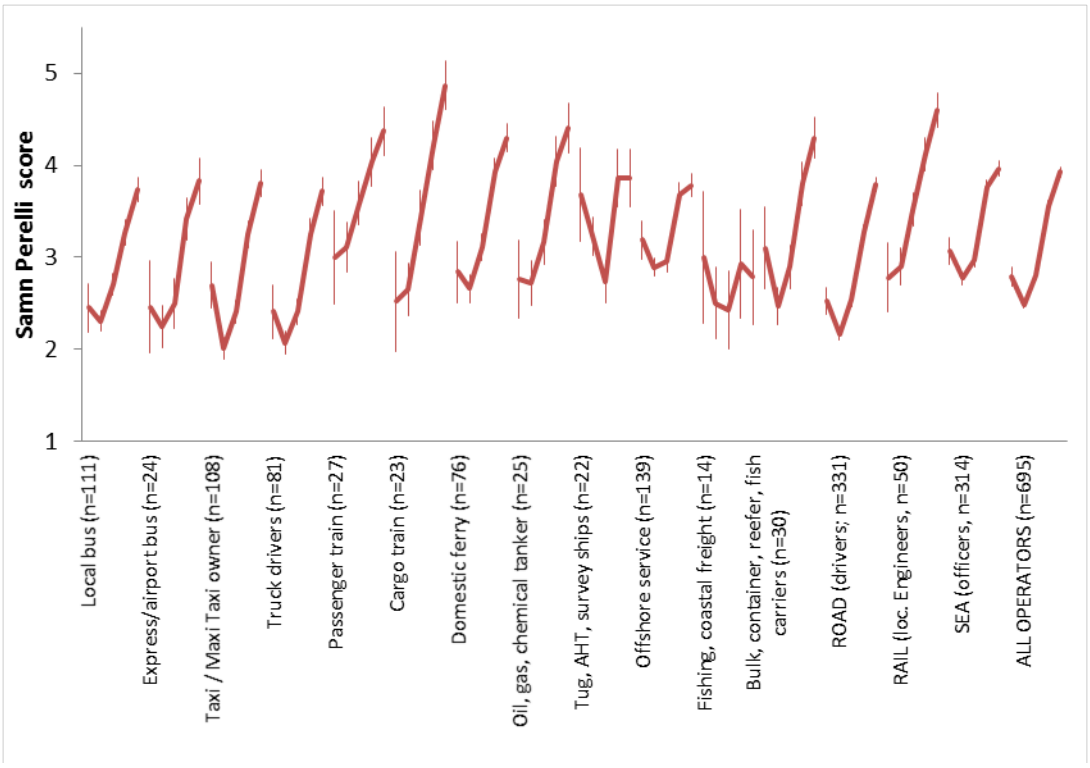
It is clear that rail operators and sea operators are statistically more sleepy than road operators during their final hour of operating. The percentage of operators reporting being sleepy in the final hour of their watch at a level that is indicative of microsleeps (KSS = 8 or 9) is given in figure 56.

Fatigue (Samn-Perelli)

Unlike the KSS scale, the Samn-Perelli measure asks operators to rate their fatigue on a scale describing tiredness as a more slightly more generalised feeling than sleepiness. Whereas the KSS scale asks respondents to rate themselves on a scale ranging from alertness to sleepiness, the Samn-Perelli scale ranges from alertness to more general tiredness (compare figure 3 and figure 4).

Figure 57 shows Samn-Perelli scores for different operator groups, again before, during and after their most recent operating period. Again, there is a distinct pattern where tiredness increases slightly from the first hour to the middle hour of driving or watch, with a greater increase towards the final hour. Again, tiredness among rail operators seems to increase more over the course of an operating period than it does for other types of operator.

The ranked scores for general fatigue for the final hour of operating, given in figure 57 show similar patterns to the ranked scores for sleepiness.



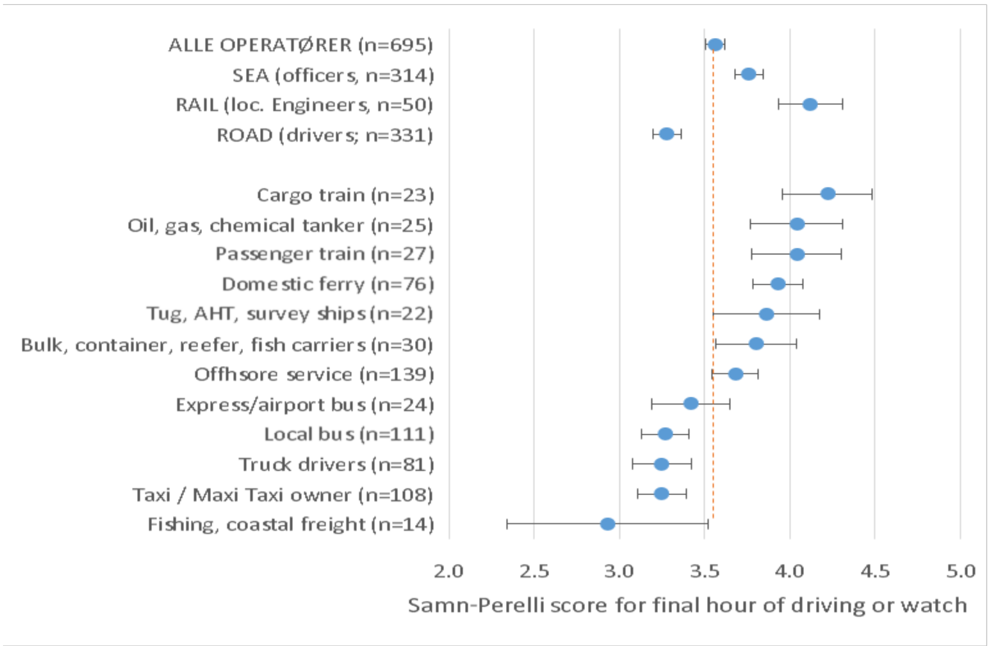


Figure 417. Samn-Perelli scores for recently completed operating period. Respondents were asked to indicate on the scale how they felt "before", during the "first hour", "middle hour" and "last hour", and after their operating period. We asked seafarers how they felt before, during and after their watch, and road and rail operators about how they felt before they began driving, and during and after their driving. Response scale ranges from 1 to 7, where 1 = Fully alert; wide awake; extremely peppy, 2 = Very lively; responsive; but not at peak; 3 = Okay; somewhat fresh; 4 = A little tired; less than fresh; 5 = Moderately tired; let down; 6 = Extremely tired; very difficult to concentrate; 7 = Completely exhausted, unable to function effectively; ready to drop. With 95 per cent confidence intervals.

Dimensions of fatigue following work (SOFI)

The Swedish Occupational Fatigue Index is one of the most validated scales for occupational fatigue, and has shown to be able to distinguish between different dimensions of fatigue for different professions: lack of energy, physical exhaustion, physical discomfort, lack of motivation and sleepiness. There were some differences for the transport operators in our survey, on comparative scores for different dimensions of fatigue (figure 58).

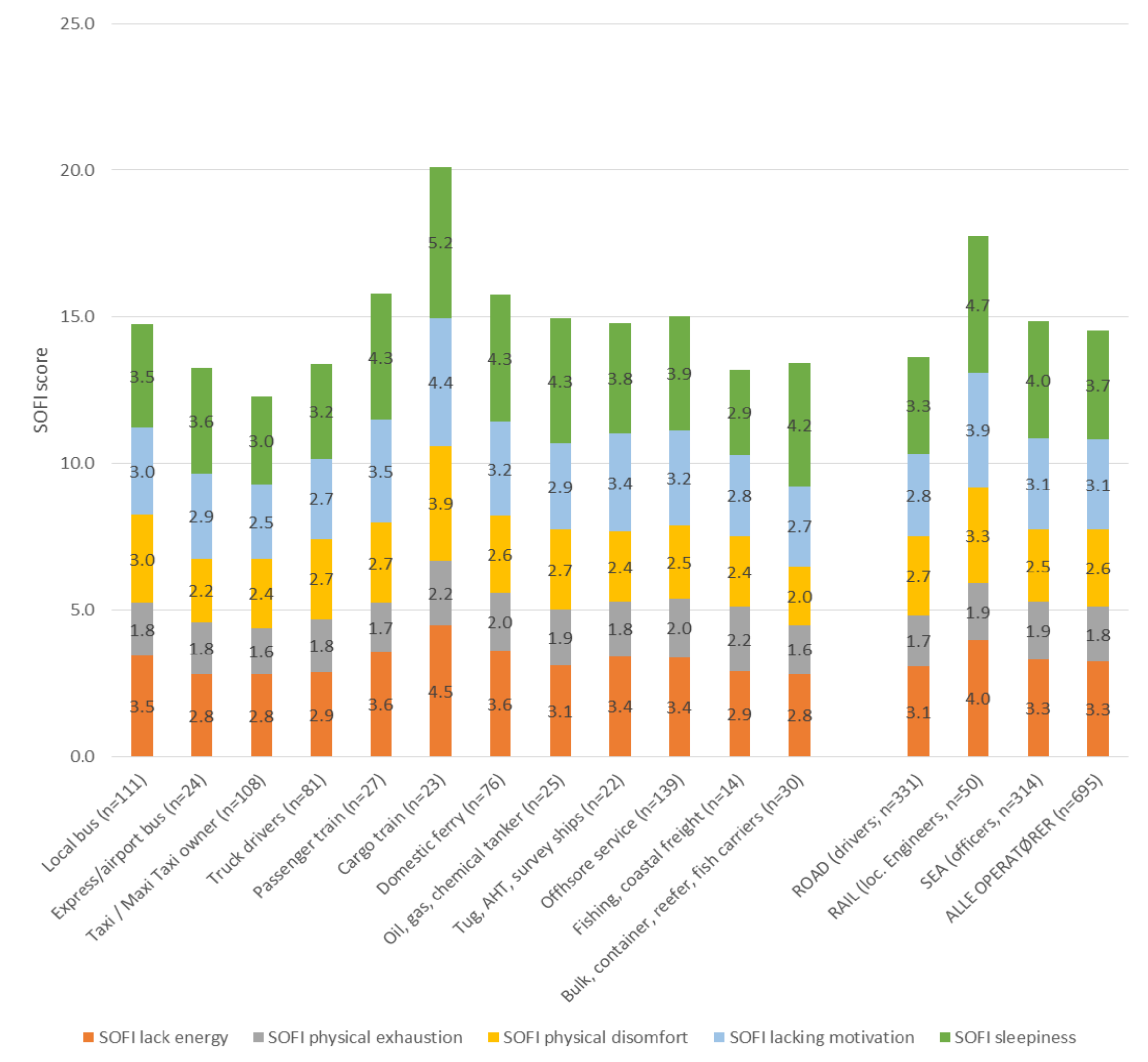


Figure 428. Scores on dimensions of the Swedish Occupational Fatigue Index (SOFI). Respondents were asked "How much do you think that the statements below describe how you felt after your work?", and given 25 items, each with a response scale ranging from 1 = not at all to 10 = to a very large degree. There were five items for each SOFI dimension. See Appendix for dimensions. The average response for the five items formed the basis of each dimension score.

Physical exhaustion was not the main problem. Scores were consistently and in some cases statistically higher for cargo train operators than several other operator groups in the sample. In terms of sleepiness, both rail and sea operators again scored statistically higher than operators in the road sector.

4.5 Fatigue-related errors (FRT Hazard Level 4)

Due to the wide range of operator functions and related tasks, we did not assess specific behavioural errors that may have been due to fatigue. Rather, we use incidents of sleeping while operating as a proxy of fatigue-related errors. Figure 59 gives prevalence rates of sleeping while operating for different types of operator.

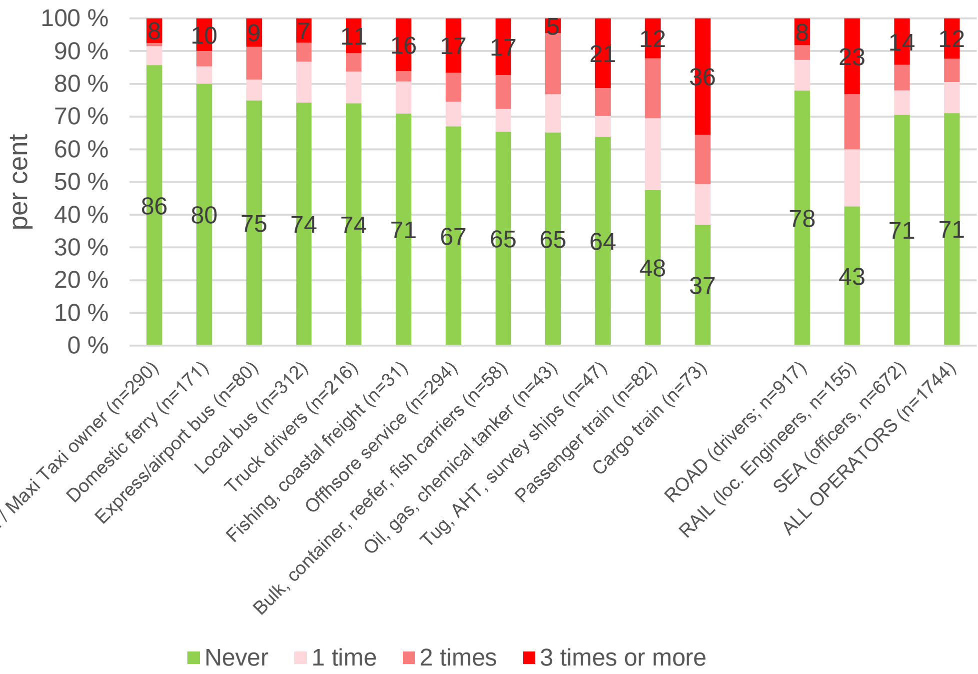


Figure 439. Operator response to "During the last 3 months, how many times have you slept (or dropped off for a moment) while you were driving at work / on watch?" Per cent.

The proportion of train operators who report nodding off while operating is highest, with 52 per cent of passenger train drivers and 63 per cent of cargo train drivers reporting doing so at least once in the three months preceding the survey. In sea transport, there seems to be a tendency for higher shares of officers working in branches more associated with monotonous conditions to report nodding off while on watch. While 35 per cent of tanker officers reported nodding off, "only" 20 per cent of ferry officers reported doing so. The consequences of nodding off while driving a heavy road vehicle are more likely to be severe, and this may in part explain why the share of road operators reporting that they nod off while operating is less than the corresponding shares for rail and sea operators. Nevertheless, 22 percent of all road operators said they had nodded off in the preceding three months, which is high given the potential consequences. In particular, the levels of heavy vehicle drivers (bus and truck drivers) reporting that they nodded off while driving at least once during the three months preceding the survey are actually higher, because of the relatively low share of taxi owner-drivers reporting doing so. One in ten truck drivers report nodding off at least three times during the preceding three months.

4.6 Fatigue-related outcomes (FRT Hazard Level 5)

Due to difficulties in comparing different types of transport accident, as well as the problems associated with assigning fatigue as cause, the survey did not assess fatigue related incidents or accidents. We did ask about the prevalence rates of different types of incident and accident (with any cause), so that we might analyse links to fatigue in future analyses.

Chronic fatigue outcomes may be indicated in **general health ratings**, in particular **musculoskeletal pain**, as well as **sickness absence** and **presenteeism**. As figure 60 indicates, there were few significant differences in health ratings among branches, although professional drivers of road vehicles report worse health than sea or rail operators overall.

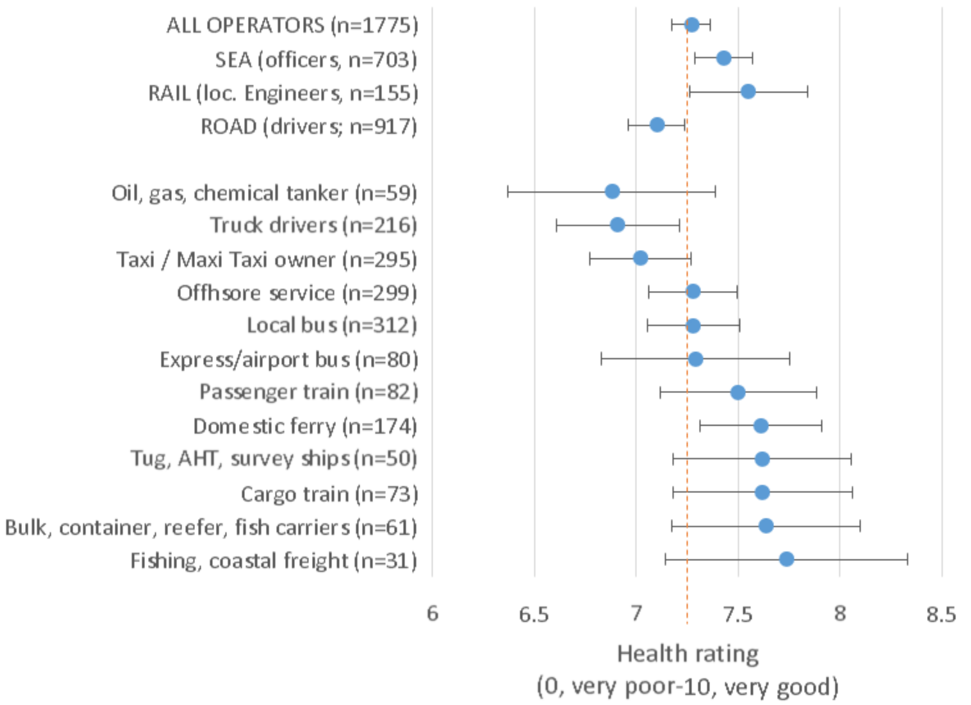


Figure 60. Health ratings of operators in response to "How would you assess your general health over the last 3 months?". Operators responded using a 11-point scale. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

Truck drivers and taxi owners in particular report relatively poor health.

Prevalence of muscular pain is also greatest for truck drivers and taxi owner-drivers, although high shares of bus drivers and cargo train operators also report muscular problems (figure 61).

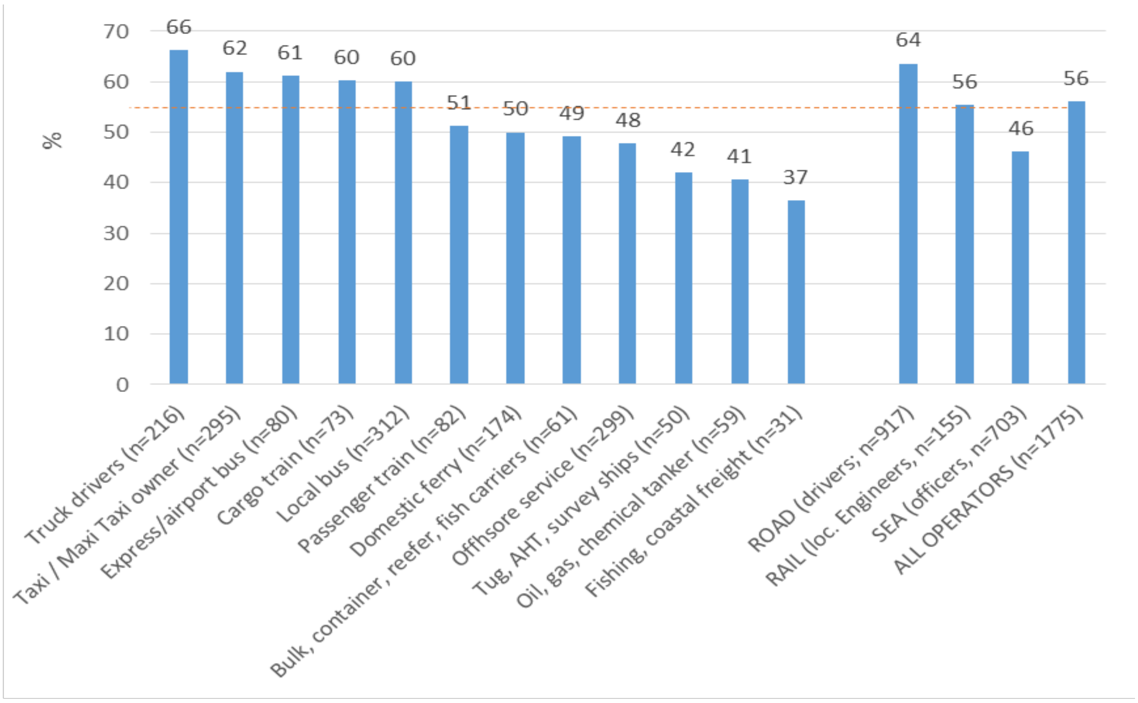


Figure 61 Shares of operators responding yes to the question "Do you suffer from muscular pains?" (over the last 3 months). Per cent.

There is a wide variation in the number of sickness absence days (figure 62), but here again prevalence appears to be high in the road sector (at least compared with watch officers the maritime sector), and especially so for truck, bus and taxi drivers.

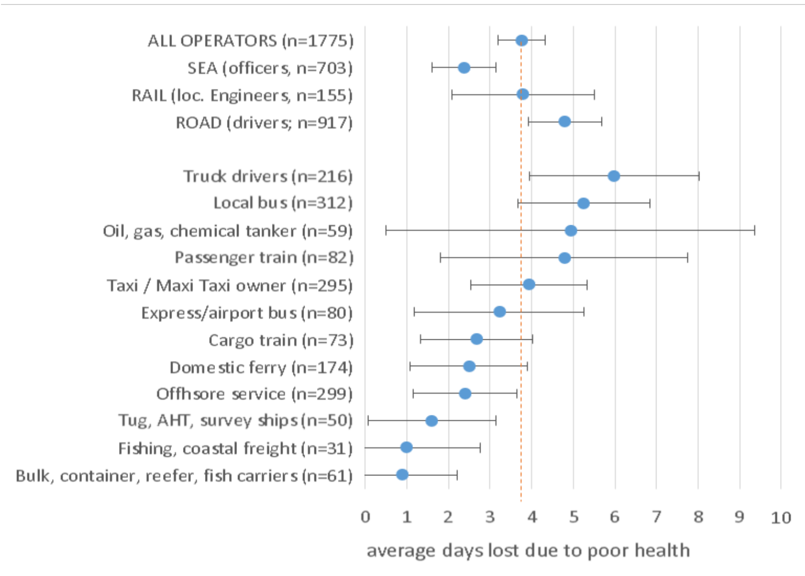


Figure 442. Days lost due to poor health over the three months prior to the survey. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

Levels of presenteeism (defined here as being at work when you are not performing well) are also higher in the road than in the rail and maritime sectors, although in this case taxi drivers, and to a limited extent truck drivers, are mainly responsible (Figure 63).

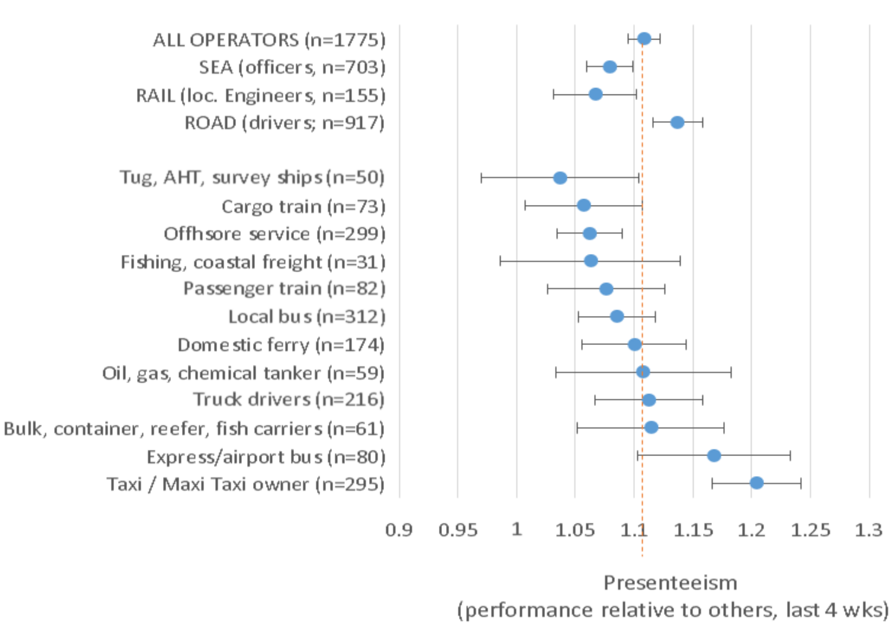


Figure 453. Operator presenteeism, i.e. being at work even though you are not performing well. A lower score indicates higher presenteeism. Respondent ratings of the usual performance for most people in their sort of job (10-point scale where 1 = worst and 10 = best) was divided by ratings of their performance over the last 4 weeks, using the same scale. Means with 95 per cent confidence intervals. Dotted line is mean for all operators.

5 Summary and discussion by transport sector

It is widely agreed that fatigue is one of the main safety threats to safe human operation of transport forms in the road, rail and maritime sectors. Despite this we know relatively little about fatigue in human operators in Norway. This report helps address this issue by surveying the fatigue risks for truck, bus and taxi owner-drivers, train operators and maritime watch officers based in Norway. We have profiled the risks at each of the hazard levels described by Dawson and McCulloch´s (2005) Fatigue Risk Trajectory (FRT), after first expanding the FRT to account for our broader operationalisation of fatigue.

According to the expanded FRT, risk factors for fatigue-related accidents should be monitored at six main hazard levels:
0. Framework conditions and fatigue-awareness culture.
1. Work characterstics (expanded from sleep opportunity).
2. Recovery from work (expanded from sleep).
3. Fatigue-related symptoms.
4. Fatigue-related errors.
5. Fatigue-related accidents / incidents.

In our risk profiling, we have concentrated on the first four of the above hazard levels. Risks at these levels should arguably be tackled first to prevent ensuing errors and accidents. It is also easier to assess these risks using self-reported surveys.

Because the risk factors that we profile are structured using a risk trajectory, they indicate which risk levels managers of different types of operator should be most concerned about as part of a fatigue risk management system.

In this discussion we wish to summarise the main challenges for different types of operator. In profiling the risks, it has not been our intention to account for the interactions among the various risk factors that undoubtedly exist, nor assess the relative influence of each risk factor on fatigue or fatigue-related risks. Rather, our aim has been to profile risks using standard, validated measures, using survey tools that managers can also use, in order to compare the main challenges for different types of operator in Norway.

5.1 Train operators

5.1.1 Sample characteristics

We surveyed 155 train operators, comprising a ca. 50:50 mix of goods and passenger train operators, from each of the main train companies in Norway. Passenger train operators from Norway´s main operating company are underrepresented in the sample relative to the national population of train drivers. Each region of Norway is well represented, though more of the operators are based in Eastern Norway where there is a greater density of population and associated rail infrastructure. Nine out of ten of the train operators are under 50 years of age, but are experienced nevertheless. 78 per cent of the cargo train operators in the sample are overweight, compared with 62 per cent of the passenger train operators. Since increasing BMI is positively associated with risk for a sleeping disorder, being overweight may affect the extent to which some train operators can recover from work.

5.1.2 Framework conditions and fatigue-awareness culture (FRT Hazard Level O: base level risks)

One in ten train operators report that they often have to drive even when they feel too exhausted to do so. This share is low relative to corresponding shares in some road and maritime branches. However, when they are too exhausted to operate, less than half of the train operators reported that they tell anyone about it. As is the case for other operators, rail operators are more likely to tell, first, colleagues and, second, friends and family if they are too exhausted to operate. Twice as many passenger than cargo train operators report that they tell their line manager or operative centre when they are too exhausted to work. Surprisingly, rail operators also score lower than some maritime branches on items assessing whether there is a culture of fatigue awareness at work. They also agree less that drivers overall understand and are aware of fatigue as a safety issue. Among all the operators we surveyed, cargo train operators agree to a clearly lesser extent that their line managers and their employers consider fatigue as a serious risk factor.

Rail operators do agree, however, that framework conditions are positive, in terms of working time violations and pay for hours worked.

5.1.3 Work characteristics (FRT Hazard Level 1)

Which aspects of work are fatiguing?

Job content

Relative to other operators, train operators report less time spent on secondary tasks. Lack of task variety may mean that they are more prone to the fatigue risks inherent in the main sustained vigilance task, which they perform for six and a half out of nine of the hours they typically spend at work.

Workload and job demands

While cargo train operators report higher physical load than passenger train operators, physical load is low compared to mental demands, which are higher than for both types of train operator than for professional drivers of road transport forms. These mental demands probably come from having to conduct a sustained vigilance task for most of the working day. Even though overall mental demand is high, train operators report that cognitive job demands are relatively low. This is not inconsistent with a main challenge from sustained vigilance, since items on cognitive job demands tend more to assess interruptions and the need to carry out simultaneous tasks. Time pressure is reported as high (for both cargo and passenger train operators) relative to operators in other sectors, although operators still rate performance as good, and there is little evidence that safety is compromised by competing goals. These findings may be consistent with an emphasis on safety in the rail sector, i.e. train operators may tend more to consider safety performance over punctuality when assessing their overall performance at work.

Job resources

Relative to operators in the road and maritime sectors, train operators report that they have little say in how their work is done (decision latitude is relatively low). Support from line managers reported by cargo is the lowest of all transport branches, but colleague support is rated quite highly.

Physical work environment

Relative to other operators (even maritime officers), cargo train operators report high levels of discomfort at work from noise and vibrations, while both passenger and cargo operators report that air quality and temperature conditions are worse than those reported by operators in several other branches. Furthermore, 37 per cent of train operators report that operating position is a frequent source of discomfort for them. Poor operating position and other sources of discomfort in the physical work environment may, together with the need for sustained vigilance throughout most of the day, be linked to the fact that 60 per cent of cargo operators report musculoskeletal problems, even though most are under 50 years old.

Work timing

Compared with other operators, train operators work the least number of hours. None of the passenger train operators and only three per cent of the cargo train operators worked more than five days a week on average, and many report working only four days a week. Train operators work about nine hours a day, which is comparable to most other land-based transport operators.

Although the quantity of work is relatively low, work may be particularly fatiguing in the way it prevents a regular sleep of sufficient quantity and quality. Almost all train operators reported working irregular hours. Train operators also report working shifts that are known to be fatiguing relatively often. 56 per cent of passenger train operators work early shifts (starting between 02:00 and 06:00 h) while 80 per cent of cargo operators work nightshifts, at least once a week. About 40 per cent of all train operators also report working backwardly rotating shifts at least once a week. This latter result is surprising given what we know about scheduling practices in the rail sector, and the reasons why drivers answered as they did may need to be investigated further[8]. Nevertheless, irregular work hours coupled with a high degree of problematic shift types, suggests that some train operators may be exposed to potentially high levels of acute sleepiness at work. Where lack of recovery is sustained over the longer term, there may also be accumulative effects of the way work is timed.

5.1.4 Recovery from work (FRT Hazard Level 2)

How much sleep do train operators get?

Relative to other operators, cargo and passenger train operators get fairly average amounts of sleep, reporting at least one hour of sleep debt on work days. Around eight per cent of cargo and passenger train operators reported getting less than 5 h of sleep in the 24 h preceding their last operating period, and 12 per cent reported

[8] One possible explanation is the extent to which drivers swap shifts with colleagues at late notice, i.e. planned schedules often differ from actual hours worked.

getting less than 12 h of sleep in the 48 h preceding their last operating period. Based on standard threshold values, this suggests that one in ten train operators may be getting insufficient sleep in terms of the acute sleepiness that may be caused at work the next day.

How do train operators sleep?

Higher shares of cargo than passenger train operators report sleeping in two or more bouts (75 per cent vs. 43 per cent) and sleeping away from home (over 90 per cent of cargo vs. 25 per cent of passenger train operators report that it is normal for them to sleep in a hotel when working). Despite these differences, both cargo and passenger train operators report that sleep quality is relatively poor.

Other aspects of recovery

Train operators report that it is relatively easy for them to detach psychologically from work, i.e. they do not tend to think a lot about work when they are not at work. However, cargo operators report relatively high levels of interference between work and home. This may reflect the large amount of night work.

5.1.5 Fatigue symptoms (FRT Hazard Level 3)

It is clear from operator ratings of sleepiness and fatigue across a preceding operating period, that of the different operators we surveyed, train operators experienced the highest levels of sleepiness and fatigue before, during and after operating. As much as 16 per cent of rail operators experienced sleepiness during the last hour of operation at levels that are associated with microsleeps. There was also a tendency for cargo operators to report higher levels of acute sleepiness and fatigue than passenger operators. Cargo operators also scored highly on fatigue after work, assessed using the SOFI. According to cargo operator responses on the SOFI, general levels of energy and motivation were low after work, and sleepiness and physical discomfort were high. Relative to other operators, general energy levels and motivation were also low for passenger operators, and sleepiness was high. Such high levels of acute fatigue while operating may be explained by the high share of periods assessed by train operators starting between 18:00 h and 06:00 h, but we should bear in mind that some of the other risk factors highlighted at Levels 0, 1 and 2 of the FRT may also play a part.

According to responses on fatigue severity over the last two weeks, which were also high for train operators relative to other operators, there are some signs that acute fatigue experienced at work generalises to life beyond work. There were however no indications that train operators are generally more sleepy across general life situations than other operators are. Despite this, one in four cargo train operators reported excessive daytime sleepiness (ESS > 10). Given their relatively young age, this may be worthy of attention.

5.1.6 Fatigue errors (FRT Hazard Level 4)

In this report we do not assess errors due to different aspects of fatigue directly, in terms of operator behaviour. Instead we have used falling asleep or dropping off while operating as a proxy for sleepiness-related errors. Relative to other operators, train operators report the highest prevalence of falling asleep while operating, with 52 per cent of passenger and 63 per cent of cargo train operators reporting that they have slept or nodded off at least once while operating at work during the three months preceding the survey. Comparative rates for professional drivers of road transport forms and maritime officers are 22 per cent and 29 per cent, respectively. For some train operators, nodding off while operating may not be unusual, with 36 per cent of cargo train operators report nodding off while operating three times or more over a three month period.

5.1.7 Summary table

A summary of the risk profile for train operators is given in table 10.

Table 10. Fatigue risk profile for train operators.

Hazard Level	Description	Fatigue risk factors for train operators
4	Fatigue-related errors (proxy measure)	• 52 per cent of passenger and 63 per cent of cargo train operators report sleeping or nodding off at least once while operating during in the 3 months preceding the survey. • 36 per cent of cargo operators report doing this at least three times.
3	Fatigue symptoms	• Train operators report higher levels of fatigue and sleepiness for the final hour of operating than any other operator. • Average sleepiness for the last hour of operating is 5.7 on a 9-point scale (KSS). • 16 per cent report severe sleepiness (KSS 8 or 9) for the last hour of operating. • Fatigue symptoms are generally worse for cargo than passenger operators. • Fatigue after work is characterised by low energy, lack of motivation, and sleepiness. • Broader fatigue, but not sleepiness, may generalise to life beyond work. • One in four cargo operators reports excessive daytime sleepiness (ESS>10).
2	Recovery from work	• Train operators sleep for an average of 6.97 h on a work day, and have an average 1.23 h of sleep debt. • Eight per cent of road operators obtained less than 5 h sleep in the 24 h preceding their last operating period. • 14 per cent obtained less than 12 h sleep in the 48 h preceding their last operating period. • Sleep quality (rated at 12.96 out of 20) is poor relative to that of road operators (13.92 out of 20). • 75 per cent of cargo operators report that their main sleep is split into two bouts. • 90 per cent of cargo operators say that it is not unusual to sleep away from home while working. • Work-home interference is high for cargo operators.
1	Work characteristics	• Main challenge from sustained demand of vigilance task. • Little task variety or control over how work is done. • Relatively high levels of discomfort from physical work environment, especially in cargo branch. • The timing of work is more problematic than amount of work. • 56 per cent of passenger operators work early shifts at least once a week. • 80 per cent of cargo operators work nightshifts at least once a week. • Almost all work irregular hours.
0	Framework conditions and fatigue awareness culture	• Ten per cent often have to drive when too exhausted. • Less than half report when they feel too exhausted to operate. • Cargo operators are half as likely as passenger to inform line manager or operative centre. • Relative to other operators, fewer rail operators agree that drivers understand and are aware of fatigue. • Cargo operators agree less than any other operator in any other sector employers treat fatigue as a serious risk.

5.1.8 Why do more train operators sleep while operating?

Train drivers might be more likely to sleep or nod off because at a subconscious level, they know they can do so without little risk of safety implications, i.e. there are several safety barriers in place to prevent anything happening even when they do nod off, e.g. ATC, dead man´s lever. In other words, there may be some form of behavioural adaptation. While this may explain differences in sleeping or nodding off between drivers of rail and road transport, it doesn´t really explain why rail operators are more likely to nod off than maritime watch officers are. In other words, there is also little risk of anything happening when watch officers fall asleep, even when they are alone on the bridge, because they will usually have more time to recover and many also have safety barriers in place (e.g. Bridge Watch Alarm System, colleagues on the bridge).

An alternative explanation we should consider is that rail operators may feel that they could report more openly in our survey the extent to which they nod off while operating, i.e. because they may be more aware of fatigue as an issue, they may be more likely to remember when they do nod off. This is an important possibility because it suggests that the responses of rail operators may merely reflect a more positive safety culture. Indeed, there is some support for this idea. The recent Horizon project would suggest that maritime watch officers fall asleep far more often than has been reported here, and our recent round of interviews with representatives of different actors in the rail and maritime sector suggested that the safety culture pertaining to fatigue was overall more positive in the rail than in the maritime sector. On the other hand, some of our quantitative findings do not support these qualitative findings. In particular, there are low levels of agreement among cargo operators that their employers are concerned about fatigue.

Of course, higher levels of sleepiness and fatigue among train operators may also reflect the time of day at which many operators – particularly cargo operators – work. We have not been able to compare different types of operator working at similar times of the day, and we hope to be able to do this in future. Nevertheless, even if time of day explains much of the increased sleepiness for train operators, it is hard to see how such levels can be acceptable. For the purposes of safety, further investigation of the high levels of sleepiness for operating train drivers is merited.

5.2 Professional drivers of road vehicles

5.2.1 Sample characteristics

We surveyed 917 road operators, of which 698 transported mainly passengers and 216 goods. Most of the passenger drivers drove scheduled buses or taxis (80 per cent), while goods drivers drove dangerous goods, groceries, building materials, loose items / parcels and other goods. Road sector operators in our sample are generally older than operators in samples from the rail and maritime sectors. As many as half are 50 years of age or older, and 23 per cent of those responding are over 60 years old. Length of experience as operator is quite low considering the high age, ranging from an average of 16 years in local bus (includes rural/regional routes) branch to 20 years in the express bus branch. On average, road operators are more overweight than sea officers. Truck drivers are most overweight, with an average BMI of 28.6, but the average BMI for all types of road operator is over 28.0.

Notably 12 per cent of local bus driver respondents were female (the highest share of any operator branch), and 11 per cent of taxi owner-drivers were female. Between 5 and 6 per cent of express bus and truck drivers were female.

5.2.2 Framework conditions and fatigue-awareness culture (FRT Hazard Level O: base level risks)

Between 18 and 19 per cent of local bus and truck drivers say they often have to drive even when they are too exhausted to do so. The corresponding share of express bus drivers is only four per cent. (We did not ask taxi drivers about this.) When they are too exhausted to drive, about half of the local bus and truck drivers do not tell anyone. As for other types of operator, most are likely to tell a colleague or friend/family before a line manager or operative centre. However about half of the road operators who report a problem do tell their line manager or operative centre.

Bus and truck drivers perceive their framework conditions less positively than passenger train operators do, but more positively than maritime watch officers do. Eleven per cent of truck drivers say they violate driving and resting regulations at least once a week, compared with six per cent of local bus and two per cent of express bus drivers. Nine per cent of local bus drivers say they violate the working time regulations at least once a week.

Truck drivers score poorly relative to other road branches on culture for fatigue awareness and reporting. Taxi owner-drivers report that they themselves and others in their position tend less to consider fatigue as a serious risk factor than bus and truck drivers do. Road sector respondents report that employers take fatigue more seriously than do operators in the other sectors. However, relative to most other stakeholders, truck drivers do not agree that shipping agents take fatigue seriously.

5.2.3 Work characteristics (FRT Hazard Level 1)

Which aspects of work are fatiguing?

Work content

Ninety per cent of bus drivers spend at least 40 per cent of their time at work driving. Express bus drivers spend somewhat more time on secondary physical tasks than local bus drivers do. In contrast, only 59 per cent of truck drivers report spending at least 40 per cent of their work time driving. Physical tasks are a dominant secondary activity for truck drivers, more so than for any other type of operator in any other sector. 59 per cent of truck drivers say that spend at least 20 per cent of their work time on physical tasks. Sixty-nine per cent of taxi driver-owners say they spend at least 40 per cent of their work time driving. Both bus, truck and taxi drivers spend considerable amounts of their work time (between five and 20 per cent of the time) on routine checks, maintenance, paperwork and waiting for jobs or at depots etc. However, waiting is a dominant secondary activity for taxi drivers. Sixty-one per cent of taxi owner-drivers spend at least 20 per cent of their work time waiting, and 39 per cent spend over 40 per cent of their work time waiting. This does not include time spent waiting in traffic.

Workload (NASA-TLX)

Drivers in different branches of the road transport sector report similar levels of mental demand, and levels are lower than those reported by operators in the maritime and rail sectors. This may reflect the fact that professional drivers report greater variety in their work tasks. It may also reflect that while driving in urban environments there are many disruptions (e.g. traffic lights, more frequent stops) that give the operator relief from the need for sustained vigilance. Generally, road operators rate physical demands as lower than mental demands, but physical demands are rated much higher by truck drivers than operators in any other branch (physical demands are rated as equal to mental demands by truck drivers).

Relative to the operator average, time pressure at work is rated as substantially lower by taxi owner-drivers, but somewhat higher by local bus drivers. The latter also rate their frustration levels as high and work performance as low relative to other drivers. Effort levels lie within the normal range for all operators. This picture may reflect the demands for punctuality that local bus drivers are subjected to, which are often incentivised but which they may feel they have little control over and can do little about (Phillips, Nævestad et al. 2015). In contrast, truck drivers report statistically greater effort and frustration at work, but may feel that there is some pay-off for this, since they rate their performance highly relative to most other types of transport operator.

Job demands

Local bus drivers rate cognitive job demands and goal conflicts as high relative to other land-based operators. This probably reflects their need to juggle the demands of traffic, passengers and punctuality, often in complex and disruptive traffic environments. Emotional demands are also high for local bus drivers relative to most other land-based operators, and this probably reflects their more frequent interaction with passengers. In line with this, taxi owner-drivers rate their emotional demands as higher than those faced any other transport operator, regardless of sector.

Job resources

There are substantial differences in decision latitude, with only taxi owner-drivers tending to agree that they can plan or decide how they do their own work. Bus drivers rate decision latitude as poor (on a par with train operators), but truck drivers seem to experience a somewhat greater degree of freedom. In relation to other branches, road sector operators do not have high levels of support. Truck drivers in particular report low support from their line managers. Local bus drivers in particular appear to have low job resources overall.

Physical discomfort

According to our responses, noise, vibration, air quality and temperature are much more frequent causes of discomfort at work for local bus drivers than for other road operators. Relative to operators in other sectors, road operators experience discomfort from operating position relatively infrequently. Taxi-owner drivers experience different forms of physical discomfort least often.

Working time

Quantity

Of road operators, taxi owner-drivers report working the most. Fifty per cent work six or seven days a week. In comparison, the shares of bus and truck drivers doing this range between 10 and 18 per cent. All road-based operators report that they *drive* for between 6.7 and 6.9 h on a typical day at work, but there is much more variation in the total number of hours that they *work*. Truck drivers work for an average of 10.6 h a day (higher than the law allows) and taxi owner-drivers for 9.9 h day (despite the fact that half work six or seven days a week). Local bus drivers spend the lowest number of hours at work (8.2 h on average).

Timing

Although low relative to train operators, between 58 and 85 per cent of road operators report working irregular work hours. Of these, truck drivers stand out in terms of finding out what sort of hours they will be working, with half reporting that they find out less than five hours before they start. While most bus drivers find out what sort of hours they will work at least 7 days beforehand, around 40 per cent find out less than seven days beforehand.

The following summarises challenges for road operators in terms of fatiguing shift types worked at least once a week;

Local bus:

- 55 per cent work split shifts.
- 52 per cent work shifts starting before 06:00 in the morning.
- 50 per cent work backwardly rotating shifts.

Express bus:

- 47 per cent work shifts starting before 06:00 in the morning.

Taxi owner-drivers:

- 45 per cent work nightshifts (start between 22:00 and 02:00).
- 38 per cent work shifts starting before 06:00 in the morning.
- 31 per cent work split shifts.

- 35 per cent work backwardly rotating shifts.

Truck drivers:

- 37 per cent work backwardly rotating shifts (possibly “encouraged” by working and driving time regulations).
- 37 per cent work shifts starting before 06:00 in the morning.

5.2.4 Recovery from work (FRT Hazard Level 2)

How much sleep do road operators get?

Together with train operators, truck drivers and local bus drivers get 6.8 h of sleep on average before work. This is statistically less sleep than maritime operators get. At 1.5 h, sleep debt is higher for truck drivers than for any other operator type, and may be linked to a relatively poor sleep quality.

Five per cent of all road operators report getting less than 5 h in the 24 h before driving, and 16 per cent report getting less than 12 h in the 48 h before driving. These are threshold levels, below which sleep deficiency often causes acute sleepiness at work the next day.

How do road operators sleep?

Approximately one in four road operators report split sleeps. Most bus, taxi and truck drivers say it is normal for them to sleep at home on work days, but over 40 per cent of truck drivers say it is also normal for them to sleep in their trucks on a work day. Truck drivers rate their sleep quality as poorest among road operator types, and taxi owner-drivers appear to have the best sleep quality of all operators on average.

Other aspects of recovery

There are no particular problems in terms of psychological detachment from work. Work-home interference is higher for truck drivers than other types of road operator.

5.2.5 Fatigue symptoms (FRT Hazard Level 3)

Road operators rate sleepiness while driving as lower than that experienced by rail operators. There is little variation among different road branches in terms of acute sleepiness while driving. All experience a sharp decrease in alertness over the course of the driving period, but the final average levels are not problematic in terms of sleepiness (all average KSS scores for final hour of operating less than 5.0). Four per cent of operators report extreme sleepiness during the last hour of operating, at levels that are known to increase accident risks. Acute fatigue scores show similar results. There is a slight tendency for express bus drivers to rate acute fatigue while driving as higher than other road operators do, but local bus drivers report more fatigue after work, according to the SOFI. Using the SOFI to survey different aspects of fatigue experienced after work, we find that local bus drivers and truck drivers report somewhat higher levels of physical discomfort, and local bus drivers lack somewhat more energy than other road-based operators. All bus drivers also report that they lack motivation somewhat more after work.

Generalised sleepiness scores on the ESS are relatively high for bus and truck drivers (average score 8.1 to 8.3) relative to taxi owner-drivers. 27-28 per cent of local bus and truck drivers report excessive daytime sleepiness (ESS > 10). Levels of generalised fatigue are relatively low for road operators. However, burnout is somewhat higher for truck drivers than for all operators on average, and it is statistically higher than for express bus and taxi owner-drivers.

5.2.6 Fatigue errors (FRT Hazard Level 4)

Of the three main sectors surveyed here, the road sector has the lowest prevalence of falling asleep while operating, according to drivers themselves. Nevertheless, shares reporting that they had nodded off or slept behind the wheel are still substantial, especially considering the greater consequence of sleeping while operating a heavy vehicle on the road. One in four of bus and truck drivers said they had nodded off while driving at least once in the three months preceding the survey. Only 14 per cent of the taxi owner-drivers said they had done so. Between seven and ten per cent of all types of road operator said they had nodded off three times or more in the three months prior to the survey.

5.2.7 Summary table

A summary of the fatigue risks for road operators is given in table 11.

Table 11. Fatigue risk profile for professional drivers of road vehicles.

Hazard Level	Description	Fatigue risk factors for road operators
4	Fatigue-related errors (proxy measure)	• 25 per cent of bus and truck drivers report nodding off or sleeping while driving at least once during the three months preceding the survey. • 7-10 per cent of all road operators report nodding off or sleeping while driving at least three times during the preceding three months.
3	Fatigue symptoms	• Drivers report a sharp decrease in alertness over the course of an operating period. • Average sleepiness for the last hour is 4.3 on a 9-point scale (KSS). • Four per cent of all road operators report levels of severe sleepiness the last hour of driving. • Local bus drivers lack more energy and report greater physical discomfort after work; truck drivers report greater physical discomfort. • 27-28 per cent of bus and truck drivers report excessive daytime sleepiness. • Truck drivers report higher levels of burnout.
2	Recovery from work	• Road operators obtain an average of 6.92 h sleep on a work day, with an average sleep debt of 1.16 h. • Sleep debt is 1.47 h for truck drivers - higher than for any other operator. Truck drivers also report poorer sleep quality (13.44 out of 20) than bus or taxi operators. 40 per cent of truck drivers say it is normal to sleep in the truck (as well as at home) on work days, which may be linked to higher reported work-home interference. • Five per cent of road operators obtained less than 5 h sleep in the 24 h preceding their last operating period. • 16 per cent obtained less than 12 h sleep in the 48 h preceding their last operating period.
1	Work character-istics	• Driving is the main operator task for all road operators. All road operators report driving between 6.7 and 6.9 h on a typical day at work. 58-85 per cent of road operators work irregular hours, and many find out at short notice what hours they will work. Overall, road operators receive low levels of job support relative to rail and maritime operators. • Truck drivers: Truck drivers say they work most – 10.6 h on a work day on average. 59 per cent of truck drivers spend over 20 per cent of work time on physical tasks, and physical demands are rated as equal to mental demands overall. There are relatively high levels of effort and frustration, but drivers also report a certain degree of freedom and higher performance achievement. • Taxi owner-drivers: Half of taxi owner-drivers work six or seven days a week, and the average reported daily working hours for taxi owner-drivers is 9.9 h. 45 per cent of taxi owner-drivers work a nightshift at least once a week. Other demanding shifts are also common. 39 per cent spend over 40 per cent of work time waiting for jobs, at ranks etc. Emotional demands are higher than for any other operator. • Local bus drivers: Rate time pressure, frustration, emotional and cognitive job demands and goal conflicts as higher than do most other drivers in road transport; yet performance achievement is lower. Report that they have least say in how they do their work. Also experience more discomfort from noise, vibration and air quality. Half of local bus drivers also work split shifts and backwardly rotating shifts at least once a week.
0	Framework conditions and fatigue awareness culture	• 18-19 per cent of truck and local bus drivers often have to drive when too exhausted. • When this happens, ca. 40 per cent tell a line manager (of those who have them). Drivers' ratings of framework conditions (violations, pay, training etc.) are less positive than in the rail sector but more positive than in the maritime sector. • 11 per cent of truck drivers and 6-9 per cent of bus drivers say they violate regulations designed to limit operating time at least once a week. • Drivers rate employers as taking fatigue relatively seriously. • Truck drivers rate shipping agents as taking fatigue less seriously.

5.3 Watch officers at sea

5.3.1 Sample characteristics

Survey responses are from 704 "sea officers", comprising 54 percent officers (of which roughly half are chief officers) and 46 per cent captains. Regardless of rank almost all have bridge watches, apart from the small minority working on tankers (51 per cent have bridge watches) and tugs / AHT / shuttle tankers, and survey ships (76 per cent have bridge watches). We grouped 675 of the "officers" into six main categories, according to the type of ship they operated on:

- Offshore service (44 per cent), containing an even spread of operators working in Norwegian and international coastal and short sea waters.
- Domestic ferry (26 per cent), working exclusively in Norwegian fjords and coastal waters.
- Bulk carriers, container ships, reefers, fish carriers (9 per cent), 69 per cent of whom worked in Norwegian waters.
- Tankers (oil, gas or chemical) (9 per cent), international waters, mostly short and deep seas.
- Tug, Anchor Handling Tugs, cable layers and survey ships (7 per cent), working an equal mix of Norwegian and international waters.
- Fishing and coastal freight (5 per cent), over half working in coastal waters or fjords, but half in deep seas.

There is considerable heterogeneity within some of the categories, but numbers limit us dividing the categories further. Fishing and coastal freight were grouped because previous reports indicate that they may be problematic in terms of working conditions.

Officer respondents were fairly evenly spread in terms of age group. Those working on domestic ferry were oldest, and most experienced (22 years on average), and those on fishing and coastal freight vessels the youngest and least experienced (19 years on average). Average BMI for maritime officers was 27.6, which is statistically lower than for road operators. However, 74 per cent were still overweight.

Less than five per cent of maritime officer respondents in any of the branch categories were female.

5.3.2 Framework conditions and fatigue-awareness culture (FRT Hazard Level O: base level risks)

Compared to land-based operators, greater shares of sea-based operators report that they need to work when they are too exhausted to do so. 23 per cent of all sea officers say they need to do this often and a further 42 per cent sometimes. Sea officers in all branch categories also report that framework conditions (e.g. violations, pay for hours worked) are worse relative to those of land-based operators. This is confirmed by responses to the questions about how often work hours exceed the regulations. Almost none of the train operators said they exceeded working time regulations at least once a week, and around ten per cent of operators in the worst road branches said the same. In contrast the following shares of maritime operators said their hours exceeded working time regulations at least once a week:

- Bulk carriers, container ships, reefers, fish carriers – 38 per cent
- Tug, Anchor Handling Tugs, cable layers and survey ships – 30 per cent

- Offshore service – 28 per cent
- Fishing and coastal freight – 21 per cent
- Tankers (oil, gas or chemical) – 20 per cent

Only 11 per cent of domestic ferry operators said their hours exceeded the regulations.

Although maritime officers may be expected to work more often when exhausted and work in excess of the working time regulations, the work culture may be more open to the reporting of fatigue. Firstly, 22 per cent of all sea-based operators said yes, they inform somebody when they feel too exhausted to work, compared to only eight and 13 per cent in the rail and road sectors, respectively. (Most say they tell colleagues, as is the case for other operators, but 30 to 51 per cent also tell their line managers.) Secondly, maritime officers agree more that they have a culture of fatigue-awareness, which assesses whether they can talk openly about fatigue or report fatigue-related incidents as being due to fatigue. Despite this, there is still a tendency for sea officers to disagree that they have a positive fatigue-awareness culture. There is also some variation among branch categories in the maritime sectors, with domestic ferry in particular agreeing less than officers in other categories that they have a fatigue-awareness culture.

Maritime officers rate their understanding of and attitude to fatigue more highly than do rail operators. There is also a tendency for operators in maritime branches to say that they themselves consider fatigue as a serious risk factor. This may reflect that they have greater experience with fatigue while operating.

Offshore service agree most that their colleagues and line managers consider fatigue to be a serious risk factor, but as for other branches line managers are rated as taking fatigue less seriously than respondents themselves and their colleagues do. Maritime operators rate that their employers take fatigue more seriously than operators in the rail sector do, but not as seriously as employers in the road sector. There is little variation among the different maritime branch categories.

5.3.3 Work characteristics (FRT Hazard Level 1)

Which aspects of work are fatiguing?

Work content

Paperwork is a major secondary activity for maritime officers, with at least one in four respondents in all branch categories apart from fishing / coastal freight saying that they spend at least 40 per cent of their working time on paperwork. For officers on tankers, paperwork is the main activity. Otherwise watch is the main activity while at work, and most report working bridge watches. Of those who report doing so, there is large variation in the shares in each category saying they are often alone on the bridge. Only one in four offshore service officers but at least one in two in the other branches said they were often alone on the bridge during a bridge watch.

Workload (NASA-TLX)

Mental demand levels are overall similar to those of train operators and, looking at the variation among maritime branches, appears to reflect the extent to which sustained vigilance is required. For example, mental demands tend to be a little lower for officers on domestic ferry and fishing / coastal freight vessels, but higher for those on tankers and container ships, where periods of sustained watch without breaks are more common. Officers rate physical demands as low, apart from those on fishing / coastal freight vessels, where physical demands are rated next highest behind goods transport by road. Time pressure demands are rated as highest by domestic ferry officers, which are probably related to contractual demands for punctuality, as is the case for local bus drivers.

Levels of effort and frustration is rated as quite high overall, and maritime officers rate their performance as statistically lower than that for land-based operators. Here domestic ferry operators stand out in that they rate their performance as statistically lower than that of any other transport branch, including other maritime branches.

Job demands

Cognitive job demands are rated as high relative to the road (excepting local bus) and especially the rail sector. Offshore service officers report highest levels of cognitive demand (on a par with local bus operators). Otherwise there is not much variation in cognitive demand among maritime branch categories. There is also little variation in emotional demand, which is high relative to emotional demands reported by train and truck operators but low relative to other job demands that maritime officers experience. Goal conflict is clearly a main job demand for maritime officers in all branches relative to that experienced by land-based transport operators (excepting again local bus).

Job resources

As for the road sector, there is considerable variation in decision latitude among maritime branches, with officers on offshore service and tug/AHT/survey vessels and tankers reporting high levels, and those on bulk and fish carriers/containers/reefers reporting lowest levels (on a par with train operators). Relative to land-based branches, maritime officers report relatively high levels of line manager support.

Physical work environment

Maritime officers were surprisingly ambivalent about whether noise and vibrations caused discomfort at work, but levels overall are still second only to cargo train operators. Responses indicate that operating position is viewed as the most frequent physical source of discomfort at work (of those we proposed), and ratings are on a par with those of train operators.

Working time

49 per cent of offshore service officers and 34 per cent of tanker officers report working over 53 days during the 90 days preceding the survey. However a considerable share of tanker officers have worked very much, with 14 per cent having worked over 64 days. Those working on bulk and fish carriers/container vessels/reefers and fishing/coastal freight vessels also work quite a lot, with 38 and 43 per cent, respectively having worked over 53 days in the 90 days preceding the survey. Only 19 per cent of domestic ferry officers had worked as many days.

In terms of hours at work on a working day, maritime officers work much more than land-based operators. Of course, most get extended periods of time off to compensate for this. Even when accounting for this, responses suggest that the total number of hours worked by maritime officers will in many cases be equivalent to and in other cases considerably more than worked by land-based operators. More importantly, because working time is compressed into several long days or weeks on board, fatigue may develop over the course of a tour of duty such that is severe relative to that experienced by land-based operators. This has not been assessed by the current survey.

Maritime officers spend 11.1 h on watch on a working day, and 12.6 h working. This is fairly consistent across different branches, except that tanker officers report spending considerably less time on watch (only 8.1 h), possibly due to more favourable watch systems. 4-8 (four hours on followed by eight hours off, which is a favourable three-watch system) is the most prevalent watch system worked by tanker officers. 6-6 (two-watch system considered to be more fatiguing by researchers) is still the most prevalent watch system. It is worked by 42 per cent of respondents, and is the most common system worked by officers on offshore service, bulk and fish carriers/container vessels/reefers, tug/AHT/survey ships and fishing / coastal freight vessels. Apart from officers on tankers, less than 16 per cent of officers in other branches worked the favourable 4-8 system. The 24-hour watch or 14-10 was the most popular watch system for domestic ferry officers. Next to 6-6, the most popular system was 12-12 (also a two-watch system), worked by 16 per cent of respondents, including substantial shares of officers on domestic ferries, tug/AHT/survey ships and offshore service also work 12-12.

It should be considered that each of the demanding shift types considered to be fatiguing in our assessment of land-based operators are the norm for maritime officers. Every 24 hours during a tour of duty, many will work nights, watches that start before 06:00 in the morning, "split shifts" and backwardly rotating "shifts". One saving grace is that the bulk of maritime officers know what hours they will work well in advance (over 40 per cent say they know over 28 days in advance). Interestingly, however, over 15 per cent of offshore service officers said they only find out about their working hours less than five hours in advance. We are not sure what the reasons for this would be, but it may merit further investigation.

5.3.4 Recovery from work (FRT Hazard Level 2)

How much sleep do watch officers get?

Officers report that their average daily sleep lengths are slightly above average (7.2 h), and their sleep debt is also slightly lower than average, at 1.05 h. However, there is some variation among branches, with domestic ferry officers reporting they normally get 6.75 h of sleep on a working day, and officers on tankers and bulk and fish carriers/container ships/reefers getting over 7.5 h. Sleep debts are inversely proportional to the amount of sleep obtained, indicating that the difference is not merely a reflection of how much sleep is needed.

Four per cent of maritime officers say they have slept less than five hours since their last watch, and 12 per cent said they had slept less than 12 hours in the 48 hours preceding their last watch.

How do watch officers sleep?

The amount of sleep may be misleading as a measure of recuperation from work-related fatigue, since sleeps will often be obtained in two periods, and thus of poorer quality. There was large variation in the shares of officers saying they slept in two or more bouts on working days, from 42 per cent of tanker officers to 87 to 90 per cent of officers on fishing/coastal freight and on bulk and fish carriers/container ships/reefers. This seems to be rather in line with sleep opportunities afforded by watch systems worked. However, there is little sign that disrupting sleep by splitting it up affects sleep quality. In fact, sleep quality scores of officers on fishing/coastal freight and bulk and fish carriers/container ships/reefers are relatively high. Despite this, maritime officers overall rate sleep quality a statistically poorer than road operators do.

Other aspects of recovery

Watch officers score low relative to rail and truck drivers on ability to detach psychologically from work outside of work hours. The exception are officers on domestic ferries, who are able to go home much more often than officers on most other vessels. Work-home interference is also high for offshore service officers.

5.3.5 Fatigue symptoms (FRT Hazard Level 3)

There is little sign that sea officers are generally more fatigued (CIS severity) or sleepy (ESS) than other transport operators. The average ESS score is 7.8, and 23 per cent report signs of excessive daytime sleepiness (ESS > 10), suggesting that there is large variation among the officers. Compared with road transport operators, sea officers score statistically higher on concentration fatigue and on burnout. Domestic ferry officers especially score consistently higher on burnout, though the difference is small.

Maritime officers overall report that they become more sleepy as the watch goes on. However officers on offshore service tug/AHT/survey ships appear only to start getting more sleepy after the middle of a watch, and appear to end up less sleepy at the end of a watch. Other branches (apart from on fishing / coastal freight vessels, for which the numbers are small) have sleepiness approaching that of train operators during the last hour of the operation or watch. The average KSS score for the last hour of watch is 5.1, and ten per cent have a KSS over 8 or 9, indicative of sleepiness at levels which are known to increase accident risks. Scores for acute fatigue generally reflect sleepiness scores. Scores on the sleepiness dimension of the SOFI are also consistent, suggesting that officers on domestic ferries, bulk and fish carriers/container vessels/reefers and tankers tend to end the watch more sleepy than those on tug/AHT/survey and offshore service ships. Overall SOFI scores suggest that officers on domestic ferries are most fatigued after their watch, and those on bulk and fish carriers/container vessels/reefers least fatigued.

5.3.6 Fatigue errors (FRT Hazard Level 4)

29 per cent of all maritime officer respondents say that have nodded off at least once on watch in the three months preceding the survey, while 14 per cent have done so three times or more. “Only” 20 per cent of officers on domestic ferries report having nodded off at least once, but there are still ten per cent who say that have done so three times or more.

5.3.7 Summary table

A summary of the risk profile for watch officers is given in table 12.

Table 12. Fatigue risk profile for maritime watch officers (includes captains).

Hazard Level	Description	Fatigue risk factors for watch officers at sea
4	Fatigue-related errors (proxy)	• 29 per cent have nodded off at least once on watch in the three months preceding the survey. • 14 per cent report doing so at least three times.
3	Fatigue symptoms	• Officers generally become more sleepy as the watch progresses, but officers on offshore service and tug/AHT/survey ships get less sleepy towards the middle of a watch. • Average sleepiness for last hour of watch is 5.1 on a 9-point scale (KSS). • Ten per cent report severe sleepiness for the last hour of watch. • Officers on domestic ferries are more fatigued after their watch than officers on other vessels (SOFI). • 23 per cent of all watch officers report excessive daytime sleepiness. • Maritime officers score higher on concentration fatigue and burnout than road operators overall.
2	Recovery from work	• Maritime officers get 7.13 h of sleep on a work day on average, and the sleep debt is slightly lower than average (1.04 h). • Domestic ferry officers get only 6.80 h on average (sleep debt 1.22 h). • Four per cent of all officers had slept less than 5 h in the 24 h preceding their watch. • 12 per cent had slept less than 12 h in the 24 h preceding their watch. • Sleep quality (13.21 out of 20) is worse for maritime officers than for road operators (13.92 out of 20), and split sleeps are common (as dictated by watch systems). • Psychological detachment from work during free time is relatively poor, apart from on domestic ferries. • Work-home interference is reported as high by offshore service officers.
1	Work characteris-tics	• Bridge watch is the main activity in most branches. • On tankers, paperwork takes more time than watch activity. One in four officers in other branches spend at least 40 per cent of work time on paperwork (does not include fishing/coastal freight). • One in four offshore service officers and at least one in two of the other officers said they were often alone on the bridge during a watch. • Mental demand levels appear to reflect the extent to which sustained vigilance is required on watch. Otherwise workload varies by branch e,g, fishing/coastal freight officers rate physical demands as relatively high, whereas domestic ferry officers rate time pressure demands as relatively high. • Job demands (cognitive, emotional demands and goal conflict) are the higher overall than in the maritime sector than in the road and rail sectors. • Overall colleague and manager support is rated highly relative to some land-based branches. • Operating position is the most frequent source of physical discomfort at work, more so than noise or vibration. • In terms of days worked in the last 90 days, tanker and offshore service officers work the most, and domestic ferry officers the least. • Maritime officers spend on average 11.1 h on watch and 12.6 h working on a normal working day. • 42 per cent of respondents work 6-6, the most prevalent watch system. Watch systems vary with type of operation.
0	Framework conditions and fatigue awareness culture	• Watch officers rate framework conditions (pay, violations, training) as poor relative to land-based operators. • 20-38 per cent of officers violate working time regulations at least once a week, depending on branch (does not include domestic ferry). • 23 per cent overall say that they often have to work when too exhausted (higher than for land-based operators). • Rates of reporting fatigue to others are high relative to road and rail. 22 per cent said they tell usually someone, most often colleagues, but 30-51 per cent tell line managers. • Slight lack of agreement that there is a culture of fatigue awareness, but officers rate this more positively than land-based operators do.

6 Future work

We have profiled several fatigue risks for land- and sea-based transport operators, mainly at levels 0, 1, 2 and 3 of the Fatigue Risk Trajectory in Table 2. The study shows that there are important differences in fatigue risks among the different transport branches. In this short chapter we wish to point out some limitations to the present study, and describe how these can be addressed by future work.

The study is entirely based on survey data, and thus has limitations in terms of response bias and representativeness. In particular, in some cases we were unable to determine absolute response rates, and this must be borne in mind when applying the results. Objective measures (e.g. behavioural observation, organisational accident levels, actigraph measurement of sleep quantity) would usefully supplement the subjective measures we have used but can be resource intensive. This implies that future studies should be confined to particular transport organisations or branches. Objective measures are particularly useful for investigating the prevalence of fatigue-related errors or fatigue-related incidents and accidents, i.e. Levels 4 and 5 of the Fatigue Risk Trajectory, which we did not assess here. Assessment of these factors is needed in the future to study the relative importance for safety, of those factors that we have already assessed at Levels 0-3.

One benefit of the present study is that it will help focus future studies on particular transport branches. The most “problematic” risk factors at Levels 0-3 of the trajectory could be selected from this report, and studied alongside risk factors at Levels 4 and 5 for that particular transport branch. The relative importance of different types of “latent” factors at earlier levels of the trajectory could then be assessed by studying their relative contribution to risk factors at later levels. For instance, we may find that sleep quality (level 2) is a main risk for sleeping on watch and groundings for maritime officers working on tankers; or we may find that cognitive job demands are a main predictor of burnout and poor safety performance for local bus drivers. In particular, such studies would help establish the importance for safety of broader and longer term fatigue relative to acute sleepiness or mental exhaustion.

Due to limited resource we have been unable to compare scores on several of the standard measures used here with scores for transport operators and other workers found in other studies. This is needed to gain a better perspective on the size of the fatigue problem for different types of Norwegian operator. We have in other words only been able to compare road, rail and maritime branches in Norway with each other. Without a systematic comparison with international studies, it is difficult to conclude about the absolute size of the fatigue problems measured here. The introduction names several resources that may be used in such a comparison.

Despite its limitations, the present study shows that each transport branch has a unique fatigue risk profile, and in doing so underlines the need for fatigue to managed as part of a Safety Management System that can be adapted to different branch contexts. However, very little has been done to map actual progress with such systems in Norway and elsewhere. Several related questions that also need to be answered to facilitate the use of such systems:

- What do companies already do to manage fatigue as a safety risk?
- Do best practice examples exist for fatigue or safety management in different types of transport branch?
- What evidence is there that fatigue management influences fatigue-related health and safety outcomes? Similarly, what is the business case for investing in such systems?
- Can we realistically expect companies with little resource to invest in fatigue risk management? Similarly, can certain branches expect to benefit more than others from investing in such systems?

Each of the above issues is also highly relevant to the air sector, which was excluded from the scope of the current report. The air sector may be useful source of best practice in safety management, and an interesting question is whether and how systems for safety management used in the air sector can be applied to other transport sectors.

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Appendix 1 SOFI items

Item in English	Item in Norwegian	Fatigue dimension assessed
Palpitations	Hjerteklapp	PE1
Indifferent	Apatisk	LM1
Lazy	Lat	S1
Exhausted	Utslitt	LE1
Tense muscles	Anspente muskler	PD1
Numbness	Nummenhet	PD2
Sweaty	Svetting	PE2
Drained	Utmattet	LE2
Listless	Giddeløs	LM2
Almost asleep	Nær ved å sovne	S2
Worn out	Utkjørt	LE3
Dozy	Døsig	S3
Passive	Passiv	LM3
Stiff joints	Stive led	PD3
Taste of blood*	Varm	PE3
Lack of initiative*	Likegyldig	LM4
Hurting	Smertefullt	PD4
Out of breath	Andpusten	PE4
Yawns	Gjespende	S4
Spent*	Kraftløs	LE4
Sleepy	Søvnig	S5
Over worked	Overarbeidet	LE5
Aching	Verkende	PD5
Breathing heavily	Tungpustet	PE5
Uninterested	Uinteressert	LM5

* Did not translate backwards

PE = physical exhaustion, LM = lack of motivation, S = sleepiness, LE = lack of energy, PD = physical discomfort.

Appendix 2 - Data

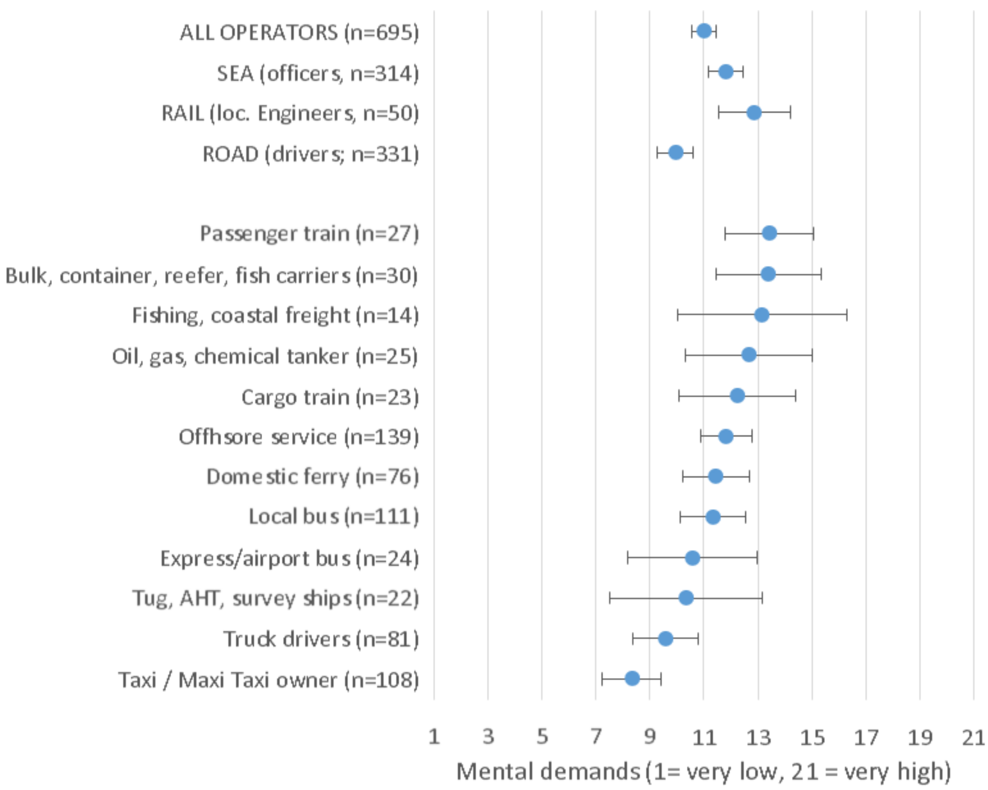
Causes of discomfort while operating

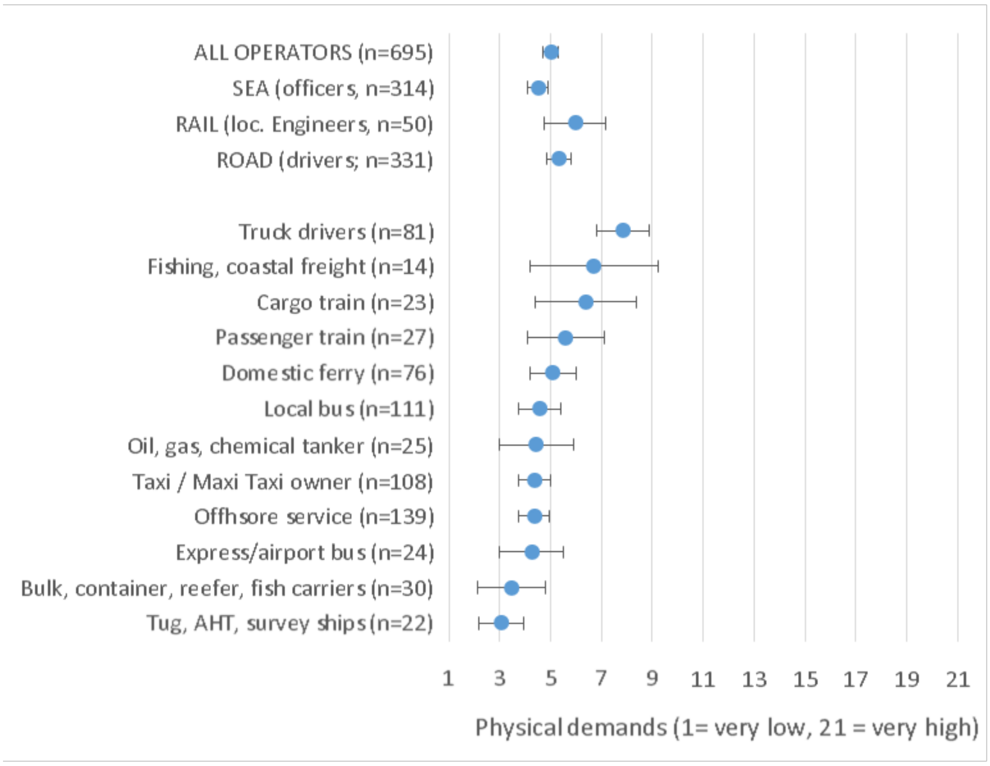
	Boredom and monotony	low CI	up CI	Noise	low CI	up CI	Vibrations	low CI	up CI	Air quality	low CI	up CI	Op. position	low CI	up CI
Local bus (n=312)	2,47	2,33	2,61	2,97	2,82	3,13	2,93	2,77	3,08	2,84	2,69	2,99	2,58	2,44	2,72
Express/airport bus (n=80)	2,09	1,82	2,36	2,19	1,92	2,45	2,01	1,75	2,28	2,14	1,89	2,38	2,58	1,75	2,25
Taxi / Maxi Taxi owner (n=294)	2,27	2,13	2,41	1,82	1,71	1,93	1,70	1,59	1,81	1,73	1,62	1,84	1,90	1,78	2,02
Truck drivers (n=216)	2,46	2,3	2,62	2,25	2,09	2,40	2,32	2,16	2,49	2,18	2,03	2,34	2,44	2,27	2,60
Passenger train (n=82)	2,67	2,4	2,94	2,49	2,22	2,76	2,40	2,14	2,67	2,57	2,31	2,83	3,01	2,73	3,29
Cargo train (n=73)	2,38	2,13	2,63	3,32	3,06	3,57	3,18	2,90	3,46	2,41	2,17	2,66	2,96	2,66	3,26
Domestic ferry (n=174)	2,75	2,57	2,93	2,57	2,39	2,75	2,52	2,34	2,71	1,91	1,77	2,06	2,94	2,74	3,13
Oil, gas, chemical tanker (n=59)	2,73	2,41	3,05	2,90	2,58	3,21	2,85	2,54	3,16	2,02	1,78	2,26	3,05	2,72	3,38
Tug, AHT, survey ships (n=50)	2,88	2,48	3,28	2,40	2,11	2,69	2,24	1,95	2,53	2,32	2,02	2,62	3,26	2,88	3,64
Offhsore service (n=299)	3,02	2,88	3,16	2,62	2,48	2,75	2,57	2,44	2,70	2,12	2,02	2,22	3,24	3,10	3,38
Fishing, coastal freight (n=31)	2,16	1,75	2,57	2,45	2,04	2,86	2,26	1,90	2,61	2,03	1,67	2,39	2,58	2,11	3,05
Bulk, container, reefer, fish carriers (n=61)	2,51	2,22	2,80	2,77	2,45	3,10	2,70	2,39	3,02	2,11	1,89	2,34	2,66	2,35	2,97
ROAD (drivers; n=916)	2,38	2,3	2,46	2,36	2,27	2,44	2,31	2,23	2,39	2,27	2,19	2,35	2,29	2,21	2,37
RAIL (loc. Engineers, n=155)	2,54	2,35	2,73	2,88	2,68	3,07	2,77	2,57	2,97	2,50	2,32	2,68	2,99	2,78	3,19
SEA (officers, n=703)	2,82	2,73	2,91	2,62	2,53	2,71	2,54	2,46	2,63	2,06	1,99	2,13	3,05	2,95	3,14
ALL OPERATORS (n=1774)	2,57	2,51	2,63	2,51	2,45	2,56	2,44	2,38	2,50	2,21	2,15	2,26	2,65	2,59	2,71

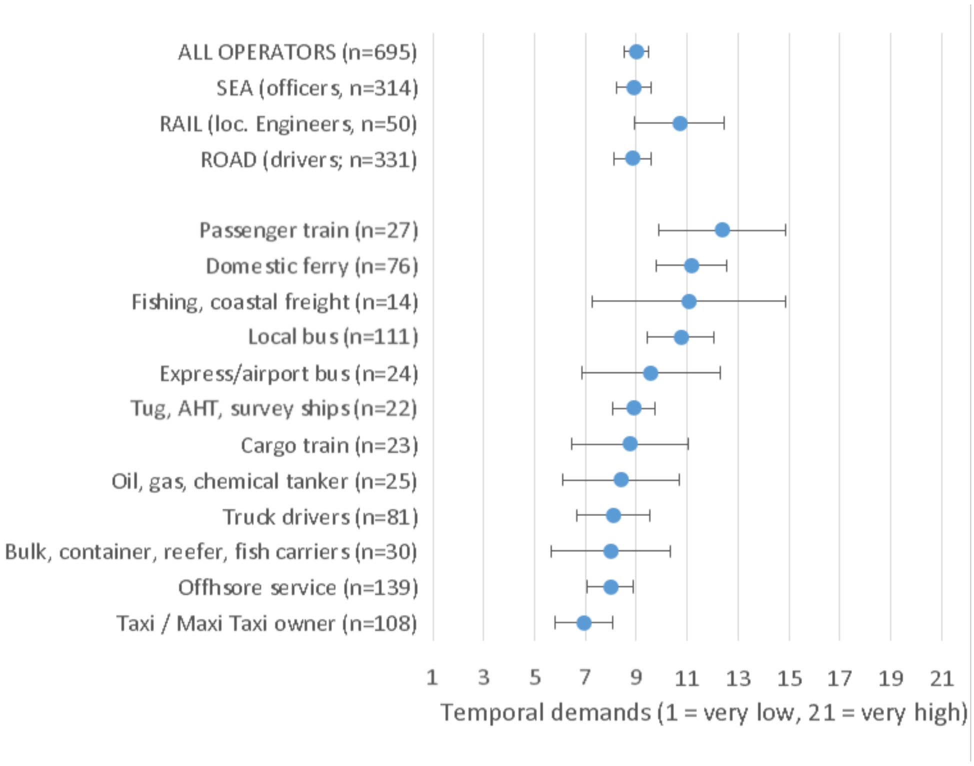
Workload over preceding 3 months (NASA-TLX)

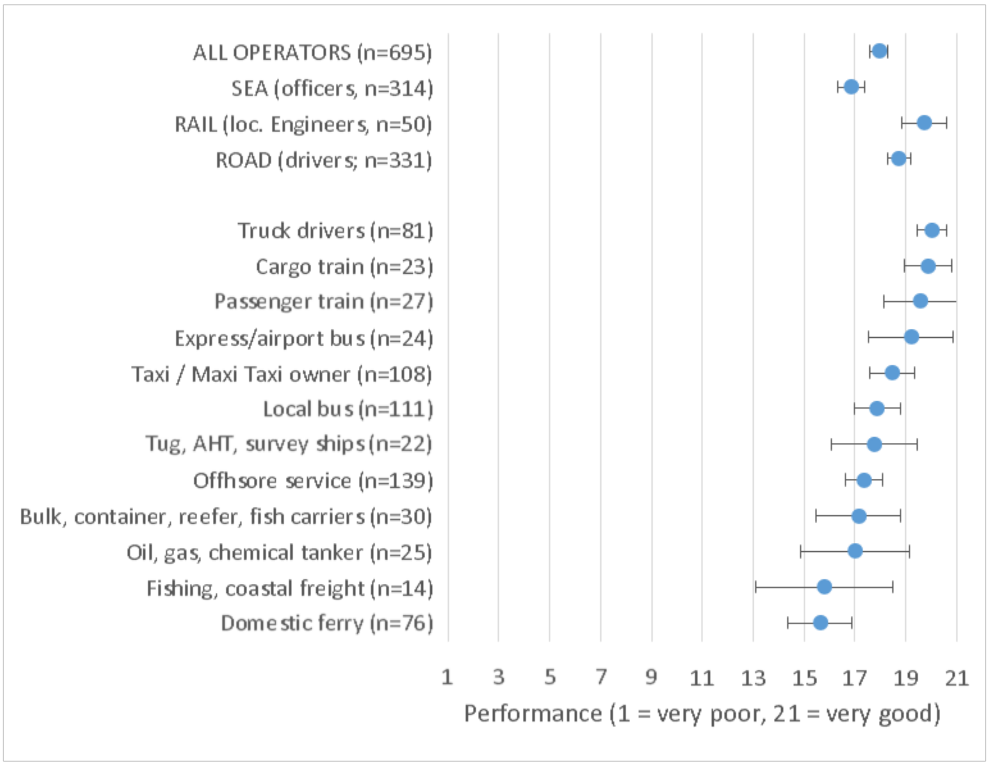
	Mental demand	low CI	up CI	Physical demand	low CI	up CI	Temporal demand	low CI	up CI
Local bus (n=312)	13,19	12,5	13,9	6,4	5,8	7,0	14,96	14,3	15,7
Express/airport bus (n=80)	13,84	12,7	15,0	7,73	6,7	8,7	14,32	13,1	15,5
Taxi / Maxi Taxi owner (n=295)	12,72	12,0	13,4	6,09	5,6	6,6	11,13	10,4	11,8
Truck drivers (n=216)	12,65	11,9	13,4	11,47	10,7	12,2	13,31	12,4	14,2
Passenger train (n=82)	14,38	13,3	15,5	4,84	4,1	5,6	15,89	14,7	17,1
Cargo train (n=73)	15,75	14,7	16,8	7,14	6,3	8,0	15,08	13,9	16,2
Domestic ferry (n=174)	14,56	13,9	15,2	5,24	4,7	5,8	15,62	14,8	16,4
Oil, gas, chemical tanker (n=59)	15,64	14,6	16,7	5,44	4,5	6,4	12,39	11,1	13,6
Tug, AHT, survey ships (n=50)	15,28	13,8	16,7	5,66	4,7	6,7	11,58	10,1	13,0
Offhsore service (n=300)	14,81	14,3	15,3	5,2	4,8	5,6	12,2	11,6	12,8
Fishing, coastal freight (n=31)	14,19	12,4	16,0	8,81	6,7	10,9	14,68	12,9	16,4
Bulk, container, reefer, fish carriers (n=61)	15,41	14,3	16,5	5,77	4,8	6,8	14,28	12,9	15,7
ROAD (drivers; n=916)	12,62	12,2	13,0	7,64	7,3	8,0	13,29	12,9	13,7
RAIL (loc. Engineers, n=155)	15,03	14,3	15,8	5,92	5,3	6,5	15,51	14,7	16,3
SEA (officers, n=703)	14,89	14,6	15,2	5,59	5,3	5,9	13,17	12,8	13,6
	Perfor-mance	low CI	up CI	Effort	low CI	up CI	Frustration	low CI	up CI
Local bus (n=312)	17,12	16,6	13,9	12,14	11,5	12,8	8,06	14,3	15,7
Express/airport bus (n=80)	18,59	17,9	15,0	12	10,8	13,2	5,34	13,1	15,5
Taxi / Maxi Taxi owner (n=295)	18,26	17,8	13,4	11,89	11,2	12,6	6,38	10,4	11,8
Truck drivers (n=216)	19,18	18,8	13,4	13,96	13,2	14,7	8,75	12,4	14,2
Passenger train (n=82)	19,16	18,7	15,5	11,74	10,6	12,9	6,33	14,7	17,1
Cargo train (n=73)	19,08	18,5	16,8	13,01	12,0	14,0	4,84	13,9	16,2
Domestic ferry (n=174)	15,25	14,5	15,2	12,97	12,3	13,7	7,91	14,8	16,4
Oil, gas, chemical tanker (n=59)	17,58	16,7	16,7	13,31	12,2	14,4	7,54	11,1	13,6
Tug, AHT, survey ships (n=50)	17,26	16,2	16,7	13,42	12,2	14,6	8,24	10,1	13,0
Offhsore service (n=300)	16,66	16,2	15,3	13,42	12,9	13,9	8,53	11,6	12,8
Fishing, coastal freight (n=31)	17,19	15,9	16,0	14,65	13,1	16,2	8,52	12,9	16,4
Bulk, container, reefer, fish carriers (n=61)	17,52	16,7	16,5	14,41	13,2	15,6	7,46	12,9	15,7
ROAD (drivers; n=916)	18,13	17,9	18,4	12,5	12,1	12,9	7,49	7,9	0,42
RAIL (loc. Engineers, n=155)	19,12	18,7	19,5	12,34	11,6	13,1	5,63	6,4	0,77
SEA (officers, n=703)	16,57	16,3	16,9	13,42	13,1	13,8	8,17	8,6	0,40

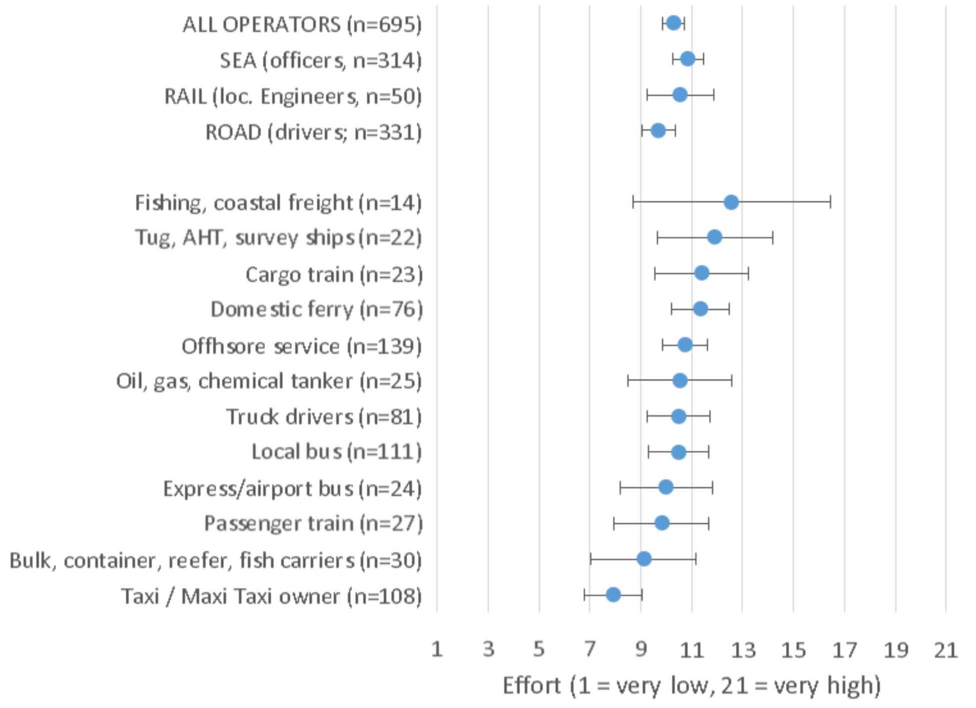
Workload for preceding shift (NASA-TLX)

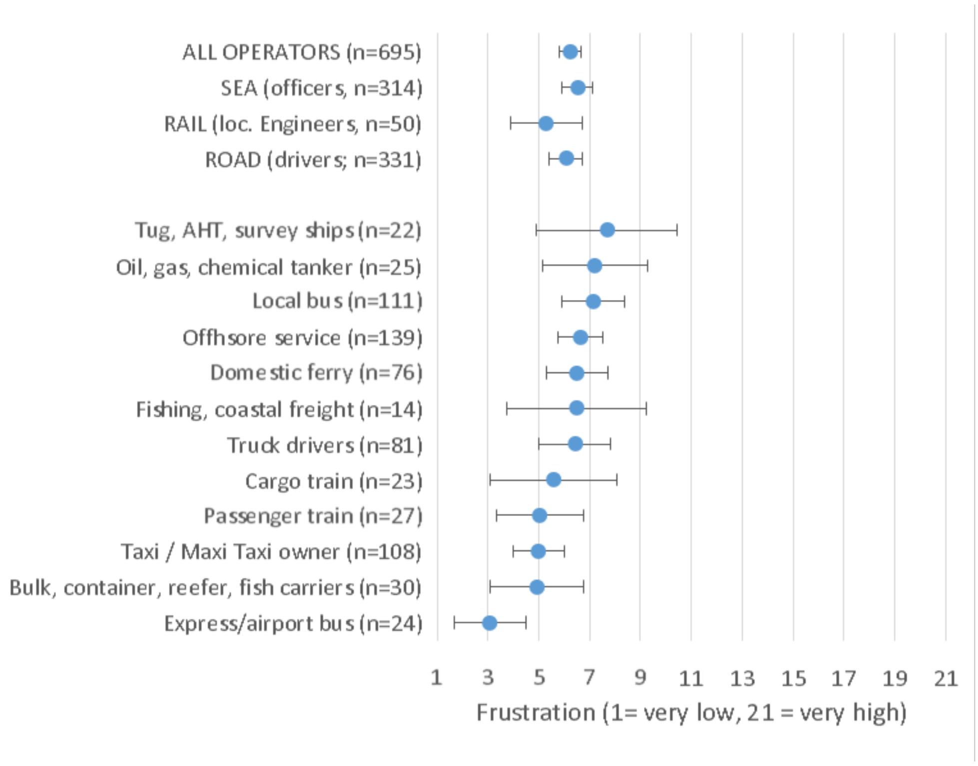





ALL OPERATORS (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Passenger train (n=27)
Domestic ferry (n=76)
Fishing, coastal freight (n=14)
Local bus (n=111)
Express/airport bus (n=24)
Tug, AHT, survey ships (n=22)
Cargo train (n=23)
Oil, gas, chemical tanker (n=25)
Truck drivers (n=81)
Bulk, container, reefer, fish carriers (n=30)
Offhsore service (n=139)
Taxi / Maxi Taxi owner (n=108)
1 3 5 7 9 11 13 15 17 19 21
Temporal demands (1 = very low, 21 = very high)


ALL OPERATORS (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Truck drivers (n=81)
Cargo train (n=23)
Passenger train (n=27)
Express/airport bus (n=24)
Taxi / Maxi Taxi owner (n=108)
Local bus (n=111)
Tug, AHT, survey ships (n=22)
Offhsore service (n=139)
Bulk, container, reefer, fish carriers (n=30)
Oil, gas, chemical tanker (n=25)
Fishing, coastal freight (n=14)
Domestic ferry (n=76)
1 3 5 7 9 11 13 15 17 19 21
Performance (1 = very poor, 21 = very good)


ALL OPERATORS (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Fishing, coastal freight (n=14)
Tug, AHT, survey ships (n=22)
Cargo train (n=23)
Domestic ferry (n=76)
Offhsore service (n=139)
Oil, gas, chemical tanker (n=25)
Truck drivers (n=81)
Local bus (n=111)
Express/airport bus (n=24)
Passenger train (n=27)
Bulk, container, reefer, fish carriers (n=30)
Taxi / Maxi Taxi owner (n=108)
1 3 5 7 9 11 13 15 17 19 21
Effort (1 = very low, 21 = very high)


ALL OPERATORS (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Local bus (n=111)
Offhsore service (n=139)
Domestic ferry (n=76)
Fishing, coastal freight (n=14)
Truck drivers (n=81)
Cargo train (n=23)
Passenger train (n=27)
Taxi / Maxi Taxi owner (n=108)
Bulk, container, reefer, fish carriers (n=30)
Express/airport bus (n=24)
1 3 5 7 9 11 13 15 17 19 21
Frustration (1= very low, 21 = very high)

Job demands and resources

	Cognitive job demands (JDR 1,2,3,4,5,10)	low CI	up CI	Emotional job demands (JDR 6,7,8,9)	low CI	up CI	Decision authority (JDR 11-16)	low CI	up CI	Goal conflict (JDR 17,18,19)	low CI	up CI
Local bus (n=312)	3,04	2,9	3,1	2,4	2,3	2,5	2,08	2,0	2,2	2,5	2,4	2,6
Express/airport bus (n=80)	2,74	2,6	2,9	2,06	1,9	2,2	2,3	2,1	2,5	2,12	1,9	2,3
Taxi / Maxi Taxi owner (n=295)	2,58	2,5	2,7	2,66	2,6	2,8	3,64	3,5	3,7	2,11	2,0	2,2
Truck drivers (n=216)	2,81	2,7	2,9	1,89	1,8	2,0	3,03	2,9	3,1	2,18	2,1	2,3
Passenger train (n=82)	2,5	2,3	2,7	2,02	1,9	2,2	2,21	2,1	2,4	1,89	1,7	2,0
Cargo train (n=73)	2,61	2,5	2,8	1,65	1,5	1,8	2,08	1,9	2,2	1,92	1,7	2,1
Domestic ferry (n=174)	3,02	2,9	3,1	2,48	2,4	2,6	2,91	2,8	3,0	2,7	2,5	2,9
Oil, gas, chemical tanker (n=59)	2,99	2,8	3,2	2,29	2,1	2,5	3,64	3,5	3,8	2,47	2,2	2,7
Tug, AHT, survey ships (n=50)	2,98	2,8	3,2	2,41	2,2	2,6	3,35	3,1	3,6	2,69	2,4	3,0
Offhsore service (n=299)	3,21	3,1	3,3	2,5	2,4	2,6	3,24	3,2	3,3	2,82	2,7	2,9
Fishing, coastal freight (n=31)	2,78	2,5	3,0	2,23	1,9	2,6	2,23	1,9	2,6	2,69	2,3	3,1
Bulk, container, reefer, fish carriers (n=61)	2,91	2,7	3,1	2,39	2,2	2,6	2,39	2,2	2,6	2,92	2,6	3,2
ROAD (drivers; n=917)	2,81	2,8	2,9	2,34	2,3	2,4	2,82	2,8	2,9	2,27	2,2	2,3
RAIL (loc. Engineers, n=155)	2,55	2,4	2,7	1,85	1,7	2,0	2,15	2,0	2,3	1,9	1,8	2,0
SEA (officers, n=703)	3,06	3,0	3,1	2,44	2,4	2,5	3,2	3,1	3,3	2,74	2,7	2,8
ALL OPERATORS (n=1775)	2,89	2,9	2,9	2,34	2,3	2,4	2,91	2,9	3,0	2,42	2,4	2,5

	Leader support (AJ_dem_res_le_koN1,2,3)	low CI	up CI	Colleague support (AJ_dem_res_le_koN	low CI	up CI
Local bus (n=284)	3,3	3,2	3,4	4,04	3,9	4,1
Express/airport bus (n=75)	3,45	3,2	3,7	4,17	4,0	4,3
Taxi / Maxi Taxi owner (n=32)	3,53	3,1	3,9	3,87	3,6	4,2
Truck drivers (n=192)	3,12	2,9	3,3	3,96	3,8	4,1
Passenger train (n=82)	3,41	3,2	3,6	4,19	4,1	4,3
Cargo train (n=73)	3,06	2,8	3,3	4,44	4,3	4,6
Domestic ferry (n=144)	3,37	3,2	3,6	4,04	3,9	4,2
Oil, gas, chemical tanker (n=39)	3,44	3,1	3,8	4,12	3,9	4,3
Tug, AHT, survey ships (n=35)	3,7	3,6	3,8	4,27	4,2	4,4
Offhsore service (n=242)	3,63	3,3	4,0	4,11	3,9	4,3
Fishing, coastal freight (n=25)	3,4	2,9	3,9	4,12	3,8	4,5
Bulk, container, reefer, fish carriers (n=42)	3,47	3,1	3,8	4,09	3,8	4,4
ROAD (drivers; n=597)	3,27	3,2	3,4	4,02	4,0	4,1
RAIL (loc. Engineers, n=155)	3,25	3,1	3,4	4,3	4,2	4,4
SEA (officers, n=551)	3,53	3,4	3,6	4,11	4,0	4,2
ALL OPERATORS (n=1303)	3,37	3,3	3,4	4,09	4,0	4,1

Sleep

	Sleep quantity (h)	SEM	low CI	upper CI	Sleep debt (h)	SEM	low CI	upper CI
Oil, gas, chemical tanker (n=59)	7,62	0,14	7,35	7,89	0,66	0,12	0,42	0,89
Bulk, container, reefer, fish carriers (n=61)	7,60	0,20	7,21	7,99	0,89	0,13	0,64	1,14
Fishing, coastal freight (n=31)	7,40	0,24	6,93	7,87	0,78	0,17	0,45	1,12
Taxi / Maxi Taxi owner (n=289)	7,12	0,07	6,98	7,26	0,92	0,06	0,80	1,05
Offhsore service (n=298)	7,12	0,07	6,99	7,25	1,09	0,06	0,98	1,19
Passenger train (n=82)	7,11	0,12	6,88	7,34	1,18	0,11	0,97	1,40
Express/airport bus (n=80)	7,07	0,12	6,83	7,31	0,78	0,10	0,58	0,98
Tug, AHT, survey ships (n=50)	7,06	0,15	6,77	7,35	1,11	0,16	0,80	1,42
Domestic ferry (n=172)	6,80	0,10	6,61	6,99	1,22	0,08	1,06	1,38
Cargo train (n=73)	6,80	0,13	6,54	7,06	1,28	0,13	1,03	1,52
Local bus (n=312)	6,79	0,06	6,67	6,91	1,24	0,07	1,12	1,37
Truck drivers (n=216)	6,77	0,08	6,61	6,93	1,47	0,09	1,29	1,66
ROAD (drivers; n=911)	6,92	0,04	6,85	6,99	1,16	0,04	1,08	1,23
RAIL (loc. Engineers, n=155)	6,97	0,09	6,80	7,14	1,23	0,08	1,07	1,39
SEA (officers, n=700)	7,13	0,05	7,04	7,22	1,04	0,04	0,97	1,12
ALL OPERATORS (n=1765)	7,01	0,03	6,96	7,06	1,12	0,03	1,07	1,17

Sleep quality over 3 months prior to survey

	Sleep quality over last 3 months	low CI	up CI
Taxi / Maxi Taxi owner (n=294)	14,59	14,2	15,0
Fishing, coastal freight (n=31)	14,52	13,4	15,6
Express/airport bus (n=80)	14,44	13,7	15,2
Bulk, container, reefer, fish carriers (n=61)	13,89	13,1	14,7
Local bus (n=312)	13,63	13,2	14,0
Tug, AHT, survey ships (n=50)	13,44	12,5	14,4
Truck drivers (n=216)	13,4	13,0	13,8
Oil, gas, chemical tanker (n=59)	13,37	12,5	14,2
Domestic ferry (n=174)	13,19	12,7	13,7
Passenger train (n=82)	13,12	12,5	13,8
Offhsore service (n=300)	12,89	12,5	13,2
Cargo train (n=73)	12,75	12,0	13,5
ROAD (drivers; n=916)	13,92	13,7	14,2
RAIL (loc. Engineers, n=155)	12,96	12,5	13,5
SEA (officers, n=704)	13,21	13,0	13,4
ALL OPERATORS (n=1775)	13,55	13,4	13,7

Sleep quality before last work period

	Sleep quality before last work period	low CI	up CI
Taxi / Maxi Taxi owner (n=107)	11,55	11,12	11,98
Truck drivers (n=81)	10,91	10,34	11,48
Local bus (n=111)	10,74	10,27	11,21
Fishing, coastal freight (n=14)	10,71	9,65	11,77
Tug, AHT, survey ships (n=22)	10,5	9,65	11,35
Domestic ferry (n=76)	10,42	9,79	11,05
Bulk, container, reefer, fish carriers (n=30)	10,37	9,48	11,26
Express/airport bus (n=24)	10,34	9,32	11,36
Passenger train (n=27)	10,22	9,20	11,24
Offhsore service (n=139)	9,64	9,26	10,02
Cargo train (n=23)	9,61	8,46	10,76
Oil, gas, chemical tanker (n=25)	9,6	8,59	10,61
ROAD (drivers; n=330)	10,99	10,72	11,26
RAIL (loc. Engineers, n=50)	9,94	9,18	10,70
SEA (officers, n=314)	10,04	9,77	10,31
ALL OPERATORS (n=694)	10,49	10,30	10,68

Psychological detachment

	Psych Detachment in free time away	SEM	low CI	upper CI
Tog, passasjer (n=43)	3,33	0,16	3,0	3,6
Tog, gods (n=70)	3,23	0,1	3,0	3,4
Ferge innenriks(n=159)	3,03	0,084	2,9	3,2
Gods, vei (n=94)	2,98	0,114	2,8	3,2
Olje-,gass-,kemikalietankeskip (n=58)	2,67	0,148	2,4	3,0
Offshore service (n=289)	2,58	0,059	2,5	2,7
Tug, AHT, surveyskip (n=46)	2,54	0,14	2,3	2,8
Bulk, kontainer, reefer, brønnbåt (n=58)	2,54	0,13	2,3	2,8
Fiskefartøy, kystfrakt (n=29)	2,4	0,21	2,0	2,8
SJÅFØRER (vei) (n=148)	2,88	0,091	2,7	3,1
LOKFØRERE (n=113)	3,27	0,088	3,1	3,4
SJØOFFISERER (n=666)	2,69	0,04	2,6	2,8
ALLE OPERATØRER (n=927)	2,79	0,035	2,7	2,9

	Psych Det in free time at home	SEM	low CI	upper CI
Tog, passasjer (n=39)	3,84	0,11	3,6	4,1
Rute-, skolebuss (n=298)	3,36	0,056	3,3	3,5
Gods, vei (n=122)	3,36	0,094	3,2	3,5
Ekspress-, flybuss (n=60)	3,34	0,11	3,1	3,6
Taxieiere (n=275)	3,14	0,06	3,0	3,3
SJÅFØRER (vei) (n=769)	3,28	0,036	3,2	3,4
LOKFØRERE (n=42)	3,8	0,1	3,6	4,0
SJØOFFISERER (n=37)	3,23	0,16	2,9	3,5
ALLE OPERATØRER (n=848)	3,3	0,033	3,2	3,4

Work-home interference

	WHI	SEM	low CI	upper CI
Express/airport bus (n=80)	2,46	0,099	2,3	2,7
Taxi / Maxi Taxi owner (n=294)	2,55	0,055	2,4	2,7
Local bus (n=312)	2,618	0,052	2,5	2,7
Fishing, coastal freight (n=31)	2,74	0,141	2,5	3,0
Domestic ferry (n=174)	2,748	0,068	2,6	2,9
Bulk, container, reefer, fish carriers (n=61)	2,78	0,1	2,6	3,0
Oil, gas, chemical tanker (n=59)	2,82	0,096	2,6	3,0
Passenger train (n=82)	2,85	0,085	2,7	3,0
Truck drivers (n=216)	2,9	0,06	2,8	3,0
Tug, AHT, survey ships (n=50)	2,99	0,1	2,8	3,2
Offhsore service (n=300)	3,03	0,046	2,9	3,1
Cargo train (n=73)	3,1	0,084	2,9	3,3
ROAD (drivers; n=916)	2,65	0,03	2,6	2,7
RAIL (loc. Engineers, n=155)	2,97	0,06	2,9	3,1
SEA (officers, n=703)	2,9	0,031	2,8	3,0
ALL OPERATORS (n=1775)	2,78	0,021	2,7	2,8

ESS

	ESS	SEM	low CI	upper CI
Local bus (n=312)	8,34	0,23	7,9	8,8
Express/airport bus (n=80)	8,15	0,37	7,4	8,9
Taxi / Maxi Taxi owner (n=295)	6,79	0,22	6,4	7,2
Truck drivers (n=216)	8,27	0,24	7,8	8,7
Passenger train (n=82)	7,34	0,38	6,6	8,1
Cargo train (n=73)	8,05	0,42	7,2	8,9
Domestic ferry (n=174)	7,64	0,3	7,1	8,2
Oil, gas, chemical tanker (n=59)	8,12	0,37	7,4	8,8
Tug, AHT, survey ships (n=50)	8,12	0,51	7,1	9,1
Offhsore service (n=300)	7,89	0,21	7,5	8,3
Fishing, coastal freight (n=31)	7,26	0,56	6,2	8,4
Bulk, container, reefer, fish carriers (n=61)	8,13	0,46	7,2	9,0
ROAD (drivers; n=917)	7,79	0,13	7,5	8,0
RAIL (loc. Engineers, n=155)	7,7	0,28	7,2	8,2
SEA (officers, n=704)	7,83	0,14	7,6	8,1
ALLE OPERATØRER (n=1776)	7,79	0,09	7,6	8,0

CIS

	CIS severity	SEM	low CI	upper CI	CIS conc.	SEM	low CI	upper CI
Local bus (n=312)	3,0179	0,05676	2,91	3,13	2,4455	0,03125	2,38	2,51
Express/airport bus (n=80)	2,8175	0,1124	2,60	3,04	2,3125	0,1105	2,10	2,53
Taxi / Maxi Taxi owner (n=295)	2,9408	0,06351	2,82	3,07	2,267	0,06622	2,14	2,40
Truck drivers (n=216)	2,812	0,0649	2,68	2,94	2,4838	0,07571	2,34	2,63
Passenger train (n=82)	3,14	0,10762	2,93	3,35	2,3293	0,0967	2,14	2,52
Cargo train (n=73)	3,1178	0,13073	2,86	3,37	2,4452	0,13744	2,18	2,71
Domestic ferry (n=174)	2,9115	0,06723	2,78	3,04	2,4741	0,074	2,33	2,62
Oil, gas, chemical tanker (n=59)	3,0136	0,122278	2,77	3,25	2,5424	0,12462	2,30	2,79
Tug, AHT, survey ships (n=50)	2,888	0,1207	2,65	3,12	2,62	0,1411	2,34	2,90
Offhsore service (n=300)	2,968	0,0524	2,87	3,07	2,535	0,0595	2,42	2,65
Fishing, coastal freight (n=31)	2,658	0,191	2,28	3,03	2,7097	0,1619	2,39	3,03
Bulk, container, reefer, fish carriers (n=61)	2,7536	0,11397	2,53	2,98	2,5164	0,11918	2,28	2,75
							0,00	0,00
ROAD (drivers; n=917)	2,9349	0,0339	2,87	3,00	2,3848	0,03627	2,31	2,46
RAIL (loc. Engineers, n=155)	3,129	0,08359	2,97	3,29	2,3839	0,08236	2,22	2,55
SEA (officers, n=704)	2,9162	0,034	2,85	2,98	2,5357	0,03755	2,46	2,61
ALLE OPERATØRER (n=1776)	2,9445	0,02329	2,90	2,99	2,4434	0,02502	2,39	2,49

OLBI

	OLBI diseng	SEM	low CI	upper CI	OLBI exhaust	SEM	low CI	upper CI
Express/airport bus (n=80)	2,1196	0,05781	2,01	2,23	2,3979	0,06355	2,27	2,52
Fishing, coastal freight (n=31)	2,125	0,09744	1,93	2,32	2,3281	0,10026	2,13	2,52
Taxi / Maxi Taxi owner (n=295)	2,2077	0,03449	2,14	2,28	2,409	0,03935	2,33	2,49
Cargo train (n=73)	2,2571	0,06654	2,13	2,39	2,6044	0,06513	2,48	2,73
Bulk, container, reefer, fish carriers (n=61)	2,2857	0,06212	2,16	2,41	2,4312	0,06985	2,29	2,57
Truck drivers (n=216)	2,287	0,03651	2,22	2,36	2,5841	0,04098	2,50	2,66
Offhsore service (n=300)	2,2963	0,02628	2,24	2,35	2,5609	0,02792	2,51	2,62
Oil, gas, chemical tanker (n=59)	2,3091	0,06837	2,18	2,44	2,5464	0,07301	2,40	2,69
Local bus (n=312)	2,33	0,03185	2,27	2,39	2,5176	0,03529	2,45	2,59
Domestic ferry (n=174)	2,3668	0,03608	2,30	2,44	2,6468	0,04091	2,57	2,73
Passenger train (n=82)	2,3882	0,05914	2,27	2,50	2,5254	0,05041	2,43	2,62
Tug, AHT, survey ships (n=50)	2,4006	0,0693	2,26	2,54	2,585	0,0809	2,43	2,74
ROAD (drivers; n=917)	2,2672	0,0188	2,23	2,30	2,4927	0,02097	2,45	2,53
RAIL (loc. Engineers, n=155)	2,3293	0,04436	2,24	2,42	2,5609	0,04032	2,48	2,64
SEA (officers, n=704)	2,3116	0,01793	2,28	2,35	2,5562	0,01985	2,52	2,60
ALLE OPERATØRER (n=1776)	2,291	0,01259	2,27	2,32	2,5249	0,01377	2,50	2,55

KSS

	KSS before	SEM	low CI	upper CI	KSS first hour	SEM	low CI	upper CI
Fishing, coastal freight (n=14)	4,5	0,6	3,3	5,7	3,0	0,5	2,0	4,0
Taxi / Maxi Taxi owner (n=108)	3,7	0,2	3,3	4,0	2,6	0,2	2,2	2,9
Truck drivers (n=81)	3,1	0,2	2,6	3,6	2,7	0,2	2,4	3,1
Local bus (n=111)	3,2	0,2	2,8	3,6	3,1	0,2	2,8	3,4
Express/airport bus (n=24)	3,5	0,5	2,6	4,4	3,3	0,4	2,5	4,1
Offhsore service (n=139)	4,5	0,2	4,1	4,9	4,1	0,2	3,8	4,4
Tug, AHT, survey ships (n=22)	5,3	0,4	4,6	6,0	4,5	0,3	3,9	5,1
Domestic ferry (n=76)	4,0	0,3	3,5	4,5	3,7	0,2	3,3	4,2
Bulk, container, reefer, fish carriers (n=30)	4,4	0,4	3,7	5,1	3,7	0,3	3,2	4,2
Passenger train (n=27)	3,9	0,4	3,1	4,6	4,2	0,4	3,4	4,9
Oil, gas, chemical tanker (n=25)	4,0	0,4	3,2	4,9	3,8	0,3	3,1	4,4
Cargo train (n=23)	3,7	0,4	2,9	4,4	3,8	0,4	3,0	4,5
ROAD (drivers; n=331)	3,4	0,1	3,2	3,6	2,9	0,1	2,7	3,1
RAIL (loc. Engineers, n=50)	3,8	0,3	3,2	4,3	4,0	0,3	3,4	4,5
SEA (officers, n=314)	4,4	0,1	4,1	4,6	3,9	0,1	3,7	4,1
ALL OPERATORS (n=695)	3,8	0,1	3,7	4,0	3,4	0,1	3,3	3,5

	KSS middle hour	SEM	low CI	upper CI	KSS last hour	SEM	low CI	upper CI
Fishing, coastal freight (n=14)	2,9	0,6	1,8	4,1	3,8	0,8	2,2	5,4
Taxi / Maxi Taxi owner (n=108)	3,1	0,2	2,8	3,5	4,0	0,2	3,7	4,4

Truck drivers (n=81)	3,1	0,2	2,7	3,5	4,1	0,2	3,7	4,6
Local bus (n=111)	3,6	0,2	3,3	4,0	4,4	0,2	4,0	4,8
Express/airport bus (n=24)	4,0	0,4	3,1	4,8	4,8	0,4	4,1	5,4
Offhsore service (n=139)	4,2	0,2	3,9	4,5	5,0	0,2	4,6	5,4
Tug, AHT, survey ships (n=22)	4,2	0,3	3,5	4,9	5,1	0,4	4,3	5,9
Domestic ferry (n=76)	4,2	0,2	3,7	4,6	5,3	0,2	4,9	5,8
Bulk, container, reefer, fish carriers (n=30)	3,9	0,4	3,1	4,7	5,4	0,4	4,7	6,1
Passenger train (n=27)	5,0	0,4	4,3	5,7	5,6	0,4	4,8	6,3
Oil, gas, chemical tanker (n=25)	4,4	0,3	3,7	5,0	5,6	0,4	4,9	6,3
Cargo train (n=23)	5,0	0,5	4,1	5,9	5,9	0,4	5,1	6,7
ROAD (drivers; n=331)	3,4	0,1	3,2	3,6	4,3	0,1	4,0	4,5
RAIL (loc. Engineers, n=50)	5,0	0,3	4,4	5,5	5,7	0,3	5,2	6,2
SEA (officers, n=314)	4,1	0,1	3,9	4,3	5,1	0,1	4,9	5,3
ALL OPERATORS (n=695)	3,8	0,1	3,7	4,0	4,7	0,1	4,6	4,9

	KSS after	SEM	low CI	upper CI
Fishing, coastal freight (n=14)	3,5	0,7	2,2	4,8
Taxi / Maxi Taxi owner (n=108)	4,8	0,2	4,4	5,2
Truck drivers (n=81)	4,8	0,2	4,3	5,3
Local bus (n=111)	5,0	0,2	4,6	5,4
Express/airport bus (n=24)	4,9	0,4	4,2	5,7
Offhsore service (n=139)	5,1	0,2	4,8	5,5
Tug, AHT, survey ships (n=22)	5,1	0,4	4,3	5,9
Domestic ferry (n=76)	5,7	0,2	5,3	6,2

Bulk, container, reefer, fish carriers (n=30)	5,7	0,4	5,0	6,4
Passenger train (n=27)	5,9	0,4	5,2	6,6
Oil, gas, chemical tanker (n=25)	5,8	0,3	5,3	6,4
Cargo train (n=23)	6,3	0,4	5,5	7,1
ROAD (drivers; n=331)	4,9	0,1	4,7	5,1
RAIL (loc. Engineers, n=50)	5,0	0,3	4,4	5,5
SEA (officers, n=314)	4,1	0,1	3,9	4,3
ALL OPERATORS (n=695)	3,8	0,1	3,7	4,0

Samn-Perelli

	Samn-Perelli before	SEM	low CI	upper CI	SamnPerelli first hour	SEM	low CI	upper CI
Fishing, coastal freight (n=14)	3.0	0.4	2.3	3.7	2.5	0.5	1.5	3.5
Taxi / Maxi Taxi owner (n=108)	2.7	0.1	2.4	3.0	2.0	0.2	1.7	2.4
Truck drivers (n=81)	2.4	0.1	2.1	2.7	2.1	0.2	1.7	2.4
Local bus (n=111)	2.5	0.1	2.2	2.7	2.3	0.2	2.0	2.6
Express/airport bus (n=24)	2.5	0.3	2.0	3.0	2.3	0.4	1.5	3.0
Offhsore service (n=139)	3.2	0.1	3.0	3.4	2.9	0.2	2.6	3.2
Bulk, container, reefer, fish carriers (n=30)	3.1	0.2	2.7	3.5	2.5	0.3	2.0	3.0
Tug, AHT, survey ships (n=22)	3.7	0.3	3.2	4.2	3.2	0.3	2.6	3.8
Domestic ferry (n=76)	2.8	0.2	2.5	3.2	2.7	0.2	2.2	3.1
Passenger train (n=27)	3.0	0.3	2.5	3.5	3.1	0.4	2.3	3.9
Oil, gas, chemical tanker (n=25)	2.8	0.2	2.3	3.2	2.7	0.3	2.0	3.4
Cargo train (n=23)	2.5	0.3	2.0	3.1	2.7	0.4	1.9	3.4
ROAD (drivers; n=331)	2.5	0.1	2.4	2.7	2.2	0.1	2.0	2.4
RAIL (loc. Engineers, n=50)	2.8	0.2	2.4	3.2	2.9	0.3	2.4	3.4
SEA (officers, n=314)	3.1	0.1	2.9	3.2	2.8	0.1	2.6	3.0
ALLE OPERATØRER (n=695)	2.8	0.1	2.7	2.9	2.5	0.1	2.4	2.6

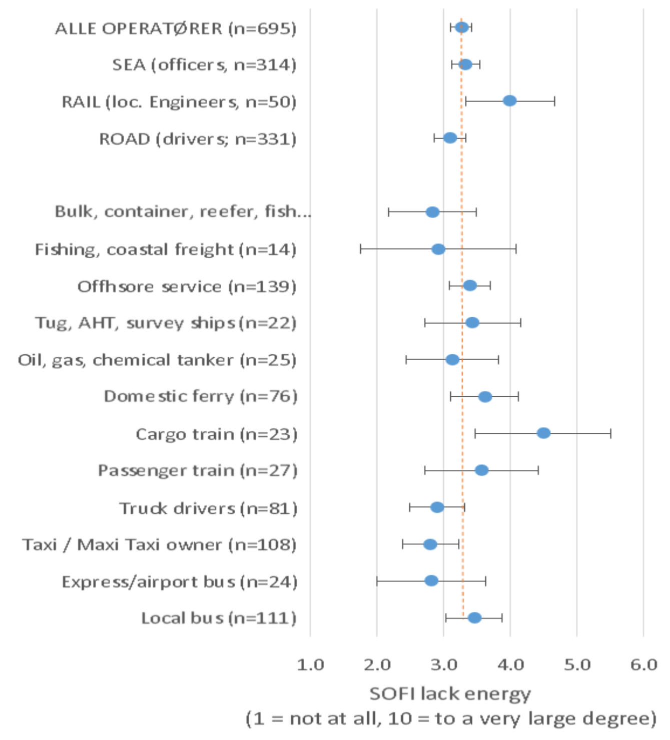
	SamnPerelli middle hour	SEM	low CI	upper CI	SamnPerelli middle hour	SEM	low CI	upper CI

Fishing, coastal freight (n=14)	2.4	0.6	1.3	3.6	2.4	0.6	1.3	3.6
Taxi / Maxi Taxi owner (n=108)	2.4	0.2	2.1	2.7	2.4	0.2	2.1	2.7
Truck drivers (n=81)	2.4	0.2	2.0	2.8	2.4	0.2	2.0	2.8
Local bus (n=111)	2.7	0.2	2.4	3.0	2.7	0.2	2.4	3.0
Express/airport bus (n=24)	2.5	0.4	1.7	3.3	2.5	0.4	1.7	3.3
Offhsore service (n=139)	3.0	0.2	2.6	3.3	3.0	0.2	2.6	3.3
Bulk, container, reefer, fish carriers (n=30)	2.9	0.4	2.1	3.7	2.9	0.4	2.1	3.7
Tug, AHT, survey ships (n=22)	2.7	0.3	2.0	3.4	2.7	0.3	2.0	3.4
Domestic ferry (n=76)	3.1	0.2	2.7	3.6	3.1	0.2	2.7	3.6
Passenger train (n=27)	3.6	0.4	2.9	4.3	3.6	0.4	2.9	4.3
Oil, gas, chemical tanker (n=25)	3.2	0.3	2.5	3.8	3.2	0.3	2.5	3.8
Cargo train (n=23)	3.4	0.5	2.5	4.3	3.4	0.5	2.5	4.3
ROAD (drivers; n=331)	2.5	0.1	2.3	2.7	2.5	0.1	2.3	2.7
RAIL (loc. Engineers, n=50)	3.5	0.3	3.0	4.1	3.5	0.3	3.0	4.1
SEA (officers, n=314)	3.0	0.1	2.8	3.2	3.0	0.1	2.8	3.2
ALLE OPERATØRER (n=695)	2.8	0.1	2.7	3.0	2.8	0.1	2.7	3.0

	SamnPerelli after	SEM	low CI	upper CI
Fishing, coastal freight (n=14)	2.8	0.7	1.5	4.1
Taxi / Maxi Taxi owner (n=108)	3.8	0.2	3.4	4.2
Truck drivers (n=81)	3.7	0.2	3.3	4.2
Local bus (n=111)	3.7	0.2	3.4	4.1

Express/airport bus (n=24)	3.8	0.4	3.1	4.6
Offhsore service (n=139)	3.8	0.2	3.4	4.1
Bulk, container, reefer, fish carriers (n=30)	4.3	0.4	3.6	5.0
Tug, AHT, survey ships (n=22)	3.9	0.4	3.1	4.7
Domestic ferry (n=76)	4.3	0.2	3.9	4.7
Passenger train (n=27)	4.4	0.4	3.6	5.1
Oil, gas, chemical tanker (n=25)	4.4	0.3	3.8	5.0
Cargo train (n=23)	4.9	0.4	4.1	5.6
ROAD (drivers; n=331)	3.8	0.1	3.6	4.0
RAIL (loc. Engineers, n=50)	4.6	0.3	4.1	5.1
SEA (officers, n=314)	4.0	0.1	3.7	4.2
ALLE OPERATØRER (n=695)	3.9	0.1	3.8	4.1

SOFI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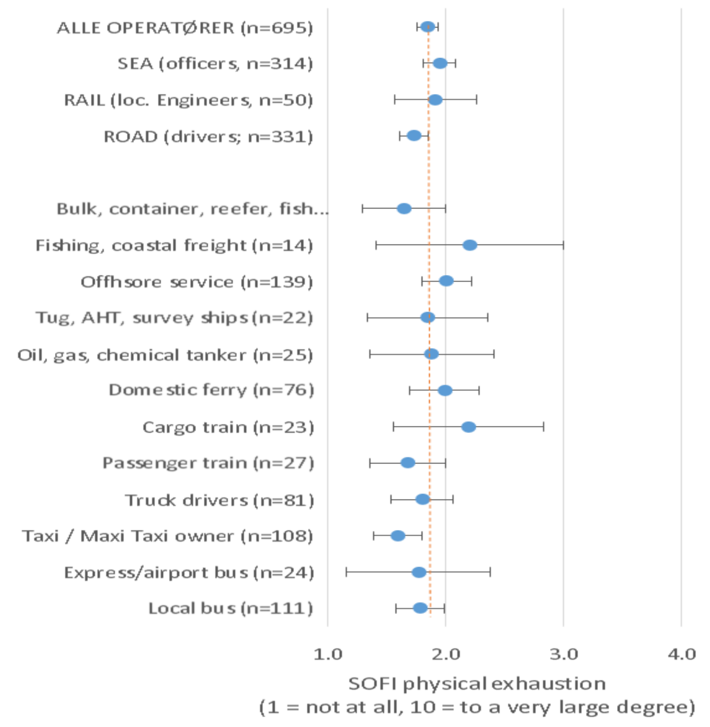
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Bulk, container, reefer, fish...
Fishing, coastal freight (n=14)
Offhsore service (n=139)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Domestic ferry (n=76)
Cargo train (n=23)
Passenger train (n=27)
Truck drivers (n=81)
Taxi / Maxi Taxi owner (n=108)
Express/airport bus (n=24)
Local bus (n=111)
1.0
2.0
3.0
4.0
5.0
6.0
SOFI lack energy
(1 = not at all, 10 = to a very large degree)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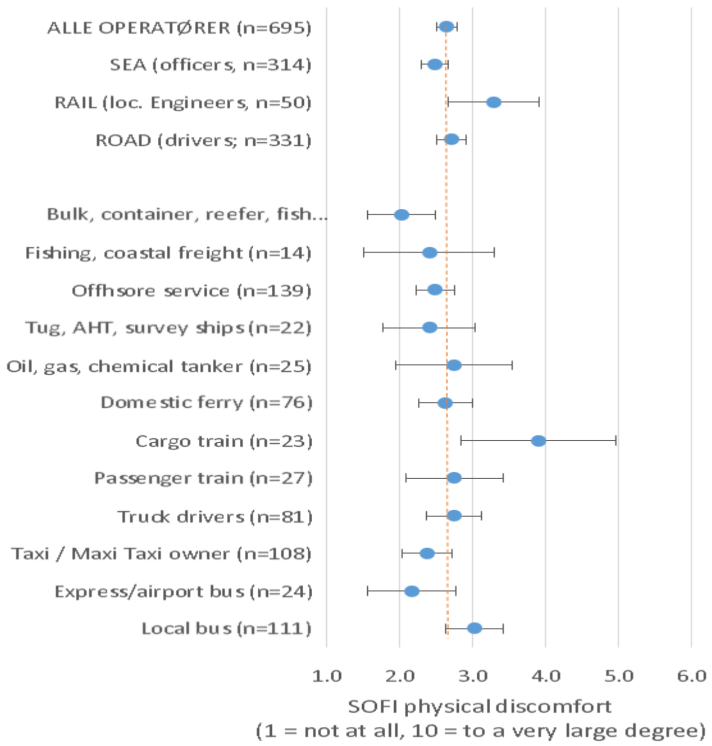
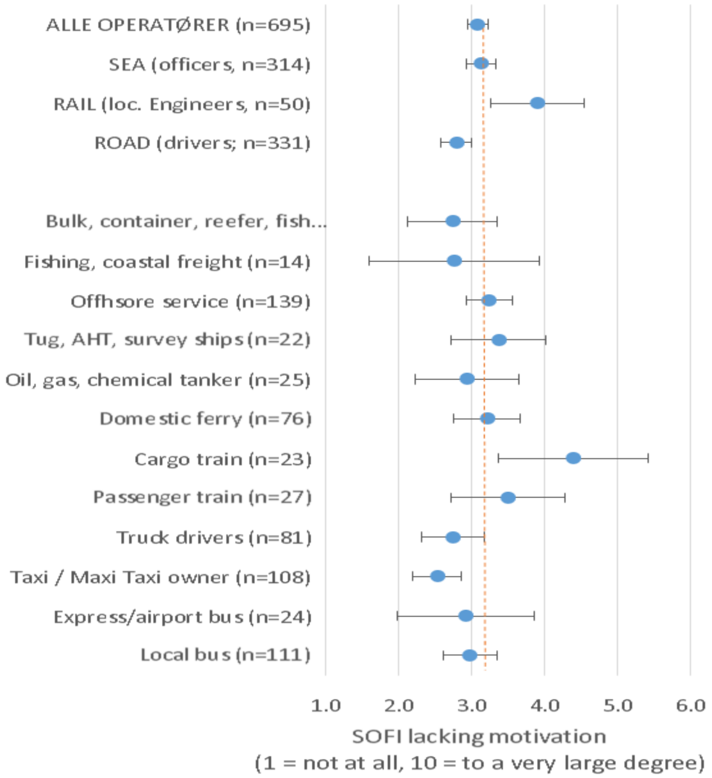
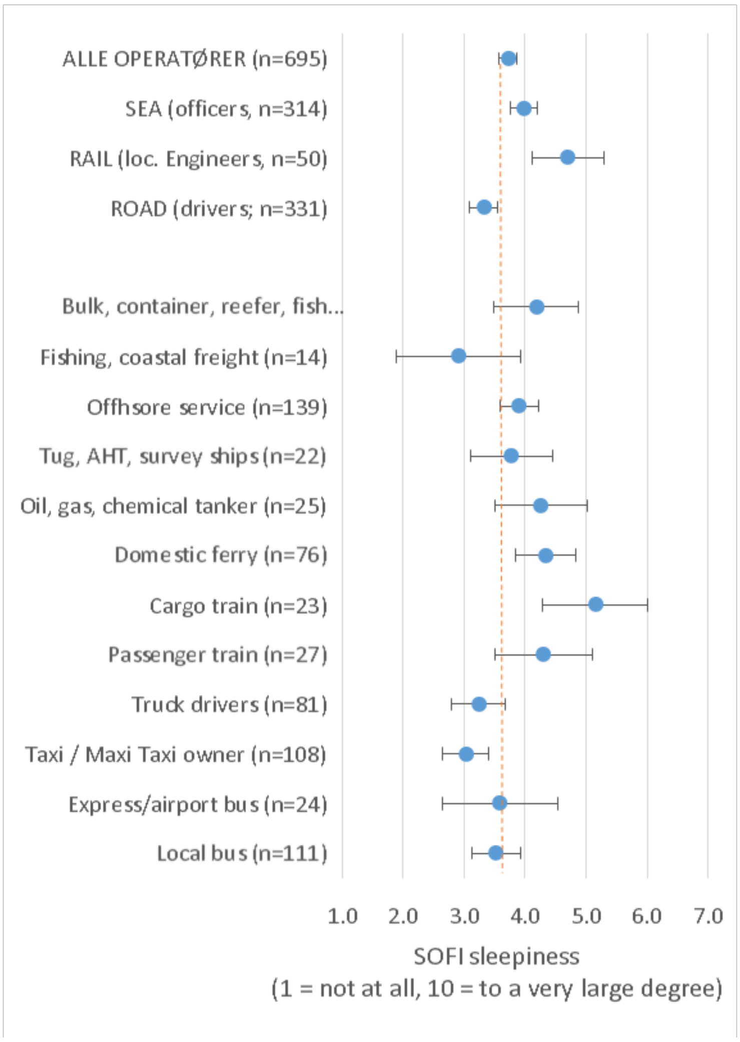
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Bulk, container, reefer, fish...
Fishing, coastal freight (n=14)
Offhsore service (n=139)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Domestic ferry (n=76)
Cargo train (n=23)
Passenger train (n=27)
Truck drivers (n=81)
Taxi / Maxi Taxi owner (n=108)
Express/airport bus (n=24)
Local bus (n=111)
1.0
2.0
3.0
4.0
SOFI physical exhaustion
(1 = not at all, 10 = to a very large degree)


ALLE OPERATØRER (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Bulk, container, reefer, fish...
Fishing, coastal freight (n=14)
Offhsore service (n=139)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Domestic ferry (n=76)
Cargo train (n=23)
Passenger train (n=27)
Truck drivers (n=81)
Taxi / Maxi Taxi owner (n=108)
Express/airport bus (n=24)
Local bus (n=111)
1.0
2.0
3.0
4.0
5.0
6.0
SOFI physical discomfort
(1 = not at all, 10 = to a very large degree)


ALLE OPERATØRER (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Bulk, container, reefer, fish...
Fishing, coastal freight (n=14)
Offhsore service (n=139)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Domestic ferry (n=76)
Cargo train (n=23)
Passenger train (n=27)
Truck drivers (n=81)
Taxi / Maxi Taxi owner (n=108)
Express/airport bus (n=24)
Local bus (n=111)
1.0
2.0
3.0
4.0
5.0
6.0
SOFI lacking motivation
(1 = not at all, 10 = to a very large degree)


ALLE OPERATØRER (n=695)
SEA (officers, n=314)
RAIL (loc. Engineers, n=50)
ROAD (drivers; n=331)
Bulk, container, reefer, fish...
Fishing, coastal freight (n=14)
Offhsore service (n=139)
Tug, AHT, survey ships (n=22)
Oil, gas, chemical tanker (n=25)
Domestic ferry (n=76)
Cargo train (n=23)
Passenger train (n=27)
Truck drivers (n=81)
Taxi / Maxi Taxi owner (n=108)
Express/airport bus (n=24)
Local bus (n=111)
1.0
2.0
3.0
4.0
5.0
6.0
7.0
SOFI sleepiness
(1 = not at all, 10 = to a very large degree)

Fatigue culture

	Positive culture for fatigue	low CI	upper CI	Positive framework culture (3,4,7)	low CI	upper CI	Driver attitudes and understanding	low CI	upper CI
Local bus (n=223)	2,27	2,1	2,4	3,84	3,7	4,0	4,02	3,9	4,1
Express/airport bus (n=56)	2,48	2,2	2,8	4,34	4,1	4,5	4,28	4,1	4,5
Truck drivers (n=156)	2,26	2,1	2,4	3,87	3,7	4,0	4,24	4,1	4,4
Passenger train (n=65)	2,44	2,2	2,6	4,25	4,1	4,4	3,78	3,6	4,0
Cargo train (n=66)	2,23	2,1	2,4	3,97	3,8	4,2	3,73	3,5	3,9
Domestic ferry (n=150)	2,57	2,4	2,7	3,66	3,5	3,8	4,31	4,2	4,4
Oil, gas, chemical tanker (n=54)	3,38	3,1	3,7	2,94	2,7	3,2	4,36	4,2	4,5
Tug, AHT, survey ships (n=45)	3,18	2,9	3,5	3,29	2,9	3,6	4,39	4,2	4,6
Offhsore service (n=252)	2,82	2,7	2,9	3,27	3,1	3,4	4,15	4,1	4,2
Fishing, coastal freight (n=29)	2,41	2,0	2,8	2,96	2,5	3,4	3,96	3,7	4,3
Bulk, container, reefer, fish carriers (n=48)	2,73	2,1	3,3	3,96	3,7	4,3	4,28	4,0	4,5
ROAD (drivers; n=450)	2,31	2,2	2,4	3,91	3,8	4,0	4,13	4,1	4,2
RAIL (loc. Engineers, n=131)	2,33	2,2	2,4	4,13	4,0	4,3	3,76	3,6	3,9
SEA (officers, n=602)	2,81	2,7	2,9	3,33	3,2	3,4	4,24		
ALL OPERATORS (n=1183)	2,57	2,5	2,6	3,65	4,0	4,2			

Institute of Transport Economics (TØI)

Norwegian Centre for Transport Research

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