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Traffic safety in bus transport: An analysis of Norway's largest transit authority's contract requirements to bus companies

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A B S T R A C T

The main objective of the study is to evaluate direct and indirect traffic safety consequences of the requirements that Norway's largest transit authority (Ruter) sets in the contracts with bus companies. To assess the representativity of Ruter's requirements and its consequences, the data focuses both on Ruter and transit authorities from other areas in Norway, serving a mix of urban and rural areas. The study is based on qualitative interviews (N = 18), a workshop, reviews of documents and a quantitative survey (N = 1012). The study indicates that transit authorities may have direct influence on traffic safety, especially if they set requirements that exceeds (inter) national legislation. Ruter does that when it comes to driver collision protection and blind zone warning systems. We also find indications of indirect impact on traffic safety through the contracts. This is firstly related to the requirements for punctuality and regularity, which we find to be related to drivers' stress, driving style and accident involvement in our quantitative analysis. It is secondly related to environmental concerns, which motivate maintaining (and increasing) a high level of passengers. Interviewees said that this influences the types of buses specified in contracts (e.g. large high capacity buses), and their routes (e.g. in narrow streets, "where people live"). They also emphasized that roads and infrastructure, for example in Oslo, are poorly adapted to bus transport. In our quantitative analysis, we found that buses that are poorly adapted to the roads they are used on, and roads that are poorly adapted to bus transport were related to bus drivers' reported stress and time pressure, which were related to risky driving style, which in turn was related to accidents. Based on the study, we developed several policy implications, that we believe also can be relevant for, and inspire other transit authorities. Ruter has applied several of these changes after our study (e.g. requiring ISO:39001 certification from the bus operators in the contracts, starting to develop a system to learn from accidents), and may thus stand out as a transit authority that other may learn from when it comes to management of traffic safety.

1. Introduction

1.1. Background

Road safety is a worldwide societal health challenge as underlined by ambitious goals to halve the number of road deaths and serious injuries by 2030 (WHO, 2018; EU, 2020). As public transport vessels, buses can help increase road safety, since by reducing traffic on the road, they help reduce individual exposure to motor vehicles; they are also less likely to be involved in serious road collisions than cars (Truong and Currie, 2019). Further improvements in traffic safety are needed, however, to reduce the number of fatalities per bus in comparison with other types of vehicle (Kim et al., 2016; ERSO, 2018) or the number of collisions per million passenger kilometers which some studies still find to be comparable to collisions per million car driver kilometers (Kaplan and Prato, 2012). Approaches to improving road safety are normally aimed at the vehicle, road or driver (Elvik et al., 2009). Through setting contractual conditions, however, transit authorities have the potential to influence each of these aspects of bus operations: vehicles, routes and drivers. Despite this, the role of transit authorities in improving traffic safety appears to have been neglected. The current paper therefore attempts to start addressing this by examining whether transit authorities influence bus safety outcomes through

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conditions they set in contracts with bus operators. Bus operators refer to bus companies that are in a contractual relationship with a transit authority or another principal (which operates according to a contract).

1.1.1. *Administration of public transport by transit authorities*

Public transport in many urban and rural areas are administered by large transit authorities, which are government agencies or public-benefit corporations created for the purpose of providing public transportation within a specific region (e.g. APTA, 2018; Urban Transport Group, 2020). Transit authorities often purchase public transport operations from companies competing through public tenders, and the companies' obligations are regulated through contracts covering a defined period, usually lasting several years. A focus on competition and contracting became widespread in the eighties, as part of attempts at deregulation to reduce costs and increase innovation. Before this, public transport operations had largely been provided by public administrations or public companies holding monopoly positions, e.g. in Europe, Canada, Australia, New Zealand (Pedro and Macario 2016). Public Service Contracts is the normal method of securing the fulfilment of public service objectives (Pedro and Macario 2016). These contracts regulate a range of different aspects related to the performance of the operators, e.g. traffic safety, environmental concerns, punctuality, universal design.

1.1.2. *Buses and traffic safety*

Prior research on the safety of buses in traffic has tended to focus on crash occurrence, types of collision and injuries caused, and risk factors (e.g. Barua et al., 2010; Chimba et al., 2010; Kaplan et al., 2012; Kim et al., 2012; Phillips et al., 2021; Rahman, 2011), but few studies have looked at how risk factors are influenced by operating conditions set by transit authorities in their contracts with operators. This is surprising given that studies are available indicating links between bus driver working conditions or between type of operator and road safety behaviour and collision outcomes (e.g. Jayatilleke et al., 2009; Phillips & Bjørnskau, 2011, Staplin et al., 2003). Indeed, one study looking at the effect of deregulation in Taiwan, concludes that organizational factors, including driver-specific, vehicle-specific and general management factors can have significant effects on the safety performance of bus companies (Chang & Yeh, 2005). Other studies implying need to examine more closely the influence of transit authorities' effects on road safety management by bus operators, include findings from USA indicating that characteristics of bus operators may be related to fatal collision outcomes in which they are involved (Blower et al., 2010), or attempts at encouraging systems for road safety management in those companies (e.g. Knipling et al., 2003; (Izquierdo, Sesemann, and Alonso 2009).

1.1.3. *How transit authorities might influence traffic safety*

Transit authorities may influence traffic safety both directly and indirectly through contracts. Contracts make up the framework conditions of the operations of the bus companies, together with e.g. national rules, enforcement, inspections, competition and economy, and business structure. We define framework conditions as external factors which sets constraints on how organizations and their employees conduct their activities (cf. Rosness et al., 2012). Previous studies have indicated the importance of branch framework conditions (e.g. legal rules, economy, competition, inspections) for road safety (e.g. Bjørnskau & Longva 2009; Crum & Morrow 2002; Edwards et al., 2014).

Tendering processes may have important direct repercussions for traffic safety, as transit authorities in several ways define the safety standards of their bus operators by specifying contract requirements. Relevant requirements relate to buses and technology, regulation and control of of driver behaviour, organizational safety management measures, route choices and the quality of infrastructure used (e.g. bus stops, parking spaces, turning points, garages). Each of these requirements can influence traffic safety (cf. Elvik et al 2009). For example, on investigating a fatal head-on collision involving two buses driving at low speed (33–34 km/h), the Accident Investigation Board Norway (AIBN) recently concluded that the severity of injury to the buses and drivers was determined in part by the low degree of collision protection afforded by the buses, even though standards prescribed by (inter)national legislation were followed. The AIBN pointed out that the contractual safety requirements set by Ruter could be stricter than the rules dictate (AIBN 2019).

Transit authorities may also influence traffic safety indirectly, through tender contract requirements which are not directly related to traffic safety, but to punctuality, regularity, environmental concerns, universal design, or choice of route (Barabino et al. 2021). For example, previous research indicates that bus driver stress, induced by having to maintain a tight schedule, influences their driving behaviour and therefore risk for accident involvement (Nævestad et al 2019a; Davey et al 2006; Öz et al 2013). In another example, transit authorities in Norway have set requirements against the use of studded tyres on the buses, because of environmental concerns. This can be bad for traffic safety, however, when the buses drive on slippery winter roads (AIBN 2019).

These examples illustrate that transit authorities may have an important role in the production of traffic safety, as they may influence traffic safety in several direct and indirect ways through contracts. Transit authorities' influence on traffic safety is important at a societal level due to the scope of their operations. Transit authorities may go beyond national legislation, by setting additional safety requirements to their bus operators, or by mapping and adjusting indirect traffic safety impacts of other requirements. In these ways, transit authorities may contribute to a higher traffic safety level in our society (Nævestad et al 2019b).

To improve the knowledge base for improvements in traffic safety based on transit authority actions, the current study investigates the traffic safety effects of the contractual conditions set by Norway's largest transit authority (Ruter) and its bus operators. Ruter administrates public transport not only in the capital Oslo (population ca. 600.000), but also in rural and semi-urban areas in the adjacent county. The bus journeys administrated by Ruter make up 41% of the bus journeys in Norway (Statistics Norway 2022; Ruter 2020). The study focuses on both traffic safety impacts related to traffic safety requirements (direct impact), and traffic safety impacts of requirements related to the environment, regularity, punctuality and universal design (indirect impact).

1.2. Aims

The aim of the study is to analyze the traffic safety impacts of Ruter's contractual requirements to the bus operators that they purchase bus transport from. The study focuses on both traffic safety requirements (direct impact), and requirements related to the environment, mobility, punctuality and universal design (indirect impact) in the contracts. To assess the representativity of Ruter's requirements and its consequences, the study focuses both on Ruter and other transit authorities and bus transport principals in Norway. These are mainly comprised of county authorities. We measure traffic safety as accidents and unsafe behavior (aggressive driving style) (cf. section 3.2.2).

2. Theoretical approach and previous research

2.1. How do transit authorities influence bus operators?

In a previous study examining how Ruter can work with traffic safety (Nævestad et al. 2019b), we identified three main elements in Ruter's system influencing bus operator priorities and practices through contract requirements: 1) The requirements that Ruter sets in the contracts with bus operators, 2) Ruter's supervision and control that the requirements are complied with and 3) Sanctions, such as fees and the bonus/malus system, which provide operators with financial incentives to comply with Ruter's requirements. The bus tender contract review provided by Pedro and Macario (2016) indicates that these elements are representative for the practices in European transit authorities, although the specific outline of the different elements may differ.

2.2. Direct impacts of traffic safety requirements in contracts

A comparative review of 50 bus tender contracts (Pedro og Macario 2016) specified 29 characteristics of the contracts (duration, gross/net, rules in case of breach of contract, etc.). Specific safety requirements were not among the 29 characteristics specified. It does not therefore seem common to issue specific requirements to traffic safety or safety equipment in tender contracts, besides assuming that laws and regulations are followed.

With this background, it may be relevant to look also at other transport sectors, and to assess whether knowledge about the effects of legal safety requirements is transferable to contract requirements set in tender processes. The research here indicates that rules and requirements for safety, for example for safety management systems, are associated with a higher level of safety (Thomas 2012), although it is difficult to identify the isolated effect of rules compared to other factors. Legal requirements for safety management systems are linked, for example, to positive safety results in the maritime sector (Lappalainen et al 2012), in railways (Zuschlag et al 2016) and in aviation (Adjekum and Tous 2020). Studies from the road sector also show positive safety effects of the voluntary ISO: 39,001 standard for road safety (Naveh and Katz Navon 2015). Based on this, we can imagine that setting contract requirements for measures with a documented effect on safety and exceeding safety requirements set by national regulations could have a positive effect on safety.

Elvik et al (2009) showed that transport companies that transport dangerous goods (ADR) have a 75% lower risk than other goods transport companies. Although this might be due to the various rules regulating this transport and the transport buyer's focus on safety, there are no studies that map the isolated effect of rules. Bjørnskau and Longva (2009) compared the safety culture levels in different transport sectors (aircraft, helicopter, bus and rail). They found the highest level of safety culture in aviation, followed by rail and bus, concluding that the safety culture and level of safety in the various modes of transport could be largely explained by referring to framework conditions such as competition, laws/regulations, type of transport and costs of accidents. Although they did not discuss in detail the rules that form the basis for safety management, they did compare, for example, the Railways Act with the regulations for the road sector.

2.3. Indirect traffic safety impacts of contract requirements

As far as we know, there are no international studies examining the indirect impact of contract requirements on road safety. When it comes to hypothetical traffic safety effects of punctuality requirements, previous research indicates a significant level of stress among bus drivers, which to some extent is related to the focus on keeping timetables (Phillips and Bjørnskau 2013). Despite the importance of stress in the bus driver profession, Phillips and Bjørnskau (2013) conclude that there are few studies that examine the possible safety effects of this. However, in their analysis of data from a survey of>1,100 Norwegian drivers, Phillips and Bjørnskau (2013) find a relationship between perceived time pressure and risky driving behaviors such as speeding or breaking driving time regulations. Other studies of drivers at work in general also find connections between stress and time pressure and accident involvement (e.g. Davey et al. 2006), which is probably due to the fact that stress and time pressure affect driving style. Similarly, Nævestad et al (2019a) find a connection between time pressure and aggressive driving style in a study that compares Norwegian and Greek bus drivers. The study finds that drivers who state that they have an aggressive driving style are more often involved in accidents, and that this is due to perceived time pressure, which is the variable that had the strongest effect on drivers' accident involvement. However, Nævestad et al (2019a)'s study finds that the effect of time pressure on aggressive driving style is reduced when the analysis also controls for organizational safety culture. The study concludes that organizational safety culture helps to reduce the effect of time pressure on drivers' risk behavior. This shows how bus companies through working with safety culture can help reduce the negative influence of time pressure and stress. A previous study indicates that some of the bus companies work systematically with safety culture based on their own internal motivation, and that some have implemented ISO:39001 voluntarily (Nævestad et al 2019b).

We have not found any international studies focusing on the indirect traffic safety effects of contract requirements that deal with conditions such as the environment, or universal design. The mentioned AIBN study presumes however that a requirement not to use studded tyres, based on environmental concerns, may have negative traffic safety implications in the winter (AIBN 2019).

2.4. Hypotheses

We test three hypotheses about how Ruter and other bus transport principals in Norway can influence traffic safety through the contract requirements, controls and sanctions. The hypotheses are based on the research we have reviewed:

1) Ruter's and other principals' systems of influencing bus operators are effective, in the sense that the systems influence bus operators' priorities and practices.
2) Ruter and other principals have a direct impact on traffic safety through contractual requirements for traffic safety, when these require higher safety standards than those set by national legislation (e.g. by requiring effective measures like blind zone warning, SMS, safety culture measures, extra collision protection for the driver).
3) Ruter and other principals have an indirect impact on traffic safety through contractual requirements related to punctuality and regularity, as such requirements may increase driver stress, influence driving risky behaviours and accident involvement.

3. Methods

3.1. Workshop

We arranged a workshop at the start of the project to motivate interviewees to participate in interviews, motivate respondents to answer the questionnaire to get input on the project's methods, our analytical model, possible measures, etc. Additionally, we wanted to get general input on our research questions from a broad and multifaceted group of stakeholders. The workshop was arranged on March 3, 2020, and approximately 60 participants were present. The workshop lasted a little over two hours. Background information about the project was provided from Ruter, the Institute of Transport Economics (TØI) and the AIBN. The Institute of Transport Economics is a national, Norwegian institution for multidisciplinary transport research. It is an independent, non-profit research foundation. A panel debate was then conducted, which focused on the key research questions of the study. The panelists represented the main employer and employee organisations in the Norwegian bus sector. In the workshop, Ruter's practices, role and potential influence on traffic safety, directly and indirectly, were discussed and compared to those of other Norwegian and Swedish bus transport buyers. When comparing Ruter with other bus transport buyers in Norway, we also draw on a recent report, focusing on the characteristics of Norwegian bus tenders and contracts, based on interviews with all the large bus transport buyers and bus operator companies in Norway (Vista Analyse 2018).

3.2. Qualitative interviews

Semi-structured qualitative interviews were conducted to generate rich descriptions of key themes to be explored and quantified in the ensuing quantitative survey (Creswell & Poth, 2017). We conducted interviews with 18 people. We interviewed two managers from Ruter, who together provided an operative and legal overview of the tender contracting process; nine people representing bus operators at management level; five bus driver trade union representatives; and two employer association representatives. All interviews were conducted by telephone, Teams or Skype. The interviews were mostly conducted in the period March-May 2020, and then there was no opportunities to do personal interviews, due to COVID-19 restrictions. Five of the interviews were conducted as group interviews. The interviews lasted from 45 minutes to two and a half hours. Most interviews lasted about an hour and a half. The interviews and questions were adapted to the different groups. The focus in the interviews was primarily on Ruter, but also on whether and how the requirements of Ruter differ from those of other transit authorities and bus transport principals in Norway.

Interviews covered six topics. We started by asking about the interviewee's own organization, about what they do, how they are involved in traffic safety work and contracts. Secondly, we asked about tenders and contracts, focusing on how the operators are involved in the tender process, about how the operators' safety work may be emphasized in the process. Thirdly, we asked about direct requirements for traffic safety in the contracts, what is required and how traffic safety is considered. In combination with this, we have also conducted a document review of the appendices to the contracts used by Ruter to get more information about the various contract requirements and how they are weighted in the tender process. Fourthly, we asked about the indirect impact on traffic safety, through requirements focusing on the environment, regularity, punctuality, universal design, etc. We also asked how the operators handle any negative effects. In addition, we asked about fees and the bonus-malus system (which involves rewards for goal attainment and fines for the opposite), and what the operators experience that Ruter/bus transport principals pay the most attention to on a daily basis (for example: regularity, environment, driving style, traffic safety). Fifth, we asked about possible future measures, i.e. conditions that are not requested in the contracts, but which could potentially have an impact on road safety. Finally, we asked about the most important elements in the traffic safety work of the interviewees' organisations, and whether they think that this safety work is sufficiently rewarded in the tender process. Two researchers took detailed notes in the interviews. These notes were reviewed, and main themes developed. Questions for use in the survey were developed from the main themes, as set out below.

3.3. Quantitative survey

3.3.1. Recruitment of respondents

After considering the statistical power needed for moderate statistical significance, we obtained survey responses from a total of 1012 respondents: 232 drivers who drive for Ruter in Oslo and Viken and 780 who drive for other principals in other parts of the country. We refer to the drivers who drive for other bus transport principals in other parts of the country, as *other drivers*. There are 14,000 bus drivers in Norway and 20% of these (i.e. 2800) drive for Ruter. Thus, the distribution of drivers who drive for Ruter (23%) vs. other drivers (77%) in our sample is relatively similar to the distribution of bus drivers in Norway when it comes to Ruter drivers vs. other drivers. Chi-squared tests were performed to examine differences between drivers who drive for Ruter and other drivers in the distribution of shares responding to questions according to the different answer categories. Power tests performed using G*Power version 3.1.97 showed that the size of our total sample was enough to detect small differences ($w = 0.3$) at probability level alpha = 0.001 and power 90% (required sample size $n = 308$; assuming 4 degrees of freedom). Analysis showed that the power achieved given the sample size used was over 99%. We have included drivers who drive for other principals than Ruter as a basis for comparison, to assess the representativeness of Ruter's requirements and consequences, and to get a better basis for our conclusions about what affects traffic safety in bus transport. We have a similar focus in the qualitative data. The drivers who drive for Ruter have been recruited from four bus operators and from two unions. The other drivers are recruited from the two unions and one of the bus operators.

In each recruitment setting, we used contact persons who passed on links to the survey with the following introduction:"Answer with regards to the situation as it was before the COVID-19 measures in Norway (i.e. before 12 March)". The survey was mainly conducted in May/June 2020. We have not calculated response rates for the various groups, because we generally lack information on how many have received the link to the survey. The link to the survey was often distributed on common digital platforms for different groups of drivers, and then we do not know how many have seen these and have had the opportunity to answer. For the drivers who were recruited through the unions, we asked whether the drivers worked for Ruter to avoid a mix up of the two samples. Thus, Ruter drivers were excluded from the union samples.

3.3.2. Themes in the survey

The survey contains 8 different topics:

1) **Background variables:** gender, nationality, age, experience, which type of bus they drive the most, etc.
2) **Dangerous situations:** how often they happen (from never, to several times a day), and what they are due to, for example: Poorly designed intersections, poorly designed bus stops, Bus type that is poorly adapted to the bus route, Strollers/wheelchairs that are not secured etc. These questions were developed based on risk factors mentioned in the qualitative interviews.
3) **Emergency braking to avoid accidents and dangerous situations**: due to: Electric scooters in and around the road, Pedestrians, Cyclists, car drivers, Other road users in the public transport lane (e.g. electric cars and cyclists), Improperly parked cars etc. These questions were also developed based on the qualitative interviews.
4) **Safety culture**. We included 5 questions about organizational safety culture, based on the GAIN index (GAIN 2001), which has been used in several studies of bus drivers and professional transport (e.g. Nævestad et al 2019a). We also included questions about the use of fleet management system technology in the buses and companies of respondents', as some of the companies use these systematically (Nævestad et al 2019b).
5) **Time pressure and stress:** We asked respondents to rank agreement with statements about time pressure and stress, taken from previous studies of bus drivers and professional drivers in general (Phillips & Bjørnskau 2013; Nævestad et al 2019a). Answer alternatives ranged from 1 (totally disagree) to 5 (totally agree). The statements concerned e.g. whether respondents experience that time pressure and deadlines can affect traffic safety whether they often are a hurry with regard to keeping the timetable.
6) **Ruter/bus transport principal and the employer's relationship with Ruter/bus transport principal:** the immediate manager's focus on avoiding sanctions from Ruter/principal for poor performance (as defined in contracts), focus on obtaining bonus for good performance. These questions were developed based on factors mentioned in the qualitative interviews.
7) **Driving style:** We have included driving style questions, partly based on the Driver Behavior Questionnaire (DBQ), (Warner et al 2011) especially three questions related to aggressive driving, which have been used in previous studies of bus drivers (Nævestad et al 2019a). These questions are: sounding the horn the horn to show aggression, become irritated with other drivers and show it in any possible way, placing the vehicle far out at intersections.
8) **Safety outcomes:** accidents, passenger falls in buses, emergency braking, violence and harassment from passengers.

3.3.3. Analysis of quantitative data

We have conducted three regression analyses. Regression analysis is a multivariate analysis where one calculates the effects of different independent variables on a single dependent variable. In the first, we examine the conditions that explain whether the drivers have been involved in accidents during the last two years while driving a bus. We use logistic regression analysis, since the dependent variables in both analyses are dichotomous, which means that they have two values (for example: Accident: no, yes). In the other two regression analyses, we examine factors predicting the drivers' driving style and experienced time pressure and stress. For the latter two we have used linear regression, since these two dependent variables are continuous. The regression analyses show effects of the independent variables that we include, controlled for the other variables in the analysis. It must be pointed out that we cannot say anything about causation in these analyses, and that some of the relationships we see may be due to so-called "non-measured" third variables.

4. Results

The structure of this section largely reflects the three hypotheses of the study (and the aims). In section 4.1, we present characteristics of the respondents. Section 4.2 (The contracts and the tender process) and 4.3 (the system for influencing bus operators) address Hypothesis 1. Section 4.4 (direct influence on traffic safety in the contracts) addresses Hypothesis 2, while section 4.5 (Indirect influence on traffic safety in the contracts) addresses Hypothesis 3. In section 4.6, we test Hypothesis 2 and 3 in multivariate regression analyses. In the results chapter, we present both qualitative and quantitative results that are relevant to the hypotheses in each of the sections addressing the respective hypotheses.

4.1. Characteristics of the respondents

The bus drivers who drive for Ruter drive in Oslo, which is the largest city in Norway (>600 000 people), and in the suburban and rural areas around Oslo. The drivers who drive for other transit authorities and county authorities drive in and around other urban areas in Norway, e.g. cities like Bergen (>270 000 people) and Trondheim (>180 00 people), and in smaller cities and rural areas. As a reflection of this, Table 1 indicates that the share of urban transport is higher among the Ruter drivers than the other drivers (49% vs. 26%). The shares of regional transport in the two groups are 22% (Ruter) versus 26% (other), while the shares for other types of bus transport were 29% (Ruter) and 48% among the bus drivers who work for other transit authorities. Prevalent other types of bus transport were long distance, express and school bus.

Six percent of the respondents driving for Ruter are women, while nine percent of the respondents among the respondents driving for other principals are women. A chi-square test shows that the difference is statistically significant at the 1% level ($P = .001$).

A chi-square test shows that the difference in the distribution of nationality between Ruter and other drivers is statistically significant at the 1% level ($P = .001$) (cf. Table 2).

The age distribution in the two samples is different: There are more than twice as many people under the age of 46 among the drivers who drive for Ruter as among the other drivers. A chi-square test shows that the difference is statistically significant at the 1% level ($P = .001$).

4.2. The contracts and the tender process

Ruter AS is a joint administration company for public transport in Oslo and parts of Viken (formerly Akershus County Authority). In 2019, 398 million journeys were made on the Ruter network, including journeys with trains, ferries, trams and metro (Ruter 2020). This is about half of the total number of public transport journeys in Norway. When looking only at bus journeys, 434 million bus journeys were made in Norway in 2019 and 41% of these (180 million) were Ruter journeys (Statistics Norway 2022; Ruter 2020).

Ruter's role is to plan, develop, coordinate, order, market and inform about the public transport opportunities. All transport operations are performed by various operating companies that run on contract for Ruter and by Vy with local trains - all within the same ticket and price system. Ruter's owners are Oslo Municipality (60%) and Viken County Municipality (40%). Ruter generally buys bus transport from four large bus companies competing about the tenders in defined areas, which are run by 10-year contracts.

We refer to contract requirements, but it is also important to mention the tender process. Ruter initiates tender processes, and the operators compete to win tenders. In these processes, Ruter influences the operators by defining the rules for the competition, i.e. what they require from the operators, what is rewarded and how much is rewarded (award criteria). The operators' response or proposal to these represent the operators' specification of how they are to carry out the assignments they compete for, and this becomes a contractual requirement. What the operators promise through their proposals in the tender process becomes contractual requirements. This is also similar to other principals.

In the procurement of bus services, Ruter carries out gross tenders with quality incentives. This means that the principal receives the ticket revenue and the operator receives a fixed remuneration from the principal in addition to a bonus for a high-quality delivery. Based on a collective assessment, the provider who achieves the best compromise between price and quality is awarded the tender. Price is weighted 40% and quality including the environment is weighted 60%. Quality is about the plan for carrying out the assignment, and this point includes safety requirements (e.g. technical requirements). In other parts of the country, it is more common to place the main weight on price, although practices may vary between Norwegian regions (Vista Analyse 2018). The tender process lasts approximately 1.5 years from the start of the project to the signing of the contract. The tender process is very resource-intensive for all parties.

4.3. The system for influencing bus operators

The system for influencing bus operators has three key elements:

Table 1
Types of bus transport that the respondents are involved in.

	Urban	Regional	Long dist./ exp	School bus	Other
Ruter	49%	22%	3%	5%	22%
Other	26%	26%	15%	9%	23%

Table 2
Respondents' nationality.

	Norw.	Other Nordic	Other west EU	Central/ Eastern EU	Asian	North/South American	African	Total
Ruter	62%	4%	3%	12%	10%	0%	8%	232
Other	87%	2%	2%	5%	1%	0%	3%	780
Total	81%	3%	3%	6%	3%	0%	4%	1012

1. **The requirements that Ruter sets in the contracts**. In a bus tender, Ruter requests tenders for several bus lines within an area. The tender specifies several requirements related to the implementation of the assignment, e.g. regularity, environment, traffic safety and universal design. These requirements are specified in the annexes to the contracts.
2. **Supervision and control of compliance with the requirements**. Ruter has its own department that follows up requirements set in the contracts. This department carries out many forms of inspections. First, they have control over where all the buses are, through the fleet management system that has GPS with real-time information. Those involved therefore receive automatically generated data, which forms the basis for continuous measurements of the operators' regularity and punctuality. This department also conducts customer satisfaction checks, including driving style. Such follow-ups are also common among other bus transport buyers in Norway, but the extent of them varies, as does the identification of non-compliance and the incentive systems that are used in the different counties (Vista Analyse 2018).
3. **The bonus/malus system**, which provide operators with financial incentives to comply with Ruter's requirements. Ruter has to ensure a good customer experience throughout the contract period. The contracts set upper limits for bonus and malus, which corresponds to a given share of the total contract value.

The results from the interviews indicate that Ruter's system for influencing the operators' practices and priorities has a major impact on the operators. Bus operator representatives said that they spend a lot of resources on paying fees, avoiding fees and on trying to obtain bonuses. Interviewees mentioned that such sanctions were also common among other principals, but they said that the outline of the sanctioning system may vary. Most of the bus transport contracts in Norway include financial rewards for compliance and fines for non-compliance, although their enforcement differs between the different transport buyers in the different Norwegian counties (Vista Analyse 2018).

The questionnaire survey included questions about the drivers' perceptions of the focus on the sanction regime of the bus transport principals. We used the word "Ruter" for the drivers who drive for Ruter and "principal" for the other drivers, driving for other principals in Norway: 1) "In my company we do everything we can to get a bonus from Ruter/the principal (for good driving style, good cleaning, good service, etc." (58 % agreeing among Ruter drivers, 41% agreeing among other drivers) 2) "My closest manager often talks about what Ruter/the principal can give us fines for (canceled departures, delays, etc.)" (60 % agree among Ruter drivers, 64% agreeing among other drivers) 2, and 3) "My immediate manager often say that we must avoid fines from Ruter/the principal (for canceled departures, delays, etc.)." (78 % agreeing among Ruter drivers, 59% agreeing among other drivers). All the differences are statistically significant at the 1%-level ($P < .001$). These results suggest that Ruter's bonus/malus system is effective in that it motivates the bus companies operating for Ruter to focus on avoiding fees.

4.4. *Direct influence on traffic safety in the contracts*

4.4.1. *Technical requirements*

Various EU requirements are often used as a basis for the technical safety requirements in buses. For equipment, a standard is used, Bus Nordic (2019), which is based on the common European bus regulations R107 (ECE R107, 2020). This applies, for example, to various requirements for the design of the buses, requirements for commuter tests, collision protection in front, etc. The Norwegian Vehicle Regulations are also used as a basis (NPRA, 2022). There is a general requirement that operators must comply with all laws and public orders. In addition, Ruter also sets minimum requirements that go beyond EU requirements (although the starting point is that Ruter should only set EU requirements); for example seat belts in class 1 buses (inner city buses), blind spot warning, collision protection for drivers (according to safety advice from the AIBN), Safety packages, where providers are evaluated on various facilities in the buses, as well as traffic safety work and winter preparedness. Other principals in Norway also provided examples going further than national legislation, e.g. seat belt requirement in class 1 buses. These requirements are set to increase safety. This applies for instance to Ruter's driver collision protection equipment, which was issued based on recommendations from the AIBN after the fatal head-on accident that was mentioned in section 1.1.3 (AIBN 2019). In this way, Ruter is a pioneer, which facilitates innovation among the bus producers and increase the safety standard in the market. This shows what kind of significance it has when Ruter sets contractual requirements going further than national legislation.

4.4.2. *Interviewees found that Ruter could have more direct impact on traffic safety*

In continuation of the preceding argument, several of the interviewees pointed out that Ruter could potentially have an even greater direct impact on traffic safety, if Ruter had made more requirements to the operators'safety management measures. Some of the interviewed operators have on their own initiative introduced a number of organizational safety measures in their companies, such as the traffic safety standard ISO: 39001, fleet management systems that focus on safe and economic driving style, systems for investigating and learning from safety incidents. However, the prevalence of such measures varies between the various operators.

When asked about ISO:39001, one of the operators said that:

> The reason why we have not certified ourselves is that there has not yet been a requirement. We rather try to create a system that works for us. There is a lot of positive elements in 39001, but not everything is equally relevant for everyone.

The operators mentioned that they write about their own company's safety work when they respond to the tenders, but they are unsure whether it is emphasized, and how much this is actually emphasized. There are no explicit requirements or criteria for this, and Ruter does not ask for documentation afterwards. The operators were therefore unsure of the extent to which their safety work is actually rewarded in the tenders.

To conclude, the interviewees generally believed that the focus in the contracts is on things other than safety, and that there is too little focus on safety in the tenders and contracts. The interviewees experienced that the main requirements in the bus tenders and contracts are: 1) Environment, 2) Regularity and 3) Customer satisfaction.

4.5. Indirect influence on traffic safety in the contracts

4.5.1. Requirements related to punctuality and regularity

Interviewees said that Ruter is concerned with punctuality and regularity in the contracts and in following them up. This is also in line with the general situation in Norway (Vista Analyse 2018). The interviewees generally believed that the requirements for punctuality and regularity are the contractual requirements with the most important indirect consequences for road safety. They believed that this has consequences for traffic safety because drivers become stressed. One of the interviewees mentioned that it "lies in the spinal cord" of the drivers that they want to keep the route plan:

> For most people, it becomes second nature to keep to the schedule. If you are too slow, you waste other people's time. It is a statement many drivers recognize. In the training, we communicate that it is the traffic that decides when we arrive, but there is something with theory and practice here. They have a desire to do their job best; be at each stop at the right time so that people don't have to wait.

One of the interviewees said that Ruter notices and reacts on delays and this may affect safety, as drivers may become stressed. As noted in section 4.3, there is a significant focus among operators on avoiding fees for canceled departures, delays, etc. Several of the interviewees also emphasized that bus drivers are often stressed due to the timetable, and of all the rules they have to abide by, both from Ruter and operators, and that stress is very common in the bus industry: "Drivers feel to a very large extent that they are in a hurry", it was mentioned. This was linked to the tenders and the competition. The operators make route plans, based on Ruter's wishes in the tenders, and the route plans are closely linked to price, on which the operators compete. In order to maintain a desired route offer, you must use a given number of buses and drivers within a given time period, and then the competitive situation will often lead to you "tightening up" where you can, it was said. The analysis of bus tenders and contracts in Norway in general also stress that the most common contract requirements are related to punctuality (regularity) (Vista Analyse 2018).

The results from the survey also show that time pressure and stress are common among the bus drivers. (cf. Fig. 1).

Among the Ruter drivers: 70% agree (64% of the other drivers agree) that they experience that time pressure and deadlines can affect traffic safety, 41% agree that they are often stressed by passengers in ways that may be detrimental to road safety (29% of the other drivers agree) and 53% agree (55% of the other drivers agree) that they often are in a hurry with regard to keeping the timetable.

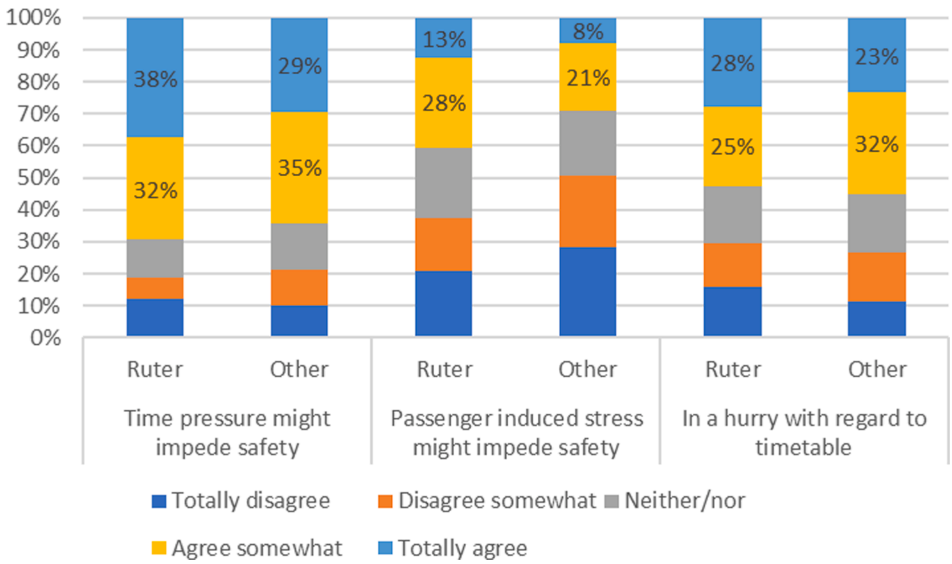

Fig. 1. Bus drivers' responses to statements regafrding stress and time pressure. Ruter drivers (N = 232) Other drivers (N = 780).

The difference between the two driver groups is significant at the 10% level for the first statement, at the 5%-level for the second (0.049) and at the 1% level for the third (P < 0.001). Thus, results indicate that being a bus driver is an occupation which involves high levels of stress.

4.5.2. Requirements based on environmental concerns

All the interviewees had a strong experience that consideration for the environment is a high priority at Ruter. They said that "there is a completely different pressure from our owners on environmental requirements" (than it is on safety requirements). This is particularly clear through Ruter's focus on, and requirements for, environmentally friendly buses. Environment is also emphasized in the bonus/malus regime that Ruter has vis-à-vis the operators. Interviewees and participants in the workshop also underlined that the other bus large transport buyers in Norway also have a strong focus on environmental requirements.

The most important environmental aspect of bus transport that interviewees focused on was related to the capacity of the bus routes and the public transport service available to passengers in various areas. The more passengers that the buses have the opportunity to transport in a given area in a given period of time, the more private car journeys the buses can replace. Regularly increasing the number of people traveling by public transport is therefore one of Ruter's main goals. When bus operators respond to Ruter's tender for targets for the number of passengers on given routes, they can increase their passenger capacity by choosing buses that carry many passengers, and/or drive the route with several buses. To transport high(er) numbers of passengers, you often add in the tender that you will choose large buses on the routes:

> Ruter will offer [passengers] the most seats – either through frequent departures or large buses. Sometimes we think we should have had smaller buses in areas that are difficult to drive, but where Ruter has to weigh up against how many passengers the route will transport.

Interviewees stressed that this need for high passenger capacity has potential traffic safety consequences, because it can lead to operators driving with (large) buses that may be unsuitable on given (narrow and difficult) road sections. This was a recurring theme in the interviews with the operators, and to some extent also in the interviews with the unions. It is an example of a potential conflict between consideration for the environment (passenger capacity/public transport service) and traffic safety. The analysis of bus tenders and contracts in Norway in general also stress that increasing passenger capacity is one of the three most common contract requirements in Norwegian bus tender contracts (Vista Analyse 2018).

In the survey, we asked the drivers whether, and how often, they experience that dangerous situations occur due to: "Bus type that does not fit the routes I drive", and 20% of the drivers who drive for Ruter (15% of other drivers), experience at least daily that dangerous situations occur due to bus types that do not fit the routes they drive. The difference is not statistically significant.

In addition, Ruter's intention to offer bus transport on given roads, for example in city areas where many people live, may lead operators to place their routes on roads that they may think are less suitable for bus transport. It was mentioned that the buses will go "where there are people", but it is not always these roads are well adapted to buses.

> (…) And then I think that those who work with traffic safety in the bus companies should be able to participate and come up with views during planning. There are many stops, detours, etc. where you do not consider that buses shall drive there. There are lots of details that I think could have made it better and safer in the city: Planning routes, physical planning. End stop design, it's a "never ending story". We provide input on how they can be designed in the safety way, but it is the architects who win. There is most focus on aesthetics [in city planning]. We should have been clearer, to make it even safer. Relatively speaking, it is safe to drive a bus in Oslo, but it is terribly cramped.

Roads that are "unsuitable" for bus transport can also be unsuitable due to poor intersection solutions, problematic bus stops, etc. and this can create dangerous situations in the drivers' work. In the survey, we therefore also asked the drivers: whether, and how often they experience that dangerous situations occur due to: "Poor intersections" or "poor bus stops". A share of 41% of the drivers who drive for Ruter (35% of the other drivers), experience at least daily that dangerous situations occur due to poor intersections. The difference is statistically significant at the 10% level (P = 0.074). When we compare bus types, we see that those who drive articulated buses have the highest proportions who respond "daily and several times a day". Corresponding shares for poor bus stops were 41% for Ruter drivers and 45% for other drivers (P = 0.723).

4.5.3. Universal design

Interviewees also mentioned that focus in universal design and access for all may have negative consequences for traffic safety. This was because rules and regulations do provide operations in which wheelchairs or other equipment are safely secured, presenting risks to the users as well other passengers. The survey shows that a total of 22% of the drivers who drive for Ruter (14% of other drivers), daily experience that dangerous situations arise due to wheelchairs or baby carriages that are not properly secured. The difference is statistically significant at the 1%-level (P < 0.001).

4.6. Multivariate analysis

4.6.1. Which factors influence drivers' self reported accident involvement?

We conduct a logistic regression analysis of the factors that predict variation in accident involvement during the last two years among all respondents. We use logistic regression because we have changed the accident variable to a dichotomous variable, i.e. whether drivers have experienced an accident (1) or not (0). A share of 24% of the drivers had experienced an accident in the last two years (minimum property damage only).

In this analysis, we first look at the effects of experience, which is divided into two values: 1) 1–10 years and 2) over 10 years. The first group reports a 30% accident involvement and the latter 20%. A Chi Square test indicates that the difference between the two is statistically significant (P =.001). We also control for exposure (1000 km driven in the last two years) in the analyses. A T-test do not indicate significantly different mean scores on the exposure variable for drivers involved in accidents (62500 kms) versus drivers who were not involved (60100 kms) in accidents (p =.658). It is, however, nevertheless important to control for this, e.g. as this usually is the most important variable influencing the prevalence of accidents (Elvik et al 2009). Type of bus transport is also included in the analyses. School bus is included, as it has the smallest prevalence of accidents among the included types of bus transport (15% vs. 25%). A Chi Square test indicates that the difference between the two is statistically significant (P = 0.026). Drivers' assessment of the buses' suitability for routes is also included. A T-test indicates significantly different mean scores on this variable for drivers involved in accidents (2.2) versus drivers who were not involved (2) in accidents (p =.0.24). Poorly designed intersections and stops are also included, and a T-test indicate significantly different mean scores for drivers on this variable for drivers involved in accidents (6.4) versus drivers who were not involved (6) in accidents (p =.004). (This variable is a sum-score index comprised of two variables: poor intersections and poor bus stops). Aggressive driving style is included in the logistic analyses, and a T-test indicate significantly different mean scores for drivers on this variable for drivers involved in accidents (5.3) versus drivers who were not involved (4.7) in accidents (p =.001). Active use of fleet management system and safety culture are also included in the analyses. T-tests did not indicate significant differences on these variables for drivers who had experienced accidents versus those who had not experienced accidents. The variables were, however, included as they have been found to be important for safety outcomes in previous research. Finally, near misses per month is included (how often drivers must brake abruptly for other road users). This variable is divided into two values: 1) 1–3 times each month and 2) Over three times each month. The former group has an accident involvement of 22%, the latter 32%. A Chi Square test indicates that the difference between the two is statistically significant (P = 0.002).

Table 4 shows the results of nine regression models with the respondents' accident involvement during the last two years as a dependent variable.

Table 4 shows, first that bus drivers' experience is related to lower accident involvement. Drivers who have over 10-year experience have significantly lower odds of being involved in accidents.

Second, the variable school bus has a significant effect on the respondents' accident involvement. School bus is coded 0 and other bus types 1. The positive B-value shows that the school bus has fewer accidents, controlled for the other variables in the model. In the comparison of the shares of drivers who have been involved in accidents, we saw that the drivers who usually drive school buses had the lowest share (15%), and that is why this variable was included. The effect of the school bus disappears in Model 6, when we take in aggressive driving style, indicating that part of the explanation for the lower accident prevalence of school bus drivers is related to this.

Third, aggressive driving style (sounding the horn the horn to show aggression, become irritated with other drivers and show it in any possible way, placing the vehicle far out at intersections) is related to accident involvement. Drivers who report a high incidence of such behavior are more likely to have been involved in an accident, controlled for the other variables.

Fourth, we see that drivers' reports of the number of dangerous situations that occur due to poor intersections and poor bus stops is related to accident involvement. This is an index consisting of two variables. "When you drive a bus (before COVID), how often do you experience dangerous situations due to: a) poor intersections and b) poor stops." The answer options range from 1) never to 5) several times a day. A high score on the index is related to a higher odds of accidents, indicating that roads and infrastructure are related to accident involvement. We also see that the variable ("how often do you experience dangerous situations due to") "Bus type that does not fit the routes I drive" is related to accident involvement in Model 4, but that it stops contributing significantly when we include the variable focusing on intersections and stops. This indicates that the suitability of the buses and the suitability of the road and infrastructure are related.

Finally, we see that being involved in over three near misses (sudden braking incidents) per day in average, is related to higher odds of accident involvement. The variable near misses is related to aggressive driving style, which only contributes significantly at the 10% level in Model 9, when the variable near misses is included.

The Nagelkerke R2 value in model 9 is 0.056, which indicates that the model explains approximately 6% of the accident involvement to the respondents in the sample. This is low and indicates that the model is poor. The model does not capture adequately the factors explaining drivers' accident involvement.

4.6.2. *Which factors influence an aggressive driving style?*

In Table 4 above, we saw that aggressive driving style was one of the most important factors explaining variation in the respondents' accident involvement. In Table 5, we examine factors influencing drivers' score on the index measuring aggressive driving style. This is a sum score index consisting of three variables (Min: 3, Max: 21), focusing on sounding the horn the horn to show aggression, become irritated with other drivers and show it in any possible way, placing the vehicle far out at intersections. We

Table 3
Respondents' age distribution.

	< 26	26–35	36–45	46–55	56+	Total
Ruter	3 %	16 %	28 %	26 %	27 %	232
Other	1 %	9 %	14 %	30 %	45 %	780
Total	2 %	10 %	17 %	29 %	41 %	1012

Table 4
Logistic regression. Dependent variable: Accident involvement last 2 years (No = 0, Yes = 1). B-values.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7	Mod. 8	Mod. 9
Experience (1–10 = 0,>10 = 1)	**1,652*** **	**1.649*** **	**1.618*** **	**1.630*** **	**1.708*** **	**1.629*** **	**1.660*** **	**1.670*** **	**1.654*** **
Thousand kms		0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
School bus (=0, Other = 1)			**1.898** **	**1.775* **	**1.757* **	1.676	1.698	1.703	1.704
Bus type poorly adapted				**1.152** **	1.072	1.053	1.044	1.039	1.022
Poor intersections/stops					**1.100** **	**1.099** **	**1.101** **	**1.098** **	**1.088* **
Aggressive driving style						**1.060** **	**1.062** **	**1.062** **	**1.055* **
Fleet management system							**0.949* **	0.954	0.954
Organisational safety culture								0.993	0.993
Near misses per day (1–3 = 1, >3 = 0)									**0.703* **
Nagelkerke R^2	0.017	0.018	0.024	0.033	0.040	0.046	0.050	0.051	0.056

* p < 0,1 ** p < 0,05 *** p < 0,01.

examine the significance of nine independent variables:

Table 5 shows, first that sex has a negative and significant effect, and this means that women have a less aggressive driving style. Second, aggressive driving style is also related to the age of the drivers. Drivers between the ages of 26 and 35, in particular, state that they have aggressive behavior in traffic.

The third result is that aggressive driving style is also related to driving an articulated bus. Drivers who drive articulated buses report a somewhat more aggressive driving style. This may possibly be related to the fact that articulated buses are large and require time and patience from other road users and are used in inner city areas where there are several different types of road users.

The fourth result is that experiencing dangerous situations because "bus type is poorly adapted to the route" also is related to aggressive driving style. Interview results indicate that this is due to cramped and narrow streets. The fifth result is that experiencing dangerous situations because of poor intersection and stops is negatively related to aggressive driving style. It is hard to explain why this contributes negatively (i.e. to less aggressive driving style).

Sixth, time pressure and stress influence drivers' aggressive driving style. This means that drivers who to a greater extent experience that they have problems keeping to the timetable, who experience that the focus on deadlines can affect safety and who are stressed by passengers, to a greater extent have an aggressive driving style.

Seventh, bus drivers who report that they often must brake abruptly for other road users to avoid accidents (e.g. el-scooters, pedestrians, bicycles, passenger cars in the bus lane) report a more aggressive driving style. This is a sum score index consisting of seven variables (min: 7, max: 35), each describing different road users for whom the drivers have to brake abruptly. Each question have five values, ranging from 1 (never) to 5 (several times each day). It might be difficult to conclude about cause and effect here, as drivers having an aggressive driving style might experience more situations where they have to brake for other road users to avoid accidents. However, questions about this were included based on the interview results indicating that the relatively unpredictable behaviour of especially vulnerable road users is a hazard that bus drivers regularly relate to. This suggests that aggressive driving style also might follow from such experiences, as underlined by the interviewed bus drivers themselves.

The Adjusted R2 is 0.159, which means that the model explains 16% of the variation in the bus drivers' aggressive driving style.

4.6.3. Which factors influence drivers' perceptions of stress and pressure?

In Table 5 above, we saw that time pressure and stress were among the important factors explaining variation in the respondents' aggressive driving style. In Table 6, we examine factors influencing drivers' experiences of time pressure and stress. This is a sum score index consisting of three variables (Min: 3, Max: 15): 1) "I am often I a hurry with regard to keeping the timetable", 2) "In my job I experience that time pressure and deadlines can affect traffic safety" and 3) "I am often stressed by passengers in ways that can be negative for road safety". We examine the significance of nine independent variables.

The first main result in Table 6 is that drivers' reports that they often have to brake abruptly for other road users is the variable that has the greatest effect on time pressure and stress.

Table 5
Linear regression. Depending variable: aggressive driving style (min: 3, max: 21). Standardized beta coefficients.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod.5	Mod. 6	Mod. 7	Mod. 8	Mod. 9
Sex	**-0.068** **	**-0.064** **	**-0.064** **	**-0.058* **	**-0.058* **	**-0.066** **	**-0.069** **	**-0.069** **	**-0.070** **
Age 26–35 (=2, Other = 1)		**0.167*** **	**0.151*** **	**0.154*** **	**0.154*** **	**0.151*** **	**0.146*** **	**0.147*** **	**0.128*** **
Articulated bus (=2, Other = 1)			**0.164*** **	**0.154*** **	**0.154*** **	**0.141*** **	**0.136*** **	**0.135*** **	**0.083*** **
Bus type poorly adapted				**0.139*** **	**0.140*** **	**0.091** **	**0.097*** **	**0.098*** **	**0.063* **
Poor intersections/stops					-0.002	-0.029	-0.028	-0.027	**-0.107*** **
Time pressure and stress						**0.166*** **	**0.163*** **	**0.164*** **	**0.101*** **
Fleet management system							**0.060* **	**0.056* **	0.050
Organisational safety culture								0.010	-0.001
Must often brake for others									**0.292*** **
Adusted R^2	0.004	0.031	0.056	0.075	0.074	0.096	0.098	0.098	0.159

* p < 0,1 ** p < 0,05 *** p < 0,01.

Table 6
Linear regression. Dependent variable: Time pressure and stress. Standardized beta coefficients.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod.5	Mod. 6	Mod. 7	Mod. 8	Mod. 9
Sex	0.037	0.037	0.038	**0.053***	0.046	0.044	0.043	0.039	0.036
Age 26–35 (=2, Other = 1)		0.018	0.011	0.019	0.018	0.013	0.011	0.010	-0.004
Articulated bus (=2, Other = 1)			**0.078****	0.048	0.047	0.020	0.018	0.027	-0.020
Bus type poorly adapted				**0.375*****	**0.298*****	**0.272*****	**0.274*****	**0.256*****	**0.219*****
Poor intersections/stops					**0.164*****	**0.142*****	**0.142*****	**0.128*****	**0.062***
Management focus on fines						**0.209*****	**0.208*****	**0.201*****	**0.182*****
Fleet management system							0.022	**0.059***	**0.052***
Safety culture								**-0.111*****	**-0.115*****
Must often brake for others									**0.221*****
Adjusted R^2	0.000	0.000	0.005	0.144	0.164	0.205	0.204	0.214	0.250

* p < 0,1 ** p < 0,05 *** p < 0,01.

The second main result is that drivers who report that the type of bus they drive is poorly adapted to the route often lead to dangerous situations, experience a higher degree of time pressure and stress. This variable is strongly related to poor intersections and stops (i.e. features of roads and infrastructure), because the contribution of poorly adapted bus type is reduced when we include poor intersections and stops in Model 5. Bus type that is poorly adapted is also related to articulated bus, which contributes significantly in Model 3, but stops doing so when we include bus types that is poorly adapted. Articulated buses are mainly used in inner city areas, where we might assume that streets are narrower and where there also is a high incidence of other (vulnerable) road users.

The third main result is that perceived time pressure and stress is higher for drivers who have an immediate manager who often talks about avoiding fines from Ruter. This shows how the company level can convey requirements from Ruter in a way that increases the experience of time pressure and stress.

The fourth main result shows that factors at the company level can also reduce drivers' experiences of time pressure and stress, because organizational safety culture has a negative effect on perceived time pressure and stress. This means that drivers who report a good safety culture, and who experience a strong focus on safety in their company, experience less time pressure and stress.

The adjusted R2 value in Model 9 is 0.250 and indicates that the model explains 25% of the variation in the respondents' time pressure and stress.

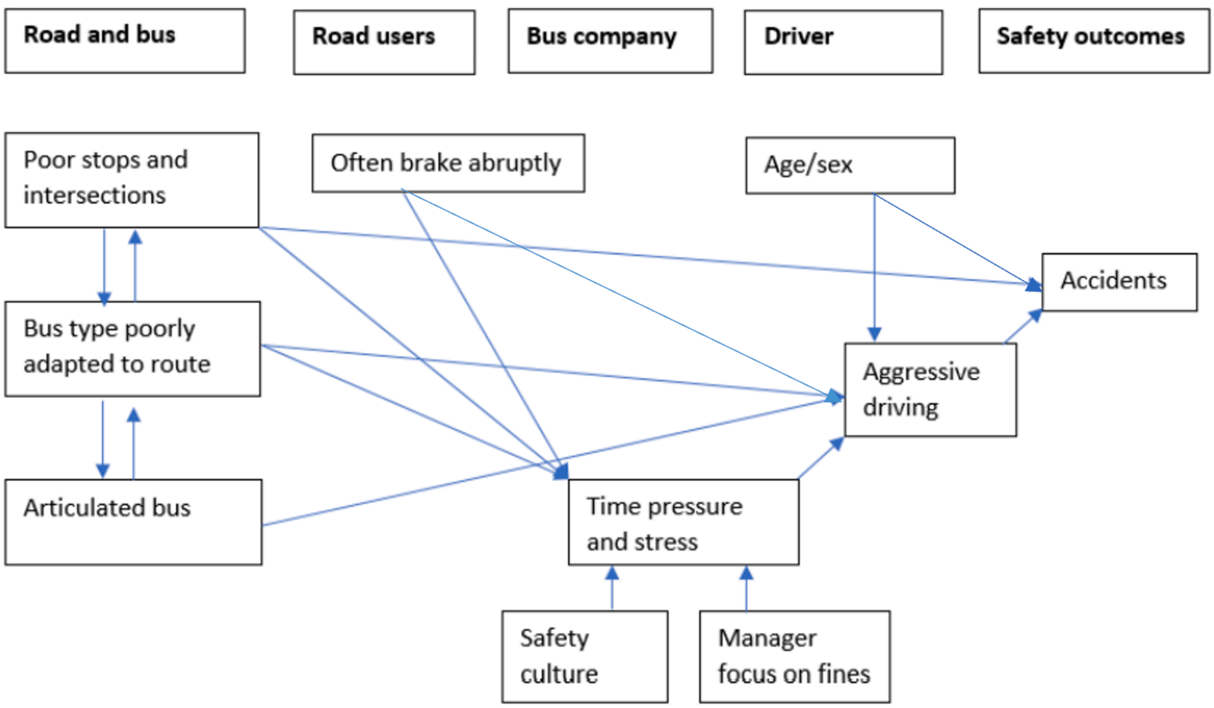

Fig. 2. Relationships in multivariate regression analysis, examining factors predicting accident involvement, driving style, time pressure and stress.

5. Discussion

5.1. Model illustrating relationships

We have conducted multivariate regression analyses to investigate factors influencing drivers' accident involvement, their behavior in traffic and their perceived time pressure and stress. In Fig. 2, we summarize the strongest correlations from these analyses. The analyses were conducted with all the drivers in the sample (N = 1012). This means that the results apply to drivers who drive in all parts of Norway, and not just those in the sample who drive for Ruter (N = 232).

Fig. 2 shows that the level of safety in bus transport is affected by an interplay between factors at several different levels: 1) The driver, 2) Bus company (also referred to as the bus operator), 3) Other road users and 4) The road and the bus. Accident involvement is influenced by low-standard road intersections and bus stops, experience and an aggressive driving style. Aggressive driving style is related to age and sex, bus type inadequately suited to demands of the route, articulated bus and driver perceptions of time pressure and stress and that the drivers often have to brake abruptly for other road users. Drivers' perceived time pressure and stress are related to (dangerous situations caused by) low-standard intersections and stops, bus type poorly matched with the demands of the route, that the drivers often have to brake abruptly for other road users, management focus on avoiding fees from Ruter/principals, and finally the analysis shows that a good safety culture helps reduce the stress level of the drivers. Although the interplay between road characteristics and bus characteristics, including parked cars also has been examined in a recent study of bus accidents (Barabino et al 2021), the model in Fig. 2 provides a unique analysis of the factors influencing bus safety, as it includes a wide range of different factors influencing bus safety.

5.2. Ruter's direct influence on traffic safety

Our results support Hypothesis 1: Our data indicate that Ruter's and other principals' systems for influencing the operators' practices and priorities have a major impact on the bus operators. This was indicated in both the qualitative and quantitative data. The results from the interviews indicate that Ruter's system for influencing the operators' practices and priorities has a major impact on the operators. Bus operator representatives said that they spend a lot of resources on paying fees, avoiding fees and on trying to obtain bonuses. Interviewees mentioned that such sanctions were also common among other principals, but they said that the outline of the sanctioning system may vary. These results are in line with previous international research, indicating that the three key elements in Ruter's and other Norwegian principals' systems for influencing the operators' practices and priorities are representative for the practices in European transit authorities (Pedro and Macario 2016). It is, however, important to note that the specific outline of the different key elements may differ (Pedro and Macario 2016). The same has been found in Norwegian research, which indicates that although most of the bus transport contracts in Norway include financial rewards for compliance and fines for non-compliance, their enforcement differs between the different transport buyers in the different Norwegian counties (Vista Analyse 2018). Principals also use different ways to identify non-compliance (Vista Analyse 2018). Examining the importance of such differences is an important area for future research.

Our results also largely support Hypothesis 2. Although we have not been able to test this hypothesis quantitatively in multivariate analysis, interviewees found that Ruter and other principals' have a direct impact on traffic safety, through the safety requirements they set for the operators in the contracts. The direct impact on traffic safety through contracts applies to cases where the principals require more than national and international regulations. In the case of Ruter, this applies to new and unique requirements for bus driver collision protection at the front of the buses, which have led to innovations among the bus producers and raised the standard in the market. Previous research (Gepner et al 2014), including the AIBN investigation described in the Introduction (AIBN 2019), indicates that this is related to positive safety outcomes. It also applies to blind zone warning technology required by Ruter in contracts. This has been found to reduce accidents for lorries and buses (Elvik et al 2009). However, several of the interviewees stated that bus transport principals in general (including Ruter) do not go far beyond what is required by law on traffic safety; that one must follow rules and regulations. Previous research shows that this is the norm in bus tenders (cf. Pedro and Macario 2016). Examining previous research, we have not found studies that identify road safety effects of traffic safety requirements in contracts. Our study therefore provides a unique contribution.

5.3. Ruter's indirect influence on traffic safety

In line with Hypothesis 3, the results from the survey and interviews show that Ruter and other principals may have an indirect impact on traffic safety through existing requirements related to the environment, regularity, universal design, etc. The interviewees generally believed that the requirements for punctuality and regularity are the contractual requirements that have the greatest indirect consequences for road safety, because drivers experience time pressure. In analysis of the quantitative data, we found a correlation between the index measuring stress and time pressure and aggressive driving style, which is related to accident involvement (cf. Fig. 2). This finding is in line with previous research (Davey et al. 2006; Nævestad et al. 2019a). Previous research also indicates a significant level of stress among bus drivers, which is among other things linked to a focus on keeping timetables (Phillips and Bjørnskau 2013). However, our results contribute with new knowledge, because we find that the experiences of drivers' time pressure and stress are related to more factors than time pressure; this is also related to the suitability of the buses for the routes, and conditions related to the road and infrastructure are also important.

Some of the interviewees also mentioned that consideration for the environment can affect traffic safety in bus transport, because this means a strong focus on regularly increasing the number of people traveling by bus and focusing on high passenger capacity on the routes (i.e. replacing private cars). Regarding Ruter, it was mentioned, for example, that the roads and infrastructure in Oslo are poorly adapted to bus transport; it is often cramped and narrow. Focusing on increased capacity for environmental reasons often means that operators use buses with room for many passengers. This may be why we see that the variable *Bus type that does not fit the routes I drive* is important for the driver stress level and driving style in the multivariate analysis (cf. Fig. 2). In accordance with this, the analysis shows that driving an articulated bus is related to a higher incidence of aggressive driving style. Previous research has found that aggressive driving style is a considerable safety problem with bus and heavy goods vehicles (Knipling et al 2003). In the current study, we provide important contextual knowledge about the antecedents of aggressive bus driving behaviours. The multivariate analysis also show that poor intersections and poor stops are related to drivers' perceived time pressure, stress and accident involvement. The interaction between buses and roads is therefore an important traffic safety issue. We do not know of any other studies that have such comprehensive examination of the sources of driver stress; timetables, other road users, roads and infrastructure, the suitability of the bus, etc. In this respect, our study contributes with new knowledge.

Finally, it should also be mentioned that several of the factors inducing driver stress are related to the urban driving environment, i.e. large buses, narrow roads, poor intersections, stops, high traffic volumes and mixed traffic. Interview results indicate that these challenges are particularly pressing for the Ruter drivers, who drive in Norway's largest city. We therefore control for these variables in the multivariate analyses, and the unique contribution of the present study is that we show the specific contributions of these different key variables.

5.4. Framework conditions are studied indirectly

The contractual requirements of Ruter and other principals are not included in the model in Fig. 2, as we only study these indirectly through our analyses of the survey data and the interview data. Some of the variables we measure (e.g. dangerous situations due to bus types that are poorly adapted to route and poor intersections/stops), were based on suggestions in the qualitative interviews. Thus, we only measure indicators of the contract requirements related to environmental concerns indirectly, through concrete questions about hazards in the work of the bus drivers. We measure contract requirements related to punctuality and regularity more directly, as the stress/pressure index includes a question about stress related to keeping the timetable.

Framework conditions for safety are often studied indirectly, and often involves uncertainty and speculation. This applies, for example, to the studies of Bjørnskau and Longva (2009) and Crum and Morrow (2002) who do not study specific data on framework conditions, or discuss the specific significance of different framework conditions against each other. The same applies to other previous studies of framework conditions. When they discuss the importance of framework conditions, they often link larger societal trends at the macro level to what they observe in the companies they study, at the meso level. An interesting question is to what extent framework conditions can actually be measured directly. The fact that framework conditions are located "at the far end of the chain of causes" means that they are imbued with uncertainty, and that the significance of framework conditions is not objectively given. Framework conditions must be interpreted, translated and negotiated, and when this happens at different analytical levels (meso, micro), the framework conditions' impact on accidents is associated with uncertainty. This makes it challenging to study framework conditions in general and traffic safety implications of contract requirements in particular.

5.5. Questions for future research

1) Better estimates of effects on accident and injuries. We assume that the mentioned requirements going further than national legislation have direct traffic safety impacts, as blind zone warning (Elvik et al 2009) and extra collision protection (Gepner et al 2014) are related to positive safety outcomes in previous research. Future studies could also calculate the effects on injuries and fatalities, based on exposure and accident data. This also applies to the indirect effects.

2) Evaluations of the effects of tyre requirements and universal design. We have not been able to evaluate all of the possible indirect traffic safety impacts identified in the interviews (e.g. universal design) or in the AIBN report, e.g. the requirement that the operators should not use studded tyres in the winter to avoid local air pollution of airborne dust. Thus, these are important issues for future research.

3) Better and additional measures of framework conditions. Given the observed importance of framework conditions in general and contract requirements in specific for traffic safety, future research should aim to develop additional and more direct measures of this. This could help future efforts to identify and thereby correct negative framework conditions.

4) Which measures are suitable to reduce bus drivers' experience of stress? The analyses show that the stress level is high among bus drivers, that it has many different sources and that it can have an impact on safety outcomes.

5) Aggressive driving style. We have seen that aggressive driving style is related to accidents and time pressure and stress. Future research should investigate the causes of aggressive driving style and measures that can reduce its incidence, such as work with organisational safety culture and fleet management system.

6) The interplay between the suitability of buses and roads. We have seen that buses that are poorly adapted to the roads they are used on, and roads that are poorly adapted to bus transport can be a risk factor. These variables and the interplay between them affect accident involvement, aggressive driving style and stress. Future research should examine these relationships further.

7) Identifying key influencing variables. The variables in the survey are based on the results of the qualitative data and previous research. The variables that are included in the multivariate regression analyses are mostly based on previous research suggesting their importance (e.g. organisational safety culture, fleet management system, customer induced stress/pressure), but also on the qualitative data (e.g. buses that are poorly adapted to the roads they are used on, poorly designed stops and intersections). This is the basis for the variables that are tested in the multivariate analyses. Although some of the key independent variables contribute significantly, indicating important results, the explained variation in the dependent variables are generally relatively low. This especially applies to the analysis with traffic accidents as the dependent variable. Thus, although our analyses indicate important findings, most of the variation in the dependent variables remain unexplained in our analyses. This indicates an important issue for future research: to identify variables influencing bus accidents and aggressive bus driver behaviour in traffic.

5.6. Methodological weaknesses

1) Unknown response rate. We have not calculated response rates for the various groups, because we lack information on how many have received the link to the survey. The link to the survey has often been distributed on common digital platforms for different groups of drivers, and we do not know how many have seen these and have had the opportunity to answer.

2) We do not know how representative the drivers are. There are 14,000 bus drivers in Norway and 20% of these (i.e. 2800) drive for Ruter. Thus, the distribution of drivers who drive for Ruter (23%) vs other drivers (77%) in our sample is relatively similar to the distribution of bus drivers in Norway when it comes to Ruter drivers vs. other drivers. We have, however, not made further assessments of how representative the two groups in the study are for the drivers who drive for Ruter and the other drivers who drive in the rest of Norway on other respects, e.g. when it comes to sex, age, ethnicity, experience (cf. Tables 1–3). Most of the respondents (80%) are, however, recruited through the two main bus driver unions organizing the bus drivers in Norway. Thus, we would expect this to ensure a representative distribution of Bus drivers on key characteristics. One of the key activities of the study was to examine factors influencing safety outcomes in multivariate analyses. In these analyses, we control for several key background variables, e.g. sex, age, experience, exposure. However, obtaining more representative samples of drivers is a key issue for future research.

3) Our conclusions are largely based on self-reported data, with the possible biases that this may entail. Respondents may, for example, remember incorrectly or poorly, they may potentially over report positive things about themselves and underreport negative things, etc. These are known issues when using self-reported data. However, we have no indications of significant effects of these types in our data.

4) Our survey was conducted during the COVID-19 pandemic. While we do not expect findings from our qualitative interviews to be affected by the pandemic, we cannot rule out that answers on some quantitative survey questions might have been influenced by the pandemic. We attempted to minimize these effects by asking drivers to answer generally for "normal" periods of operation. Before each survey question about drivers' experiences, we stated that "Remember that all the questions in the survey concern the situation before the Corona measures in Norway (i.e. before 12. March 2020)." Additionally, in all questions about driver behaviour, experiences with conflicts etc. we wrote in parenthesis ("before Corona"). The survey was mainly conducted in the spring of 2020, and thus we may expect that the drivers' memories of "normal operations" were relatively fresh. We cannot rule out, however, that some responses – especially to questions on time pressure, stress and aggressive driving – may have been influenced by the quieter road conditions of the pandemic. We do not expect that this reduces the importance of our findings, since any links found for these variables might be expected to be weaker rather than stronger, if answers were influenced by the pandemic.

5) correlations among the independent variables in the regression analyses?

As several of the independent variables in the multivariate regression analyses might be (strongly) correlated (e.g. aggressive driving style, organisational safety culture), we have checked for multicollinearity. This might be a problem in the analyses, as coefficients may become very sensitive to small changes in the model, reducing precision of the estimate coefficients, which may weaken the statistical power of the regression (Frost, 2020). Multicollinearity can be checked by examining the variance inflation factors (VIF), which identifies the correlation between independent variables, and the strength of that correlation. A VIF value of 1 indicates no correlation, VIF values between 1 and 5 suggest moderate correlation, but it is not severe enough to warrant corrective measures, while VIFs > 5 represent critical levels of multicollinearity where the coefficients are poorly estimated, and the p-values are questionable (Frost, 2020). The highest VIF values in our regression analyses were for the variables: buses poorly adapted to routes (1.4), poor intersections and stops (1.3) and time pressure and stress (1.4) These, levels are far lower than the critical levels of multicollinearity, and thus it does not seem that the independent variables in the regression analyses are strongly affected by multicollinearity.

5.7. Policy implications

As noted, the study was based on Ruter's wish to further develop its work on traffic safety. Based on the study, we have developed several policy implications, that we believe also can be relevant for and inspire other transit authorities, as interviewees also said that the results applied to these. Ruter has applied several of these changes after our study (e.g. requiring ISO:39001 certification from the bus operators in the contracts), and may thus stand out as a transit authority that other may learn from when it comes to management of traffic safety. In the following, we present our main policy suggestions based on the study:

1) Setting clearer requirements for, and reward organizational safety measures. Our analyses indicate that a good safety culture may reduce drivers' experience of stress (cf. Fig. 2), and previous research indicates positive safety outcomes of such measures (Gregersen et al 1996; Zuschlag et al 2016). Additionally, research that compares safety level and (inter) national regulatory requirements between sectors and sub-sectors in transport, indicates a connection between requirements for SMS and safety level (Lappalainen et al 2012; Thomas). Our results indicate that the bus operators to different degrees have SMS and safety culture. Thus, introducing requirements for organizational safety management will ensure that more resources attributed to such measures. It will probably also ensure a minimum standard for all operators and raise the quality even more. Bus operators largely welcomed such requirements. International studies also stress the importance of SMS for bus companies (Izquierdo et al 2009; Barabino et al 2021).

2) Measures to reduce stress. Our data indicate that being a bus driver is a stressful profession (cf. Fig. 2), and that time pressure and stress are related to driving style. Measures aiming to reduce stress should be considered, e.g. flexible timetables, or focusing on the time interval between the buses instead of the timetable.

3) Measures to assess the interaction between road and bus: risk analysis. Results from the interviews and the survey indicate that the interaction between road and bus has an indirect impact on traffic safety. Risk analysis of requirements for bus equipment on given routes should be carried out, perhaps in the start of tenders.

4) Transit authorities' role as a "guiding star" on traffic safety. A large transit authority like Ruter is well placed to maintain an overview of how various factors affect traffic safety in bus transport, and has opportunities to influence several aspects of the operators' priorities and practices. Ruter's work with traffic safety should be systematized, and Ruter should take a coordinating role in relation to the bus operators and other actors that affect safety in bus transport. This could involve e.g. to: a) assign people dedicated to safety work in Ruter and in the operator companies, b) establishing a joint forum for traffic safety among Ruter and the bus operators, c) Conduct risk analysis related to the interaction between bus and road, d) Establish a system for learning among the bus operators, organized by Ruter, e) Acting as a road safety ambassador for operators against third parties, e.g. municipalities, the Norwegian Public Roads Administration, bus suppliers. Other transit authorities and principals could also apply all or some of these measures, depending on their size.

6. Conclusion

The main objective of the study was to review the traffic safety consequences of all the requirements that a transit authority sets in the contracts with operators. The study indicates that a transit authority can have considerable direct influence on traffic safety, especially if it sets requirements that exceed (inter)national legislation, like Ruter does when it comes to collision protection and blind zone warning systems. We also find indications that the transit authority may have an indirect impact on traffic safety through contracts, through requirements for punctuality and regularity and through achieving environmental sustainability goals by increasing the number of passengers travelling by bus, for the sake of the environment. The study therefore supports the notion that further road safety improvements could be achieved by attending to the role transit authorities have in influencing traffic safety of its bus operations. Based on our analysis, we have provided several recommendations as to how a transit authority like Ruter can further develop its traffic safety engagement. These recommendations also may be relevant for other transit authorities. After the study, Ruter has followed up several of our recommendations, e.g. by requiring traffic safety certification (ISO:39001) of their bus operators in new contracts, by considering new types of bus schedules to reduce bus drivers' perceived stress, and by starting to develop a system to learn from accidents.

CRediT authorship contribution statement

Tor-Olav Nævestad: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Rune Elvik:** Methodology, Investigation, Writing – original draft. **Vibeke Milch:** Methodology, Investigation, Writing – original draft. **Katrine Karlsen:** Methodology, Writing – original draft, Investigation. **Ross Phillips:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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