

Innovation and traffic safety: analysis of four Norwegian county authorities

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Abstract: This study examines the relationships between traffic safety innovations, innovation culture, and safety culture in four Norwegian county authorities three years after a comprehensive structural reform. Following the reform, the county authorities had to establish new organisations, routines, and systems. The study is based on qualitative interviews (N=42) and a quantitative survey (n=392) among people who work with traffic safety and/or mobility in the county authorities. The qualitative results show in particular that the respondents have gained new perspectives on traffic safety as a result of being co-organised with new professional groups. Additionally, we see examples of new methods and new forms of collaboration in traffic safety being implemented. The survey results show statistically significant differences between the county authorities' scores on an index for traffic safety innovations. County authorities' scores on this index is predicted by the county authorities' innovation culture, which in turn is predicted by safety culture. This indicates that innovation culture should be understood as an aspect of a learning safety culture. We find statistically significant differences between county authorities with respect to how demanding the organizational changes related to the regional reform have been for the county authorities studied. The results from this study can also be useful for change processes in other organisations.

Keywords: innovation culture, safety culture, traffic safety innovations

1 Introduction

1.1 Background

Innovation has proven to be highly important in the field of traffic safety (Belin et al., 2012). Fagerberg (2005) defines innovation as an idea for a new product or a process that is implemented in a specific context. The context is key to defining innovation. To count as an innovation, it is sufficient for the idea, practice, or object to be perceived as new by the implementer,

even if others have already implemented it (Rogers, 2003). Innovation is also crucial in the traffic safety management of public entities. Previous studies show that Vision Zero, which is a radical innovation in traffic safety, has contributed to Norway and Sweden having the lowest number of traffic fatalities in the world (Belin et al., 2012; Craens et al., 2022). Innovation is a crucial component of Vision Zero and Safe System (Elvik et al., 2023).

International and Norwegian studies also demonstrate that the regional governance level is fundamental in traffic safety work in countries with high levels of traffic safety (Belin et al., 2012; ITF OECD, 2022; Craens et al., 2022; Krogstad, 2020). In Norway, county authorities play a key role in the national traffic safety work, because they serve as the organizational intermediary between the state and municipalities. County authorities are responsible for recommending and coordinating traffic safety measures within the county. This entails coordinating the traffic safety measures of municipalities and collaborating with regional actors such as the Norwegian council for traffic safety (Trygg Trafikk), the police, and various other organizations. County authorities also function as regional planning authorities, school owners, responsible for public transport and public health, and procurers of public transport services (Nævestad et al., 2023). They are also major employers with staff who commute for work. All these roles provide opportunities for comprehensive traffic safety management.

The role of county authorities in Norwegian traffic safety work has, however, undergone significant changes in recent years. Through the regional reform, which came into effect on 1 January 2020, planned to be completed by 2024, the number of counties in Norway was reduced from 19 to 11. This involved reorganization and merging processes of old structures, groups, and personnel in 13 of the original county authorities. At the same time, county authorities took over the administrative responsibility for all county roads, which accounts for approximately half of the public road network in Norway, previously managed by the national public roads administration (NPR). This responsibility includes planning, construction, management, operation, maintenance, and traffic safety work. This responsibility is significant for traffic safety, as contributing accident factors related to road conditions or the road environment were identified in 43% of fatal accidents during the period 2017–2020 (Hesjevoll et al., 2022). Additionally, the county road network has the highest accident risk among the road networks (Statens vegvesen, 2022) and faces significant maintenance backlog.

In January 2020, seven new county authorities were thus faced with a range of challenges in developing new merged administrations, and in developing new systems to manage county roads. At the same time, the county authorities were required to maintain their

key functions in the field of traffic safety. These changes involved new compositions of personnel, organizations, routines, etc. The new county authorities were formed by merging old county authorities, while also incorporating many individuals who had previously worked with county roads in the NPR. These are change processes that likely require a significant amount of time and energy. At the same time, we can imagine that such changes can provide opportunities for learning and innovations that have the potential to enhance traffic safety, for example, in the development of new systems, methods, and routines for traffic safety management. Given the importance of these different mechanisms, it is important to study the status of the county authorities' traffic safety management three years after the regional reform.

Recent research shows that innovation is a key premise for traffic safety improvement in Vision Zero and the Safe System approach (Elvik et al., 2023). This research does, however, not examine the organisational and cultural conditions which allow traffic safety innovation to take place. This is the topic of the present paper. Defining the conditions facilitating and impeding traffic safety innovation is key to continued progress in traffic safety management within the Safe system approach.

Previous research shows that there is a relationship between innovation culture and self-reported innovation outcomes in organizations (West & Anderson, 1996; Mathisen et al., 2008; Bower et al., 2003; Newman et al., 2020). Therefore, we assume that there is a relationship between a positive innovation culture in the county authorities and innovations and learning in traffic safety work (*Hypothesis 1*).

Previous research also shows that reforms and organizational changes can have consequences for innovation culture. Innovation culture refers to the extent to which members of organizations perceive that the organization encourages, supports, and enables innovation (Newman et al., 2020). Reforms and reorganizations often lead to new compositions of people, new communication networks, and new patterns of interaction (Eisenhardt & Tabrizi, 1995; Karim, 2009). This can create a new climate for learning and innovation by bringing together new perspectives and challenging them in ways that foster the emergence of new ideas (Gherardi et al., 1998; Karim, 2009; Meyer & Marais, 2009). Newman et al. (2020) refer to innovation climate as shared perceptions

at the group or organizational level regarding the extent to which group or organizational processes encourage and enable innovation. The changes associated with the regional reform and the dissolution of the common road administration particularly involve new groups starting to work in the same organization, including individuals from merged county authorities and those who previously worked at in the NPRA. Additionally, the new county authorities were mandated to create new organizations, systems, and routines. Based on previous research, we assume that the new compositions of people and professional groups have created a new climate for learning and innovation (*Hypothesis 2*) in the county authorities, three years after the regional reform.

However, it should also be noted that if reorganizations are too extensive or energy-consuming, they do not lead to learning and innovation but rather to dissatisfaction, uncertainty, and organizations being ill-equipped to manage their key tasks (Karim, 2009; Meyer & Marais, 2009) (*Hypothesis 3*). Therefore, it is not guaranteed that the county authorities have developed a strong innovation culture.

Previous studies show that learning is one of the key elements of a strong safety culture (Reason, 1997; Pidgeon & O'leary, 2000). Therefore, we assume that the county authorities' innovation culture is strongly related to their safety culture (*Hypothesis 4*).

1.2 Aims

In this section, we present the aims of the study. Based on what has been described above, this study aims to examine:

1. Innovation outcomes in the county authorities' traffic safety work
2. Innovation culture in the county authorities
3. Factors influencing innovation outcomes in the county authorities
4. Factors influencing innovation culture in the county authorities.

2 Theoretical approach and previous research

2.1 Innovation in traffic safety work

While invention refers to the emergence of a new idea, innovation is about putting that idea into practice.

Innovation is not just about inventing something new; it can also involve adopting something in a new context or organization (Fagerberg, 2005). Introducing a new traffic safety measure in one country, inspired by something similar in another country, is also an innovation. Elvik et al. (2023) analyze the significance of innovation in the traffic safety management of public actors in a study of Norwegian traffic safety plans over the past 20 years. Some of the most important innovations related to the Vision Zero concept are conceptual innovations, which involve new ways of seeing the world, new perspectives, or purposes for traffic safety work in general. Vision Zero represented a new approach to responsibility, aiming to create a road system where road users are not killed or seriously injured if they comply with applicable laws and regulations (Elvik, 2022; Belin et al., 2012). This also assigns significant responsibility to road authorities and owners. It should also be noted that after 10 years of Vision Zero in Norway, in 2010, new interim goals for the number of fatalities and serious injuries were set on the path to Vision Zero. This occurred in both Norway and Sweden and is linked to further reductions in the number of fatalities and serious injuries in both countries (Elvik et al., 2023; Varhelyi, 2016). In the first 10 years of Vision Zero, it was considered immoral to have a goal for fatalities and serious injuries that was not zero. In the work on Vision Zero, innovations related to safety indicators were also developed, which were monitored annually. As the number of fatalities and serious injuries decreased, indicators related to road users (speed, alcohol impairment, seatbelt use), road infrastructure (kilometers with median barriers, traffic safety inspections), and vehicles (age of the vehicle fleet, percentage of vehicles with full Euro NCAP score) were developed (Elvik et al., 2023). Elvik et al. (2023) conclude that these gradual innovations in the continuous improvement of traffic safety work in Norway have contributed to fewer fatalities and serious injuries in traffic.

2.2 Innovation culture

If we accept that innovation is important for traffic safety work, it is crucial to understand what promotes (and hinders) innovation. Several studies have identified strong relationships between innovation culture and self-reported innovation outcomes in their own organizations (West & Anderson, 1996; Mathisen et al., 2008; Bower et al., 2003; Newman et al., 2020).

In this study, we define innovation culture as aspects of organizational culture that are relevant to innovation. Schein (1992) defines organizational culture as: ‘*A set of shared basic assumptions that a group has learned while solving external/internal problems and that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*’. ‘Basic assumptions’ refer to what Schein (1992) calls the deepest cultural level of ‘taken-for-granted’ assumptions that govern what we pay attention to, what things mean, how we react emotionally, and how we act. Organizational culture and organizational climate refer to different analytical levels related to the same empirical phenomenon. Organizational climate represents snapshots, or manifestations, of organizational culture. The climate concept is often used to describe quantitative measurements of culture in organizations (Flin et al., 2000). However, the terms organizational climate and culture are often used interchangeably. In this study, we adopt the same approach.

Innovation culture is about the extent to which members of organizations perceive that the organization encourages and enables innovation (Newman et al., 2020). This may involve specific encouragement of innovation from managers and colleagues, autonomy and freedom, as well as access to necessary resources such as expertise, materials, information, etc.

Measurements of innovation culture and innovation climate typically focus on the following characteristics of the organization:

1. Facilitation and emphasis on innovation among managers and employees, i.e. the extent to which employees perceive the organization as open to change, supportive of new ideas, and tolerant of diversity among members.
2. Availability of resources, i.e. the degree to which resources are perceived as sufficient within the organization (Newman et al., 2020).

Regarding factors that influence innovation culture, previous research indicates that managers play a particularly important role. Leaders can foster a culture of innovation by encouraging and rewarding creativity, implementing new ideas, establishing expectations (Anderson & West, 1998). Additionally,

managers can facilitate innovation by influencing organizational structure, group composition, problem-solving routines, resource allocation, competence, and granting autonomy, among other factors (Keller, 2001; Tierney et al., 1999; Somech, 2006; Puccio et al., 2008).

Innovation culture is influenced by organizational structure (Zennouche et al., 2014). High levels of centralization and strict hierarchy are seen as hindrances to learning and innovation, as they limit information flow and communication. Conversely, decentralization fosters greater participation and facilitates the exchange of multiple perspectives in creative ideation processes. However, excessive decentralization may impede coordination and the facilitation of systematic learning across different actors. The concept of ‘balanced empowerment’ reflects this balance between top-down and bottom-up dynamics in innovation processes (Sundbo, 1996). Additionally, the availability of resources is positively related to innovation since resources are needed to develop new ideas (Zennouche et al., 2014).

As mentioned, organizational changes and reforms that lead to new compositions of people and new patterns of interaction can impact innovation culture and outcomes (Eisenhardt & Tabrizi, 1995; Karim, 2009). Studies of various interventions for organizational learning show that learning and cultural change often occur when different individuals’ opinions, interpretations, and experiences of practices are confronted (Richter & Koch, 2004). This happens through comparisons of perspectives and reflection on one’s own practices (Gherardi et al., 1998; Richter & Koch, 2004). If the organizational changes are too extensive or energy-consuming, they do not lead to learning and innovation but rather dissatisfaction, uncertainty, and organizations becoming less equipped to manage their key tasks (Karim, 2009; Meyer & Marais, 2009).

The innovation culture of the county authorities will also be conditioned by and influence the interaction with the government on one side and the municipalities on the other. Such a broader approach to understanding innovation and learning culture beyond the framework of individual organizations reflects the insight that innovation is systemic. The research literature on innovation systems emphasizes that innovation cannot be seen as an isolated phenomenon but rather arises through the interaction between different types of actors (Lundvall, 1992; Edquist, 1997; Klein Woolthuis

et al., 2005). Central to such a systemic understanding is the innovation potential that lies in the interaction and feedback between actors possessing different competencies and complementary perspectives. Such a systemic understanding has also been further developed and applied at a regional level, where the focus has been on how interaction and collaboration among various actors take place within a specific regional context, with its respective actors, networks, and institutional and infrastructural characteristics (Asheim & Isaksen, 2002; Cooke, 2004; Maskell & Malmberg, 1999).

2.3 Safety culture

In addition to the factors mentioned above, innovation culture in organizations is also influenced by safety culture. Safety culture can be understood as a focused aspect of organizational culture (Nævestad, 2010; Haukelid, 2008; Guldenmund, 2000; Antonsen, 2009). In line with this, safety culture can be defined as safety relevant characteristics of organizational culture (Antonsen, 2009; Nævestad, 2010). More specifically, we define it as shared and safety-relevant ways of thinking or acting that are (re)constructed through negotiations among people in social contexts (Nævestad, 2010).

There has been extensive research on the characteristics of good safety cultures. Leadership commitment to safety, employee engagement in safety, mutual trust, and reporting are often emphasized as core factors (Nævestad, 2010). Reason (1997) has identified five essential aspects that characterize organizations with a good safety culture:

1. **Informed culture:** The organization gathers data on both accidents and incidents (near-misses) and conducts proactive measures such as safety audits and safety climate surveys.
2. **Reporting culture:** All employees report incidents and near-misses and participate in safety climate surveys, among other reporting activities.
3. **Just culture:** Employees are encouraged to report incidents, as they trust that the management will handle incident reports and implicated individuals in a fair manner.
4. **Flexible culture:** The organization has the ability to adapt and change its practices
5. **Learning culture:** The organization has the ability to learn from reported incidents, safety audits, etc., in order to improve safety.

Most studies on safety culture and safety management systems are based on this understanding of safety culture. Several studies from various sectors find correlations between different aspects of safety culture (such as management and employee commitment to safety, learning, reporting) and other safety outcomes (accidents, behavior, incidents, violations) in aviation (Hudson, 2003; Patankar, 2019), railway (Zuschlag et al., 2016), maritime sector (Lappalainen et al., 2012), and the road sector (Naveh & Katz-Navon, 2015). However, it is challenging to determine which specific safety culture traits have the greatest impact on safety. It is often emphasized that management commitment to safety is crucial, combined with a systematic and group learning process that involves identifying potential hazards, implementing measures, and following up on the process (Nævestad et al., 2018). This aligns with what Reason (1997) refers to as a learning culture.

Research traditions study different sub aspects of organizational culture, such as innovation culture (Newman et al., 2020) and (learning) safety culture (Antonsen, 2009). Since these sub aspects of organizational culture appear to be relatively overlapping, we can expect relationships between different sub aspects of organizational culture, such as innovation culture and safety culture. It is not surprising, for example, if organizations that have a learning safety culture (Reason, 1997) also have a strong innovation culture (Newman et al., 2020). However, as far as we know, there are no studies examining the relationship between innovation culture and safety culture. The research on innovation culture and safety culture does not appear to overlap.

3 Method

The present study has used a mixed-method approach, with both qualitative interview data and quantitative survey data. To get an understanding of the study topic, we started with qualitative interviews in each of the studied county authorities. The general focus here were the hypotheses of the study, i.e. to which extent the regional reform has involved possibilities to learn and innovate (positive effects) related to traffic safety, and to which extent has it required resources, time and energy (negative effects). We summed up the results of the county authorities' experiences, and based on the interview results (and previous research), we developed a quantitative survey to examine the prevalence of the

main tendencies from the interviews, and to examine relationships between key variables. Thus, we use the qualitative interviews both to develop the quantitative survey, and to shed light on the survey results, as these are closely related to the interviews.

3.1 Quantitative survey

3.1.1 Recruitment

We recruited 392 respondents from the four county authorities. The survey was conducted between November 2022 and February 2023, targeting all employees working in four county authorities' departments for transport or mobility. When we recruited the county authorities, we wanted to include county authorities that were different with respect to size, level of reorganization and part of the country. This is reflected in the four participating county authorities. As we want to keep the county authorities as anonymous as possible in the study, we do not provide additional information about them, and this is not relevant to the results either. The most important thing is the extent of reform, in addition to the variables that we measure in the survey (e.g. perceived resources required by the reorganization, safety culture, innovation climate). See Table 1 for a summary of the counties and their organisational changes related to the regional reform.

The respondents were recruited through our contacts in each county authority, who reached out to the managers of all departments within transport or mobility. These department managers were provided with an information text and a link to the survey, which they shared with their employees via email. It was emphasized that the data would be handled by researchers from the Institute of Transport Economics, and that the results would be treated confidentially. To stimulate a high response rate, we informed respondents that they could provide their contact information to participate in a drawing for a gift card worth NOK 5000 (approx. EUR 450).

3.1.2 Themes in the survey

The themes in the survey are based on the results from the interviews and previous research. Below, we summarize the survey distributed to participants. All non-demographic questions were answered on a likert scale from 1 (completely disagree) to 5 (completely agree), and the option 'I do not know'. Responses

with 'I do not know' are removed from tables, figures, and models. Below, we summarize the most central questions, and their Cronbach's Alpha after creating an index based on the type of question. The distribution of answers for all questions are presented in Appendix A.

Innovation: The questions regarding innovation began with (Cronbach's Alpha: .908): *'We will now ask questions about new changes after the regional reform / end of shared road administration in your county authority. Have you used the changes as an opportunity to:*

- *reorganize the departments working on transportation and traffic safety?*
- *introduce new methods in traffic safety work?*
- *implement new systems and routines in traffic safety work?*
- *introduce new ways to collaborate with external partners in traffic safety work?*
- *introduce new ways to collaborate with municipalities in traffic safety work?'*

Two questions about *learning* were included in the innovation index because they measure conceptual innovation. Each individual question was presented in the form of statements:

- We have a more comprehensive perspective on traffic safety than before.
- I have gained a better understanding of how the county authority's work can influence traffic safety.

Innovation culture, based on [Patterson et al. \(2005\)](#) (Cronbach's Alpha: .877):

- New ideas are often received in a constructive manner in my workplace.
- My immediate supervisors are quick to identify the need for doing things differently.
- Assistance for developing new ideas is readily available in my department.
- In my department, we regularly discuss whether the methods we use to do our job are adequate.
- In this organization, we frequently test new ways people can collaborate.
- There are regular discussions in my department about whether we work together effectively.

Table 1 Summary of the three main changes in the four studied county authorities

	Merged from former counties?	Has taken over the responsibility for administering county roads and has incorporated former employees from the NPRA?	Scheduled for split-up?
County authority 1	Yes	Yes, taken in from the former county departments	No
County authority 2	Yes	Yes, taken in from the former county departments	Yes: 01.01.2024
County authority 3	Yes	Yes, taken in from the former county departments	Yes: 01.01.2024
County authority 4	No	Yes, taken in from the former county departments	No

Top Management Focus on Traffic Safety, based on Naevestad et al. (2023) (Cronbach’s Alpha: .862):

- The county authority’s top administrative management considers traffic safety to be very important.
- The county authority’s top political management considers traffic safety to be very important.

Safety Culture, partly based on the GAIN index for safety culture (GAIN, 2001) (Cronbach’s Alpha: .875):

- My immediate supervisor considers traffic safety to be very important.
- My closest colleagues consider traffic safety to be very important.
- At my workplace, we often discuss the traffic safety consequences of the decisions we make.
- Among my colleagues, we strongly focus on how our work influences traffic safety in the county.
- All my colleagues have plenty of opportunities to suggest ways we can contribute to increased traffic safety.

Questions about Reorganization and Influencing Factors, developed based on the qualitative interviews we conducted (Cronbach’s Alpha: .669):

- Reorganizations have demanded a lot of time, energy, and resources in my county authority.
- There was uncertainty for a long time about how my organization should be structured.
- Reorganizations have diverted focus away from our key tasks related to traffic safety (e.g., CTSC, Traffic Safety Plans, administration of county roads).

Resources in traffic safety work, based on the qualitative interviews (Cronbach’s Alpha: .602):

- We have insufficient financial resources to perform tasks related to traffic safety.
- We have insufficient professional resources, tools, and equipment to perform tasks related to traffic safety.

Other questions. The survey also includes other questions about influencing factors, based on the qualitative interviews:

- The COVID-19 pandemic made it challenging for us to establish a new organization.
- The split up of my (newly merged) county authority has impeded the climate for discussing and implementing new solutions.

Finally, we recorded gender, age, area of work, managerial level, the respondents’ employment start date in the county authority (before or after 2020), and their previous workplace before 2020 (county authority, the NPRA or another organization).

3.1.3 Analysis

We conducted two regression analyses with the results from the survey. The first analysis examined the factors that explain the variation in respondents’ answers to the traffic safety innovation index. The second analysis examined the factors that explain the variation in innovation culture. We used linear regression since the dependent variables can be treated as continuous. The regression analyses demonstrate the effects of the independent variables we included, controlling for other variables in the analysis. It should be noted that these analyses do not establish causation, and some of the relationships observed may be due to unmeasured third variables.

3.2 Qualitative interviews

3.2.1 Composition of the sample and recruitment

We conducted semi-structured interviews with a total of 42 key individuals from the four county authorities: 10 from County 1, 13 from County 2, 9 from County 3, and 10 from County 4. The selection of these four county authorities to participate in the study was based on their differences, including varying degrees of reforms and different sizes. All interviews were conducted digitally via Microsoft Teams between March and October 2022, with interview durations ranging from 40 minutes to 1.5 hours.

We employed a strategic sampling method, where the interviewees were selected based on criteria relevant to the research questions. We focused on assembling a sample that represented various roles in traffic safety work across the four county authorities. Our goal was to include individuals who had previously worked in the NPRA as well as other employees from the county authorities. Simultaneously, we aimed to include key personnel actively involved in traffic safety and employees whose work was indirectly related to traffic safety. The criteria were communicated to the contact persons in the four county authorities. Subsequently, these contact persons provided us with the contact information of relevant individuals, who were then approached via email with a request to participate in the interviews.

Approximately half of the interviewees were already employed by the county authorities before the regional reform, while the other half consisted of individuals who had previously worked for the NPRA and had transitioned to the county authorities. We did not interview elected politicians. All the interviewees work within the following areas:

- Traffic Safety
- Traffic safety Action Plan Unit (CTSC)
- Staff/Administration
- Operation and Maintenance
- Planning and Management
- Public Transport and Mobility
- Road Construction and Development
- Public Health and Education
- Strategy and Development.

3.2.2 Themes in the interview guide

The guide included questions about the interviewees' work situation before and after the region reform and the end of the shared road administration, focusing on organizational changes. We asked the interviewees whether they believed they had managed to maintain key functions after the reorganizations. The interview guide also contained questions about new forms of collaboration, work methods, tools, perspectives, etc.

Furthermore, the guide included questions about the status of quality systems, the merging process, and the forthcoming split up of two of the newly merged county authorities. This split up was a reversal of the reform, based on regional referendums. Finally, we asked about factors that have influenced potential learning and innovation after the region reform, as well as views on possible consequences for traffic safety. Key individuals with specific responsibilities in the field of traffic safety were also asked questions related to CTSC before and after the regional reform, and questions related to the traffic safety plan/transportation plan.

Video recordings were made for all interviews. The interviewers took notes during each interview, and some of the interviews were fully transcribed. In accordance with standard research ethics, the study was reported to the NSD (Norwegian Centre for Research Data). Informed consent was obtained in each interview.

3.2.3 Analysis

We conducted thematic analyses of the interviews, systematically recurring themes in the interviewees' descriptions of specific topics (Braun & Clarke, 2006). In the first step of the process, the interviews were carefully read several times and then coded. The codes were then organized and grouped into broad categories. In the next step, the categories were reviewed. During this part of the process, we assessed the categories in relation to each other and the material, and necessary adjustments were made. Some categories described the same overarching concept and were merged, while others emerged as subcategories under a more general theme. The result is overarching descriptions that address the most prominent trends (similarities and differences) in the interview data, related to each of the research objectives. The coding and analyses were conducted by three individuals who discussed the

analyses. All interviewees were provided with our presentation of the interview results for review and quality assurance. The analyses were also discussed with and quality-assured by our contact persons in each county authority.

4 Results

4.1 Characteristics of the respondents

In Table 2, we show a comprehensive overview of the respondents. Although there are some variations regarding age and gender, their differences are not statistically significant. When it comes to respondents' job position level, County authority 4 stands out with a relatively low number of employees among its respondents (58%). In the other county authorities, the proportions of employees range between 77% and 88%. The differences are statistically significant at the 1% level ($p=0.003$). Approximately two-thirds of the respondents were hired in 2020. The exception is County authority 4, where over one-third of the respondents were hired in 2022. We observe that approximately 60% of the respondents hired in 2020 came from the NPRA before being employed in the studied county authorities in 2020. These are largely people working with county roads, who chose to switch employer to the county authority as the county authority took over the administrative responsibility for the county roads. Before the regional reform in 2020, the four county authorities were comprised of eight county authorities. Only 8% of the respondents worked in one of these before 2020. We have standardized the departments sub-divisions across county authorities, for these to be comparable across the counties.

4.2 Innovation and learning in traffic safety work

This section is related to the first aim of the study, which is to examine innovation outcomes in the county authorities' traffic safety work. First, we present results from the quantitative survey and then results from the qualitative interviews.

4.2.1 Results from the survey

To provide an overview, we present the results from the survey as figures displaying the share of respondents agreeing to the different statements. Figure 1 shows the percentage of respondents who agree and strongly agree with statements in each county authority regarding items listed under innovation and learning. These

were introduced with: 'Have you used the changes as an opportunity' to e.g 'introduce new ways to collaborate with municipalities in traffic safety work', 'introduce new methods in traffic safety work, or general statements about learning, like: 'We have a more holistic perspective on traffic safety than before', 'I have gained a better understanding of how the county authority's work can influence traffic safety'. See Appendix A for the full wording of the questions and distribution of responses for each question.

Based on Chi-square tests, we observe statistically significant differences between the county authorities regarding the various statements. County authority 1 consistently has the highest proportion of respondents who agreed with the statements, while County authority 3 has the lowest proportion of respondents who agreed. The differences between the county authorities are statistically significant at the 10% level for the first statement, at the 1% level for the statements about new methods and systems, and at the 5% level for the statement regarding new collaboration with municipalities. However, the differences in the proportions of the county authorities for the statement about collaboration with external parties are not statistically significant. Finally, the differences between the county authorities for the last two statements about learning are statistically significant at the 1% level. The highest proportion of respondents agree with the last two statements in County authority 1, and the lowest in County authority 3.

Comparing statements across county authorities, we notice that there are more respondents who agree that they have used the reform as an opportunity to reorganize the departments working with traffic safety, and the second highest number of respondents agree with the statement that they have gained a better understanding of how the county authority's work can impact traffic safety.

We created a sum score index for innovation in traffic safety work (min: 7, max: 35 points). The results on the index are presented in Table 3.

In line with the results from the Figure 1, we can see that County authority 1 has the highest score on the index, while County authority 3 has the lowest. The differences between the county authorities are statistically significant at the 1% level ($p < .001$).

Table 2 An overview of the characteristics of the respondents

County authority (CA)		CA 1	CA 2	CA 3	CA 4	TOTAL
Age	<26 yrs	1%	2%	1%	0%	1%
	26–35 yrs	12%	17%	15%	28%	16%
	36–45 yrs	23%	25%	25%	14%	23%
	46–55 yrs	39%	24%	36%	36%	33%
	56+ yrs	26%	33%	24%	22%	27%
Gender	Female	29%	38%	44%	46%	39%
Respondents’ job levels in each county authority	Head of department, service, or unit	5%	3%	1%	6%	3%
	Middle manager in department, service, or unit	9%	3%	11%	16%	8%
	Other manager	10%	6%	7%	20%	9%
	Employee, staff member	77%	88%	81%	58%	79%
Year the respondents in each county authority were hired	2022	9%	8%	9%	36%	12%
	2021	5%	10%	7%	2%	7%
	2020	64%	66%	67%	58%	65%
	2019–2015	7%	6%	6%	2%	6%
	Before 2015	16%	10%	10%	2%	11%
Respondents’ workplace before 2020	The NPRA	69%	67%	58%	50%	63%
	Merged county authority	11%	6%	12%	2%	8%
	Other than mentioned	21%	27%	30%	48%	29%
Respondents current work	Operation and maintenance	24%	34%	28%	28%	29%
	Construction and development	26%	21%	29%	24%	25%
	Planning, management, and authority	21%	23%	12%	42%	22%
	Public transport and mobility	12%	14%	15%	0%	12%
	Strategy and development	12%	8%	16%	6%	11%
	Other/miscellaneous	7%	1%	0%	0%	2%
TOTAL		102	131	109	50	392

Table 3 The four county authorities’ scores on the index for innovation and learning in traffic safety work (min: 7 points, max: 35 points)

County authority	Mean	N	Standard deviation
County authority 1	18.9	44	3.9
County authority 2	17.5	64	4.3
County authority 3	14.4	34	4.1
County authority 4	17.9	20	2.9
TOTAL	17.3	162	4.3

4.2.2 Results from the interviews

New forms of internal organization. The first form of innovation mentioned by the interviewees was new forms of internal organization within the county authorities. These changes were implemented due to the merger of previous administrations and the inclusion of personnel coming from the NPRA.

Several interviewees mentioned that they used this opportunity to refine the best principles from the merged organizations and make organizational improvements.

‘The first assignment was to make a completely new department that did not already exist. We started with one person, who was me. Then we needed to map the organization: how many units do we need, and who will lead them? (...) Defining the roles we had to fill, and to start with blank sheets is a wish come true. It is not often we get the opportunity to do that.’ (Interviewee, County authority 1).

Two relevant factors in the new organization were:

- The inclusion of personnel from the NPRA who worked with county roads.
- Several county authorities organized transportation together with other departments, such as public

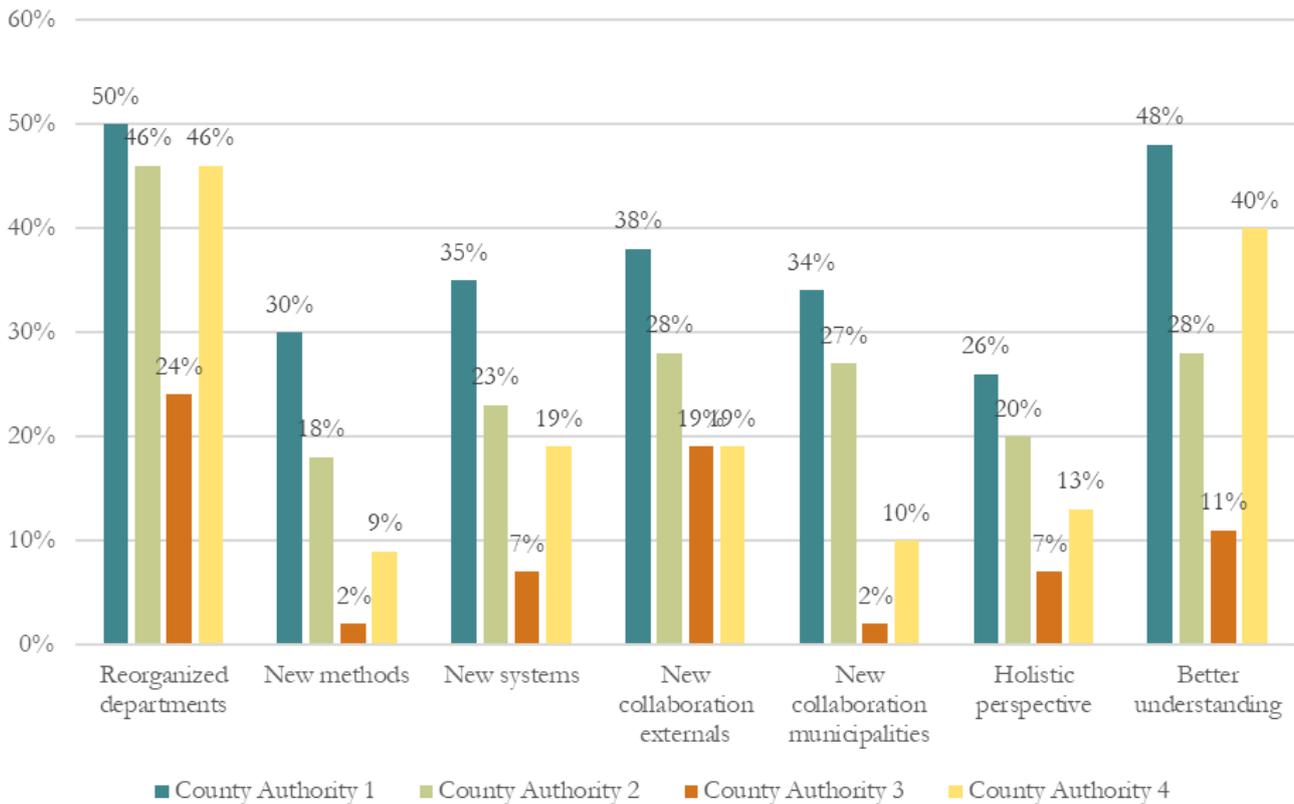


Figure 1 Proportions of respondents who agree (‘agree’ and ‘strongly agree’) with five statements about innovation in traffic safety work in each county authority. The percentages are calculated after excluding respondents who answered: ‘do not know’.

transport, construction, property, or county roads.

We define the second point as innovation, because the interviewees described this as a new way of thinking about organization.

County authority 4 maintained its county structure and is the only county authority in the study that did not undergo a merger of existing county authorities. However, they still carried out a reorganization of the aforementioned type because they incorporated the county roads department from the NPRA. In County authority 3, personnel from the NPRA were to a greater extent organized in their own separate departments, and not merged with other departments, as in County authorities 1, 2 and 4. As we will see below, this led to less organisational learning related to traffic safety.

New methods in traffic safety work. In County authority 1, one of the employees had developed a model for analyzing risk factors for run-off-road accidents in curves while working at the NPRA (before January 2020). He brought this model with him and further developed it when he started working for the county

authority. Additionally, he implemented the model in the county authority’s traffic safety work. The model describes the relationship between curve characteristics and the risk of run-off-road accidents. In connection with this work, lists were created where curves were ranked based on their risk of run-off-road accidents. The curves were linked to road references allowing specific measures to be implemented for curves with a high risk of run-off-road accidents. Additional innovations were developed related to this, e.g. map solutions, policy for implementing measures based on certain levels of risk combined with certain levels of traffic volume etc.

‘In County authority 1, we have developed the results from the analysis further by looking at how the results can be used in the most efficient way possible. We look at e.g. the calculated risk in the curves against traffic volume, to create a plan of where we believe we will get the most traffic safety for the money by implementing measures. (...) In addition, we have recently created a map solution that is very nice. It shows all the curves in a live map which we can filter on e.g. traffic

volume and risk level. (...) We use the risk curve data by selecting sections and going on inspections of risk curves on these sections. During the inspections, we decide what measures we have to take. (Interviewee, County authority 1).

Other examples of new methods include making assessments of possible ways to achieve as much traffic safety as possible with limited financial resources. One mentioned example was the rules for illuminating pedestrian crossings. Handbooks, for instance, state that there should be lighting on both sides. However, in a context of limited finances, this can be challenging to accomplish. County authority 1 therefore considered having lighting on only one side, for example, thereby having some lighting in two pedestrian crossings instead of full lighting (as prescribed by the handbook) in one. County authority 1 contacted the Institute of Transport Economics to examine what research says about such a possible solution and its potential consequences. This was related to assessments in County authority 1's group for evaluating non-conformities (e.g. discussing more or less grey zone violations of handbook requirements). In a context of financial scarcity, this also illustrates how a non-conformity group can be an arena for innovation to develop 'smart solutions' and maximize traffic safety with the available resources.

New systems and routines. The regional reform required the county authorities to establish new systems and routines. Several of the interviewees emphasized that within their own department, there was a focus on thinking innovatively, and after the reform, they had the opportunity to develop a quality system that was more tailored to the roads in their own county. They mentioned that the template for the NPRA quality systems for county roads is a general road type meant to fit 'everything and nothing' because this quality system was applied nationwide.

New ways of collaborating with external parties in traffic safety work. New bodies for collaboration on traffic safety were established as a result of the changes and reforms in 2020. This can be seen as ways to fulfill the regional sector responsibility. For example, County authority 2 established a professional network for traffic safety, cycling, and pedestrian issues.

New ways of collaborating with municipalities in traffic safety work. Interviewees in County authority 2 mentioned that they had developed a new type of collaboration with municipalities, which they described

as 'partnership agreements on equal terms'. This meant that the collaboration should be more on the municipalities' terms than before, and that the relationship between the county authority and the municipalities should be more equal than before.

New principles and ways of thinking. Consistent with the results from the survey, interviewees reported that they had acquired a *more holistic perspective on traffic safety* in the county authorities, due to the changes. This is a result that applies to all county authorities and is one of the most important findings from the qualitative data. It means that interviewees have obtained a broader understanding of all the ways that the county authorities directly and indirectly influence traffic safety, e.g. as planners, administrators and maintainers of county roads, as procurers of public transport (influencing bus safety), school owners (influencing the traffic safety attitudes of pupils), large employers with people driving in their work, responsibility for zoning plans in the county, assistance to municipalities in their traffic safety work etc. This was seen as a result of new forms of organization, where these different roles often were placed in the same departments. It was mentioned that combining different environments working (directly and indirectly) with traffic safety also strengthened the traffic safety work in the county authority:

'Since traffic safety has become a professional environment, where we can meet and feel the different cultures; with different disciplines gathered, we can lift traffic safety as a part of a new societal development, where we relate traffic safety to public health in general. It is not just a 'grey topic' in the program, relating to speed bumps and orange school bags. We are now a professional environment working with future transport.' (Interviewee, County Authority 2).

It was also mentioned that combining different environments working (directly and indirectly) with traffic safety facilitated learning from a fatal bus accident on winter roads, and more effective implementation of preventive measures. The county authority has an overall responsibility for public transport procurement and winter maintenance. In the new County authority 1, these different professional environments are located in the same department, and they can therefore cooperate and communicate in ways that involve a more holistic management of traffic safety:

'Our strength is the co-organisation of public road maintenance and public transport. We had a fatal

accident at (...). The accident analysis board came in to analyse it. That was a wake-up call, which led to improvement of the winter maintenance. We also contacted the bus companies to get information about sharp curves or steep sections. This was an incident which required cooperation between the people working with winter maintenance and the people working with public transport in our department. There was no tradition for this, previously.' (Interviewee, County Authority 1).

Other examples like this were provided from County authority 2 and 4.

Interviewees who came from a former county authority mentioned that they gained a new perspective on traffic safety in the county authority after they incorporated personnel from the NPRA who worked with county roads. For example, in County authority 4, they mentioned that the work on traffic safety plans improved after including people who work with county roads in the county authority.

'Now that we have included many of those who worked with county roads in the Norwegian Public Road Administration in the county authority, it is easier to work holistically [with traffic safety]. This is particularly evident in the work with the regional transport plan and the measures that are proposed there.' (Interviewee, County Authority 4).

It was mentioned that the measures became more realistic, and the traffic safety plans became more comprehensive than before, after integrating the county roads department and bringing together everyone working on traffic safety in the county authority. This involved cooperation between people working with physical traffic safety measures on county roads and people working strategically with road safety plans in the county authority.

'We have seen new opportunities for collaboration; I have become more familiar with [different projects]. I know more about what's going on, and it is easier for me to relate it to other things that we work with. (...) As far as I remember, this was also one of the reasons why county roads were included in the county authorities; to think more holistically. More people discover opportunities for learning, see opportunities for collaboration and learn things they didn't know before.' (Interviewee, County Authority 1).

These are examples of how the role of coordinating and recommending traffic safety measures in the

county authority improved by including people who manage county roads. A more holistic perspective on traffic safety was also mentioned related to the collaboration between those working with the procurement of public transport and those working on traffic safety, which occurred due to co-organization. One consequence of this was that both parties became aware of how to better address traffic safety concerns in the procurement of public transport by imposing traffic safety requirements.

Interviewees who came from the NPRA emphasized that they gained a new perspective on traffic safety in the county authority through interaction with other employees in the county authority. They mentioned, among other things, that they learned more about all the ways the county authority can influence traffic safety. The interviewees from the NPRA talked about a strong safety culture and a strong focus on traffic safety in their previous organization, while the county authority has a broader focus on mobility. Several mentioned that they had gained a broader perspective on traffic safety, considering it as one of several aspects of mobility and sustainability.

The interviewees considered these new perspectives as a result of the new forms of organization in the county authorities after the regional reform, which involved co-organization between personnel from the NPRA and those who worked in the county authorities before 2020. Some interviewees mentioned that before the regional reform in 2020, there used to be less contact between the NPRA and the county authority. They mentioned that they now work more holistically than before, and new collaborative constellations emerged due to the reorganization that followed the dissolution of the shared road administration. The exception to this was County authority 3, where personnel who came from the NPRA in 2020 were less co-organized with those who worked in the county authorities before 2020.

Another example of new principles and ways of thinking after the reorganizations is related to *viewing traffic safety as one of several aspects of mobility*. This perspective is also reflected in the county authorities moving away from having specific plans for traffic safety to more general plans for transport or mobility, where traffic safety is considered one of several aspects. This new way of thinking was particularly emphasized as new by the interviewees working with county roads and was different from the approach they

were accustomed to from the NPRA. The interviewees working with county roads generally emphasized that they perceived a stronger focus on mobility in the county authority than at the NPRA (where traffic safety and Vision Zero goal were overarching values) They experienced that the county authorities focused more on zero growth (in personal car traffic) than the Vision Zero concept.

The interviewees also highlighted that they think more holistically in their preventive work by incorporating a *general focus on sustainability*. This is the third example of new principles and ways of thinking, especially in County authority 2, where the aim was not necessarily to focus solely on traffic safety but to make comprehensive considerations that also include the environment, climate, and safety. This entails evaluating the introduction of new traffic safety measures in line with sustainability principles.

A fourth example of a new way of thinking/principle strongly emphasized and implemented by personnel involved in recommending and coordinating measures in County authority 2 is the idea of *using traffic safety resources where they have the most impact*. It was mentioned that in practice, this could mean allocating funds to the most effective physical measures on the county road network and prioritizing away from e.g. attitude campaigns with a less certain impact.

4.3 Innovation culture in the county municipalities

This section is related to the second aim of the study, which is to examine innovation culture in the county authorities. First, we present results from the quantitative survey and then results from the qualitative interviews.

4.3.1 Results from the survey

Table 4 presents the scores on the index for innovation culture in the various county authorities (see Appendix A for the full wording of the statements that make up the index, including distribution of responses).

We can see that the score is highest in County authority 1 and lowest in County authority 3. The differences are statistically significant at the 1% level ($p < .001$). The average score of 19.9 on the innovation culture index corresponds to an average of 3.3 on all the questions (i.e. 19.9 points divided by 6 statements). This score is slightly above ‘neither agree nor disagree’ on all the

Table 4 Scores on the index for innovation culture in the municipalities

County authority	Mean	N	Standard deviation
County authority 1	21.1	102	3.8
County authority 2	20.3	131	4.0
County authority 3	18.0	109	4.6
County authority 4	20.7	50	4.5
TOTAL	19.9	392	4.3

questions on average (toward ‘agree’). The average score in County authority 3 corresponds to a response of ‘neither agree nor disagree’ on all the questions.

4.3.2 Results from the interviews

The interview results indicate that the culture of innovation was related to the opportunity for change presented by the regional reform. Interviewees generally stated that in their respective county, they viewed the regional reform and the related changes as an opportunity to implement new and improved methods, systems, and routines. This was particularly emphasized in County authority 2, where the interviewees highlighted a strong focus on thinking innovatively about traffic safety work.

‘I experienced that that the traffic safety work should be innovative. (...) The leading idea was that we should think anew and do things differently.’ (Interviewee, County authority 2)

The culture of innovation and learning in the new county authorities was also attributed to the new composition of departments and individuals in the new county authorities, involving interaction between professional communities that had not previously collaborated. As noted, both those who came from the NPRA and those who came from the former counties emphasized that they had gained new perspectives on traffic safety through working with new professional groups and individuals. This was emphasized by interviewees in all counties.

Several interviewees who worked with county roads believed that they could use the regional reform and the dissolution of the shared road administration as an opportunity to develop a quality system that was better suited to the roads in their respective county. However, interviewees noted that the reversal of the regional reform in County Authority 2 and 3 impeded such efforts.

Finally, the interviews indicated a difference between interviewees who worked with coordinating traffic safety measures in the county and those who were involved in administering county roads. The latter group placed greater emphasis on continuity in their traffic safety work and highlighted that they were mostly the same individuals doing the same work with the same rules.

4.4 Factors influencing innovation culture and innovation

In this section, we focus on factors influencing innovation outcomes in the county authorities (third aim), and factors influencing innovation culture in the county authorities (fourth aim), based on qualitative data. We organize the below text based on themes reported in the interview.

The organizational changes have required significant time and energy. Interviewees in the merged county authorities experienced that the process of merging required a considerable amount of time and energy. They emphasized that the counties and the merged groups had different routines, systems, cultures, organizational structures, and collaboration methods with municipalities and other external entities. All of these aspects needed to be combined while creating new organizations, and decisions had to be made on how to proceed. Designing new common organizational structures and routines that catered to all needs as much as possible demanded a lot of time and energy. One interviewee mentioned that the changes and reorganization took away time and resources that could have been used for innovation:

‘Much of the time we used for innovation and development is now spent on reorganization. (...) There are some exciting technologies coming up, such as inexpensive sensors at critical locations that can be implemented in a management system. We started looking into it. Vehicle sensor technology to assess road conditions. (...) These projects were put on hold when we have to start reorganizing.’ (Interviewee, County Authority 3).

Split up and reorganization fatigue. Interviewees who previously worked in the NPRA expressed that they are tired of ongoing reorganizations that have taken place over many years. First, they spent their two last years in the NPRA preparing to change workplaces before the regional reform (2018–2020).

Then, they had two years in the county authority (2020–2022) while working to establish a new organization. In 2022, they faced two more years in the county authority (2022–2024) while waiting for the split-up, and the new county authority where they will work. Reversals of the mergers (i.e. the split-up), which were decided in some county authorities, led to reduced job satisfaction. The reversals resulted in two more years of reorganization processes, which diverted attention away from regular work tasks. Most interviewees had negative views about the reversals. This was because specialized working environments, which were initially small, were now expected to become even smaller when newly merged county authorities were split up into more county authorities. They anticipated that the most significant consequences would be within operations and maintenance. Even among employees who did not come from the NPRA, there were fears that the specialized environments would become smaller, leading to a loss of the established expert communities that were created after the mergers and the regional reform.

COVID-19. Many mentioned the COVID-19 pandemic as a central barrier in establishing and coordinating the new county authority organizations. The fact that employees were working from home and couldn’t meet physically was noted as a major challenge in the process of setting up new organizations, fostering good relationships, and promoting collaboration among new colleagues.

Resources: financial and expertise. An essential theme that emerged from the interviews was that, along with the responsibility for county roads county authorities also inherited a significant backlog in the maintenance of the county road network. Several interviewees mentioned that there is no room in the budget to carry out the necessary improvements, and there are also sudden demands for repairs. This can impact the construction of school roads, pedestrian pathways, and other transportation plans. Several interviewees noted that there are now smaller specialized environments and thinner staffing among those working on road maintenance and administration of the county roads, and they have lost several support functions that they had in the NPRA.

Relationship with regional and local politicians. For the interviewees working with county roads, it a new experience to have a more active engagement with county politicians. Several of them also experienced a

different type of interaction with municipal politicians than before. Some mentioned examples of municipal politicians who contacted county politicians and/or the media to advocate for their issues and influence decisions, particularly related to specific road measures (speed limits, speed bumps, etc.). Many stated that this takes time and resources. On the other hand, some suggested that this contact could have positive consequences because regional politicians have resources and decision-making authority. These experienced changes can be attributed to the fact that the county authority is a political entity, whereas the NPRA is not.

The size of the new county authorities. Interviewees from County authority 2 explained that the size of the county authority and the number of municipalities posed a challenge that influenced the quality of traffic safety work. They described the difficulty of maintaining good communication with all municipalities.

4.5 Multivariate analyses

In this section, we focus on the third and the fourth aim, respectively, which are to examine factors influencing innovation outcomes and innovation culture in the county authorities. We examine this based on the quantitative data, in multivariate regression analyses.

4.5.1 Factors influencing innovation in traffic safety work

In section 4.3, we observed differences among the county authorities' results on the index for innovation in traffic safety work. Table 5 presents the results from multivariate regression analyses, where we examine the variables influencing scores on the index for innovation in traffic safety work.

The analyses show that innovation culture is the variable that contributes the most to explaining the variation in the index for innovation in traffic safety work. A high score on the innovation culture index is correlated with a high score on the traffic safety innovation index.

The variable County authority 1 contributes significantly and positively. This aligns with what we observed in section 4.1, where County authority 1 had the highest score on the traffic safety innovation index. The coefficient for County authority 1 is nearly halved from Model 6 to 7 when we introduce innovation

culture. This indicates that innovation culture accounts for a substantial part of the explanation for why County authority 1 has the highest score on the index for innovation in traffic safety work.

Third, the variable measuring focus on traffic safety among the top political and administrative management contributes positively and significantly.

Fourth, we observe that the job position variable, i.e. whether one is a manager, contributes significantly and positively to scores on the index for traffic safety innovation, indicating that manager report a higher level of traffic safety innovations in traffic safety work.

The adjusted R² value indicates that the variables explain 49% of the variation in the dependent variable.

4.5.2 Factors influencing innovation culture

In the analyses in Table 5, we observed that innovation culture was the variable that contributed the most to explaining the variation in the county authorities' innovation in traffic safety work. In Table 6, we examine factors explaining variation in innovation culture.

First, *safety culture* contributes the most to explaining the variations in the counties' scores on the innovation culture index. The coefficients are positive, indicating a relationship between having high scores on the traffic safety culture index and high scores on the innovation culture index, controlled for several other variables. Additionally, we observe that the significant contribution of the variable 'County authority 1' was reduced when we included the safety culture variable in Model 5. This is because County authority 1 has a high score on the safety culture index, and it partly explains the relationship between County authority 1 and innovation culture in Models 4 and 5.

Second, the *traffic safety focus* of the top political and administrative management significantly and positively contributes to innovation culture. The significant contribution of the variable 'County authority 1' disappears when we include this index, suggesting that County authority 1 scores high on the variable 'traffic safety focus of top management'.

Third '*reorganization has required time and resources*' significantly and negatively contributes to innovation culture. The negative contribution of this variable indicates that respondents who agree with these statements score lower on the innovation culture

Table 5 Linear regression. Dependent variable: Index for innovation in traffic safety work. Standardized beta coefficients.

Variable	Mod.1	Mod.2	Mod.3	Mod.4	Mod.5	Mod.6	Mod.7	Mod.8	Mod.9
Female	.077	.095	.105	.090	.106	.150*	.117*	.108*	.098
Age (Over 56 yrs = 2, else = 1)		.160**	.147*	.142*	.135*	.160**	.185***	.185***	.150**
Department (Coll./mob. = 2, else = 1)			-.146*	-.158*	-.145*	-.125	.054	.053	.039
Worked in CA before 2020 (= 2, else = 1)				.061	.039	.020	.091	.101	.086
Position (leader = 2, else = 1)					.182**	.169**	.093	.095	.124**
County authority (CA1 = 2, others = 1)						.244***	.154**	.147**	.125**
Innovation culture							.636***	.637***	.578***
Lacking TS resources								.067	.074
TS focus top management									.178***
Adjusted R ²	.000	.019	.034	.031	.059	.111	.468	.469	.493

* p < 0.1; ** p < 0.05; *** p < 0.01

index. This variable is correlated with the variable ‘splitting has dampened the climate for innovation’, which explains the reduction in significance level when included in Model 9.

The adjusted R² value indicates that the variables explain about 40% of the variation in the dependent variable.

5 Discussion

5.1 Innovation results and innovation culture

The first and second objectives of the study were to examine innovation results and innovation culture in the traffic safety work of the county authorities. The county authorities scored moderate on the index for innovation culture and the index for traffic safety innovations. The average score on the index for innovation culture was 3.3 for all questions, indicating slightly better than ‘neither agree nor disagree’ on average. The average score on the index for traffic safety innovations corresponds to an average of 2.5 for

all questions, which is between ‘disagree’ and ‘neither agree nor disagree’. These scores clearly suggest opportunities for improvement.

Despite relatively modest scores on the index for traffic safety innovations, we found several examples of traffic safety innovations in the interviews. County authority 1 had implemented a new method for risk assessment of curves on county roads. Some interviewees mentioned new and better adapted quality systems for the administration of county roads. Interviewees from County authority 2 talked about new ways of collaborating with municipalities and other external partners in traffic safety work. They also mentioned several conceptual innovations, i.e. new principles for traffic safety work. We found most traffic safety innovations in County authority 2, and the interviewees reported a strong innovation culture in this county authority after the implementation of the regional reform.

The results from the survey seem to be somewhat in contrast to this: County authority 2 did not score

Table 6 Linear regression (dependent variable: Index for innovation culture; standardized beta coefficients)

Variable	Mod.1	Mod.2	Mod.3	Mod.4	Mod.5	Mod.6	Mod.7	Mod.8	Mod.9
Sex (Female = 2, male = 1)	.099*	-.090	-.084	-.063	-.081*	-.084*	-.080*	-.068	-.071
Department (Op./Maint. = 2, else = 1)		.042	.037	.054	-.024	-.017	-.023	-.026	-.016
Position (Manager = 2, else = 1)			.070	.066	.057	.057	.037	.042	.037
County authority (CA1 = 2, else = 1)				.155***	.102**	.071	.060	.062	.044
Safety culture					.556***	.463***	.477***	.482***	.469***
TS-focus top management						.241***	.202***	.196***	.171***
Reorg. time/resources							-.133***	-.117**	-.094*
COVID-19 pandemic								-.077*	-.055
Reversal of regional reform									-.099*
Adjusted R ²	.007	.005	.007	.027	.331	.377	.391	.395	.399

* p < 0.1; ** p < 0.05; *** p < 0.01

highest on either innovation culture or traffic safety innovations. One possible reason for the discrepancy between qualitative and quantitative data could be the time aspect. The interviewees in the interviews who talked about the innovation culture in County authority 2 primarily referred to the period immediately after the regional reform, while the survey questions measuring innovation culture were distributed three years after the reform and did not have the same retrospective perspective. Additionally, County authority 2 will be split up again into three new county authorities in 2024—a decision which has had a significant negative impact on the innovation culture.

The most consistent innovation across all county authorities was that the interviewees reported a more comprehensive and holistic perspective on traffic safety. They attributed this to the co-organization with individuals who previously worked in the merged county authorities and those who came from the NPRA.

These findings reflect an innovation system perspective, i.e. how the composition of actors with different expertise and perspectives can complement each other and thus be a central prerequisite for mutual learning and innovation in the field of traffic safety (Asheim & Isaksen, 2002; Cooke, 2004; Maskell & Malmberg, 1999). Previous studies also emphasize the importance of analyzing the regional level from an innovation system perspective (Lundvall, 1992; Edquist, 1997; Klein Woolthuis et al., 2005). The results of our study on learning effects from the co-organization of different professional groups illustrate the significance of facilitating continuous interaction and learning across actors and perspectives.

The third objective of the study was to examine factors influencing innovation results in the county authorities. We hypothesized that there is a relationship between the county authorities' innovation culture and their innovation results in traffic safety work (Hypothesis 1). We conducted multivariate analyses to test this hypothesis while controlling for several contextual

factors. The results show that the most significant variable influencing innovation results is innovation culture. This is consistent with previous research. Several studies have found strong correlations between innovation culture and respondents' self-reported innovation outcomes in their organizations (West & Anderson, 1996; Mathisen et al., 2008; Bower et al., 2003; Newman et al., 2020). Another key variable influencing both innovation results and innovation culture was the top management's focus on traffic safety. Leadership focus is crucial in both innovation culture research (Anderson and West, 1998) and safety culture research (Flin et al., 2000). We did not find that respondents' perception of the status of available resources in traffic safety work contributed significantly, which contradicts previous research (Keller, 2001; Tierney et al., 1999; Somech, 2006; Puccio et al., 2008).

5.2 Factors influencing innovation culture

The fourth objective of the study was to examine factors influencing innovation culture in the county authorities. Previous research indicates that reforms and organizational changes that lead to new compositions of people, new communication networks, and new patterns of interaction can create a new climate for learning and innovation, allowing new perspectives to meet and confront in ways that give rise to new ideas (Eisenhardt & Tabrizi, 1995; Gherardi et al., 1998; Karim, 2009; Meyer & Marais, 2009). The changes related to the regional reform and the dissolution of the shared road administration particularly involve new groups starting to work in the same organization, i.e. individuals from merged county authorities and individuals who previously worked in the NPRA. Additionally, the new county authorities were mandated to create new organizations, systems, and routines.

Therefore, our hypothesis 2 suggested that the new compositions of people and professional groups have created a new climate for learning and innovation in the county authorities, three years after the regional reform. The quantitative data do not support Hypothesis 2. The scores on the index for innovation culture were moderate in the studied county authorities. However, the qualitative data support Hypothesis 2. This is particularly true for the interviewees from County authority 2, who described a strong innovation climate after the regional reform. They attributed this to

the regional reform creating an opportunity to build something new, and this was seen as an opportunity to implement new solutions.

Another reason why the qualitative data support Hypothesis 2, is that the most consistent innovation in the study is precisely due to new compositions of people, new communication networks, and new patterns of interaction (Eisenhardt & Tabrizi, 1995; Karim, 2009). The most pervasive innovation across all county authorities is a more holistic perspective on traffic safety. This is an example of a conceptual innovation that emerged from the co-organization of individuals who worked in the merged county authorities with individuals who came from the NPRA. This new composition of people created new communication networks and new interaction patterns, leading to new perspectives on traffic safety (Gherardi et al., 1998; Karim, 2009; Meyer & Marais, 2009). It appears that this conceptual innovation occurred to a lesser extent in County authority 3, where there was less co-organization of individuals from the merged county authorities and individuals from the NPRA.

Conceptual innovations provide new perspectives, purposes, and views of the world that challenge and replace previous perspectives. This can also be linked to the concept of a paradigm shift. It involves seeing a new phenomenon not seen before (framing) or seeing an existing phenomenon in a new light and understanding it in a new way (reframing) (Berg, 1985). Framing and reframing create new frames of reference that underlie new interpretations and new actions. Framing and reframing a phenomenon are essential as they motivate and legitimize new strategies and actions.

Both the quantitative and qualitative data support Hypothesis 3, indicating that if reorganizations become too extensive or energy-consuming, they do not lead to learning and innovation but rather to dissatisfaction, ambiguity, and organizations becoming less equipped to manage their key tasks (Karim, 2009; Meyer & Marais, 2009). The qualitative data show that the following factors impeded the innovation climate in the county authorities: the reorganizations requiring significant time, energy, and resources, fragmentation, and organizational fatigue. Additionally, the impact of COVID-19 was mentioned. In the multivariate analyses, we observed that the index measuring whether the reorganizations demanded significant time, energy, and resources significantly

and negatively influenced the innovation culture. Simultaneously, we found a positive relationship between top management's focus on traffic safety and innovation culture, which is in line with previous research (Flin et al., 2000; Anderson & West, 1998).

5.3 Innovation culture and safety culture

We hypothesized that the county authorities' innovation culture would be strongly related to their safety culture. Our results support this hypothesis. In the multivariate analysis of factors influencing innovation culture, safety culture was the variable with the most substantial impact. The strong correlation we find between safety culture and innovation culture is likely due to several factors.

First, learning is a key characteristic of a good safety culture. Reason (1997) defines a good safety culture, among other things, as a learning culture where the organization can learn from reported incidents, safety reviews, etc., to improve safety. In line with this, most studies of safety culture understand it as strong management engagement in safety combined with a systematic and group-based learning process, where potential hazards are identified, measures are implemented, and the process is followed up (Hudson, 2003; Patankar, 2019; Zuschlag et al., 2016; Naveh & Katz-Navon, 2015; Lappalainen et al., 2012). Organizational learning is closely linked to innovation, because the part of organizational learning that involves creating new knowledge is often a prerequisite for innovation. However, new ideas also need to be implemented for something to be called innovation.

Second, both the indexes for innovation culture and safety culture measure employee involvement. Both good innovation culture and good safety culture are characterized by encouraging and rewarding employees' initiatives. In a good or learning safety culture, it is crucial for employees to be vigilant and report relevant information within the organization (Reason, 1997). Similarly, a positive innovation culture is characterized by employees taking the initiative for new solutions (Newman et al., 2020).

Third, effective management is a crucial variable that can influence both good safety culture and good innovation culture. This involves leaders signaling to employees that they desire input and involvement, rewarding initiatives and suggestions, and facilitating open communication.

Despite finding a strong correlation between innovation culture and safety culture, which is also theoretically expected, there are to our knowledge no studies that examine the relationship between innovation culture and safety culture. The results indicate that innovation culture should be understood as an element of a learning safety culture. Since measurements and studies of safety culture do not focus on innovation in the traffic safety domain, this should be included in future studies.

5.4 Questions for future research

5.4.1 Can safety culture have negative effects on innovation?

There are, however, also reasons to believe that safety culture could have negative effects on innovation. Safety culture places strong emphasis on learning, but primarily learning from events, incidents, etc., that are reported into a reporting system (Reason, 1997). A learning culture involves employees openly reporting events without fear of punishment (Reason, 1997). The purpose is for the management to gain as good an understanding as possible of the safety challenges the organization faces, i.e. an informed safety culture (Reason, 1997).

However, implementing new solutions, i.e. innovation, is different from this. Safety culture research and innovation research have different outcomes and desired states. It can hypothetically be argued that the safety culture field is conservative and risk-averse. The focus is on implementing a good safety management system and not deviating too far from what the system dictates in practice ('drift into failure'). In safety culture research, a gap between the system and practice is considered a sign of poor safety culture, and the primary focus is on avoiding accidents. Thus, it can be said that a status quo without accidents is considered positive. On the other hand, in the context of innovation, the goal is to implement new things, so the status quo is not viewed as positively. It might therefore be argued that innovation culture allows for more experimentation and 'risk-taking', while safety culture entails a greater focus on preservation and conservatism. At the same time, innovations are beneficial for safety, and thus, it is essential to discuss this paradox. Moreover, a key aspect of the continuous improvement process that positive safety culture work entails, is to implement new and effective measures. Innovation is critical to safety improvement in this context (Elvik et al., 2023). These are important

question for future research.

5.4.2 What is the importance of innovation for traffic safety?

We have not studied the traffic safety effects of the innovations in this study, but previous research indicates that innovation is crucial for improving traffic safety. [Elvik et al. \(2023\)](#) concluded that several incremental innovations in the continuous improvement of traffic safety work in Norway have contributed to fewer fatalities and serious injuries in traffic.

For many of the traffic safety innovations we have identified in this study, it is challenging to examine their effects on fatalities and serious injuries. This applies, for example, to a more holistic understanding of traffic safety and new models for collaboration with external partners or municipalities in traffic safety work. These are traffic safety innovations that relate to the county authorities' key role in recommending and coordinating traffic safety measures.

Previous research shows that systematic and planned traffic safety work of this kind is essential ([Elvik et al., 2023](#)). The new method for identifying curves with a high accident risk, which was implemented in County authority 1, is an example of an innovation that directly influences traffic safety. This innovation serves as a management tool for county roads, aligning with the county authority's second key role in traffic safety: planning, operating, and maintaining the county road network.

5.4.3 What comes first?

In this study, we assume that innovation outcomes result from innovation culture, which is then related to safety culture and a strong management focus on traffic safety. However, it is challenging to determine what comes first, for example, whether a good innovation culture creates a good safety culture, or if it is the other way around. These are important questions that can be explored in future studies.

5.4.4 What do the comprehensive changes mean?

It is also relevant to question what the comprehensive changes brought about by the regional reform mean for the governance of traffic safety in Norway. With the regional reform and the dissolution of the shared road

administration, the country transitioned from having one major player in the field of traffic safety (the NPRA) to one major and several smaller players. The number of employees in the NPRA was nearly halved, while the responsibility for county roads was transferred to the county authorities. These changes altered the institutional landscape for traffic safety governance in Norway in a way that increases the need for coordination and collaboration. It is important to study what these changes mean for the future: whether they lead to institutional fragmentation or increased collaboration, new thinking, and creativity.

5.5 Practical implications: what can we learn from the results?

In this study, we have examined traffic safety innovations, innovation culture, and safety culture in four Norwegian county authorities, with the regional reform as the backdrop. The background is that in 2020, the county authorities had to establish new organizations, routines, and systems. The starting point of the study was that these changes could offer opportunities for new ways of thinking and innovation in traffic safety work, while also demanding significant time, energy, and resources. We studied the county authorities three years after the reform came into effect and found considerable differences between them.

Our results suggest that some county authorities have performed better than others in the changes we studied. County authority 1 appears to have performed the best, while County authority 3 consistently scores lower on most outcome measures. Our findings indicate that reorganizations that require substantial time, energy, and resources are negatively related to innovation culture and traffic safety innovations. Lengthy change processes (and reversals of reforms) are likely to be particularly challenging.

On the other hand, a strong management focus on traffic safety and a good safety culture are associated with innovation outcomes and innovation culture, even in county authorities that have undergone substantial changes and reorganizations. These factors appear to mitigate the negative effects of reorganizations that demand considerable time, energy, and resources.

A very relevant question, that is evoked by our results is whether it is necessary to re-organise in order to facilitate organisational learning, and new and broader perspectives on traffic safety. Although we have

found that this has happened, especially in some of the studied county authorities, we should not use the results of the study to recommend re-organisation to facilitate learning and new perspectives. The purpose of the reorganization related to the regional reform in Norway, was primarily political (i.e. to make larger counties and give them more tasks) and not primarily to contribute to learning (although benefits related to giving county authorities a comprehensive responsibility for traffic safety also was mentioned, e.g. a more holistic approach to traffic safety management). Nevertheless, we find that learning and innovation has occurred, especially in some county authorities. Our study shows, however, that the learning and new perspectives have come at considerable costs, related to time, energy, and resources. Some of the county authorities have experienced higher costs in this respect, and fewer gains (e.g. county authority 3). The reorganization has also delayed the maintenance of key functions related to traffic safety for some time (Naevestad et al., 2023). The reversal of the reform in some counties (County authority 2 and 3) was also political, and has induced more costs on the personnel working with traffic safety in these county authorities. Our study has, however, pointed to some factors that may influence negative and positive results of reorganization. To conclude this discussion, one of the main positive mechanisms related to learning that has been highlighted by this study is that new compositions of people, new communication networks, and new patterns of interaction can create a new climate for learning and innovation by bringing together new perspectives and challenging them in ways that foster the emergence of new ideas (Gherardi et al., 1998; Karim, 2009; Meyer & Marais, 2009; Richter & Koch, 2004). It is not unreasonable to expect that this also can happen by bringing people from different organizations, scientific disciplines and with different work tasks etc. together in different types of cooperation and communication arrangements (i.e. not through permanent reorganization). This is indicated by previous research (Gherardi et al., 1998; Richter & Koch, 2004). On the other hand, results also indicate that the implementation of some innovations (e.g. new methods and systems) seem to require new organisations, presumably as reorganization provides the opportunity for the fulfilment of new ideas. This points to interesting questions for future research: which innovation require reorganisations (if so: how much?), and which do not?

5.6 Methodological limitations

We have not included all county authorities in Norway. In this study, we only focus on four county authorities, and we do not know how representative they are of all the Norwegian county authorities. However, it should be noted that these four county authorities are diverse. For instance, we have a large county authority, one that was not merged with any other county authority in 2020, and two county authorities that are planned to be split up into (reversing the 2020 reform). Nevertheless, to obtain a comprehensive picture of the situation in Norway, we would need to include more county authorities.

We cannot assume that all respondents work directly and indirectly with traffic safety, and this may influence their level of knowledge about all the questions regarding traffic safety. There are considerable proportions of respondents who have answered ‘do not know/not relevant’ to the questions about traffic safety innovations (up to around 30% for some questions). We have excluded these respondents from the analyses of the shares indicating agreement with the statements about traffic safety innovations, and in the multivariate analyses of the factors influencing this. The reason for calculating the shares agreeing after excluding those who answered ‘do not know’ is to focus on the proportions agreeing with the statements among those who actually have knowledge of and/or an opinion about this. Our interest is not in measuring the degree of knowledge about innovations, but the extent of innovations. We cannot assume that all respondents have knowledge about all these statements. By removing the ‘do not know’ responses, we can also reduce the effects of potential biases among the respondents in the county authorities. The consequence of filtering out those who answered ‘do not know’ is that the number of participants included in these analyses may become relatively small, as they only consist of those who did not answer ‘do not know’ for any of the questions involved in the index. Moreover, it is also important to discuss what it means to work with traffic safety. Many of the county authorities’ employees work on matters that have indirect implications for traffic safety (e.g. purchasing public transportation, public health, zoning plans, etc.), and it is important to include them in the study as well. One of the main results of our study is that the people working indirectly with traffic safety also learned that their work has implications for traffic safety.

The samples include many individuals coming from the NPRA. Approximately 60% of all participants in this study are from the NPRA, and most of them were employed by the county authorities in 2020. In total, 65% were employed in 2020, while 17% were employed before that. This suggests that the participants may be somewhat skewed, but this does not necessarily have to be the case. The number of participants working with recommending and coordinating traffic safety measures in the county authorities is not very large compared to the number working with county roads and coming from the NPRA. Based on information from some of our contact persons in the county authorities, the proportion of former employees from the NPRA should have been even greater in the survey, because the number of employees who work with county roads (and who come from NPRA) is several times higher than the number of employees who work on recommending and coordinating traffic safety measures (for example 200 against 15 employees).

6 Conclusion

This study examines the relationship between traffic safety innovations, innovation culture, and safety culture in four Norwegian county authorities three years after the comprehensive structural reform known as the regional reform. One key finding from the qualitative data is that the interviewees have gained new perspectives on traffic safety as a result of being co-organized with new professional groups. The results also provide examples of new methods and collaborative approaches that have been adopted in traffic safety work. The quantitative results reveal significant differences between the county authorities concerning the degree of traffic safety innovations. These differences are primarily explained by the county authorities' innovation culture, which, in turn, is predicted by safety culture. The findings indicate that innovation culture should be understood as an element within a learning safety culture. The study shows substantial variations in the extent to which the organizational changes associated with the region reform have influenced the studied county authorities.

CRedit contribution statement

Tor-Olav Naevestad: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing—

original draft. **Vibeke Milch:** Conceptualization, Methodology, Writing—original draft. **Jenny Blom:** Conceptualization, Methodology, Writing—original draft. **Rune Elvik:** Conceptualization, Methodology, Writing—original draft. **Markus Bugge:** Conceptualization, Methodology, Writing—original draft. **Håkon Endresen Normann:** Conceptualization, Methodology, Writing—original draft. **Erland Skogli:** Conceptualization, Methodology, Writing—original draft. **Lars Even Egner:** Methodology, Writing—original draft.

Declaration of competing interests

The authors declare no competing interests.

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Results from the study have also been presented in a comprehensive Norwegian report (Naevestad et al., 2023). While the present study focuses on traffic safety innovations, the report examines the extent to which county authorities have been able to maintain their key traffic safety roles after the regional reform.

Ethics statement

The methods for data collection in the present project have been approved by Norwegian Agency for Shared Services in Education and Research (SIKT) which assists researchers with research ethics of data gathering, data analysis, and issues of methodology. Written informed consent for participation was required for this study in accordance with the national legislation and the institutional requirements.

Availability of data

The data are available on request to the authors.

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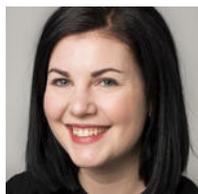
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behaviour and cognition, including but not limited to traffic safety, energy retrofitting, psychometrics, and restorative psychology. This has given a wide variety of methodological tools to apply to new research questions. His current research interests revolve around the human-vehicles interaction, and how various human cognitive limitations manifest in traffic safety.



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A Distribution of responses to survey questions

	Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree	N
Innovation and learning index						
...reorganize the departments working on transportation and traffic safety.	3%	13%	42%	35%	7%	207
...introduce new methods in traffic safety work.	4%	26%	53%	16%	1%	191
...implement new systems and routines in traffic safety work.	5%	24%	49%	21%	2%	190
...introduce new ways to collaborate with external partners in traffic safety work.	5%	23%	45%	25%	3%	194
...introduce new ways to collaborate with municipalities in traffic safety work.	5%	21%	53%	20%	2%	183
We have obtained a more holistic perspective on traffic safety than before.	14%	26%	43%	15%	2%	226
I have gained a better understanding of how the county authority's work can influence traffic safety.	10%	21%	39%	28%	2%	242
Innovation culture						
New ideas are often received in a constructive manner in my workplace.	3%	5%	28%	56%	9%	392
My immediate supervisors are quick to identify the need for doing things differently.	5%	11%	40%	37%	6%	392
In my department, we regularly discuss whether the methods we use to do our job are adequate.	6%	13%	45%	33%	4%	392
In this organization, we frequently test new ways people can collaborate.	4%	11%	27%	47%	10%	392
There are regular discussions in my department about whether we work together effectively.	6%	20%	41%	30%	3%	392
Top management focus on safety						
The county authority's top administrative management considers traffic safety to be very important.	3%	6%	36%	43%	12%	392
The county authority's top political management considers traffic safety to be very important.	3%	7%	42%	38%	10%	392
Safety culture						
My immediate supervisor considers traffic safety to be very important.	3%	3%	22%	48%	24%	392
My closest colleagues consider traffic safety to be very important.	1%	2%	20%	53%	25%	392
At my workplace, we often discuss the traffic safety consequences of the decisions we make.	2%	8%	24%	49%	17%	392
Among my colleagues, we strongly focus on how our work influences traffic safety in the county.	2%	5%	29%	47%	17%	392
All my colleagues have plenty of opportunities to suggest ways we can contribute to increased traffic safety.	1%	5%	34%	47%	13%	392
Questions about Reorganization and Influencing Factors						
Reorganizations have demanded a lot of time, energy, and resources in my county authority.	1%	2%	6%	37%	49%	392
There was uncertainty for a long time about how my organization should be structured.	1%	9%	18%	35%	28%	392

Continued on next page

Table A.1 continued

	Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree	N
Reorganizations have diverted focus from our key tasks related to traffic safety (e.g., CTSC, Traffic Safety Plans, administration of county roads).	2%	12%	38%	27%	21%	317
Resources in traffic safety work						
We have insufficient financial resources to perform tasks related to traffic safety.	4%	11%	45%	24%	16%	392
We have insufficient professional resources, tools, and equipment to perform tasks related to traffic safety.	3%	15%	47%	29%	6%	392
Other questions						
The COVID-19 pandemic made it challenging for us to establish a new organization.	4%	11%	45%	24%	16%	392
The split of my county authority has impeded the climate for discussing and implementing new solutions.	3%	15%	47%	29%	6%	392

Not all the respondents received the questions about reorganisation and learning. As these questions involve comparison with the previous situation (before 2020), respondents who were not in the public roads administration or in the county authorities before 2020 are filtered away from these questions in the survey. The questions about reorganisation and learning also included a ‘do not know’ alternative. For these questions, we have calculated shares who after removing those who answered ‘do not know’. The reason is that these questions relate to specific types of innovation and learning, which requires knowledge of and opinions about this (cf. Section 5.6). We are not interested in measuring the degree of knowledge about this, but the degree of innovations. We cannot take it for granted that all respondents have knowledge of all these statements. By removing ‘do not know’, we can also reduce the effects of any biases between the respondents in the county authorities, e.g. when comparing results across county authorities. The same applies to the question: ‘Reorganizations have diverted focus from our key tasks related to traffic safety’.