DATA-DRIVEN TRAFFIC SAFETY APPROACH: NORWEGIAN CASE STUDY

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ABSTRACT
Tis study was financed by a research and development program called Better Traffic Safety (2013–2018) of the Norwegian Public Roads Administration (Road directorate). This paper presents the potential for using innovative data-driven methods to facilitate development of traffic safety policy. Traffic safety-relevant data from diverse sources and cross-databases need to be considered to reinforce decision support tools for traffic safety policy. New data forms and types can help decision makers to be more responsive and flexible in making regulatory interventions to achieve traffic safety goals. The future of transport requires analysing available raw data more effectively and to be more reactive and proactive to prevent incidents and accidents occurring. This will help intervention on specific locations and issues, for example improving road infrastructure or putting in place new measures. The results of this study show that children do not perceive the traffic environment around schools as safe. Thanks to a digital application, their opinions about the city environment were collected and their experience on their way to school were extracted to analyse the places where they felt less safe when crossing the roads. Other data sources were investigated and showed that there is potential to create a cross-database for developing effective decision-making tools for data-driven traffic safety policy. This paper explains how a new data-driven strategy will be more effective at reducing risk accident and traffic impact around schools.
Keywords: traffic safety, schools, school road safety, schoolchildren, policy.

1 INTRODUCTION

In the framework of the Research and Development program, called Better Traffic Safety (BEST, 2013–2018), the Road Directorate of the Norwegian Public Roads Administration (NPRA) financed projects with different research themes related to traffic safety [1]. The program started in 2013, lasted five years and had a cost of NOK 30 million. The main purpose of BEST was to generate knowledge that would be decisive for prioritising effective traffic safety measures. The BEST projects were related to topics such as speed and accidents, human tolerance, road traffic risks, driver support systems, paternalism, and shared space. The results of the projects are presented in single reports with no real connections with each other. In this context, in 2017, the road directorate decided that the results could be used and compiled in the form of scenarios. The scenarios retrieved themes and results from BEST projects and described traffic situations. The objective was to show how some changes or developments have the potential to reduce the number of road fatalities and serious injuries. SINTEF, Scandinavia's largest research organisation, proposed a scenario for safer school roads.

The International Transport Forum at the OECD already stated in a report in 2016 that data are necessary for ensuring the safe operation of traffic, to respond to incidents in real time and to understand crash patterns and trends [2]. The way data is collected, and types of data sources are likely to change and require more pro-active data-collection methods in the future. There is a need to evaluate data-driven approaches to traffic safety integrating new data sources for identifying risky locations (before accidents occur). This is also crucial for decision makers for allocating resources and investing in new infrastructure. The future of transport and during the hybrid period where only a share of vehicles will be autonomous

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require analysing available raw data (not only vehicle data) more effectively and be more reactive and proactive to prevent incidents and accidents to occur [3]. There is a knowledge gap concerning which data to be collected and whether the data would be reliable. New data driven methods are therefore difficult to be tested and put in place since there are uncertainties about the results that could conduct to identify safe places as risky or the opposite, to neglect risky places. Over the past decade, evidence based, and data-driven road safety management based on ex post and ex ante evaluation of individual interventions and intervention packages in road safety strategies, have proven to be effective (Wegman, 2015). These are based on "what happened" and casualty rate trends for different road user categories [4]–[6]. There is a need to exploit and systemic other new data sources than crash data, such as self-reported risky road crossings. However, decision makers are facing the challenges related to the choice of data types and quantity to collect as well as the technical issues with data management, sharing and integration in traditional databases. In addition, there are some uncertainties about data analysis, algorithms, and evaluation methods to be used. The traffic safety organisations need to understand how to become more data driven in traffic safety analysis and data decisions.

An ambitious road safety goal has now been set in the Norwegian National Transport Plan (NTP) for the period of 2014–2023 [7]. By 2024, the number of fatalities and seriously injured should not exceed 500. Fig. 1 shows that this target is reachable if the on-going efforts put into road safety continue over the coming years. However, we can also assume that the growth of new micro-mobility users and automated vehicles on roads could require new types of measures and ways to improve traffic safety.

School roads are central in making children active in their everyday lives. However, schools and parents do not know how old children must be to walk alone or cycle to school. Even the level of bicycle training they should have has been discussed. Most parents of young children prefer to drive them to school and leisure activities to save time and because they consider school roads dangerous. At the same time, the national cycling strategy has the objective to having 80% of schoolchildren walk and cycle to school (NPRA, 2014–2023) [8]. How can this target be reached, and what could be done to make school roads safer?

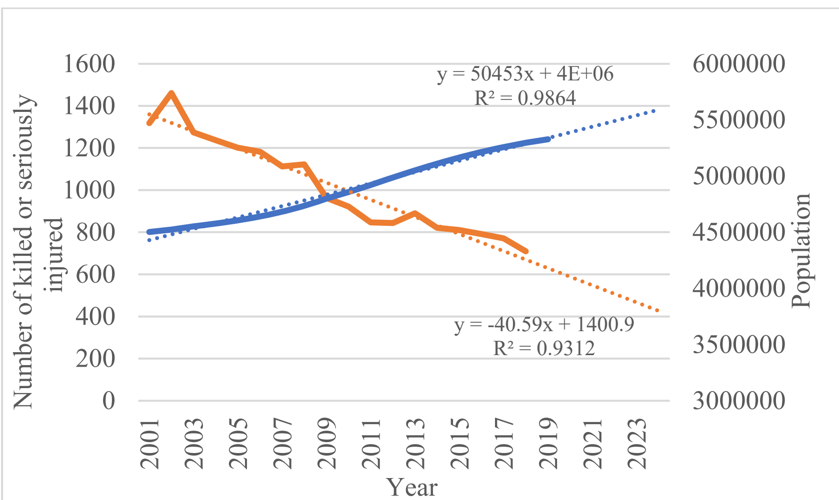

Figure 1: Evolution of the Norwegian population and number of those killed and seriously injured.

Hjorthol and Nordbakke have shown that, in 2015, around 73% of children aged 6–12 years old lived less than two kilometres from school [9]. Around 42% of school roads had speed limits between 40 and 60 km/h, and 21% were above 60 km/h. Approximately 28% stated that they had to share the roads with motorised traffic for more than half their journey to school, and 60% of schoolchildren had access to roads with sidewalks or bicycle and pedestrian paths. Among those who did not have such access, two-thirds used roads with a speed limit over 30 km/h. Around 63% of the children stated that they had to cross one or more intersections with no traffic lights on their way to school, and only 5% crossed roads with traffic lights. Among children who cycled to school, 42% stated that they cycled alone; 46% cycled with their friends and 12% with their parents. Hjorthol and Nordbakke (2015) have found that parents who drove their children to school were worried about the safety of school roads [9]. Bjørnskau & Ingebrigtsen (2015) showed that driving their children to school reduced the risk of injury but increased the risk of other children who cycled and walked [10]. We can also argue that, in places where there is a large share of schoolchildren who cycle to school, there is a safety in numbers effect that positively influences car drivers' behaviour [11].

In 2018, one pedestrian under 15 years old was killed, and 77 pedestrians and 71 cyclists under 15 years old were injured, 70.1% and 33.8%, respectively, when crossing a road [12]. It is important to note that Bjørnskau (2014) has shown that statistics and accident data were not fully reported and are incomplete [13].

Children under 15 years old are particularly vulnerable cyclists. They cycle more than the other road user groups, and they have very little knowledge about traffic safety rules, giving way at intersections and blind spots, and they have little experience travelling in traffic. They also often cycle on sidewalks and cycle paths, which can increase risks at intersections and when exiting car-free zones. To be able to walk or cycle alone to school, children need to be able to distinguish between what it is important to focus on and what they should ignore. Children have also difficulties with sharing their attention between several locations. They need to be able to plan what to do and to make choices according to the context of the traffic situation.

2 MATERIALS AND METHODS

The research considered road accident cases involving young children under 15 years old in the municipality of Trondheim, Norway between 2000 and 2016. The municipality of Trondheim covers an area of around 530 km^2 with a population of approximately 185,000 inhabitants.

Data from different sources have been crossed out:

- Data from the National Road Database (NVDB) owned by the Norwegian Public Road Administration (NPRA). This database provides static data such as traffic accidents and average annual daily traffic. Other data are also available: road characteristics, speed limits, traffic signs, road markings, bumps, crossings, traffic light position, road lighting, etc. The user interface facilitates the data access and statistical analysis for research institutes.
- Data collected by the municipality: Travel habits, transport priorities and transport mode use from/to primary schools in the municipality (all grades, gender difference).
- Information provided by the municipality related to the traffic safety plan around the primary schools. Status of "perceived traffic dangerous areas" with description of the

problem and the organization responsible for improvement (either the municipality or NPRA).

- Data from the digital application, barnetråkk.no, that provide information about how the schoolchildren perceive the surroundings of their school.

NPRA and the municipality of Trondheim provided the author of this study access to the data. Configuring the today unstructured use of these data should be a target for facilitating the improvement of traffic safety work around schools.

The type of accident, location, and severity, as well as the travel habits and opinions of children and parents on the school roads in the municipality, were examined. The objective was to investigate the potential for improving the traffic safety of school roads with a more data-driven approach.

3 RESULTS

3.1 Accidents

Fig. 2 shows that the number of accidents has decreased with a moderate slope since 2000, as has the number of accidents involving children under 15 years old as a pedestrian or a cyclist. Between 2012 and 2016, the average number of accidents with children as pedestrians or cyclists is four and five, respectively. Around 16% of the accidents involving a pedestrian and 13% involving a cyclist were with a child.

Fig. 3 shows the locations of accidents with children and adolescents (under 17 years old) as pedestrians or cyclists from 2012 and 2016. In total, there were 18 accidents with children as pedestrians and 24 as cyclists. They were more prone to accidents in densely populated areas.

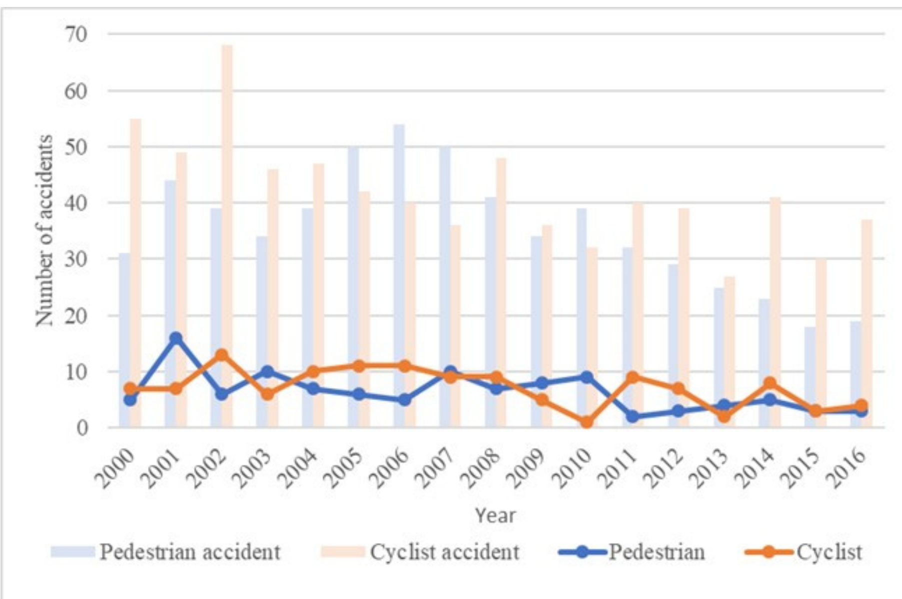

Figure 2: Number of accidents with children under 15 years (pedestrian or cyclist) in the municipality of Trondheim, 2000–2016.

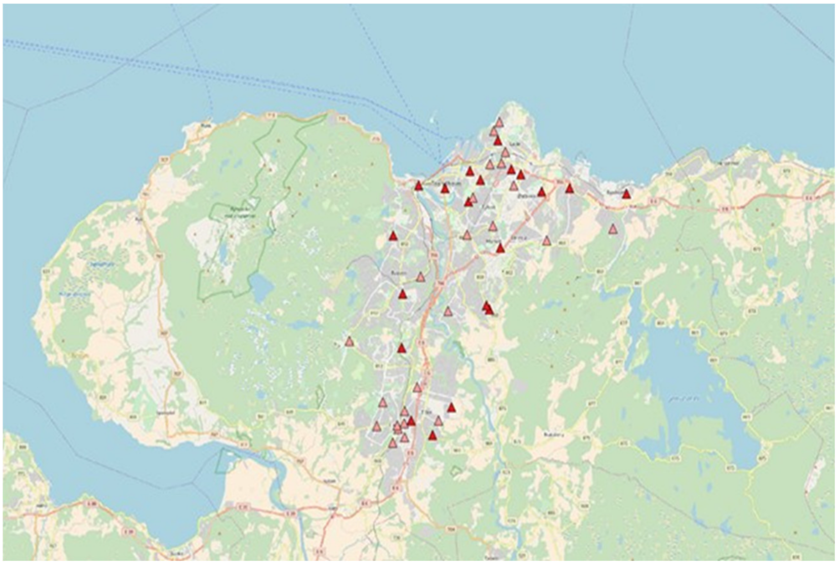

Figure 3: Locations of accidents with children and adolescents, either as pedestrians or cyclists in the municipality of Trondheim (2012–2016). Red colour: pedestrian; pink colour: cyclist.

3.2 Accidents with children or adolescents as pedestrians

Around 94% of accidents (*N*=17) with a child or an adolescent under 17 years old in the municipality of Trondheim between 2012 and 2016 were collisions with a motorised vehicle, 83% with a car and 11% with a heavy vehicle. There was one collision with a bicycle. One child was seriously injured, 89% of children were slightly injured (*N*=16) and one child was unharmed. All of these accidents belong to nine different categories of accidents (e.g., in a pedestrian crossing, outside a pedestrian crossing, at an intersection).

3.3 Accidents with children or adolescents as cyclists

Around 92% of accidents with a child or an adolescent under 17 years old as a cyclist (*N*=22) in the municipality of Trondheim between 2012 and 2016 were collisions with a motorised vehicle. Only two of them were single accidents. All of these accidents belong to 13 different categories of accidents (e.g., collision with a vehicle at an intersection or on the road when cycling on the road or leaving the pedestrian path).

3.4 Travel habits

The data analysis also shows that they were less likely to be involved as a pedestrian in an accident during the summer period and, in contrast, they cycle less during the Norwegian winter period due to the icy and snowy road conditions. The purpose of their journeys, such as leisure activities or travel to or from school, is only known for approximately 20% of the accidents (*N*=8). This information is unfortunately not available in the national database (NVDB) [14]. Bakken (2017) has examined factors affecting children's travel habits in the Trondheim municipality [15]. The study showed a link between greater travel distance and altitude metres between home and school and the number of children being driven to school. The analysis indicated that school districts with a higher proportion of address points within five minutes of travel time have fewer children driven to school. Bakken has also reported conflicts between those who walk and cycle, and with those who are driven to schools during busy times of day.

Since 2013, the department of Miljøenheten (Trondheim municipality) has recorded the travel habits of schoolchildren in 15 primary schools in Trondheim. The goal was to find measures to encourage more children to choose to walk or cycle to school. Fig. 4 shows a decrease in the average percentage of schoolchildren who have been driven to school by parents. The share was 21% in 2014 and decreased to 13% in 2017. The proportion of schoolchildren being driven to school has decreased for all schools except one, the Hallset school, which has the highest number of address points situated more than 15 minutes of cycling time away [15]. The results show that the numbers of schoolchildren who cycle to school decrease during the autumn, and, according to the municipality, those who cycle during the summer are more used to walking than being driven to school in the spring.

From October to December 2017, travel habits were registered for 4,322 children in 35 primary schools. Parents answered a questionnaire about how their children travelled to school, and the results showed that 61% walked to school, 19% cycled, 15% were driven to school and 4% travelled by bus. From first to fifth grade, there was a change in the schoolchildren's travel habits: the number who walked or cycled increased with age. The youngest were driven to schools by their parents by parents (40%), but the percentage decreased sharply from 40% to 10% between first and third grade. The results from the survey show that parents chose to drive children for several reasons, such as lower travel time, long distance, poor weather conditions and dangerous roads. Among parents who drove their children to and/or from school that day (*N*=821), 31% stated that the school roads were too dangerous to let the children to walk or cycle to school (*N*=200). Roche Cerasi et al. (2011) showed that risk perception is crucial for transport mode use [16].

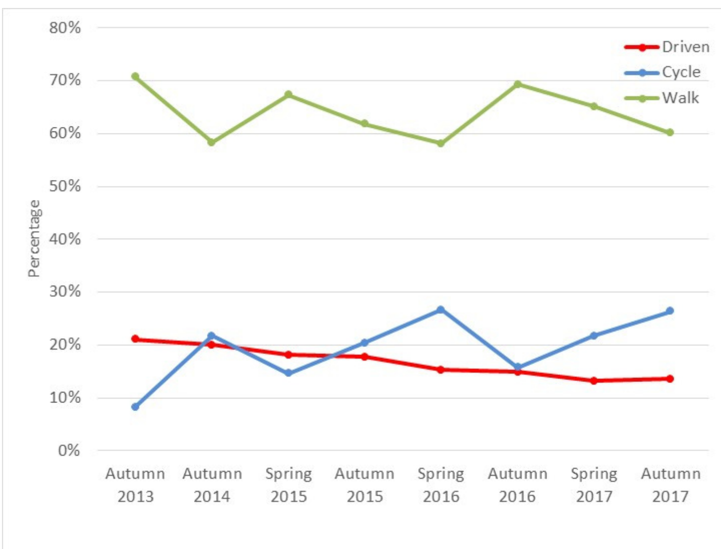

Figure 4: Average percentages of schoolchildren being driven, walked or cycled to school between 2013 and 2017 for 15 schools in the municipality of Trondheim.

3.5 Schoolchildren's perceptions of roads

With the digital application Barnetråkk, children and adolescents register how they experience and use the local environment. This allows authorities to develop specific measures to improve the city's attractiveness. The municipality collected these data from schoolchildren in fifth grade in 2013. Children evaluated the places as to be avoided or to be changed. They also described why they liked or did not like the places. The children mentioned a total of 1,284 locations as scary places for them. The results show that 60% of the places they did not like were for reasons not related to road safety (*N*=768). The environment was often not attractive because of garbage, broken windows, drunk people, drug dealers, etc. Even if the places were not directly traffic-related, tagging and rubbish in underground tunnels for pedestrians and cyclists may affect the behaviour of children who can choose to cross dangerous roads instead of using the tunnel.

Places described as dangerous have been grouped into seven categories: risky traffic, high speed or drivers not stopping, poor maintenance, poor visibility conditions, lack of lighting, lack of or dangerous traffic light intersection, lack of or dangerous pedestrian crossings, and lack of footpaths or cycling lanes.

Fig. 5 shows the share for each category. Of the places mentioned, 26% were described as having risky traffic due to heavy traffic (*N*=136). Around 9% are roads with drivers who drive too fast over the speed limits and do not stop at pedestrian crossings (*N*=48), and 7% are roads or sidewalks with poor maintenance (*N*=37), and children noted that they were slippery and dangerous. Slippery pavement may affect the transport mode use of both children and adults. For 3% of places, the poor visibility conditions made it impossible for children to see cars coming while crossing the road (*N*=13), and for 26%, the lack of lighting (*N*=136) made the roads dangerous for them. Schoolchildren may choose not to use a safe shortcut or a forest with no lighting and walk along a busy road without pavement. Approximately 12% of the comments were related to missing or dangerous traffic lights (*N*=64), whereas 16% were related to missing sidewalks, cycling lanes, or dangerous pedestrian crossings (*N*=82).

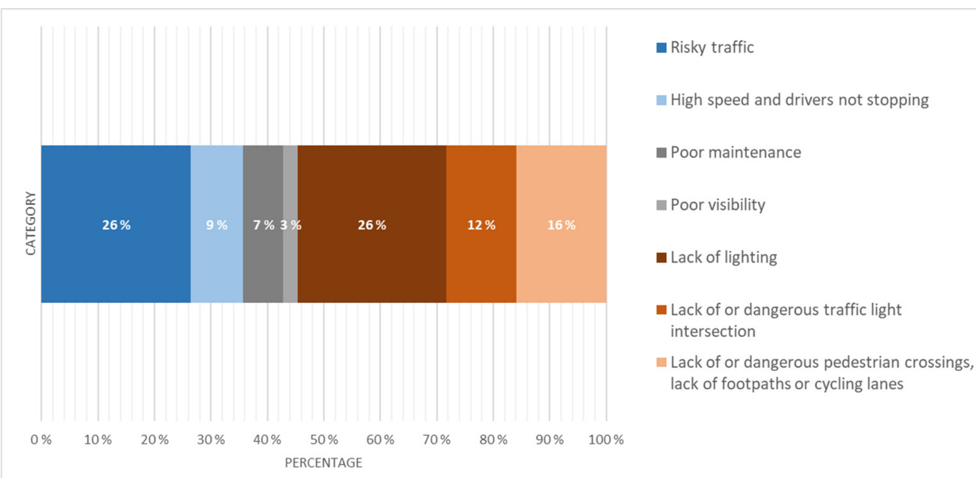

Figure 5: Share of risky traffic categories.

Fig. 6 shows the places the children mentioned as dangerous (*N*=516). The seven categories are marked with different colours in addition to the accidents reported in Fig. 3. In each school district, several intersections or crossings were reported as difficult to cross. In addition, lighting, traffic lights or crossings were noted as missing around schools. It is important to note that the schoolchildren wrote these comments; no option was suggested.

The author of this study selected one school based on previously reported accidents and the number of comments the children made. An analysis of the school surroundings and the infrastructure at two crossings showed that one speed bump was missing before a crossing point, and a police control later confirmed that the drivers drove too fast in the 30 km/h school zone. Observations made at rush hour and during winter showed that there is a match between the perceived dangerousness of places and the reality.

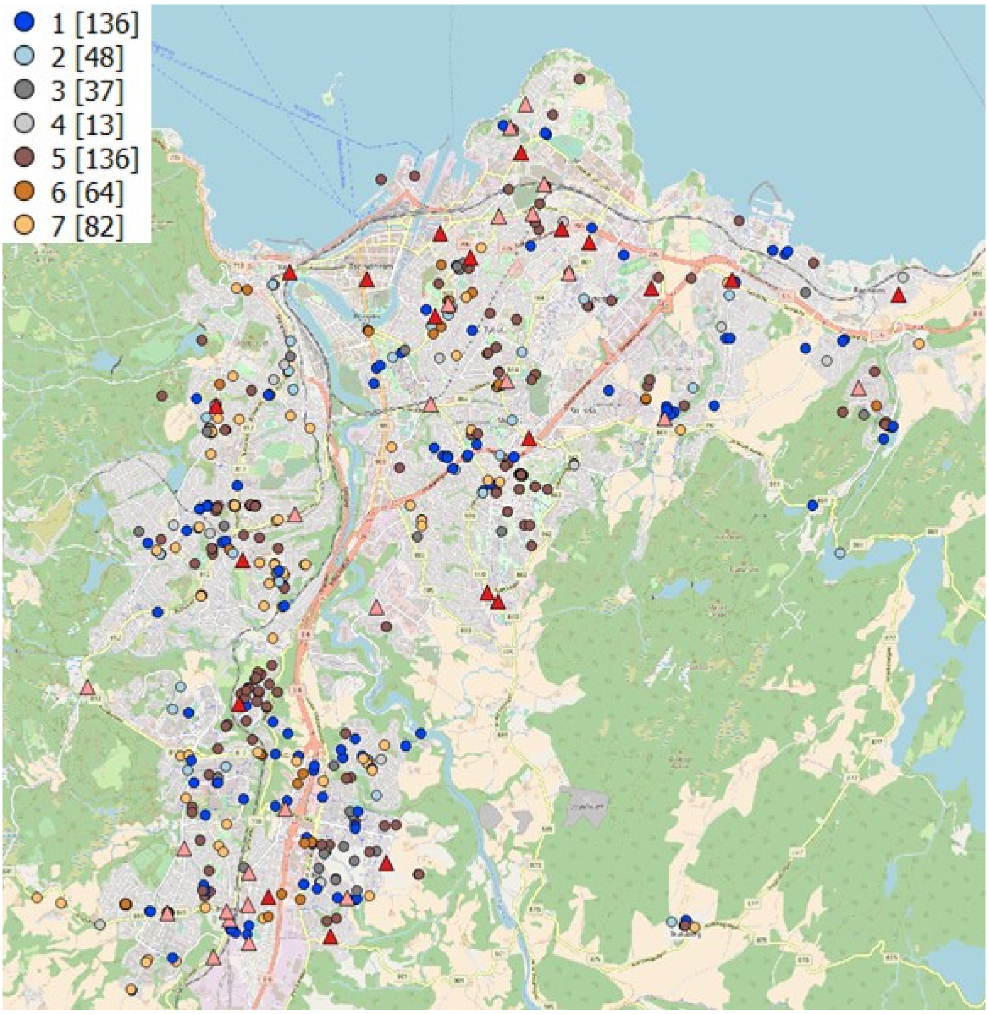

Figure 6: Schoolchildren's perception of risky traffic places per category.

Table 1: Schoolchildren's perceptions of local roads.

Categories		Examples of comments
1	Risky traffic	"high car traffic," "high traffic"
2	High speed and drivers not stopping	"drive too fast," "cars do not stop," "no sign or speed bump"
3	Poor maintenance	"need for better maintenance," "slippery and dangerous," "need sprinkling sand/salt in winter"
4	Poor visibility	"you cannot see the cars coming," "difficult to see that cars are coming"
5	Lack of lighting	"dark," "lack of lighting," "I want lights," "I want streetlamps"
6	Lack of or dangerous traffic light intersection	"Green lights at the same time for pedestrians and cars," "dangerous traffic light intersection," "I want traffic lights"
7	Lack of or dangerous pedestrian crossings, lack of footpaths or cycling lanes	"must have pedestrian path," "want a pedestrian crossing," "dangerous to cross," "I want pavement here!"

4 DISCUSSION

Norwegian standards recommend various measures that are most widely used in school areas. These measures are not mandatory, and some schools have, for example, roads with a speed limit over 30 km/h to facilitate the traffic of public transport modes or traditional pedestrian crossings with no speed bumps. Many facilities are also old and should therefore undergo inspections to ensure that they still meet the recommended standards. There are many differences between schools, intersections, and crossings that it may be crucial to compare the physical infrastructure around schools and map the more urgent needs and changes. This could be done with the help of the national road database (NVBD) [14] after updating the data or improving the quality of the information. This national database is crucial for road safety and it would be useful to incorporate a functionality such as a digitalised examination of the traffic safety indicators for each school.

Based on the thorough investigation done in this study, we recommend developing more requirements or at least a handbook with specific requirements and recommendations for school roads. Many measures are available that can provide higher safety (e.g., traffic signals, elevated footpaths, underground tunnels) and can make drivers slow down (e.g., speed bumps, speed control). Better road lighting, pedestrian crossing signs and good visibility conditions are important at crossing points. The digitalisation of traffic safety conditions and measures for schools could facilitate the control of the safety level and reduce the time it takes to implement new measures. It would be therefore easier to see the difference between "how it is" and "how it should be". With a more data-driven approach, the work of traffic safety officers of the municipality will be highly facilitated.

The traffic environment is not adapted to schoolchildren. It is important that traffic rules are taught in schools. However, training the motor and cognitive skills of schoolchildren is more critical. Moving in complex traffic situations requires more than knowing the traffic rules. Cycling requires motor skills, such as balancing and steering, and cognitive skills, such as attention, concentration, planning and decision-making. Many of these skills are not acquired at young ages. Schoolchildren need to learn how to evaluate risks, where and when to direct their attention and how they can orientate themselves. Crossings and intersections without traffic signals are particularly difficult for schoolchildren. They become vulnerable because they tend to have too much confidence in traffic rules. They have difficulties evaluating the speed and position of vehicles, and their height prevents them from seeing beyond the cars. Younger children do not focus on relevant visual elements and are unable to keep their attention on dangerous traffic situations. They have difficulty coping with a large amount of information, and their reaction time is longer than for adults. We also recommend developing infrastructure that is more adapted to the children's abilities when moving in complicated traffic situations: Which infrastructure is best for them? We still need a clear description of success criteria that make a school route, an intersection or a crossing safe for children walking or cycling to school. The road infrastructure must compensate for the children's lack of skills. The collection of risk perception of schoolchildren showed that there is still improvement to be done. The children's perception and challenges should be taken in consideration. It would be therefore easier to compare the subjective report with the traffic safety infrastructure in specific locations near schools and to discover needs for new infrastructure. This is crucial if the municipalities want to increase the number of children walking or cycling to school.

5 CONCLUSION

This study showed that a data-driven traffic safety approach could improve the traffic safety work for the municipalities if the use of all these data sources becomes more structured. There is a large potential in using data from the national road database, perceived safety from schoolchildren, parents and employees of schools, reports from school rectors, police control reports, municipality traffic safety reports, accident/hospital databases, mobility data analysis and traffic safety education courses. Some of them may be more valuable than others, and this should be investigated in the future. The Trondheim municipality already adopted a proactive and innovative stance in conducting investigations on subjective risk of schoolchildren with a digital application. However, the digitalisation of traffic safety and challenges (such as multi-source complexity, big data analysis, data privacy, data accuracy, misuse of data and hacking) need to be further investigated. There is a need to proceed the necessary deep change and to test more promising new data-sharing models in order to facilitate road safety inspection and rapid implementation of traffic safety measures. In addition, large amounts of data will soon be available thanks to geolocation, artificial intelligence, automated image analysis, drones, satellites, cameras, crash/event data recorders and vehicle sensors. It is therefore crucial to innovate and to start using data-driven analytics for traffic safety.

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