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Research article

Heart Zone as a measure to influence traffic safety culture: which factors influence culture change?

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Abstract: Measures to influence traffic safety culture in designated areas (e.g. schools) exist in several different countries across the world. The Norwegian traffic safety scheme Heart Zone is a measure that aims to influence the traffic culture within a specific geographical area. The study examines whether four Norwegian schools have managed to establish a Heart Zone traffic safety culture, factors facilitating and impeding the implementation of Heart Zone traffic safety culture and subsequent changes in parents' traffic safety behavior. The study is based on survey data from four Norwegian schools (n = 220) and qualitative interviews (n = 19). Although the level of implementation varies, results from the interviews and the survey suggest that the schools have established Heart Zone cultures, where large proportions of the parents drop the children off at the recommended drop-off zone, when driving, are attentive to students who come walking/cycling within the Heart Zone and walk or cycle when transporting children within the Heart Zone. The Heart Zone culture is related to changes in parents' traffic safety behaviors and reductions in dangerous traffic situations. The study identifies specific factors facilitating and impeding traffic culture change, related to enclosed geographical areas like the Heart Zone, developing an analytical model that researchers and future traffic culture measures like this can learn from.

Keywords: Heart Zone, school road safety, traffic safety culture

1 Introduction

1.1 Problem and consequences

Children's school travels have undergone substantial changes recent decades. Since the 1970s, the portion of children that are being driven to school instead of cycling or walking, have increased dramatically in Norway (Fyhri & Elvebakk, 2011; Hjorthol & Nordbakke, 2015; Høye et al., 2022; Ellis et al., 2019). The most recent national travel behavior study shows that 17–24 percent of school children were driven to school in 2020, depending on season compared to 3% in 1997 (Opedal et al., 2020). Similar trends have been reported in other western countries (Mcdonald, 2007; Westman et al., 2017).

An increase in school trips made by car, can have negative consequences in multiple areas. Increased reliance on motorized transport is associated with a reduction in active modes of transport (i.e. walking and cycling) (Ellis et al., 2019) and lower levels of physical activity (Cooper et al., 2003), heighten traffic volumes and congestion in the vicinity of schools Rothman

et al. (2014), and reduced air quality (Wilson et al., 2007). Moreover, increased traffic in the area around school also influences parents and students perception of how safe the area is, which in turn can result in more parents choosing to drive their children. Numerous studies have identified traffic safety concern as a primary reason for why parents drive their children to school (Fyhri & Elvebakk, 2011; Hjorthol & Nordbakke, 2015; Hillman et al., 1990; Opedal et al., 2020; Ellis et al., 2019; Dellinger, 2002).

Schemes aimed to reduce motorized traffic around schools and to promote active travel mode are found in many different countries. School Safety Zones, for example, are common in several Canadian cities and in the UK (London, 2023; Toronto, 2023). The concept School Streets, where motor vehicle traffic is prohibited or strictly limited in streets surrounding schools, is popular in several countries, including Italy, UK, Belgium, France, Scotland, Austria, USA, New Zealand and Australia (Clarke, 2022; Thomas, 2022; Edinburgh, 2016).

In Norway, a similar scheme is 'Heart Zone', which aim to ameliorate traffic conditions, reduce traffic in the vicinity of school (particularly related to parental driving), and thereby make it safer for children (and other vulnerable road users) to walk and cycle. The concept involves establishing a designated zone (Heart Zone) around the school, where motor vehicle access is restricted (NCRS, 2021). This is accomplished primarily through educational and awareness-raising measures such as walking and cycling campaigns, bicycle training, parental information and symbolic sanctions, as well as simple and cost-effective infrastructure measures (e.g. signage, road markings, redistribution of parking spaces, improved zebra crossings etc.). The concept must be adapted to the local traffic conditions and challenges at the specific school. This means that the school itself defines where the Heart Zone should be localized, and what specific measures should be included. Hence, a Heart Zone in one school may be quite different from a Heart Zone in another school.

Since it was introduced in the early 2010s, it has rapidly gained in popularity. To date 352 schools have implemented Heart Zones (NCRS, 2024), and the number is expected to increase, as it recently was embedded in the Norwegian government's national strategy for traffic safety (SD, 2021).

In 2016, the city council in Bergen, Norway decided that all of the municipality's 66 public primary schools should establish Heart Zone by the end of the city council's current term (Bergen, 2020). Bergen municipality is thus the first municipality in Norway to have made a political decision on the systematic establishment of Heart Zones at all primary schools in the municipality. The current study reports from an evaluation following the Heart Zone Project in Bergen Municipality.

Heart Zone is an initiative designed to foster a safer traffic culture by reducing car traffic, especially from parental driving, within its area, thus reducing exposure and risk to vulnerable road users. It advocates for increased walking and cycling to school, extending beyond safety to also benefit environmental and public health. Because there are few studies that focus on traffic culture in general, the current study on research on traffic safety culture.

1.2 Aims of the study

The study had four aims:

1. Examine changes in traffic culture as a result of Heart Zone, and whether the schools have established a Heart Zone traffic culture.
2. Examine changes in parents' traffic safety behavior as a result of Heart Zone.
3. Examine factors facilitating and impeding the implementation of Heart Zone traffic safety culture.
4. Examine parents' perception of changes in dangerous traffic situations after Heart Zone implementation.

1.3 Heart Zone

The Heart Zone initiative is a comprehensive, multisectoral road traffic safety scheme developed through the collaboration of key road traffic actors, including the Norwegian Council for Road Safety, the Norwegian Road Administration, the Police, the Norwegian Directorate of Health, the Environmental Agents, Cyclists' National Association, and the Parents' Committee for Basic Education. This multisectoral approach highlights the importance of collaboration among various stakeholders at different levels.

A Heart Zone can be initiated from various parties such as students, school principals, faculty members, parent-

teacher associations (PTAs), or even municipalities. In Bergen, Norway, the scheme was initiated politically by the City Council.

Key actors in the Heart Zone scheme include:

- Municipalities, which hold important roles as road and school owners, planning, and approval authorities.
- School management, which play a pivotal role in implementing the scheme and function as a collaborative link between the municipality and the school, and ensuring involvement of the pupil council and PTA.
- Road owners like county authorities, the National Road Administration, private road owners and other actors (such as local businesses in the vicinity of the school) who need to be informed and involved in the planning and implementation.
- The Norwegian Council for Road Safety and police, offering professional advice and traffic control support respectively.

The implementation of Heart Zones in Bergen Municipality commenced in 2017, involving a total of 66 primary schools. A project group was established to coordinate the implementation process, however each school were responsible for establishing the Heart Zone locally at the school and develop their own traffic safety plan.

Several types of measures can be implemented as a part of the Heart Zone scheme. Educational and awareness-raising measures include walking and cycling campaigns, bicycle training, artistic activities to engage students, traffic education, parental information, visible guards near the heart zone during drop-off and pick-up times, and symbolic sanctions, such as 'Heart Zone tickets' distributed to parents or others that do not adhere to the Heart Zone recommendations (for example driving within the Heart Zone). Infrastructure measures includes establishment of drop-off zones at the Heart Zone boarder, Heart Zone signage and road markings, redistribution of parking spaces in the vicinity of the school, traffic-calming measures such as speed pumps, zebra crossings.

In the Bergen Heart Zone project, the City Council decided to prioritize educational and awareness-raising measures and cost-effective infrastructure measures such as signage, road markings, and where feasible, drop-off zones. Additionally, schools in need had the opportunity to apply for funding dedicated to minor infrastructural enhancements, such as the installation of speed bumps, improvements of bus stops near the school and the upgrading of zebra crossings.

2 Theoretical approach

2.1 Traffic safety culture

There are numerous definitions of the concept Safety culture. In broad terms, safety culture refers to taken-for-granted values and norms shared by a group of people, which serve as frames of reference and inform safety-related behaviors (Antonsen, 2017). There are different approaches to studying safety culture. One strand of safety culture research concerns examining how safety culture as common frames of reference that underlie interpretations of actions, dangers and workplace identity, which motivates and legitimizes behavior that affects safety (Antonsen, 2009; Nævestad, 2010). Another strand of research is that of safety climate, which is commonly understood as snapshots of, or manifestations of, safety culture (Flin, Mearns, O'Connor & Bryden, 2000), covering topics such as safety perceptions, workgroup norms and perceptions concerning managers' focus on safety (Flin et al., 2000; Kines et al., 2011).

When used in road transport, the term safety culture has traditionally been applied to organizations and people within organizations. This particularly applies to professional drivers who are employed by companies (Davey et al., 2006; Huang et al., 2013; Wills et al., 2005). Previous studies show relationships between safety culture and safety outcomes (safety behavior, accident risk) in companies with professional drivers (Davey et al., 2006; Huang et al., 2013; Nævestad, Hesjevoll & Phillips, 2018; Wills et al., 2005) (Davey et al., 2006; Huang et al., 2013; Wills et al., 2005). In addition, studies of safety culture interventions, with pre- and post-measurements, test and control groups, have indicated up to a 60% reduction in accident risk in the road sector (Gregersen et al., 1996). A recent review of studies evaluating safety culture interventions show that interventions that the majority of interventions had a positive effect on safety culture, however, interventions incorporating elements relating to importance of safety, leadership style and behavioral monitoring appears to be the most successful types (Aburumman et al., 2019).

Applying the safety culture perspective to non-professional road users is also highly relevant, because these include high-risk groups, such as young and old road users who drive in high-risk situations. e.g. at weekends, in the evening/night, with friends. However, applying the concept of safety culture to these groups means shifting the focus to other social units than organizations, e.g. countries, communities, peer groups, families. There are several challenges linked to this, because the boundaries tend to be more unclear than, for example, work organization. How do we determine who should be considered inside and outside the local community? (Nævestad & Bjørnskau, 2012). Although researchers seem to agree that safety culture is also important for non-professional road users, there are still no definitions of traffic safety culture that are widely accepted by traffic safety researchers (Edwards et al., 2014). In this paper, traffic safety culture is defined as common and safety-relevant ways of behaving in traffic, common norms for such behavior, and thus common expectations about the behavior of others in traffic (Nævestad et al., 2019). This definition is applicable at the national level, in local communities, peer groups and families.

This definition operationalizes traffic culture as descriptive norms, which are defined as our perceptions of what others actually do (Cialdini et al., 1990; Ward et al., 2010). Descriptive norms can influence behavior by providing information about what is 'normal' (Cialdini et al., 1990). With this operationalization of traffic culture as descriptive norms, it is theoretically assumed that the mechanism mediating between culture (common norms and expectations) and traffic behavior is 'subtle social pressure' (Cialdini et al., 1990). This means that our knowledge of what is 'normal' or 'socially accepted' based on our assumption of what others usually do, motivates our own behavior in traffic

Finally, it should be mentioned that there are relatively few studies of traffic safety culture among non-professional road users, and that this term is somewhat immature in a research context. More research is needed to further explore (*a*) the mechanisms that generate traffic safety culture in different socio-cultural contexts (nations, communities, peer groups, families), (*b*) theory about the relationship between culture and behavior, and (*c*) how this knowledge can be used to develop successful interventions to improve traffic safety.

2.2 How does traffic culture change?

2.2.1 Influencing safety culture in geographical areas

While most studies on traffic safety culture largely have focused on professionals within an organizational context, there are examples of studies that have explored factors influencing traffic safety culture in other socio-cultural units, such as nations, regions and peer groups. Some studies have found relationships between traffic safety culture, traffic safety behavior and accident risk in comparisons of different countries and regions (Nævestad et al., 2019; Luria et al., 2014; Özkan et al., 2006).

In their study of factors influencing national traffic safety culture, Nævestad et al. (2019) identify five key factors affecting traffic safety culture in Norway and Greece: *(1)* road user interaction, shaped by shared norms and interactions among road users. This is in line with several studies indicating that shared norms continually are created through interactions among road users in traffic (Bjørnskau, 2014; Luria et al., 2014; Özkan et al., 2006) *(2)* road infrastructure, which lays the premise for road user interaction through road quality, markings, and design; *(3)* enforcement levels, which is closely related to road user behavior (Elvik et al., 2009); *(4)* driver training, which serve to normalize expectations regarding road user behavior and the behaviour of other road users; and *(5)* the demographic composition of road users (e.g. gender, age, level of education) which potentially can influence traffic safety culture through influencing driving behaviors and road user interaction, which in turn contribute to shape traffic safety culture.

2.2.2 Factors influencing the implementation of safety culture interventions

Heart Zone aims to influence the safety culture of road users within a specific geographical area. Yet, the implementation of the scheme is led by an organization (i.e. the school). Accordingly, the principal and school staff are responsible for implementing and following up of the initiative. The outcome of any safety culture intervention is closely related to the organizational context and the implementation process. Therefore, research on safety culture implementation is also relevant to this study.

A large body of literature suggest that management involvement and commitment is a fundamental prerequisite for safety culture measures to be successful (Edkins, 1998; Flin et al., 2000; Lappalainen et al., 2012; Zuschlag et al., 2016). Edgar (Schein, 2004) argues that management and culture are intrinsically linked, detailing 'six primary embedding mechanisms' describing how managers influence culture within an organization: *(1)* What areas they focus on, measure and control, *(2)* How they respond to crises and critical events; *(3)* How they allocate resources within the organization; *(4)* How they serve as role models, teach, and coach employees; *(5)* How they distribute rewards and status (*6*) How they recruit, promote, and sanction. Through these mechanisms, managers are influential when it comes to prioritizing and legitimizing safety culture interventions.

Employees' support for the intervention measures also influences safety culture change (Newnam & Oxley, 2016; Zuschlag et al., 2016). Mistrust between managers and employees can have a negative impact (Amtrak, 2015; Zuschlag et al., 2016). Framework conditions such as work capacity, workload, and time pressure will influence the quality of the implementation process (Bye & Aalberg, 2020; Størkersen et al., 2020) (e.g. if managers and employees experience strong work pressure, and have many competing tasks, they may have little time to work on the measures).

Ensuring that the measures that are being implemented are adapted to the context is also important. That is, that the measures are compatible with the organizational systems, or the work the employees will do (Bye & Aalberg, 2020; Størkersen et al., 2020).

2.3 The relationship between culture change and behavioral change

Several studies find relationships between culture change and behavioral change. This applies to both cross-sectional studies and intervention studies. Cross-sectional studies of professional drivers find relationships between drivers' safety behavior and organizational safety culture (Nævestad et al., 2019; Wills et al., 2005; Davey et al., 2006). Intervention studies from a number of different sectors also find that measures to improve safety culture led to improvements in safety behavior (and subsequent reductions in accidents and safety incidents), for example in the railway sector (Zuschlag et al., 2016) and in bus transport (Naveh & Katz-Navon, 2015). The study by Zuschlag et al. (2016) from the railway sector finds that improvement in safety culture leads to an 80% reduction in risk-taking behavior and an 81% reduction in accidents. The study has both before and after measurements and a test and control group. The aforementioned studies also find that a number of demographic variables influence safety behavior, for example age, gender, experience, nationality (Nævestad et al., 2019; Zuschlag et al., 2016). The assumed mechanism explaining the relationship between culture change and behavioral change could be that when culture changes, the prescribed norms for behavior changes, in a way which leads to changed behavior (Cialdini et al., 1990). This is due to subtle social pressure to behave in conformity with the 'new norms' (i.e. the new ways that other people act).

3 Methodology

3.1 Triangulation of data

In order to answer the research questions, multiple sources of data were combined, including interview data and survey data. The following text provides more detailed information on how the data was collected and analyzed.

3.2 Focus group interviews and interviews

To gain in-depth insight into the organizational context of the project, map experiences from implementing Heart Zone, and to identify factors that have promoted and hindered implementation of the Heart Zone Scheme, focus group interviews and individual interviews were conducted with informants that have had different roles in the Heart Zone project. This included relevant individuals at the municipality level, and at the school level.

Informants from the municipality included members from both from the project group and the steering group, which include central actors that have been involved with rolling out the Heart Zone scheme in Bergen Municipality and monitoring the process (n = 9). Two focus group interviews were conducted with a total of nine members from the project group and the steering group, which represented main actors from the municipality. Two interviews were also conducted with former members of the project group and the steering group.

Informants from schools that have implemented Heart Zone Scheme included principals, staff, as well as PTA-members and members of the student council, where applicable.

Tree focus group interviews and six individual interviews were conducted with a total of 19 informants from six different schools that have implemented Heart Zone. A total of three focus group interviews and 6 individual interviews were conducted. Written information about the project and the purpose of the study was first communicated to the principals at each individual school. The principals passed on further information to people from the school management, PTA and the pupil council. The schools were selected to reflect variations with respect to school size and location, as well as variations in terms of what time the scheme was introduced (i.e. early or late in the project period) (Table 1). We were made aware that some schools decided to discontinue the scheme. To illuminate this perspective in the evaluation, one of the schools that chose to discontinue Heart Zone was also included in the study.

All interviews, both focus group interviews and individual interviews, were conducted digitally via Microsoft Teams. All of the interviews were recorded, and manually transcribed to text.

3.2.1 Interview guide

Semi-structured interview guides were used in both the focus group interviews and the personal interviews. A separate guide was developed for the project group/steering group and one for the schools.

The interview guide contained the following main topics:

- Organization of the work with Heart Zone
- The process of introducing the scheme
- Experiences related to the process of introducing the scheme
- Experienced results as a result of Heart Zone
- Collaboration (both within and between actors)
- Barriers/driving forces in the process

The interview guides used for the focus group interviews were adapted somewhat to facilitate discussion between the participants to the greatest extent possible and contained fewer questions.

3.3 Quantitative survey

A survey was distributed late autumn 2021, to four schools in Bergen that had introduced Heart Zone. In developing the survey for this study, we drew upon established theoretical frameworks on safety culture, including seminal works by Flin et al. (2000) and Schein (2004), which provided foundational insights into the constructs of safety culture. These theoretical perspectives were further enriched by empirical data collected through interviews and focus group discussions conducted as part of our preliminary research phase. This combination ensured that the survey items were deeply rooted in both theory and real-world experiences relevant to the Heart Zone context. Despite the availability of existing and validated surveys related to safety culture, a conscious decision was made to develop a survey tool tailored specifically for the Heart Zone evaluation. This approach was adopted to ensure that the survey would precisely address the unique aspects and objectives of the Heart Zone initiative, which may not have been adequately captured by standard, validated scales.

These are different schools than the schools that partook in interviews. Information about the survey and requests for participation were sent out to principals at six different schools. The electronic survey was sent by e-mail (link) to parents and staff at four of the schools, via the principal. A total of 240 people responded. The survey was developed and distributed through the software Survey Design.

3.3.1 Topics in the survey

The survey contained 69 items in total. In the following, a description is provided of the major topics covered in the survey and examples of questions.

Background variables. Gender, age, school, occupation (parent at the school, employee at the school), distance from home to school. Employees at the school have also been asked what kind of position they have and how long they have been employed at the school. Parents at the school were asked about the grade their children ware in, whether their children attend after-school care, and whether they currently have, or have had a role in the PTA.

Knowledge about Heart Zone. Index consisting of seven items. Examples of statements: '*I am well aware that the school has a Heart Zone*' and '*I have received good information about the Heart Zone*'. Response was

Table 1 Overview of schools included in the evaluation

School	Time of Heart Zone implementation	School size	Location	Traffic situation
School 1	Early implementation	Large	Residential area slightly outside city center	Through roads, some car traffic
School 2	Early implementation	Large	Densely built-up area outside city center	Located near main thoroughfare
School 3	Early implementation	Medium	Densely built-up area outside city center	Through roads, some car traffic
School 4	Not implemented	Large	Sprawled area, outside city center	Located near main thoroughfare
School 5	Recent implementation	Medium	Downtown area	Little car traffic
School 6	Subsequent implementation	Large	Densely built-up area outside city center	Through roads, some car traffic

Time of implementation: early implementation (2018/2019), subsequent implementation (2020), recent implementation (2021).
School size: medium-sized school (< 300 students), large school (> 300 students); based on definition from Statistics Norway and figures from gis.udir (2021).

given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree.

Top management and PTA commitment. Respondents' perceptions of school management's and PTA's commitment to Heart Zone was measured with the following statements: 'Heart Zone is an important priority for the school's management' and 'Heart Zone is an important priority for PTA. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree. The questions were combined into an index.

Implementation. Degree of implementation was measured with an index consisting of four statements focusing on activities and measures carried out in relationship with the Heart Zone. (*1*) Walking groups are organized to make it easier for more students to go to school, (*2*) A drop-off zone has been established outside the Heart Zone, (*3*) It is easy to drop-off/pick-up in the drop zone and (*4*) You get reactions from the school management if you drive unnecessarily within the Heart Zone. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree. The questions were combined into a sum score index (min: 4, max: 20) (Cronbach's Alpha: .672).

Traffic situation around the school. The traffic situation and the composition of road users in the area around the school are measured using the following two statements: '*The school is located in an area with a lot of car traffic*' and '*it is mainly parents and teachers who drive in the area around the school*'. This gives a rough indication of what the traffic environment around the school is like, as well as what the composition of road users in the area around the school is like. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree.

Behavior in the Heart Zone. Behavior in and around the Heart Zone was measured with statements that deal with one's own behavior: '*I often use the recommended drop zone to drop off my/my children*' and '*I rarely drive within the Heart Zone*'. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree.

Perceived stress. Perceived stress was measured through the statement *'I often experience stress/time pressure when I travel to/from school*'.

Sanctioning. The perceived degree of sanctioning of unnecessary driving behavior in the Heart Zone was measured by the following statement: '*You get reactions from the school management if you drive unnecessarily within the Heart Zone*'. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree.

Heart Zone t raffic safety culture, measures as descriptive norms. Statements measuring norms about what is perceived as normal behavior in the Heart Zone during drop-off/pick-up was introduced by the text '*When I travel in the Heart Zone during drop-off/pick-up, other parents usually...*' which was preceded by the following statements: '*...drop off the children at the recommended drop-off zone, when they are driving*',

'*...are aware of students walking/cycling within the Heart Zone*', '*...walk or cycle when accompanying children within the Heart Zone*'. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree. The questions were combined into an index (Cronbach's Alpha: .596).

Perceived effects of Heart Zone. The survey contained several statements about perceived effects of Heart Zone and perceived consequences of the school having established a Heart Zone. The statements were introduced by the following text '*The fact that the school has implemented Heart Zone has led to...*'. Four measures measure changed behavior of other people, three questions measure changes in perceived traffic safety, two questions measure respondents' own traffic safety behavior and four questions measure traffic safety culture. Response was given on a five-point scale ranging from 1 = completely disagree to 5 = completely agree.

3.3.2 Statistical analyses

Statistical analysis of survey data was performed using SPSS 29.

Correlation analyzes were carried out to explore relationship between items. Cronbach's alpha was calculated for all indexes used in the analyses. ANOVA was used to study group differences in traffic culture and traffic culture change. Finally, three regression analyzes were carried out. In the first, factors explaining variation in traffic culture measured as descriptive norms was examined. In the second, factors predicting changes in respondents' traffic safety behaviors was examined and in the third, factors in respondents' perceptions of reductions in traffic conflicts.

3.4 Research ethics

In line with research ethical practice, the study was reported to and approved by the Norwegian Center for Research Data (NSD). Furthermore, the study was carried out in line with Research Ethics Guidelines for social science research and the humanities (NESH, 2021). All the informants who participated in interviews received written information in advance of the study about the project and about the processing of personal data. Informed consent was obtained in writing, where it was made clear that consent can be withdrawn at any time. None of the informants have made use of this opportunity. The student council representatives in the study were all under the age of 15 and are thus considered minors. If minors are to participate in research, informed consent must be obtained from parents. Information about the study was sent to their parents via the school management, and written informed consent was obtained before the interviews.

4 Results

4.1 Characteristics of the respondents

Survey respondents were recruited from four schools. A total of 240 respondents responded to the survey. A total of 220 of the 240 respondents were parents, while 20 were employed at the school. Employees (n = 20) were excluded from the analyzes presented in this paper. The reason is that there were generally few employees who had responded. Moreover, employees are in a different situation than the parents, and travel to the school outside peak hours for pick-up and delivery. All references to the sample or respondents in the rest of the text are exclusively to parents. Table 2 shows the number and proportion of parents from each school.

Table 2 Number and proportion of parents from each school

School	Number	Percent
School A	27	12%
School B	81	37%
School C	63	29%
School D	49	22%
TOTAL	220	100%

The response rates among schools were generally consistent, though School A had slightly fewer participants. The bulk of the feedback came from School B. Out of the total, 48 parents reported current or past membership in the Parent-Teacher Association (PTA). Thus, most survey participants were not PTA members. Fifty-nine percent of the parents have children in grades 1–3, and 70% are parents of children in grades 4–7, indicating some parents have children across different educational stages. Approximately one-third of respondents have children enrolled in after-school programs, highlighting demographic overlap. The sample showed a notable majority of female respondents, at 61%, while 4% chose the option 'prefer not to say' for their responses.

Table 3 gives an overview of the age distribution in the sample. The majority of the respondents (59%) were between 36 and 45 years old. 26% were between 46 and 55 years old.

Table 3 Overview of the age distribution among the parents

Age	Number	Percent
Under 25	2	1%
26–35 years	28	13%
36–45 years	130	59%
46–55 years	58	26%
Over 56 years	2	1%
TOTAL	220	100%

Respondents were asked about their typical modes of transportation to/from school, as well as the distance between their homes and the school. The majority of parents reported either driving (45%) or walking or cycling (46%), with a small portion utilizing public transportation (3%). Additionally, 4% of parents indicated their children were entitled to free school transport, while 3% selected the option 'other' for their travel method. Regarding proximity to the school, 71% of the respondents reside within a 2 km radius, with 32% living less than 1 km away and 39% situated 1–2 km from the school.

Table 4 shows modal shares for each school, while Table 5 shows the distribution of respondents' residential proximity to school.

Table 4 shows that modal shares vary quite a bit between the schools in the study, and that car driving is the predominant mode at most of the schools. School A has the highest driving rate at 67% and the lowest rate of walking/cycling at 11%, while the majority (70%) of respondents at school B walk or cycle to school. Modal shares are closely linked to residential distance from the school. Table 5 shows that the majority of respondents live more than 2 km away from the school. Conversely, most respondents at school B live within a radius of 2 km from the school.

The survey presented participants with statements regarding travel time and distance to school, requiring parents to express their level of agreement. Fifteen percent of the parents concurred with the statement, '*It is too far to cycle or walk to school from where I/we live.*' Additionally, 39% of the parents agreed with the assertion, '*I have to drive because I have little time in the morning*'.

Table 5 Distribution of residental distance from schools in the study (Percent)

School	< 1 km	1–2 km	> 2 km
School A	15%	30%	56%
School B	37%	48%	15%
School C	35%	33%	32%
School D	28%	37%	35%

4.2 Heart Zone traffic culture and changes in traffic culture

This section relates to the first aim of the study, which was to examine changes in traffic culture as a result of Heart Zone, and whether the schools have established a Heart Zone traffic culture.

4.2.1 Quantitative results

The traffic culture within the Heart Zone was measured by examining descriptive norms, specifically the respondents' perceptions of common travel methods among parents and students. Sixty percent of respondents believe that other parents typically use the recommended drop-off zone when driving, while 72% perceive that parents generally are vigilant regarding students walking or cycling within the Heart Zone. Additionally, 51% of respondents feel that it is usual for other parents to walk or cycle when transporting their children within this area, suggesting a significant presence of a 'Heart Zone culture' among parents at the surveyed schools.

The survey further investigates shifts in traffic culture through questions like whether the implementation of the Heart Zone has resulted in reduced car usage for school drop-offs and pickups and increased walking or cycling among students. Thirteen percent of respondents agreed that there has been a decrease in car usage, whereas 11% concur that more children now walk or cycle to school. Notably, agreement rates for reduced car use ranged from 19% at School B to 6% at School C, and agreement rates for the statement that more children now walk or cycle to school, ranged from 22% at School D to 2% at School C, suggesting variations in initial conditions and the degree of cultural change across schools.

Figure 1 shows Heart Zone traffic culture measured as descriptive norms (min: 3, max: 15 points) and changes in traffic culture (min: 2, max 10 points) at the various schools.

Table 4 Modal shares for schools in the study

School	Driving	Walking / Cycling	Free school transport	Public transport / Other
School A	67%	11%	18%	4%
School B	24%	70%	0%	6%
School C	52%	38%	3%	7%
School D	59%	33%	2%	6%

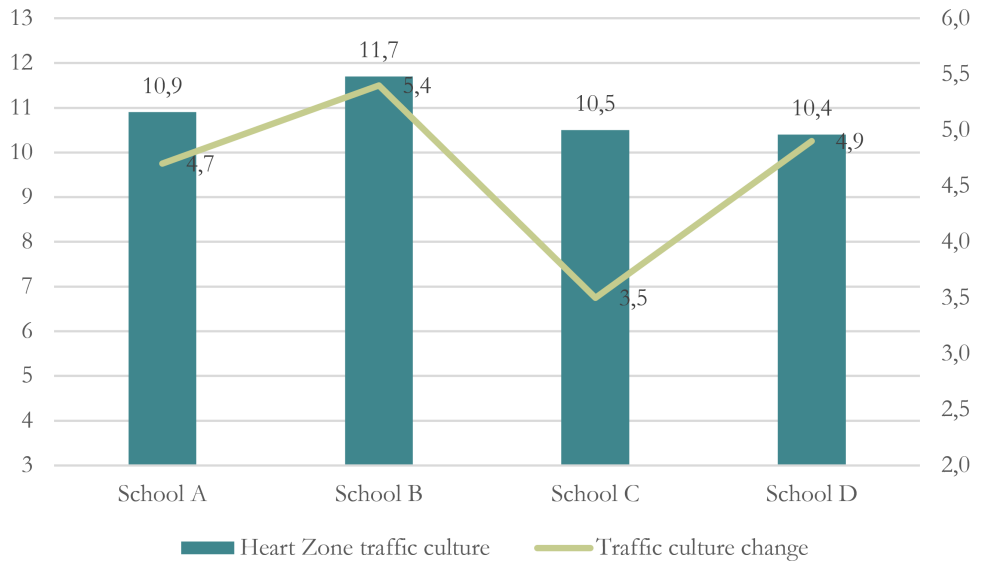

Figure 1 Heart Zone traffic culture measured as descriptive norms and changes in traffic culture at the various schools (n = 220)

Figure 1 illustrates that School B achieved the highest ratings in terms of Heart Zone traffic culture, as determined by descriptive norms, and also scored highest in the index measuring changes in traffic culture. The disparities observed in the first index are statistically significant at the 1% level ($p = 0.008$), and the differences in the second index reach significance at the 5% level ($p = 0.017$). These findings suggest that School B has experienced the most pronounced impact on Heart Zone traffic culture among the surveyed schools.

4.2.2 Qualitative results

In the interviews with key informants from the schools, participants were asked about experienced outcomes following the implementation of the Heart Zone initiative. The experienced impact of having established a Heart Zone varied significantly across the institutions. Informants from two schools reported no substantial change from the pre-Heart Zone conditions. At School 1, several informants believed the ineffectiveness of the Heart Zone, primarily was attributable to suboptimal drop-off zones. They pointed out issues such as inadequate space and insufficient areas designated for safe student drop-offs and pickups.

Conversely, at School 5, traffic around school had not really been a problem before the implementation of Heart Zone. The majority of students, parents, and staff already walked or cycled to school. Members of the school management pointed out that they had not noticed considerable effects from implementing the scheme, but at the same time, Heart Zone had not really been a major focus at the school.

Still, informants from several schools reported that the Heart Zone initiative had led to notable improvements in traffic culture and the overall traffic conditions near the school. At three schools, many interviewees observed that the Heart Zone contributed to reducing traffic congestion during student drop-off and pick-up times. They also noted a decrease in car usage, with parents increasingly organizing walking groups for their children.

Several informants recognized that the Heart Zone initiative has played a crucial role in enhancing awareness about driving and traffic safety in the vicinity of the school, yielding positive outcomes for parents, students, and staff alike. Furthermore, one informant highlighted that the Heart Zone has been instrumental in fostering a sense of identity for both the school and the local community.

'I think we see a difference, and that helps build identity. And it is known among everyone in the city that [name of school] has Heart Zone, and that is something we can prove.' Employee in the school management, school 2

Despite the Heart Zone initiative, several schools continue to face challenges with significant car traffic within the zone, especially during peak times such as the pre-Christmas period or on days with bad weather, leading to occasional traffic congestion. Many attributed these challenges to persistent parental attitudes and ingrained habits. There is a consensus that achieving the desired cultural shift in travel behavior is a long-term endeavor, requiring ongoing, focused efforts founded on robust collaboration between the school and the Parent-Teacher Association (PTA).

A PTA representative from School 6 noted that the Heart Zone initiative has helped delineate the school's existing responsibilities regarding traffic safety. They observed that as a result of the Heart Zone efforts, the school's administration has become more engaged in traffic safety initiatives than previously, fostering enhanced collaboration between the PTA and the school on traffic safety and the security of school routes. Additionally, some individuals believe that the Heart Zone has increased the potential to propose and secure approval for physical improvements on municipal roads within the Heart Zone area.

Both PTA representatives and school employees reported success in obtaining approval for measures that had previously been denied. Additionally, many indicated that Heart Zone is now being considered in conjunction with planned developments within the area.

4.3 Changes in parents' traffic safety behavior

This section relates to the second aim of the study, which was to examine changes in parents' traffic safety behavior as a result of Heart Zone.

4.3.1 More cycling and walking and less car driving

Parents were asked about changes in their school commute methods post-Heart Zone implementation, with specific reference to modes of transportation for school drop-offs and pick-ups. Approximately 18% of respondents reported an increase in walking and cycling, whereas 14% noted a decrease in car usage. However, 82% of the parents indicated no change in their travel habits, a result that should be interpreted in light of their pre-existing transportation preferences, as a substantial number already walked or cycled before the initiative was implemented.

The data reveals that the Heart Zone initiative has led to a notable, though varied, reduction in car use among parents, with the percentage of parents who report driving less ranging from 19% at School A to 12% at School D, likely reflecting different baselines and levels of implementation. Additional factors may also affect these behavioral shifts.

A breakdown by residential distance from the school shows differing impacts: 20% of those living within 1 km, 14% of those within a 1–2 km range, and 11% of those living 2.5–5 km away reported driving less. This gradient suggests that the Heart Zone's influence on transportation choices is most pronounced among those residing closer to the school.

4.3.2 Increased awareness of vulnerable road users in the Heart Zone

The survey included questions to assess the impact of the Heart Zone initiative on parental awareness and concerns regarding traffic safety and vulnerable road users around the school. Specifically, parents were asked whether the Heart Zone led to increased awareness of vulnerable road users during child drop-off/pick-up and whether it heightened their concern for traffic safety on school roads.

For the first question, 46% of the parents agreed that the Heart Zone had made them more aware of vulnerable road users, while 21% disagreed, 18% remained neutral, and 15% were unsure. Regarding the second question, a higher percentage, 54%, concurred that they had become more concerned with traffic safety around the school, with 17% disagreeing, 18% providing neutral responses, and 10% uncertain.

These findings are in line with interview findings, suggesting that the Heart Zone initiative has resulted in increased awareness and concern for traffic safety and the well-being of vulnerable road users in the vicinity of the school.

4.4 Factors facilitating and impeding implementation and culture change

This section relates to the third aim of the study, which is to examine factors facilitating and impeding the implementation of Heart Zone traffic safety culture.

4.4.1 Qualitative results

Findings indicate that the source of initiation, which in this case was political, has had both positive and negative implications for the implementation processes. The management of the project at the municipal level significantly enhanced its anchoring within the municipality, providing the Heart Zone initiative with a solid starting point. However, feedback from the schools indicated that this approach also had some drawbacks, for example that the initiative felt forced upon them.

The involvement of school management has been crucial in integrating the measure into the school's formal processes and prioritizing it where feasible. They have consistently worked to ensure that the Heart Zone initiative is regularly included on the agenda and discussed in key forums, such as parent meetings, student council meetings, and PTA meetings.

The PTA has played a significant role in advancing the Heart Zone initiative. At many schools, the PTA's robust commitment to local traffic safety has established a solid foundation for collaboration on the Heart Zone project. Serving as a vital link between the school and parents, the PTA has contributed significantly to fostering a culture of safety, and contributing to attitude-forming elements of the scheme, such as mediating information. Furthermore, it has bolstered the school management's efforts by offering recommendations and disseminating additional information to the parents.

Results indicate a relationship between regular and consistent engagement with the project, and a higher perceived benefit among the schools. However, the limited capacity of school management has significantly hindered implementation. Interviews revealed that school administrators faced challenges allocating adequate time and resources to the Heart Zone initiative, given the myriad of other obligations requiring their attention.

The COVID-19 pandemic appears in a number of contexts as an inhibiting factor with significant consequences for Heart Zone work. For the school management, restrictions, infection control measures and related operational challenges have led to reduced capacity and the opportunity to prioritize Heart Zone. Additionally, important platforms for interaction among school management, the student councils and PTA were inaccessible for extended periods during the pandemic, further impeding the process.

The traffic safety plan was recognized by many as a valuable resource and appears to be a facilitating factor. Introduced by the project group, it has often helped in organizing existing traffic safety efforts at schools. Additionally, it provides guidance for the school management's efforts in fostering a safety-oriented mindset.

'*The most important job we did was to become aware of the dangers we did not discover ourselves. You do not always see what could potentially go wrong, before it has gone wrong (...) The work [related to the traffic safety plan] helped to identify what the problem was.*' – Former member of the school management, school 4

Many interviewees praise the concept of the Heart Zone initiative, yet they note that its practical implementation has fallen short of expectations. This discrepancy was primarily related to additional infrastructure measures that were planned, including the positioning and sizing of signs and markings, which were delayed at many schools, as well as the effectiveness of the designated drop zones. For certain schools, challenging traffic conditions and limited space hindered the establishment of effective drop zones within the project's budget constraints. Findings suggest that the schools situated in traffic-friendly areas where the geographical and traffic conditions did not require substantial changes, report the most positive experiences from the project.

At Schools 1 and 4, both early adopters of the Heart Zone initiative, there have been significant challenges in devising effective solutions within the allocated budget. These challenges arise from constraints such as limited space and the difficulty of creating effective drop zones, compounded by the schools' proximity to heavily trafficked roads. These factors have impeded the successful establishment of a Heart Zone perceived

as both functional and safe at these locations.

Specifically, School 4 opted against implementing the Heart Zone due to adverse physical and traffic conditions, which would necessitate more comprehensive measures than the budget could accommodate.

Additionally, the school management noted that they were already engaged in extensive non-physical measures, such as attitude-building activities, and felt that the project did not significantly enhance their existing traffic safety efforts.

4.4.2 Quantitative results

The survey contained 11 statements that measured the implementation of Heart Zone (cf. Table 6). These focus on both infrastructure measures, awareness-raising measures and statements relating to organizational routines. In order to identify which statements most effectively measure the effective implementation of Heart Zone, correlation analyses were carried out to examine relationships between these variables and three important outcome variables: (*a*) Heart Zone traffic culture measured as descriptive norms, (*b*) Knowledge of Heart Zone and (*c*) Whether parents drive their car more seldom while dropping off/picking up their children, as a result of Heart Zone.

The analysis indicates that four implementation measures in particular were correlated with all three outcome measures: *1*) Walking groups are organized to make it easier for more students to go to school, *2*) A drop-off zone has been established outside the Heart Zone, *3*) It is easy to pick up/deliver in the drop zone and *4*) You get reactions from the school management if you drive unnecessarily within the Heart Zone (Table 6).

These measures are about physical infrastructure measures (related to the drop zone) and cultural measures (arranging walking groups and leadership reactions). We have combined these four measures into a Heart Zone implementation index (min: 4 points, max: 20 points) (Cronbach's Alpha: .672). The results show that School B (16.6 points) scores the highest on the index, followed by School D (12.3 points), School A (11.6 points) and School C (11.1 points). The difference between the schools on the Heart Zone implementation index is significant at the 1% level ($p =< .001$). The differences on the index indicate better implementation of the Heart Zone measures we are asking about at school B.

4.5 Parents' perceptions of reductions in dangerous traffic situations

This section relates to the fourth aim of the study, assessing parents' perceptions of changes in traffic safety following the implementation of the Heart Zone initiative. The primary objective of the Heart Zone is to minimize car exposure near schools and enhance awareness of vulnerable road users, thereby reducing the incidence of conflicts and accidents between vehicles and these users, ultimately improving traffic safety. Furthermore, the establishment of walking groups as part of the Heart Zone initiative may also reduce conflicts, leveraging a 'safety in numbers' effect.

The survey included questions about traffic conflicts, specifically whether the implementation of the Heart Zone has resulted in a decrease in hazardous traffic situations during the drop-off and pick-up times at school. According to the findings, 35% of respondents agreed that there have been fewer dangerous situations since the Heart Zone was established, while 12% disagreed, 10% were neutral, and 38% were unsure. Additionally, 46% of the parents felt that the journey to school has become safer post-implementation, with 23% disagreeing, 10% remaining neutral, and 22% unsure. Lastly, 53% of respondents reported an increased focus on traffic safety at the school and along the school route, compared to 18% who disagreed, 2% who remained neutral, and 27% who were unsure.

4.6 Regression analyses

Two regression analyses were conducted to explore the factors influencing *a*) the traffic culture within the Heart Zone, as indicated by descriptive norms, and *b*) changes in driving behavior, specifically whether respondents reported driving less following the school's designation as a Heart Zone. These analyses aimed to identify which independent variables account for the variation in responses to these two dependent variables.

4.6.1 What predicts Heart Zone traffic culture, measured as descriptive norms?

Table 7 shows the variables influencing Heart Zone traffic culture measured as descriptive norms.

Table 6 Correlations between variables

Heart Zone implementation variables	Traffic culture	Knowledge about	Less car driving
(1) Heart Zone is a topic that has been discussed at parent meetings that have been held over the past year	n.s.	.53**	n.s.
(2) All new parents receive information about Heart Zone	n.s.	.70**	n.s.
(3) The school has routines to ensure that product deliveries, cleaning and janitorial services that include driving take place in line with the Heart Zone recommendations	.26*	.37**	n.s.
(4) Walking groups are organized to facilitate more students going to school	.34**	.33**	.30**
(5) Signs have been put up on the school grounds showing where the Heart Zone starts	n.s.	.57**	n.s.
(6) A drop zone has been established outside the Heart Zone	.32**	.31**	.29**
(7) All new employees receive information about Heart Zone	.43*	.65**	n.s.
(8) It is well organized around the school so that students can travel safely to school from where the Heart Zone begins	.32**	.32**	n.s.
(9) There is clear signage showing where the Heart Zone starts	n.s.	.54**	.18*
(10) It is easy to collect/deliver at the drop zone	.32**	.18**	.21**
(11) You get reactions from the school management if you drive unnecessarily within the Heart Zone	.17**	.14*	.30**

Traffic culture: Heart Zone traffic culture measured as descriptive norms
Knowledhe about: knowledge of Heart Zone
Less car driving: whether respondents drive their car more seldom when dropping off/picking up their kids as a result of Heart Zone
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7 Linear regression (dependent variable: Heart Zone traffic culture measured as descriptive norms; standardized beta coefficients)

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5
Sex	.08	.05	.10	.10	.14
Age		.12	.11	.10	.03
Index Heart Zone knowledge			**.21****	**.20***	.07
Heart Zone commitment				.04	-.15
Heart Zone implementation index					**.58*****
Adjusted R^2	-.004	.000	.035	.026	.279

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The analysis indicates that the primary factor significantly influencing the variation in Heart Zone traffic culture, as measured by descriptive norms, is Heart Zone Implementation. This index, which comprises four statements, shows a positive relationship; higher scores on the implementation index correspond to higher scores on the traffic culture index, after controlling for gender, age, school management's prioritization of Heart Zone, and familiarity with the initiative. Essentially, more effective implementation correlates with a stronger impact on descriptive norms.

In particular, schools that organize walking groups to encourage more students to walk, establish drop-off zones, and have school management actively discouraging unnecessary driving within the Heart Zone, tend to have more parents who consistently use

the recommended drop-off zones when driving, are mindful of students walking or cycling within the Heart Zone, and choose to walk or cycle when transporting their children. Model 5 accounts for 28% of the variation in the dependent variable, Heart Zone traffic culture.

4.6.2 What influences respondents' changes in traffic safety behavior?

Following the implementation of the Heart Zone initiative, 14.5% of parents reported a reduction in their car use for dropping off and picking up their children, irrespective of their previous habits. Additionally, 46% of parents indicated an increased awareness of vulnerable road users during the school drop-off and pick-up times, and 54% expressed a heightened concern for traffic safety both on the school road and at the school itself as a result of the Heart Zone initiative. These statements have been aggregated into an index, demonstrating internal consistency with a Cronbach's Alpha of 0.722

The variable 'Heart Zone traffic culture' shows a significant and positive contribution in Model 4, indicating a clear relationship between the traffic culture within the Heart Zone at schools and changes in respondents' traffic safety behavior. Specifically, this suggests that when a larger number of parents choose to walk or cycle to school, adhere to designated drop-off zones, and demonstrate heightened awareness of vulnerable road users, there is an increased likelihood that respondents will reduce their driving, become more conscious of vulnerable road users, and place greater emphasis on traffic safety both at the school and on surrounding roads.

Furthermore, our findings suggest a close relationship between the Heart Zone traffic culture and its implementation. Specifically, the significance of the Heart Zone traffic culture in Model 5 diminishes when the Heart Zone Implementation Index is included. This extended index encompasses the original four implementation questions, alongside measures of management and PTA commitment to the Heart Zone. Notably, the Heart Zone Implementation Index significantly influences changes in respondents' traffic safety behaviors. Thus, there appears to be a direct correlation among the implementation of Heart Zone measures, the ensuing traffic culture, and the observed modifications in traffic safety behaviors.

Finally, knowledge of Heart Zone measures and PTA membership also contribute significantly to traffic safety behavior change.

The adjusted R2 value is .194. This indicates that the variables in the model explain 19% of the variation in the respondents' traffic safety behavior.

4.6.3 What influences perceptions of dangerous traffic situations?

A total of 35% of the parents agreed that here have been fewer dangerous traffic situations related to drop-off and pick-up of children at school than before Heart Zone implementation. Table 9 shows dependent variables in the regression model that predict change in parent's perceptions of dangerous traffic situations in the vicinity of school.

The Heart Zone traffic culture significantly and positively influences Model 3, indicating a correlation between the culture within Heart Zones at schools and respondents' perceptions of reduced dangerous traffic situations during child drop-off and pick-up times since the implementation of the Heart Zone.

Moreover, the impact of Heart Zone traffic culture is demonstrably linked to the actual implementation of the Heart Zone measures. This is evident as the contribution of the 'Heart Zone traffic culture' variable diminishes in Model 4 upon the inclusion of the Heart Zone Implementation Index. This index significantly affects respondents' perceptions, further indicating a reduction in dangerous traffic situations related to child drop-off and pick-up at school post-Heart Zone implementation. The adjusted R^2 value is .386, and indicates that the variables in the model explain 39% of the variation in the respondents' traffic safety behavior.

5 Discussion

The first objective of this study was to investigate the changes in traffic culture following the implementation of the Heart Zone initiative, particularly assessing whether the schools have successfully established a Heart Zone traffic culture. Traffic safety culture is defined according to Nævestad et al. (2019) as the collective and safety-oriented behaviors in traffic, shared norms for such behaviors, and the resultant common expectations regarding others' behavior in traffic. Results from both interviews and the survey indicates that numerous schools have adopted Heart Zone cultures. In these environments, parents

Table 8 Linear regression (dependent variable: changes in traffic safety behavior; standardized beta coefficients)

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7
Sex	-.12	-.12	-.12	-.16	-.15	-.12	-.13
Age		.02	.01	-.02	-.06	-.04	-.02
Distance to school			-.09	-.09	-.04	-.04	-.05
Heart Zone traffic culture				**.24****	.08	.07	.09
Heart Zone implementation ext.					**.36*****	**.28****	**.29****
Knowledge Heart Zone						**.21***	**.22***
PTA (= 2, Other = 1)							**.24****
Adjusted R^2	.001	-.012	-.018	.027	.118	.145	.194

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 9 Linear regression (dependent variable: There have been fewer dangerous traffic situations related to drop-off and pick-up of children at school, than prior to Heart Zone implementation; standardized beta coefficients)

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4
Sex	.07	-.01	-.07	.04
Age		**.25***	.18	.06
Heart Zone traffic culture			**.47*****	**.23****
Heart Zone implementation ext.				**.48*****
Adjusted R^2	-.01	.03	.23	.39

* p < 0.1, ** p < 0.05, *** p < 0.01

typically adhere to recommended drop-off zones when driving, remain vigilant of students walking or cycling within the Heart Zone, and opt to walk or cycle when transporting their children within the area. Additionally, the interviews underscored that the Heart Zone initiative has significantly raised awareness of traffic safety among the school community.

5.1 What influences implementation of a Heart Zone traffic culture?

One of the key theoretical objectives of the study was to identify the specific factors facilitating and impeding traffic culture change, related to enclosed geographical areas like a Heart Zone, to develop knowledge that researchers and future traffic culture measures like this can learn from. This relates to the third aim of the study. The paper does that by developing further the model of traffic culture change suggested by Nævestad et al. (2019), which focuses on safety culture change in geographical areas, combining this with safety culture models focusing on safety culture change within organizations (Schein, 2004; Nævestad et al., 2018). This hybrid approach to safety culture change is needed, first as the Heart Zone is a measure to influence traffic culture in an enclosed geographical area, including a range of different road users (e.g. students, parents, teachers, delivery services). Second, as this process largely is led by an organization (i.e. the school). This analytical approach is the unique contribution of the study. Figure 2, depicts an analytical model, developed based on the qualitative and the quantitative data from this study. The model depicts relationships observed based on the data, and the hybrid theoretical approach to safety culture research. Given that this is a new model based on a relatively small sample, the relationships depicted indicate issues that should be examined further in future research.

5.1.1 Factors related to implementation of culture in geographical areas

Interaction of road users. Previous research indicates that shared norms continually are created and recreated through interaction among road users in traffic (Luria et al., 2014; Nævestad et al., 2019; Özkan et al., 2006). Our results also indicate the importance of this. The quantitative data indicate that one of the important drivers of a Heart Zone traffic safety culture is that that walking groups are organized to make it easier for more students to go to school. This also aligns well with the results from the interviews, where walking groups are

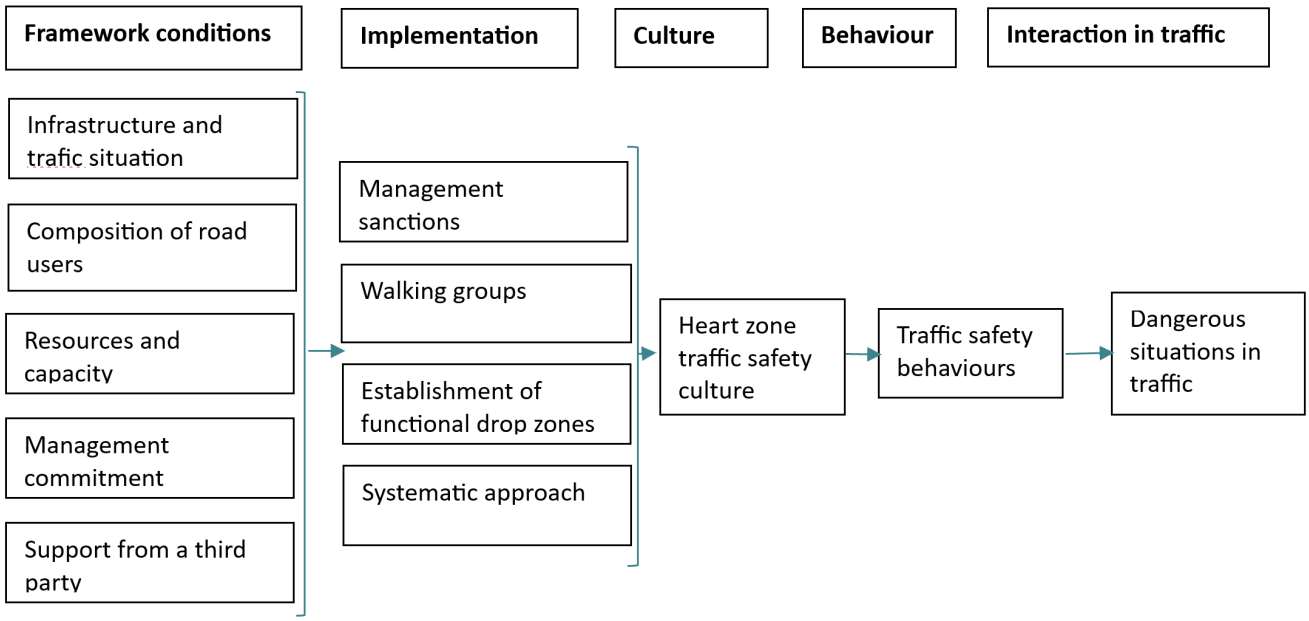

Figure 2 Analytical model of relationships developed based on the qualitative and the quantitative data

highlighted as a measure that many schools experienced has worked well.

Infrastructure and traffic situation. Our results indicate that infrastructure is an important factor influencing the implementation of a Heart Zone traffic culture. The quantitative data indicate that the following variables are related to implementation of a Heart Zone traffic culture: that a drop-off zone is established outside the Heart Zone and that it is perceived to be easy to pick up/deliver at the drop-off zone and. The importance of infrastructure for traffic safety culture is in line with previous research (Nævestad et al., 2019; Özkan et al., 2006).

The qualitative data reveal that the suitability of the surrounding infrastructure significantly impacts the feasibility and effectiveness of establishing a Heart Zone at various schools. There is a notable variance in the initial conditions for implementing the Heart Zone initiative, particularly in terms of infrastructure and traffic conditions. In certain cases, schools are located in environments where the existing infrastructure and traffic situation are conducive to the establishment of a Heart Zone without significant physical modifications. Conversely, at other schools, challenges presented by the infrastructure, roads, and nearby traffic conditions have made it difficult to find effective and optimal solutions (for example for finding optimal areas that can function as drop off zones, or establishing alternative routes for motorized traffic).

The effectiveness and acceptance of a Heart Zone significantly depend on its perceived adequacy, which in turn promotes a sense of engagement and ownership within the school community. Satisfaction typically arises from a combination of tangible physical improvements and efforts to cultivate a safety-conscious mindset. Nevertheless, when initial conditions are marred by problematic infrastructure and complex traffic situations, and when adjustments to meet Heart Zone standards are constrained, the perceived shortcomings of the solution can hinder the initiative's overall success.

The qualitative data suggest that the successful implementation of a Heart Zone partly hinges on the existence of specific physical conditions. In the absence of such conditions, efforts to foster a safety-oriented culture alone may prove insufficient. While some schools benefit from favorable physical environments conducive to the Heart Zone concept, such as adequate lighting, suitable areas to establish drop-off zones, and minimal nearby heavy traffic, others face inherent challenges that require additional resources and extensive infrastructure improvements for effective resolution.

Schools with less suitable infrastructure and traffic conditions may also find it more difficult to carry out impactful attitude work. On the one hand, many of the drivers who are responsible for the car traffic around the schools will be people outside the school's sphere

of influence, who do not have children at the school and neither receive information nor participate in forums where information about Heart Zone is shared.

The composition of road users as an impeding factor. Previous research has demonstrated the significance of road user composition on traffic culture (Ellis et al., 2019; Nævestad et al., 2019). Heart Zone aims to influence the composition of road users by reducing motorized traffic in the vicinity of the school, and increase the share of pedestrians and cyclists. However, findings indicate that in the vicinity of some schools, the composition of road users may also include several 'external' road users that are not affiliated with the school. This diversity presents a challenge in influencing traffic culture within a geographically defined area like the Heart Zone, as not all individuals passing through may be aware of the Heart Zone measures or understand their objectives. It is conceivable that in areas where road users are more homogenous, primarily consisting of individuals associated with the school, fostering a unified traffic culture could be more straightforward. Conversely, in settings where the mix of road users includes a significant number of individuals unconnected to the school, establishing a shared traffic culture becomes more challenging.

5.1.2 Factors related to implementation of culture interventions in organizational settings

Management sanctions. Sanctioning unnecessary driving in the Heart Zone also appears to be an important factor. The quantitative data indicates the importance of the fact that one gets reactions from the school management if you drive unnecessarily within the Heart Zone. This is in line with research on cultural management in organizations (Schein, 2004). The fact that leaders signal cultural values through sanctions is a very central way of influencing culture. In studies of traffic safety culture within geographical areas, the police generally have the role as a sanctioning authority, influencing traffic safety culture and behavior (Elvik et al., 2009; Özkan et al., 2006). In a study on the implementation of School Streets at two schools in London (Thomas, 2022), the placement of video cameras outside school entrances, coupled with the issuance of tickets, proved effective in ensuring that parents and others complied with the rules.

Management commitment. Interview data indicates that the role of the school management has been important in that the measure has been incorporated into the school's formal processes and given priority where possible. They have largely worked to ensure that Heart Zone is regularly put on the agenda and discussed in important forums such as parent meetings, pupil council meetings and PTA meetings. The PTA has also played an important role in the Heart Zone work. This is in line with research on safety culture finds that management commitment to safety is the most fundamental prerequisite for safety culture measures to be successful (Flin et al., 2000). Qualitative results indicate that school management commitment was of great importance for the Heart Zone culture. This is in line with much previous research which shows that commitment from top management is a very important prerequisite for safety culture measures to be successful (Edkins, 1998; Flin et al., 2000; Lappalainen et al., 2012; Zuschlag et al., 2016). Several studies on school streets implementation indicate the importance of management commitment (Noble et al., 2021; Thomas, 2022; Edinburgh, 2016).

When the initiative receives support from the school management, it gives a clear signal that this is something the school prioritizes. Furthermore, findings suggest that it is crucial that the measure is integrated into the school's routines and included in key discussion forums, such as parent meetings and student councils, as well as communicated through essential channels to parents and students. This is in line with Schein (2004) 'concept of day-to-day management. The results indicate that commitment from the PTA also has been important.

Systematic approach. In the interviews, the traffic safety plan is highlighted by several as a useful tool and appears to be a promoting factor. The traffic safety plan has contributed to systematizing the traffic safety work that the schools already do, while at the same time giving direction to the attitude-creating work of the school management. Several previous studies also find that work with plans in line with the continuous improvement approach, facilitates safety culture change, particularly through safety management systems (Lappalainen et al., 2012; Zuschlag et al., 2016).

Resources and capacity. Interview results indicate that the school management's limited capacity was a factor impeding implementation to a large extent.

Several expressed in the interviews that it has been challenging for the school management to devote sufficient time and resources to Heart Zone. This is in line with previous research, which shows that in some contexts, employees may have little time to work on the measures, and this may affect the quality of the process (Størkersen et al., 2020; Bye & Aalberg, 2020). Moreover, qualitative data also indicates the importance of economic framework conditions: at schools 1 and 4, which were both early adopters of the Heart Zone work, they have experienced difficulties in finding good solutions within the budget framework.

Support from a third party is also indicated as important in the qualitative data, which indicated that the status as a municipal area of investment contributed to giving Heart Zone a good starting point. The importance of support from a third party is in line with results from previous research, which indicate that successful interventions often are facilitated by support from third parties (Zuschlag et al., 2016).

5.2 What influences changes in respondents' traffic safety behavior?

The second aim of the study was to examine changes in parents' traffic safety behavior as a result of Heart Zone. We define traffic safety culture as common and safety-relevant ways of behaving in traffic, common norms for such behavior, and thus common expectations about the behavior of others in traffic (Nævestad et al., 2019).

This definition operationalizes traffic culture as descriptive norms, which is defined as our perceptions of what others actually do (Ward et al., 2010). Descriptive norms influence behavior by providing information about what is 'normal' (Cialdini et al., 1990). Our multivariate analyzes show a relationship between descriptive norms among the parents who responded to the survey and their own behavior. With our operationalization of traffic culture as descriptive norms, we theoretically assume that the mechanism mediating between culture (common norms and expectations) and traffic behavior is 'subtle social pressure' (Cialdini et al., 1990). This means that our knowledge of what is 'normal' or 'socially accepted' based on our assumption of what others usually do, motivates our own behavior in traffic.

5.3 Limitations and recommendation for future research

An experimental pre-post design, incorporating both control and experimental groups, is often regarded as the 'gold standard' for evaluating the effects of interventions. However, due to the considerable variations between schools in their definitions and implementations of the Heart Zone, a traditional experimental design was deemed unsuitable for this context. Ideally, a pre-post design would have been employed; however, data collection commenced only after the Heart Zone initiative was already implemented in Bergen, making such a design unfeasible. This limitation is acknowledged in our study. For future research on the Heart Zone, adopting a more robust design is recommended to ensure a comprehensive analysis of the initiative's long-term impacts.

The data for this study were derived from a selected sample of schools, chosen to reflect variations in size, traffic conditions, and duration of Heart Zone implementation within Bergen Municipality The sample encompasses interviews and surveys from only six and four schools, respectively, out of the 66 implementing the scheme. This selection may not fully represent the broader range of environments and experiences across the entire municipality, which can be considered a limitation.

Despite the limited sample size, the study incorporates a diverse array of schools that varying in size, traffic conditions, and the duration of Heart Zone implementation. The diverse experiences and outcomes reported in both the interviews and survey results suggest that our sample encompasses a broad spectrum of school environments. Consequently, there is substantial reason to believe that this evaluation provides an insightful overview of how the Heart Zone initiative has been implemented across different institutional environments.

In this evaluation, a mixed-methods approach, integrating both qualitative and quantitative data sources was employed. Triangulating data in this manner is advantageous as it enables a comprehensive analysis of the implementation process, offering both depth and breadth of understanding. The qualitative data offer detailed accounts of the organization and firsthand experiences of the scheme. Conversely, the quantitative data provide insights into the perception and impact of the measure on traffic culture among the

target group, allowing for the statistical examination of relationships and trends.

A weakness of the study is that we have used data sources that are largely based on self-reported responses. Several types of bias can arise in research, with common examples including bias due to fallible memory, where respondents may recall events inaccurately or vaguely. In both surveys and interviews, social desirability bias is a well-known issue, where respondents or informants might alter their responses to present themselves in a more favorable light, often resulting in over-reporting or under-reporting certain behaviors or opinions. Although there are no clear indications that social desirability significantly impacted our results, there is evidence suggesting that memory biases affected the responses, particularly among informants from schools that implemented the Heart Zone early on. Many informants noted difficulties in recalling specific details due to the time elapsed since the implementation. Nevertheless, there were also several who pointed out that talking about the process in the interview situation helped to help them remember.

Another point for discussion concerns the demographics of the survey respondents. Although we received responses from 240 individuals, the absence of data on the total number of recipients means that we cannot calculate the response rate. Typically, individuals with a strong interest in the subject matter are more likely to participate in such surveys. Notably, there is an over representation of women among the respondents, consistent with research indicating that they often assume greater responsibility for tasks associated with 'the third shift', including managing children's daily school activities. This skew in the sample could plausibly influence the outcomes observed in our study.

6 Conclusions

Both the results from the interviews and the survey suggest that several schools have established Heart Zone cultures, where parents usually drop the children off at the recommended drop-off zone, if they are driving, are attentive to students who come walking/cycling within the Heart Zone, walk or cycle when transporting children within the Heart Zone. The Heart Zone culture is related to changes in parents' perceived traffic safety behaviors and reductions in perceived dangerous traffic situations.

CRediT contribution statement

Vibeke Milch: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing—original draft. **Tor-Olav Nævestad:** Conceptualization, Formal analysis, Investigation, 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 (Milch & Nævestad, 2022).

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.

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