Subjective Road Safety

Approach for Dutch municipalities to gain insight into subjective road safety

Transport, Infrastructure and Logistics

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by

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TU Delft kennis netwerk spv Strategisch Plan Verkeersveiligheid SWOV INSTITUTE FOR ROAD SAFETY RESEARCH

Preface

For this thesis project I came to SWOV. During my earlier years of study, I had regularly come across reports and articles published by the institute. These topics had always fascinated me greatly, so I decided to ask if they had a place for my graduation project. To my delight, they did. After consultation, I started a project on subjective road safety. Although I knew little about the subject at the time, it immediately appealed to me and still does.

The subject of this report lies at the intersection of technical elements and the human aspect of traffic. I find that particularly interesting. Despite the long road to graduation, I never got tired of the subject. On the contrary, I keep seeing how fascinating, dynamic and important it is in today's society.

I have faced many obstacles during this project and beyond. I would like to thank everyone who has supported me through it all. It has been a long road, but your support has made it possible. First of all, I would like to thank Charlotte, who has supported me intensively on behalf of SWOV. I cherish our substantive discussions, but also the moments when we chatted about something else. I will miss this dearly. I would like to thank Haneen and Eleonora for their input, their commitment and for giving me space when I needed it. I would also like to thank Bert for his trust and interest, even in the background.

Finally, I would like to thank my friends and family for their continued support and trust. Cécile, thank you for allowing me to work in your office when it was otherwise very quiet. Selma, thank you for the 'working from home days' with you. Frank, thank you for your support during this time. Thank you all for all the times you proofread my chapters and gave me valuable feedback. I could not have done this without you.

Anne de Hoop
Delft, November 2024

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Summary

A Dutch summary is provided hereafter.

Introduction

Road safety in the Netherlands has deteriorated in recent years. After a long period of decline, the number of road casualties has unfortunately started to rise again. This is happening at a time when road safety goals are becoming increasingly demanding and ambitious by pursuing zero road deaths and casualties. This situation makes a change of approach necessary. At national level, the Strategic Road Safety Plan has been established. This plan puts more emphasis on a risk-based approach. It uses safety performance indicators to determine whether certain areas can be made safer before accidents occur. The plan also mentions subjective road safety as a possible source of information.

Yet it remains unclear how subjective road safety can contribute to the risk-based approach and thereby reduce traffic casualties, which is also seen as objective road safety. Municipalities receive many complaints from citizens about road safety. However, dealing with these complaints is difficult and time-consuming because there are no clear guidelines in this area. Although municipalities recognise the importance of subjective road safety, they lack sufficient insight and tools to deal with it effectively.

Objectives

Municipalities would like to work on subjective road safety, but the available scientific studies often do not match the requests they have. This research focuses on clarifying the ambiguity surrounding subjective road safety. To provide insight into subjective road safety, it is first important to investigate what exactly this concept means. It is also necessary to look at the different methods available to measure subjective road safety. Next, it is essential to investigate whether these methods are compatible with practical use and suitable for application within municipalities.

For this study, a main question and three sub-research questions have been formulated. The three sub-research questions are:

1. *How is subjective road safety defined and measured in scientific literature?*
2. *How is subjective road safety defined and measured by stakeholders and how do they use this information in their activities?*
3. *What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies*?

Main research question:

How can subjective road safety be measured and the outcomes be used in policies in municipalities in the Netherlands?

Methods

Three methods were used in this study. First, a scientific literature study is conducted. The literature reviewed was identified using six different search terms. The search terms used were ('subjective road safety'), ('subjective traffic safety'), ('subjective safety' AND (road OR traffic OR transport)), ('perceived risk' AND (road OR traffic)), (('individual safety perception') AND (road OR traffic OR transport)) and (('safety perception') AND (road OR traffic OR transport)). This literature was supplemented by forward and backward snowballing and by research provided by experts in the field. Contact with these experts was established mainly through SWOV. After a selection based on title and abstract, 31 relevant studies remained to be included in the literature review.

Next, grey literature is examined, as it is often closer to practice than scientific literature. For the grey literature, stakeholders, knowledge organisations and interest groups have been considered. Of these stakeholders, 13 were included in the study.

Finally, interviews were held with several municipalities in the Netherlands. These municipalities were selected on the basis of four different characteristics: the municipality's knowledge of subjective road safety, the number of inhabitants, the location, and the urbanisation of the municipality. Different characteristics were used to get a picture of the whole spectrum of different types of Dutch municipalities. In total, 10 municipalities were approached, of which traffic officials from six municipalities participated in the interviews. This is because the remaining four municipalities unfortunately did not respond to requests to participate.

The interviews are semi-structured. In the pre-structured format, five main topics are set up: the definition of subjective road safety as perceived by the municipality, the available data the municipality currently has to map subjective road safety, the goals municipalities had with regard to subjective road safety, the resources available to take measurements, and the municipality's needs with regard to dealing with subjective road safety. The interviews were conducted through

Teams and lasted about one hour. Thematic analysis was used for processing. The interviews were transcribed and coded, after which the codes were linked to themes within the interviews. Following this, links were made to draw conclusions from these themes.

Results

The scientific literature is found that there is no common definition of subjective road safety. It is often referred to as risk perception and the feeling of road safety. In this study, a division was made into different aspects of subjective road safety that should be included to get a complete picture of this concept. These aspects are:

- **Emotional aspects**: The feeling of safety or fear in traffic situations
- **Cognitive aspects**: The assessment of risks and dangerous situations
- **Individual dimension**: The personal perception of road safety
- **Social dimension**: The shared concerns or perceptions within a community
- **Concern for themself**: Concern about one's own safety
- **Concern for others**: Concern about the safety of others, such as children or vulnerable road users
- **Active participation**: The experience of road safety as an active participant
- **Passive observation**: The observation of road safety without direct involvement (for example as an observer)

For municipalities and interest groups, the focus is more often on the emotional side when defining subjective road safety, although an explicit definition is often lacking. In addition, they place more emphasis on the tension between objective and subjective road safety.

In science, proactive methods are used to measure subjective road safety, often in the form of experiments or before-and-after studies. Methods used in the scientific literature include: surveys, interviews, the use of machine learning or measurements of physiological traits.

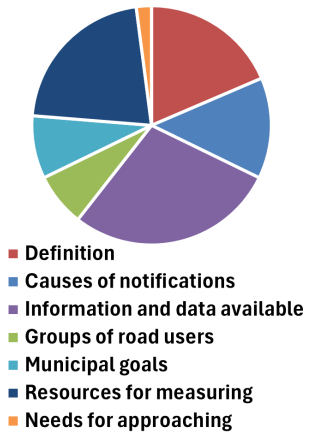

Figure 1: Proportion of different themes

In practice, municipalities and interest groups take a more reactive approach. They collect information mainly through citizen complaints, which are often submitted via websites or apps. In addition, some municipalities use surveys and neighbourhood interviews to gain better insight, usually in response to reports or when infrastructure changes are planned.

In the coding process, 101 different codes were used to represent the content of the six interviews. These codes were divided into seven themes, namely Definition of subjective road safety as it is understood by the municipalities; Causes of notifications of subjective road safety Information, data and investigations already available to municipalities; Groups of road users that stand out in subjective road safety; Municipal goals for subjective road safety; Resources within municipalities for approaching subjective road safety; and Municipal needs for approaching subjective road safety. The distribution of the frequency with which codes were mentioned within these themes is shown in Figure 1.

The interviews show that municipalities have difficulty separating subjective from objective road safety. Many municipalities find it difficult to deal with subjective road safety when no objective cause can be found. In addition, it takes a lot of time to identify causes. Almost all information received by municipalities is reactive and obtained through complaints. Municipalities are not waiting for more data, but are looking for a structured way to deal with the many ambiguities surrounding subjective road safety. This handling and decision making are further complicated by the fact that no concrete goals have yet been set within municipalities for subjective road safety.

Discussion

This research highlights the importance of a clear and consistent definition of subjective road safety in scientific research, consisting of emotional, cognitive, individual and social aspects, as well as concern for self, others, active participation and passive observation. Currently, the focus is mainly on risk perception, but a more integrated approach can provide a more complete picture. This also applies to future research on self-driving vehicles, where a broader focus can contribute to better-designed systems that match human needs and experiences.

In this study, only six interviews were used. As a result, it is not possible to make statements about the differences between these municipalities on this basis. For follow-up research, it could be interesting to investigate to what extent certain characteristics of municipalities or neighbourhoods influence subjective road safety.

In addition, this study takes a step towards clarifying subjective road safety. It is known that subjective and objective road safety influence each other, although the two forms coexist. It would be particularly interesting to understand more about the variables that lie between the two. These variables could help predict changes in objective road safety when subjective road safety changes, and vice versa.

Conclusion

1. *How is subjective road safety defined and measured in scientific literature?* Subjective road safety is often defined in the literature as the perception of risk or sense of safety in traffic. Measurements use surveys, interviews, machine learning, or physiological data, usually with a proactive approach in experimental or before-and-after studies.
2. *How is subjective road safety defined and measured by stakeholders and how do they use this information in their activities?* Stakeholders, such as municipalities and interest groups, often focus on the emotional side and do not use a uniform definition. Measurements are usually reactive and based on citizen complaints, supplemented by surveys and neighbourhood interviews. Processing the information is time-consuming and structure is lacking.
3. *What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?* Municipalities want to make citizens feel safe and reduce unsafe situations, but concrete goals are often lacking. The data collected can be used to set priorities when addressing traffic problems, but again a guideline is missing.

Main research question:

How can subjective road safety be measured and the outcomes be used in policies in municipalities in the Netherlands?

Subjective road safety can be measured by both proactive and reactive methods, depending on the kind of goal a municipality has about subjective road safety. This study offers a first step in clarifying the concept of subjective road safety. It highlights that subjective road safety encompasses more than just emotions or risk perceptions, such as the aspects emotional, cognitive, individual and social, concerns about oneself or concerns about another, actively participating or passively observing. By using reactive and proactive measurement methods and taking into account the interaction between subjective and objective road safety, municipalities can develop targeted policies that both increase feelings of safety and reduce road casualties.

Samenvatting

Introductie

De afgelopen jaren is de verkeersveiligheid in Nederland verslechterd. Na een lange periode van daling in het aantal verkeersslachtoffers is er helaas weer een stijgende trend zichtbaar. Dit terwijl de gestelde doelen op het gebied van verkeersveiligheid steeds strenger en ambitieuzer worden door het na streven van nul verkeersdoden en slachtoffers. Deze situatie vraagt om een verandering in de aanpak. Op nationaal niveau is het Strategisch Plan Verkeersveiligheid opgesteld. In dit plan wordt meer nadruk gelegd op een risico-gestuurde aanpak. Hierbij wordt met behulp van safety performance indicators bepaald of specifieke gebieden veiliger kunnen worden gemaakt, nog voordat er ongevallen plaatsvinden. In dit plan wordt ook de subjectieve verkeersveiligheid genoemd als mogelijke bron van informatie.

Toch blijft het onduidelijk hoe de subjectieve verkeersveiligheid kan bijdragen aan de risico gestuurde aanpak en daarbij het verminderen van het aantal verkeersslachtoffers, dat ook wel wordt gezien als de objectieve verkeersveiligheid. Gemeenten ontvangen veel klachten van burgers over verkeersveiligheid. Het verwerken van deze klachten is echter moeilijk en tijdrovend, omdat er op dit gebied geen duidelijke richtlijnen bestaan. Hoewel gemeenten het belang van subjectieve verkeersveiligheid erkennen, ontbreekt het hen aan voldoende inzicht en handvatten om hiermee effectief aan de slag te gaan.

Doelen

Gemeenten willen graag aan de slag met subjectieve verkeersveiligheid, maar de beschikbare wetenschappelijke onderzoeken sluiten vaak niet aan bij de vragen die zij hebben. Dit onderzoek richt zich op het verduidelijken van de onduidelijkheid rondom subjectieve verkeersveiligheid. Om inzicht te bieden in subjectieve verkeersveiligheid, is het allereerst belangrijk om te onderzoeken wat dit begrip precies betekent. Daarnaast moet worden gekeken naar de verschillende methoden die beschikbaar zijn om subjectieve verkeersveiligheid te meten. Vervolgens is het essentieel om te onderzoeken of deze methoden aansluiten bij de praktijk en geschikt zijn voor toepassing binnen gemeenten.

Voor dit onderzoek zijn een hoofdvraag en drie deelvragen opgesteld. De drie deelvragen zijn:

1. *Hoe wordt subjectieve verkeersveiligheid gedefinieerd en gemeten in de wetenschappelijke literatuur?*
2. *Hoe wordt subjectieve verkeersveiligheid gedefinieerd en gemeten door belanghebbenden en hoe gebruiken zij deze informatie in hun activiteiten?*
3. *Wat zijn de doelstellingen van gemeenten met betrekking tot subjectieve verkeersveiligheid en hoe gebruiken zij deze informatie in hun beleid?*

Hoofdonderzoeksvraag:

Hoe kan subjectieve verkeersveiligheid worden gemeten en hoe kunnen de uitkomsten worden gebruikt in het beleid van gemeenten in Nederland?

Methodes

In dit onderzoek zijn drie methodes gebruikt. Allereerst is er een wetenschappelijk literatuuronderzoek uitgevoerd. De onderzochte literatuur is gevonden aan de hand van zes verschillende zoektermen. De gebruikte zoektermen zijn: (”subjective road safety”), (”subjective traffic safety”), (”subjective safety” AND (road OR traffic OR transport)), (”perceived risk” AND (road OR traffic)), ((”individual safety perception”) AND (road OR traffic OR transport)) en ((”safety perception”) AND (road OR traffic OR transport)). Deze literatuur is aangevuld door middel van forward en backward snowballing en door onderzoeken die zijn aangedragen door experts uit het veld. Het contact met deze experts is voornamelijk via SWOV tot stand gekomen. Na een selectie op basis van titel en abstract zijn er 31 relevante onderzoeken overgebleven die in het literatuuronderzoek zijn meegenomen.

Vervolgens is er onderzoek gedaan naar grijze literatuur, omdat deze vaak dichter bij de praktijk staat dan wetenschappelijke literatuur. Voor de grijze literatuur is er gekeken naar stakeholders, kennisorganisaties en belangenorganisaties. Van deze betrokken partijen zijn er 13 meegenomen in het onderzoek.

Als laatste zijn er interviews gehouden met verschillende gemeenten in Nederland. De keuze voor deze gemeenten is gemaakt op basis van vier verschillende karakteristieken: De voor keniins van een gemeente over subjectieve verkeersveiligheid, het aantal inwoners ven de gemeente, de locatie, en de stedelijkheid van de gemeente. Er is gebruikgemaakt van verschillende karakteresiteken om een beeld te krijgen van het gehele spectrum an verschillende soorten Nederlandse gemeenten. In totaal zijn 10 gemeenten benaderd, waarvan verkeersambtenaren uit zes gemeenten hebben deelgenomen aan de interviews. Dit omdat de overige vier gemeente helaas niet hebben gereageerd op de verzoeken om deel te nemen.

De interviews zijn semigestructureerd. In de vooraf opgestelde structuur zijn er vijf hoofdonderwerpen opgesteld: de definitie van subjectieve verkeersveiligheid zoals die door de gemeente word gezien, de beschikbare data die de gemeente op dit moment heeft om subjectieve verkeersveiligheid in kaart te brengen, de doelen die gemeenten hedden met betrekking tot subjectieve verkeersveiligheid, de beschikbare middelen om metingen te doen, en de behoefte van de gemeente met betrekking tot het omgaan met subjectieve verkeersveiligheid. De interviews zijn via Teams afgenomen en duurden ongeveer één uur. Voor de verwerking is gebruikgemaakt van een thematische analyse. De interviews werden uitgeschreven en gecodeerd, waarna de codes zijn gekoppeld aan thema's binnen de interviews. Hierna zijn verbanden gemaakt om conclussies te kunnen treken uit deze thema's.

Resultaten

In de wetenschappelijke literatuur is gevonden dat er geen gangbare definitie is van subjectieve verkeersveiligheid. Er wordt vaak gesproken over risicoperceptie en het gevoel van verkeersveiligheid. In dit onderzoek is een splitsing gemaakt in verschillende aspecten van de subjectieve verkeersveiligheid die moeten worden meegenomen om een volledig beeld te krijgen van dit concept. Deze aspecten zijn:

- **Emotionele aspecten**: Het gevoel van veiligheid of angst in verkeerssituaties
- **Cognitieve aspecten**: Het inschatten van risico's en gevaarlijke situaties
- **Individuele dimensie**: De persoonlijke perceptie van verkeersveiligheid
- **Maatschappelijke dimensie**: De gedeelde zorgen of percepties binnen een gemeenschap
- **Zorg om zichzelf**: Bezorgdheid over de eigen veiligheid
- **Zorgen om anderen**: Bezorgdheid over de veiligheid van anderen, zoals kinderen of kwetsbare weggebruikers
- **Actieve deelname**: De ervaring van verkeersveiligheid als een actieve deelnemer
- **Passieve observatie**: Het observeren van verkeersveiligheid zonder directe betrokkenheid (bijvoorbeeld als waarnemer)

De werkdefinitie die is opgesteld na de analyse van de wetenschappelijke literatuur is: *"Het gevoel van onveiligheid dat mensen ervaren in het verkeer, of ze er nu actief aan deelnemen of niet, voor alle vervoerswijzen.*"

Bij gemeenten en belangenorganisaties ligt de focus vaker op de emotionele kant wanneer zij een definitie geven van subjectieve verkeersveiligheid, hoewel een expliciete definitie vaak ontbreekt. Daarnaast leggen zij meer nadruk op de spanning tussen objectieve en subjectieve verkeersveiligheid.

In de wetenschap worden proactieve methoden gebruikt om subjectieve verkeersveiligheid te meten, vaak in de vorm van experimenten of voor- en nastudies. Methoden die in de wetenschappelijke literatuur worden gebruikt zijn: enquêtes, interviews, het gebruik van machine learning of metingen van fysiologische eigenschappen.

In de praktijk hanteren gemeenten en belangenorganisaties een meer reactieve aanpak. Zij verzamelen informatie voornamelijk via klachten van burgers, die vaak worden ingediend via websites of apps. Daarnaast maken sommige gemeenten gebruik van enquêtes en buurtinterviews om beter inzicht te krijgen, meestal als reactie op meldingen of bij geplande veranderingen in de infrastructuur.

In het coderingsproces zijn 101 verschillende codes gebruikt om de inhoud van de zes interviews weer te geven. Deze codes zijn onderverdeeld in zeven thema's, namelijk de definitie van subjectieve verkeersveiligheid zoals de gemeenten die verstaan, de oorzaken van meldingen van subjectieve verkeersveiligheid, en de informatie, gegevens en onderzoeken waarover gemeenten al beschikken. Daarnaast zijn groepen weggebruikers die opvallen in de context van subjectieve verkeersveiligheid, gemeentelijke doelen en middelen voor de aanpak van subjectieve verkeersveiligheid, en de behoeften van gemeenten voor deze aanpak. De verdeling van de frequentie waarmee codes binnen deze thema's zijn genoemd, wordt weergegeven in Figuur 2.

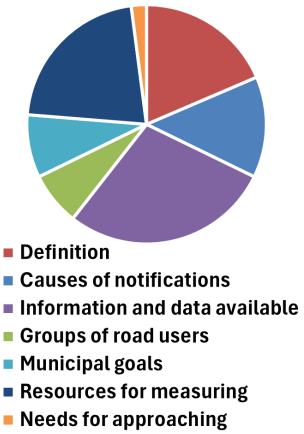

Figure 2: Verhouding tussen verschillende thema's

Uit de interviews blijkt dat gemeenten moeite hebben met de scheiding tussen subjectieve en objectieve verkeersveiligheid. Veel gemeenten vinden het lastig om met subjectieve verkeersveiligheid om te gaan wanneer er geen objectieve oorzaak te vinden is. Daarnaast kost het veel tijd om de oorzaken te achterhalen. Bijna alle informatie die bij gemeenten binnenkomt, is reactief en wordt verkregen via klachten. Gemeenten zitten niet te wachten op meer data, maar zoeken een gestructureerde manier om om te gaan met de vele onduidelijkheden rondom subjectieve verkeersveiligheid. Deze omgang en het nemen van beslissingen worden extra bemoeilijkt doordat er binnen gemeenten nog geen concrete doelen zijn vastgesteld voor subjectieve verkeersveiligheid.

Discussie

Dit onderzoek benadrukt het belang van een duidelijke en consistente definitie van subjectieve verkeersveiligheid in wetenschappelijk onderzoek, bestaande uit emotionele, cognitieve, indi-

viduele en sociale aspecten, evenals zorg voor zichzelf, anderen, actieve deelname en passieve observatie. Momenteel ligt de nadruk vooral op risicoperceptie, maar een meer geïntegreerde benadering kan een completer beeld opleveren. Dit geldt ook voor toekomstig onderzoek naar zelfrijdende voertuigen, waar een bredere focus kan bijdragen aan beter ontworpen systemen die aansluiten bij menselijke behoeften en ervaringen.

In dit onderzoek is enkel gebruikgemaakt van zes interviews. Hierdoor is het niet mogelijk om op basis hiervan uitspraken te doen over de verschillen tussen deze gemeenten. Voor vervolgonderzoek zou het interessant kunnen zijn om te onderzoeken in hoeverre bepaalde kenmerken van gemeenten of buurten invloed hebben op de subjectieve verkeersveiligheid.

Daarnaast zet dit onderzoek een stap in de richting van meer duidelijkheid over subjectieve verkeersveiligheid. Het is bekend dat subjectieve en objectieve verkeersveiligheid elkaar beïnvloeden, hoewel deze twee vormen naast elkaar bestaan. Het zou bijzonder interessant zijn om meer inzicht te krijgen in de variabelen die tussen beide liggen. Deze variabelen kunnen helpen bij het voorspellen van veranderingen in de objectieve verkeersveiligheid wanneer de subjectieve verkeersveiligheid verandert, en vice versa.

Conclusie

1. *Hoe wordt subjectieve verkeersveiligheid gedefinieerd en gemeten in de wetenschappelijke literatuur?* Subjectieve verkeersveiligheid wordt in de literatuur vaak omschreven als de perceptie van risico of het gevoel van veiligheid in het verkeer. Metingen maken gebruik van enquêtes, interviews, machine learning, of fysiologische gegevens, meestal met een proactieve aanpak in experimentele of voor en na-studies.
2. *Hoe wordt subjectieve verkeersveiligheid gedefinieerd en gemeten door belanghebbenden en hoe gebruiken zij deze informatie in hun activiteiten?* Belanghebbenden, zoals gemeenten en belangenorganisaties, richten zich vaak op de emotionele kant en hanteren geen uniforme definitie. Metingen zijn meestal reactief en gebaseerd op klachten van burgers, aangevuld met enquêtes en buurtinterviews. Het verwerken van de informatie kost veel tijd en structuur mist.
3. *Wat zijn de doelstellingen van gemeenten met betrekking tot subjectieve verkeersveiligheid en hoe gebruiken zij deze informatie in hun beleid?* Gemeenten willen burgers een veilig gevoel geven en onveilige situaties verminderen, maar concrete doelen ontbreken vaak. De verzamelde gegevens kunnen worden gebruikt om prioriteiten te stellen bij het aanpakken van verkeersproblemen, maar ook hier mist er een richtlijn.

Hoofdonderzoeksvraag:

Hoe kan subjectieve verkeersveiligheid worden gemeten en hoe kunnen de uitkomsten worden gebruikt in het beleid van gemeenten in Nederland?

Subjectieve verkeersveiligheid kan gemeten worden met zowel proactieve als reactieve methoden, afhankelijk van het soort doel dat een gemeente heeft over de subjectieve verkeersveiligheid. Dit onderzoek biedt een eerste stap in het verduidelijken van het concept van subjectieve verkeersveiligheid. Het benadrukt dat subjectieve verkeersveiligheid meer omvat dan alleen emoties of risicopercepties, zoals de aspecten emotioneel, cognitief, individueel en maatschappelijk, zorgen over zich zelf of zorgen over een ander, actief deelnemend of passief observerent. Door reactieve en proactieve meetmethoden en rekening te houden met de interactie tussen subjectieve en objectieve verkeersveiligheid, kunnen gemeenten gericht beleid ontwikkelen dat zowel het gevoel van veiligheid vergroot als het aantal verkeersslachtoffers vermindert.

Contents

Abbreviations

Abbreviation	Definition
CBS	Statistics Netherlands (Centraal Bureau voor de Statistiek)
CROW	Knowledge organisation safe and sustainable physical environment
RWS	Rijkswaterstaat
SPI	Safety performance indicators
SPV	Strategic Plan Road Safety (Strategisch Plan Verkeersveiligheid)
SWOV	Institute for Road Safety Research
VNG	Vereniging van Nederlandse Gemeenten
VVN	Veilig Verkeer Nederland
WHO	World Health Organisation

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Introduction

In September 2023, a European study revealed that four out of ten Amsterdam residents feel unsafe in traffic (NOS nieuws, 2023). This research included 25 European cities, and Amsterdam ranked the lowest in terms of perceived safety (Lupas, 2023). The feeling of insecurity in traffic is not limited to large cities alone. Throughout the Netherlands, municipalities receive reports and complaints about unsafe traffic situations.

This study will look at this subjective road safety. In the Netherlands, many municipalities receive complaints about unsafe traffic situations and it is difficult for these municipalities to deal with these complaints. What is the value of such complaints if there are no real accidents?

1.1. Context of the study

Mobility is very important in the Netherlands. Almost everyone participates in transport. According to Statistics Netherlands (Centraal Bureau voor de Statistiek, Veld, Schakel, & Heukelingen, 2023), participation in transport was 73.8 percent in 2020, with people over the age of 6 making an average of 2.3 journeys per day.

The transport system plays a crucial role in facilitating these journeys and has become deeply integrated into our daily lives. The responsibility for road safety in the Netherlands falls largely to the government. The Ministry of Infrastructure and Water Management has a mission to ensure that people can navigate traffic safely (Ministerie van Infrastructuur en Waterstaat, 2010). To ensure this, the Strategic Plan Road Safety (SPV 2030) was developed (Ministerie van Infras-

tructuur en Waterstaat et al., 2018).

To make this a reality, longer-term road safety targets are being set at European and national level. The EU's road safety vision comes from Sweden's 'Vision Zero'. This states that the goal should be zero deaths and injuries on the roads, as any loss of life is morally unacceptable.

In the Netherlands, the road safety vision 'Sustainable Safety' has been formulated, which also incorporates the human scale of vision zero (SWOV, 2018). The Strategic Plan for Road Safety 2030 (SPV 2030) has been implemented at national level (Ministerie van Infrastructuur en Waterstaat et al., 2018). This includes the EU target of zero road fatalities by 2050.

SPV 2030 takes a risk-based approach, using Safety Performance Indicators (SPIs) to enable a more proactive policy. It is no longer enough to rely solely on road injury and fatality data, also known as objective road safety, to prevent all road injuries and fatalities.

This SPV 2030 also describes subjective road safety within the risk-based approach. It highlights that although there is no clear relationship between subjective and objective road safety, it can be used by municipalities in the risk-based approach. Complaints about road safety could be used as a signal to investigate further the risks of the traffic situation.

Unfortunately, the number of road deaths has increased recently, despite the tightening of safety goals (Mulders et al., 2023). This increases the incentive for improvements and seems to give more attention to the risk-based approach.

Many municipalities in the Netherlands receive complaints about road safety. Because of the unclear relationship with objective road safety, it is not clear what can and should be done in every situation. When looking at the measurable SPIs in this situation, there is not always a clear risk, which makes handling these complaints individually often difficult for the municipalities. How do municipalities deal with this information and what is the right approach?

It is clear that subjective road safety has an impact on the traffic system. A survey showed that almost half of Amsterdam's cyclists sometimes take a different route to avoid certain intersections (Lupas, 2023). This is not always desirable for the municipality. Road safety is more than not getting into an accident. But it is difficult to deal with the subjective part of this topic.

The scientific literature studies the effects of various factors on subjective road safety through various before and after studies. However, these are not practice-oriented, and municipalities cannot use this knowledge to process complaints and make appropriate policies. Chapter 3 discusses this in more detail.

Also, the methods used in the research literature to get a picture of subjective road safety are often different from the methods used in municipalities. For example, different studies may use biomedical data to look at subjective effects on individuals, set up experiments where people's

reactions to different situations can be monitored in real time, or use machine learning techniques to collect social media data. This is a very different situation from how the municipality receives information on subjective safety, which is mainly in the form of complaints. One method used in both literature and research is conducting surveys, but the form is inconsistent in the municipality and it is difficult to draw conclusions or correlations based on this limited data.

This study addresses the ambiguity surrounding subjective road safety for municipalities, a concept that is often only superficially discussed and without a clear, universally accepted definition in either government or academic contexts. Municipalities are interested in understanding subjective road safety, but the methods currently used do not provide a comprehensive view. Complaints from citizens cover a wide range of issues and vary in quality. While surveys collect some information, they are inconsistent and results don't always reach the right departments, limiting their usefulness for practical application.

The uncertainty is not only about what subjective road safety means, but also about how municipalities should approach it. Government plans including SPV2030 (Ministerie van Infrastructuur en Waterstaat et al., 2018) give municipalities significant responsibility for road infrastructure and safety in the Netherlands and expect them to pursue a more proactive, risk-based approach. This shift marks a departure from the previous dependency on objective accident data, with a new accent on preventing accidents by improving road conditions beforehand. Subjective road safety might serve as a valuable metric in this approach, but it is unclear how municipalities should effectively evaluate and incorporate citizen complaints.

This confusion is further increased by the lack of a clear relationship between subjective and objective road safety as stated in the scientific literature, making it difficult for municipalities to determine the importance of public opinion in road safety policy. Although municipalities receive complaints that provide insight into perceived safety, they often struggle to determine the value of this information and to identify best practices for incorporating it into decision making. This study sets out to explore these uncertainties by examining how municipalities can incorporate subjective road safety into a proactive, evidence-based approach.

1.2. Research scope

In the Netherlands, there are four major road authorities. These are Rijkswaterstaat (RWS), the provinces, the municipalities, and water boards (Ministerie van Infrastructuur en Waterstaat, n.d.). These road authorities are responsible for the maintenance and safety of their part of the roads. The national government is responsible for national roads, provincial roads fall under the responsibility of the provinces, water boards are responsible for water board roads such

as polder roads, and municipal roads are the responsibility of the municipalities (Ministerie van Algemene Zaken & Rijksoverheid, 2011). This project will mainly focus on the subjective road safety on municipal roads.

The focus on subjective road safety on municipal roads has three reasons. First, municipal roads have the biggest safety issues. In 2022, a significant increase in traffic fatalities on roads within urban areas is visible, with over 60 percent of the traffic fatalities occurring on road types for which municipalities are responsible, including 29 percent on 50 kilometers per hour roads and 13 percent on 30 kilometers per hour roads. In the last named category, there has been an 86 percent increase compared to 2019-2021 (Oude Mulders et al., 2023).

Secondly, it also seems that most dissatisfaction and feelings of unsafety are experienced on these roads. This is evident from the number of complaints on the map of Veillig Verkeer Nederland (VVN) participatiepunt (Safe Traffic Netherlands participation centre) (Veilig Verkeer Nederland, n.d.-b). This could be because many people feel a greater sense of responsibility for their own neighborhood and therefore are more likely to report situations that directly affect them.

As a third point, it is primarily the municipalities in the Netherlands that struggle with the question of how to handle the complaints regarding unsafe traffic situations. When municipalities assess reports or complaints of perceived unsafe traffic spots alongside actual accident locations, also known as blackspots, there seems to be little correlation at times. For municipalities, this type of data makes it difficult to make grounded choices on how to use money and manpower to improve infrastructure. Simultaneously, addressing each report demands a significant amount of time, which is often a requirement within municipalities. This can lead to a substantial increase in workload due to these reports.

In this research, the perception of safety for autonomous vehicles is not included due to the still uncertain situation surrounding this topic. There is much ambiguity regarding how developments in this field will unfold, including aspects such as regulations and the types of autonomous vehicles that will eventually emerge. Autonomous vehicles are still in a dynamic stage of development, making it challenging to gain a clear understanding of their impact on the mobility industry and the broader society.

1.3. Relevance of the research

Scientific studies on subjective road safety have so far been mainly situation-specific, with little attention paid to general studies covering a wider area. Many of the research studies have focused on before and after studies to assess the effects of particular interventions on people's

perceptions of safety. There is a lack of literature focusing on how subjective road safety links to objective safety measures and what this means for policy making and interventions. In addition, there is a need for a clear definition of subjective road safety. This research will contribute to filling these gaps by providing a broader perspective and a basis for further theoretical development and practical application in the field of road safety.

From a social perspective, research into subjective road safety and how municipalities deal with it is important for the safety and well-being of citizens. Municipalities have the responsibility to provide infrastructure within urban areas that is not only objectively safe, but also ensures contentment among their citizens. A deeper insight into the large number of complaints and how municipalities can manage them can help municipalities make more informed choices and better grounded policies and decisions. This can lead to more targeted policy measures and infrastructural adjustments that take the subjective perception of safety into account while promoting objective road safety. By taking a systematic approach and using substantiated information, municipalities can more effectively address road safety complaints and create a safer and more liveable traffic environment for all residents. In this way, this study will contribute to the pursuit of the national goal of preventing all traffic fatalities.

1.4. Research questions

This study focuses on investigating how municipalities should deal with subjective road safety. The main and sub-research questions are formulated below. When answers are found to the sub-questions, the main question can be answered. In the following, the questions are explained one by one.

Main research question:

How can subjective road safety be measured and the outcomes be used in policies in municipalities in the Netherlands?

Sub-research questions:

1. How is subjective road safety defined and measured in scientific literature?
2. How is subjective road safety defined and measured by stakeholders and how do they use this information in their activities?
3. What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?

In the first sub-question, the focus will be on investigating the definition in the scientific literature. Here it is important to look at the different indicators and measuring instruments used in the

scientific literature for subjective road safety research. It is also interesting to investigate whether there are different patterns or trends regarding the perception of subjective road safety.

The aim of the second research question is to get a clear understanding of interest organisations and interest groups concerned with subjective road safety. These groups also collect data and engage in actions to focus on subjective road safety. It is important to understand how subjective road safety is understood and addressed in real-world contexts beyond academic research. These groups are often closer to the municipality and also have more connection to the citizens in the municipalities compared to the scientific literature. It is also interesting to see the differences in their perception of subjective road safety within these groups. By obtaining a more accurate understanding of how subjective road safety is considered in practice, appropriate interviews can also be conducted to ultimately refine this view.

The third sub-question explores the objectives of municipalities concerning subjective road safety and what they hope to achieve through these objectives. This involves examining the goals and strategies outlined by local governments in their efforts to enhance road safety perceptions within their jurisdictions. By understanding the specific aims of municipalities in this regard, the conclusion can overcome the practical implications and challenges associated with implementing subjective road safety measures at the local level. Without this information, a strategy for addressing subjective road safety cannot be formulated. Therefore, this question must be answered before addressing the main research question.

Together, these sub-questions contribute to addressing the overarching research question: how can subjective road safety be measured and utilized with the assistance of a framework among municipalities in the Netherlands? By examining subjective road safety from multiple perspectives – scientific literature, local interest groups, and municipal objectives – the aim is to develop a comprehensive understanding of how subjective road safety can be assessed and leveraged effectively within the municipal context. The questions are diagrammed in Figure 1.1.

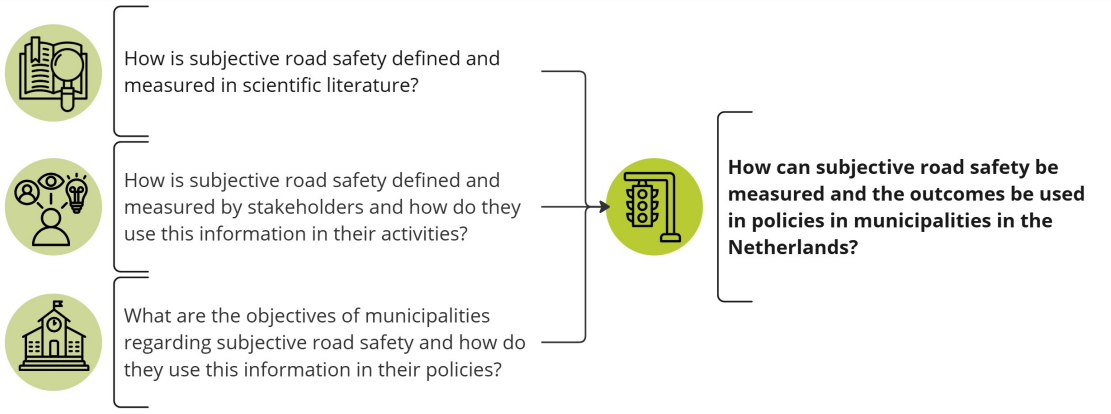

Figure 1.1: Sub- and main research questions

Having answered these research questions, it is important to reflect on what the research has contributed. This research is a step towards improving road safety, which includes both subjective and objective road safety. As mentioned earlier, this is necessary because road safety has been under pressure in recent years.

The contribution of this study is to provide more insight into the subjective aspect of road safety. To date, there has been limited research on this component from a practical viewpoint, making it difficult to formulate well-founded policies. By providing more insight into subjective road safety and how it can be effectively measured, an important first step is taken to improve the approach in this area. Ultimately, this will also allow better consideration of objective road safety. By integrating both aspects, a positive impact on overall road safety can be obtained.

1.5. Reader's guide, structure of the report

In this research report, Chapter 2 outlines the methodology. Chapter 3 covers the literature review of the scientific sources. Chapter 4 presents the grey literature review. The results of the interviews are given in Chapter 5. Chapter 6 introduces the initial approach for the municipalities to subjective road safety data. Finally, Chapter 7 offers the conclusions and discussion.

2

Methodology

This chapter will explain the different methods used in the research in order to answer the different sub-questions and thereby the main question. First, a scientific literature study is done. This is followed by a review of the grey literature is this research area. Finally, interviews with several municipalities in the country are conducted. Figure 2.1 illustrates how these methods relate to the different research questions.

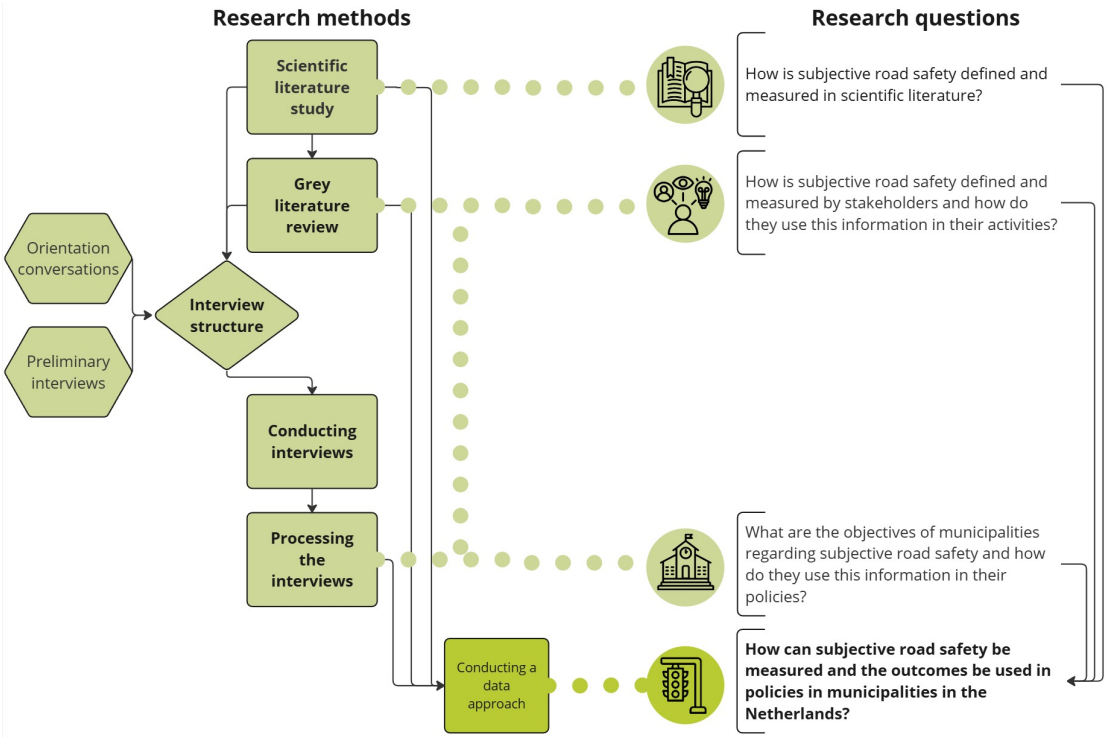

Figure 2.1: Different methods connected to the research questions

2.1. Scientific literature study

In this study, the first step was to examine the definition of subjective road safety. For this purpose, scientific literature was used as a reference. This analysis was conducted using the search engine ”Scopus”. Six different search terms were employed. Within these terms, a selection was made based on the title of the paper. Table 2.1 shows the search terms and the number of selected papers. Out of the 591 papers viewed, 122 were selected based on their titles. This number was increased by forward and backward snowballing. Additionally, several papers were added based on recommendations from external experts in the field until saturation was achieved. The selected papers amounted to 168. Papers were grouped and further screened based on the abstract. Relevance to this research was considered, and papers on self-driving vehicles and AI were not included. The total number of papers used for the literature chapter was 31.

Table 2.1: Checked scientific literature

Searchterm	Number of hits	Selected on title	Selected on abstract
(”subjective road safety”)	1	1	
(”subjective traffic safety”)	3	2	
(”subjective safety” AND (road OR traffic OR tansport))	25	13	
(”perceived risk” AND (road OR traffic))	413	76	
(”individual safety perception”) AND (road OR traffic OR transport)	2	0	
(”safety perception”) AND (road OR traffic OR transport)	161	36	
via snowballing and experts		46	
Total	**591**	**168**	**31**

2.2. Grey literature review

For a complete overview, focusing solely on information from scientific literature was not sufficient. For a comprehensive analysis, other sources such as research reports, thesis reports, and governmental documents were also used. This ”grey” literature provided a better impression of how society views the concept of subjective road safety and made the link to societal perspectives more apparent. The aim of this literature was to gain insight into the extent to which municipalities already consider subjective road safety. It was examined whether municipalities were already using resources to collect data on subjective road safety and the motivations behind these efforts.

First, an overview was created of the different parties and organizations interested in subjective road safety. These parties included various advisory agencies, government bodies, research institutes, and interest groups. A total of 13 parties were included in this grey literature review.

The definitions of these parties were investigated, along with other keywords commonly associated with subjective road safety in society. This literature focused mainly on the Netherlands and was therefore in Dutch. Following this, the ways in which municipalities could gain insight into subjective road safety were examined.

2.3. Interviews with municipalities

This section will explain the interviews. These interviews were held with traffic experts working at various municipalities in the Netherlands.

2.3.1. Purpose of the interview

The interviews in this study mainly focus on two goals. The first goal is to gain insight into the intentions of the municipalities to monitor the subjective road safety in their municipality. The second goal is to find out which funds and means municipalities have available to implement an investigation on this subject.

Besides these two main topics, the interview is also used to check what the municipality means by subjective road safety. Questions will also be asked about the methods currently used and where they can be improved. Finally, there will be room to zoom in on the needs of municipalities. This is more practical than the goal of the municipality.

2.3.2. Conducting the interviews

To maximize the effectiveness of the interviews, orientation conversations were held with people from the field. The main reason for holding the orientation conversations was to gain insight into the field of subjective road safety. This helped shape the problem statement and provided foundational knowledge for this research. The orientation conversations also contributed to the design of the interviews. For answering the research questions, the orientation conversations were only indirectly involved. An overview can be found in Appendix B. Following the orienting conversations, two preliminary interviews were also conducted. Figure 2.1 shows the indirect connection between these conversations and the interviews, enabling the answering of the research questions. It emerged from these pre-interviews that interviewing municipalities with prior knowledge of subjective road safety would be most valuable.

To conduct the interviews, three types of approaches were considered: structured, semi-structured, and unstructured. In this study, the semi-structured method was chosen because it allowed interviewees the flexibility to discuss other relevant points of interest without losing sight of the interview and research objectives. To structure the interview, questions were developed on the main points of the interview (Wildemuth, 2016). Within these points, there was room for open discussion, and additional questions could also be posed.

The outline and structure of the interview were prepared after the orienting conversations (Appendix B and the literature study (Chapter 3)) and can be found in Appendix C.4. The interviews were conducted in March 2022, in the aftermath of the COVID-19 pandemic. Consequently, the decision was made to conduct the interviews via video call, using the Teams software for this purpose.

Selecting the municipalities

Because of the scope of this study, there was a maximum capacity for conducting interviews, and only a selection of six municipalities in the Netherlands could be interviewed. For the selection of the municipalities, characteristics were chosen that may be important for the municipality's view on subjective road safety. The influence of these characteristics was not investigated and is outside the scope of this study. However, by including municipalities with different characteristics, a complete picture of the information was obtained. With only six municipalities, this is not a complete reflection of all municipalities in the Netherlands, but by including different types of municipalities, something can be said about the whole range of municipalities in the Netherlands.

The choices for selecting municipalities were made based on four characteristics. First, municipalities that had already been involved in subjective road safety in some way were considered. Subsequently, characteristics such as urbanization, size, and location were simultaneously taken into account. For these characteristics, different categorization groups were used. The data used for this purpose came from Statistics Netherlands and included areas in the Netherlands as of 7 July 2021 (Centraal Bureau voor de Statistiek, 2021). After this date, changes occurred in the classification of Dutch municipalities (Centraal Bureau voor de Statistiek, 2022). Due to municipal mergers, 341 municipalities remained instead of 345 (Table 2.2).

For each category, a description was provided to explain why it was included and how the subdivision within this category was established. More details about these categories can be found in Appendix C.

Awareness of subjective road safety

To obtain an overview of the municipalities that already had an understanding of subjective road safety, a Google search was first performed. The term "subjective road safety in municipality" was used. This search was conducted on 14 February 2022. Since the internet is changeable, different results could appear at another time, but this approach provided a reliable impression of several municipalities that had already engaged with this topic. The search extended to page 5, covering approximately 50 results. These results mainly consisted of municipal policy documents, such as mobility plans, action plans, and traffic safety plans, in which subjective road safety was addressed. This method produced a list of 20 different municipalities. After a discussion with VNG, another five municipalities known to have ideas on the subject were added.

Urbanity

The categorization of urbanity was determined by the density of addresses in the area. For this purpose, five categories were established by Statistics Netherlands, which were adopted in this study (Centraal Bureau voor de Statistiek, n.d.-c). These categories are shown in Table 2.2.

Table 2.2: Degree of urbanisation of the municipality

Code	Description	Number of Municipalities
1	Area address density of 2500 or more	22
2	Area address density from 1500 to 250	72
3	Area address density from 1000 to 1500	73
4	Area address density from 500 to 1000	124
5	Area address density of less than 500	50
Total		**341**

Municipality size

Municipality size was determined by the number of inhabitants in a municipality (Centraal Bureau voor de Statistiek, n.d.-a). CBS used eight classes for classifying municipality size. To ensure representation in this study, a classification of four classes was used. These classes are shown in Appendix C. This adjusted scale was also applied in an earlier report by SWOV (Bax, Uijtdewilligen, Kint, & Commandeur, 2020).

Distribution in the Netherlands

The location of the municipality within the Netherlands was also considered in the selection of municipalities to be interviewed. For this purpose, different regions of the country were used, known as NUTS 1 regions. This division was created for the regional categorization by the European statistics office Eurostat, to facilitate regional comparisons within Europe (Centraal Bureau voor de Statistiek, n.d.-b). Given the limited number of interviews possible in this study, this classification was more suitable than, for instance, a provincial classification. The data for categorizing municipalities into these regions was obtained from CBS (Centraal Bureau voor de Statistiek, 2021).

Within this framework, the Netherlands was divided into four regions. These categories are shown in Table 2.3 and in Appendix C. They are also visually represented on a map of the Netherlands in Figure 2.2.

Figure 2.2: Country sections

Table 2.3: Distribution of location in the Netherlands

Code	Country sections	Provinces	Number of Municipalities
1	Northern Netherlands	Groningen, Friesland, Drenthe	40
2	Eastern Netherlands	Overijssel, Flevoland, Gelderland	82
3	Western Netherlands	Utrecht, Noord-Holland, Zuid-Holland, Zeeland	136
4	Southern Netherlands	Noord-Brabant, Limburg	87
Total			345

Interviewed municipalities:

By taking into account all the previous points, a selection of 10 different municipalities was made. Finally, interviews were conducted with six of these municipalities, as not all 10 municipalities responded to the requests. The six interviews were sufficient to provide an overall picture of the different municipalities in the Netherlands. These municipalities were, in alphabetical order, Heiloo, Hengelo, Houten, Leeuwarden, Utrecht, and De Wolden. Characteristics of these six municipalities are shown in Table 2.4.

Table 2.4: Interviewed municipalities

Municipality	Country section	Municipality size	Urbanisation
Heiloo	Western Netherlands	20 000 to 50 000 inhabitants	Area address density from 1 000 to 1 500
Hengelo	Eastern Netherlands	50 000 to 100 000 inhabitants	Area address density from 1 500 to 2 500
Houten	Western Netherlands	50 000 to 100 000 inhabitants	Area address density from 1 500 to 2 500
Leeuwarden	Northern Netherlands	100 000 inhabitants or more	Area address density from 1 500 to 2 500
Utrecht	Western Netherlands	100 000 inhabitants or more	Area address density of 2 500 or more
De Wolden	Northern Netherlands	20 000 to 50 000 inhabitants	Area address density of less than 500

2.3.3. Processing the interviews

After conducting the interviews, they need to be processed to extract information from them. As the data from the interviews is qualitative in nature, it is important to process it in a systematic way. This allows conclusions to be drawn from the interviews in the most transparent way possible. There are two methods for analysing interviews that are commonly used: content analysis and thematic analysis, as described by Neuendorf (Neuendorf, 2018). Both analysis methods are suitable for processing qualitative data, yet there are differences. The similarity between these two methods is that both involve coding the text from the interviews. This involves using a short sentence or word to describe the content of selected pieces of text. In content analysis, these codes are prepared in advance. They are specifically searched for in the text. Here, however, there is the risk that content may be lost due to the lack of context. This analysis searches for certain words and sentence frequencies and is therefore fast and very suitable for large amounts of data. The focus is on quantification, with this comes the loss of some of the meaning behind the text. Neuendorf also describes Thematic coding. Here, codes or labels are also used but these are not predetermined. This makes this way more labour-intensive but also more suitable for extracting more underlying information from a text (Neuendorf, 2018). For the interviews in this study, thematic analysis was chosen. This approach provided more flexibility and could extract deeper information from the text. Since six interviews were included in this study, this was the most suitable method.

The thematic analysis is conducted inductively (Thomas, 2006). This means that no predetermined codes were established prior to the analysis process. The themes that emerge are entirely dependent on the data found within the interviews.

While multiple approaches can be used to conduct a thematic analysis, Braun and Clarke describe it as a six-step process (Braun & Clarke, 2006). The following describes how these steps were carried out in the analysis of the interviews of this study.

Phase 1: Familiarizing with the data

The first step after conducting the interviews was to transcribe the entire interviews into text. Since the interviews were recorded, transcription was completed using software. The software used for this purpose was Trint (Trint, n.d.). The text was then checked for language and interpretative errors by reviewing all the text and interviews simultaneously. Following this, the interviews were printed out and reviewed. Key pieces of text were manually highlighted. Additionally, each interview was re-listened to ensure that notable remarks and intonations, which may be missed during transcription, were not overlooked.

Phase 2: Generating initial codes

An initial layer of codes was created to cover the content of these text segments. These codes or labels were created for the relevant information. For this purpose, a software package was used: Atlas.ti (Atlas.ti, n.d.). Although the interviews were conducted in Dutch, the codes were immediately translated into English to prevent misunderstandings later in the process.

Phase 3: Searching for themes

The identified codes were reviewed, and themes were sought. These themes represent broader categories under which various codes can be grouped.

Phase 4: Reviewing the themes

Sometimes, not all identified themes are actually relevant or have enough codes to be significant. In this step, the themes are evaluated to determine whether they hold value or if some should be combined.

Phase 5: Defining and naming the themes

In this step, the content is further refined by examining the relationships between the codes and themes.

Phase 6: Producing the report

For this study, the most notable points are described per theme. These may include codes that appear either rarely or frequently. Observations can also be made regarding the distribution across municipalities; however, for privacy reasons, these are not specified in the text. In this step, the original interview text is also revisited to verify the conclusions. This process is facilitated by the software used, which makes it easy to maintain an overview.

Finally, a link was made to the questions that could be answered using the interviews, and an interim conclusion was drawn. This conclusion was then discussed with an expert from VVN.

3

Defining subjective road safety: scientific literature study

This chapter examines what is known about subjective road safety in the scientific literature. This literature review will be carried out as detailed in the methodology (Section 2.1). The information from this literature review will answer the first sub-question: ”How is subjective road safety defined and measured in the scientific literature?”

The scientific literature is often lacking in definitions of subjective road safety. The concept of subjective road safety also borders on many other related concepts such as perception and risk. A 1995 study entitled ”The Effect of Environmental and Design Parameters on Subjective Road Safety” (Zakowska, 1995) is one of the first studies to write about subjective road safety. This study does not go into defining subjective safety, but uses a rating scale to try to understand how subjective safety is perceived. Drivers are asked about their perceived level of safety in different road designs. They are asked to indicate their perceived level of safety on a rating scale. The scale used in this experiment ranges from 1 ”unacceptable risk perceived” to 7 ”no risk perceived” (see Figure 3.3). In this example, it is clear that many terms are used interchangeably without going into the underlined relationships and differences. The terms subjective road safety, level of safety and perceived risk are used here to refer to the same issue.

This chapter consists of five sections, the first three of which address the different definitions associated with subjective road safety. As in the example above, there are several concepts

that need to be explained. For this purpose, three main concepts from the scientific literature are used: subjective road safety in Section 3.1, as it is central to this study; risk perception in Section 3.2, as it is primarily considered in scientific studies; and the different ways in which subjective road safety has an impact on traffic safety in society in Section 3.3.

This is followed by Section 3.4 discussing the different methods used in the scientific literature to measure subjective road safety. Section 3.5 summarises the findings from the literature that will be further considered in this study and that are important for answering the sub-question.

3.1. Understanding subjective road safety, definitions and frameworks

First, the concept of subjective road safety is discussed. This is also the term that is used in this research. When looking into the studies that use this term, it is noticeable that not many studies emerge in the peer-reviewed literature. As can be seen in Table 2.1 in Section 2.1 on research methodology, ”subjective road safety” in Scopus gives a very limited number of hits.

While there is limited literature available on subjective road safety, there are numerous related concepts with similar definitions. The existing literature on subjective road safety and subjective safety presents a variety of definitions (Abedi & Sacchi, 2024). This variety contributes to the complexity and lack of clarity surrounding subjective road safety. To provide clarity, this section will delve into these different components.

The components used in this section are explained in pairs. This is because many of them appear to be opposites, but both are important for subjective road safety. First, subjective versus objective road safety is considered. This is followed by emotional and cognitive, individual and societal, concern for oneself or another and active participation or observation.

3.1.1. Subjective versus objective

The World Health Organisation (WHO) considers safety to be more than not being injured (Nilsen et al., 2004). The WHO defines safety in two dimensions, the objective dimension and the subjective dimension. The objective dimension is explained as behavioural and environmental factors in relation to external criteria. The subjective dimension is explained as an individual’s feelings, a person’s internal perception of being safe.

As described by Nilsen, the relationship between objective and subjective security is unclear. And while they certainly influence each other, they can do so in so many different ways that they are best treated as two distinct aspects. Figure 3.1 (Nilsen et al., 2004) shows objective and subjective safety as a system of axes. Their mutual function is unknown, but it can be said that

it is desirable for both aspects to be ”positive” and considered.

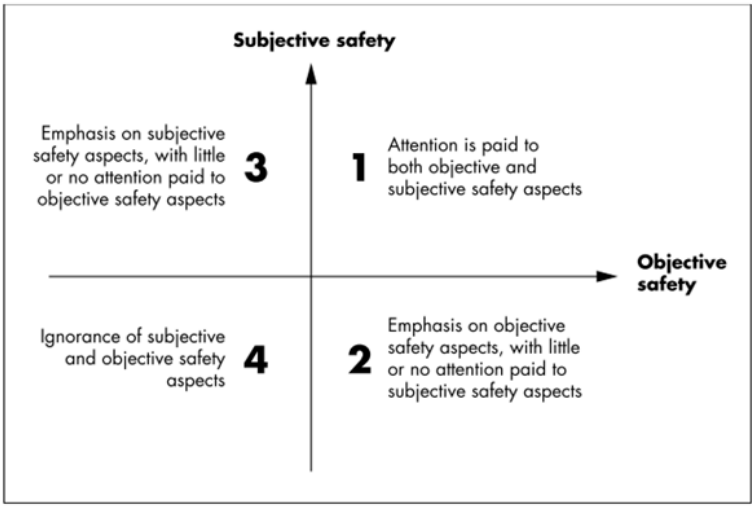

Figure 3.1: Defining safety concepts: subjective and objective

Objective or statistical road safety is a measure based on the number of recorded road accidents and injuries (Sørensen & Mosslemi, 2009). Sometimes it is also expressed in terms of risk. This means that it is described as the probability of an accident or injury occurring per unit of traffic exposure.

In the Netherlands, data on accidents, casualties and injuries are used to determine objective road safety (SWOV, CROW, & Kennisnetwerk SPV, 2022). These figures are often regarded as the most important for reducing accidents and injuries, and, therefore, improving road safety. The Dutch and European targets also focus on these objective road safety figures. The European goal ’Vision Zero’ means halving all road deaths by 2050 (Europese Commissie, 2019).

Subjective road safety is more difficult to define, but is generally understood as the feeling of safety (Sørensen & Mosslemi, 2009). In most cases, objective road safety and subjective road safety influence each other. However, there are so many different variables involved that the relationship between these two components cannot be predicted, as shown in the study by Sørensen and Mosslemi. That they influence each other is certain, but how and what the result is is uncertain. This has to be taken into account when changing one in order to affect the other.

An example of an infrastructure intervention that improves subjective safety is the installation of a zebra crossing. Many people feel safer crossing at a zebra crossing (Mastora, Paschalidis, Nikiforiadis, & Basbas, 2023; Swain, Oswin, Truelove, & Larue, 2024). However, studies show that objectively there are very few, if any, safety benefits. This is because the driver’s view of

the road markings is limited (Nygårdhs, Fors, Eriksson, Nilsson, & L, 2010; SWOV, 2020), and as people are more likely to feel seen anyway, this can lead to a false sense of safety and ultimately more accidents. Opposed to this is latent traffic safety, which objectively causes few traffic casualties but is still experienced as being unsafe. This is described further in Subsection 3.3.1.

3.1.2. Emotionally and cognitively

The definition of subjective safety in some cases separates the cognitive part from the emotional part (Abedi & Sacchi, 2024). Emotional safety refers to people's uncertainty, fear and anxiety. So this part is very much based on people's feelings without necessarily having a reason or cause. An emotional response is often much more intuitive, such as fear and anxiety (Lazarus & Folkman, 1984).

Lazarus also mentions that the cognitive part deals with the more rational nature of a person and focuses on the perceived risks of an accident or collision. This cognitive part is influenced by people's experiences and external influences. These include road visibility, infrastructure and weather conditions. Cognitive road safety involves thinking about the probability of an accident and how realistic it is that an unsafe situation will occur. Each individual has their own perceptions here, which therefore has an impact on the subjective road safety they experience (Lazarus & Folkman, 1984).

As Sjöberg describes it, subjective safety consists of two parts: an emotional component which includes, among other things, uncertainty, fear, anxiety and worry, and a cognitive component which represents the perceived risk of an accident or injury (Sjöberg & Torell, 1993). This explains why these terms are often used interchangeably without it being clear whether the emotional component is meant. Risk perception is further explained in section 3.2.

3.1.3. Individual and societal

In scientific research, individual people are studied to get a view of subjective road safety. Often statistical tests are carried out to see if a conclusion can be drawn about the population (Rohrmann & Renn, 2000). As described earlier in Section 3.1.2, subjective road safety in itself is an individual phenomenon. It is influenced by experience, but also by culture and changes in society.

In scientific research it is important to check that something is not an individual outlier. An individual who is very afraid of the traffic is isolated from the group and is negligible in the population. Science is about the big picture, and the effects of small groups in studies disappear in

the population. For a municipality, these small groups often have a different value.

It is also true that subjective road safety is an individual matter, as explained in the section on emotional and cognitive subjective road safety (3.1.2). However, it is also true that there is a societal trend and that cultural differences affect the 'societal' subjective road safety (Lund & Rundmo, 2009).

3.1.4. Concern for oneself or another

Subjective safety is also the feeling of unsafety for other people. For example, parents worry about their children when they walk and play nearby traffic (Sørensen & Mosslemi, 2009).

Subjective safety also plays a role in the perception of the safety of others. People worry about loved ones who are involved in road traffic while they themselves are not involved or are not affected by their own subjective safety (Elvik, Kolbenstvedt, & Strangeby, 1999).

An example often cited is parents who worry about their children playing on the street, or parents who feel unsafe walking to school with their children, or letting them walk to school alone. Feelings of insecurity often result in parents taking their children to school by car before going to work (Hoekstra, Mesken, & Vlakveld, 2010). This makes the area around schools very congested with motorised transport at peak times, which can contribute to the feeling of insecurity (Geerts, 2015). This seems to become a vicious circle.

3.1.5. Active participation or observation

A distinction can be made between experiencing road safety while participating in traffic and without actual participation, for example by just thinking about traffic or observing traffic. The part related to active participation in traffic can be investigated in studies where information is collected during a route. This can be done, for example, by using a simulator, applying traffic measurement tools, or measuring physiological characteristics.

Many studies also look at the feelings experienced in traffic after the event. When asked about subjective road safety, people may be asked specifically about how they felt during traffic participation. This then indicates active participation.

Another approach focuses on feelings of fear of traffic situations that have not occurred. According to Vlakveld (Vlakveld, Goldenbeld, & Twisk, 2008), fear is about what might happen in traffic. This fear therefore does not require actual participation in traffic. People can also be anxious without exposing themselves to the situation. In extreme cases, anxiety can lead to the avoidance of exposure and traffic, as seen in conditions such as street fear (agoraphobia) (Kuch, Cox, Evans, & Shulman, 1994) or fear of driving (Fischer, Heider, Schröder, & Taylor, 2020).

3.2. Risk perception

Risk perception is often mentioned together with subjective road safety (Sørensen & Mosslemi, 2009). In this report, however, it is important to distinguish between these two concepts.

Risk perception includes attitudes and expectations (Sjöberg, 2000) and is not just a matter of sensory experience. It can be understood as a combination of two factors: the likelihood of an accident and the potential consequences of that accident (Rohrmann & Renn, 2000). Perceived risk in transport is mainly related to three factors: the potential for disaster, the likelihood of death in an accident, and the degree of control over the activity and its outcome that is perceived (Amundsen & Bjørnskau, 2003). This is equivalent to subjective risk, as it involves a personal assessment of the probability and severity of accidents (Vlakveld, 2009).

In 'The Methodology of Risk Perception', the question is raised whether risk perception can exist in the absence of actual risk. According to(BREHMER, 1987), risk perception does not emerge in the absence of a real risk. This raises the debate of subjective versus objective safety. Even when there is no objective risk, people can still perceive risk. Risk is always about the potential for something to happen in the future. It is typically defined as the likelihood of an event occurring and its potential impact or damage. While this definition suggests a technical concept that can be easily measured, risk perception is often much more complex.

Risk perception is dominated by a psychometric approach that focuses on the subjective aspects of perceived risk (Rundmo & Nordfjærn, 2017). The characteristics of perceived risk include factors such as: voluntariness of the risk, immediacy of the effect, knowledge of the risk by the person exposed to it, scientific knowledge of risk control, unfamiliarity, and severity of the consequences.

Perceived risk is a collection of thoughts, beliefs and constructs that go beyond the measurability of future events. In this way, although risk perception is often discussed interchangeably with subjective safety, it is actually a more specific and limited concept. It touches on the complexity of subjective road safety, but focuses on the contiguous part of it. There is less room for purely emotional feelings.

3.3. Impact of subjective road safety

Subjective road safety affects society in a number of ways. This is because people's behaviour on the road changes as a result of subjective road safety. These changes in behaviour affect objective road safety. This can be positive, resulting in fewer accidents, but it can also be negative. This subsection will explain three different ways in which subjective road safety affects people. These are: latent safety, behavioural adaptation, and coping.

3.3.1. Latent safety

Latent safety or latent unsafety refers to traffic situations that are not safe but appear so when objective road safety figures are considered. In Figure 3.2 it can be seen that latent safety is placed in the graph with low subjective road safety while objective road safety is high as few accidents happen. In these situations, for example, there are many 'near misses' but no actual collisions. In terms of latent road safety, measuring subjective road safety seems to be an indicator that could be used to detect these situations. If this can actually be done, subjective road safety could be used as a safety performance indicator to include these situations even before accidents actually happen. However, it should be noted that there is a known relationship with objective road safety (Vlakveld et al., 2008).

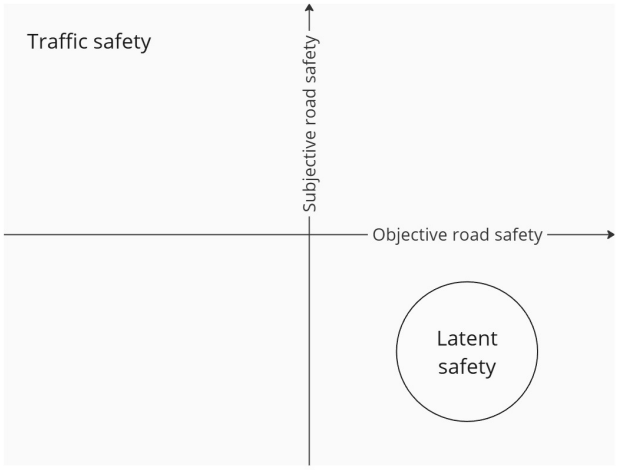

Figure 3.2: Placement of latent safety in relation to objective and subjective road safety

An example of a latent road safety situation is that due to increased workload, fewer accidents occur because of increased alertness. However, this does not make people feel safe, and people who cannot cope with this workload will also avoid these situations. As a result, there may be few accidents in a situation where people are extra vigilant.

A good example of this is 'shared space' in road traffic. Here, few accidents often happen but people experience stress, high workload and feeling of unsafety (Tzouras, Karolemeas, Bakogiannis, & Kepaptsoglou, 2021).

3.3.2. Behaviour adaptation and Coping

Feeling unsafe can make people behave differently in traffic. In different situations, people behave differently in traffic. When the feeling of safety is high, people pay less attention. When

there is a feeling of insecurity, alertness increases, which can lead to fewer accidents.

This principle comes from the phenomenon of behaviour adaptation and is also known as risk compensation. This shows that perceived risks cause people to make different choices in traffic. A part of this concept is also called 'Not Intended'. A change can have many influences on different factors and thus bring about unintended changes in behaviour (Rudin-Brown & Jamson, 2013).

Because feelings of insecurity are unpleasant, people try to neutralise these negative feelings. This is known as 'coping' (Lazarus & Folkman, 1984). For example, parents may choose to drive their children to school because they feel it is too busy to let their children cycle to school alone.

Another example is people who are afraid to go out in the evening because they think it is too dark. Or cyclists who change their route to avoid certain junctions or choose a more convenient route because they feel comfortable here (Uijtdewilligen, Baran Ulak, Jan Wijlhuizen, & Geurs, 2024).

The choices people make for road safety are not always the ones they want to make. Choosing to drive because it is too busy to cycle does not make the road safer. Similarly, when one feels unsafe due to mixed traffic on a road, for example, one can make certain choices to avoid this. A person chooses a coping strategy to deal with the feeling of unsafety. This may involve avoiding situations by choosing a different time or detour (Chataway, Kaplan, Nielsen, & Prato, 2014).

3.4. Measuring subjective road safety: research methods used

In the scientific literature, different methods are used to investigate subjective road safety or perceived road safety. This section discusses the different methods and their advantages and disadvantages.

It is noticeable in scientific research that many studies take the form of before and after studies or use experiments. This is because a scientific study often looks at a single characteristic that is changed and what the effect is. This means that many of these studies are very situation-specific. This allows better conclusions to be drawn about the subjective road safety of specific road designs.

The methods used in the scientific literature are likely to be different from those used by local authorities. To gain more insight into this, the grey literature is further examined in Chapter 4.

3.4.1. Survey

One of the most common methods in the scientific literature is the use of surveys or questionnaires. These surveys can be broadly divided into questions that follow an experiment or path,

and questions that stand alone. Most surveys are based on an experiment, as described in (Wu, Guo, Yuan, & Wei, 2009). However, there are also questionnaires that are administered without an experiment and ask for a general picture, as in (Lund & Rundmo, 2009) , which examines differences between two countries. Another option is to distribute surveys to individuals who meet the study's requirements (Uijtdewilligen et al., 2024), where people in large cities receive an invitation to complete the questionnaire.

These surveys always involve a subset of the population and use statistical tests and models to draw conclusions about the whole population. The questions asked in these studies are very important. In 1995, for example, Zakowska used the rating scale shown in Figure 3.3 (Zakowska, 1995). Variants of this type of scale are still used in questionnaires on subjective road safety (Zakowska, 1995).

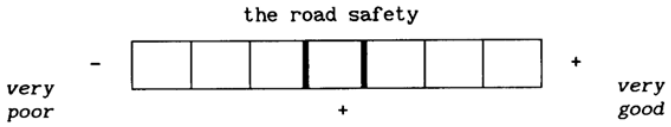

Figure 3.3: Rating scale Level of safety: "unacceptable risk perceived" to "no risk perceived"

3.4.2. Interviews

Interviews are also a method used in scientific research to understand subjective road safety. These interviews can go into more detail than a survey, but often take longer. Sometimes there is not much difference between an interview and a survey. If a survey uses a structured interview with mostly closed questions, much more data can be collected (Møller & Hels, 2008). The ability to extract more information and depth from respondents is an other advantage of interviews. It can also be used as a supplement to explore a study in more depth (Lee & Kim, 2021).

3.4.3. Machine learning

Machine learning can be used to process large amounts of data and turn it into information. A study in April 2024 (Abedi & Sacchi, 2024) used machine learning to process Twitter data and create a subjective picture of road safety.

A disadvantage of utilizing social media platforms is that they engage only a subset of the population, resulting in a potentially biased sample. The geolocation is often a large area, which also means that a lot of data is needed to say anything. It is still unclear whether the method will be appropriate at a municipal level. If used well, these tools will be very cost-effective for processing large amounts of data. This could help policy makers.

3.4.4. Physiological traits

Another way of collecting data without asking for an opinion is through physiological traits. Physiological traits are characteristics of people that are related to their functioning. They are the natural processes that affect a person's processing. An individual has no conscious control over them.

Eye tracking data can be used to collect objectively measurable data on perceptions of safety. For example, it was used in a study by Gadsby, Tsai and Watkins in 2022 (Gadsby, Tsai, & Watkins, 2022). It measures whether participants focus on a particular item on the road and for how long. An advantage is that participants can take part in traffic in a real situation. This makes the feedback more realistic compared to an experiment in a closed system.

Disadvantages are that this type of study has a small group of participants. This study involved 17 people. Special equipment is needed and the data is not easy to process. Just looking at the subject is not enough to say anything about people's perceptions of it. By measuring what people look at, it can give insights on what attracts their attention and say something about how people behave in traffic. However, it is difficult to say anything about subjective safety. This study also used a second, complementary method, a survey.

Other physiological measures used to understand subjective road safety include heart rate, pupil size, blood pressure (Wu et al., 2009) and breathing (Vlakveld, 2009). However, these methods have similar advantages and disadvantages.

The overall conclusion is that this method can be used to gain insights into some aspects of subjective road safety. The physiological traits show how a person's body reacts as a result of the amount of stress or fear. This comes from the emotional part of subjective road safety but provides less insight into the other aspects that are relevant to subjective road safety.

3.5. Findings from the scientific literature

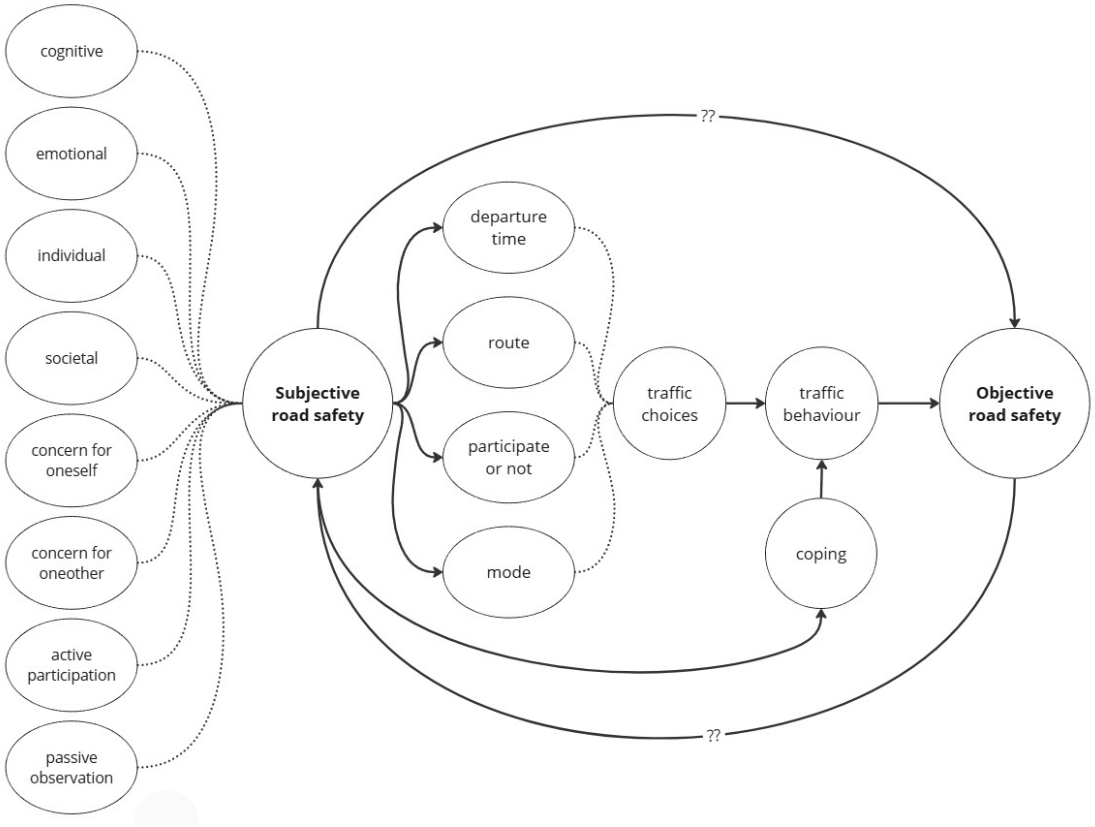

Figure 3.4: Overview of scientific findings

Figure 3.4 shows an overview of the various findings from the scientific literature. The dotted lines in the figure indicate that the elements are part of the overarching component. Thus, the figure shows that the eight elements mentioned in this chapter together form subjective road safety. Influence is represented by a solid line. Subjective road safety influences the different types of choices people make when participating in traffic. When these choices are changed, this is called behavioural adaptation. Not only are traffic choices influenced by subjective road safety, but when subjective road safety is low, it can also lead to coping. Coping and the traffic choices that are made as a result influence the traffic behaviour. This traffic behaviour in turn affects objective road safety. A difficult element is that subjective and objective road safety also influence each other in other ways. It is currently unclear which factors lie in between, which makes it difficult to predict how this influence works.

From this chapter, there are a number of conclusions that should be taken into account in this study. Firstly, it is worth highlighting that there are many aspects of subjective road safety that scientific studies do not take into account or that researchers do not consider.

Objective and subjective road safety are not mutually exclusive and are in fact always present at the same time. Although subjective road safety is often mentioned in the same context as risk perception, there are differences. Subjective safety is a broader concept and does not only focus on the cognitive and situation-specific part that risk perception stands for.

It is also clear that many methods can be used in research to gain insight into subjective road safety, but these methods are mainly situation-specific or require many resources to obtain this information. There are also many parameters that can influence subjective road safety, but it is not yet clear how this information can be used to get a better picture of the situation.

In the scientific approach, all methods are proactive. The researcher is looking for answers. People are asked what they think and how they feel. This may influence how they feel. When physiological traits are used, this effect is probably the smallest because no specific questions are asked, but even here the participant is aware of the research, which can still have an influence. It can also be argued that the impact of road safety on society is high. Therefore, it seems useful to get a more concrete picture of the situation and how to deal with it. On the basis of this literature alone, it is difficult to make progress at the municipal level.

To answer the sub-question: *How is subjective road safety defined and measured in the scientific literature?*
A working definition of subjective road safety has been established: ”Subjective road safety refers to the perceived sense of unsafety that individuals experience in traffic, whether they are actively participating or not, across all modes of transport”.

What is important to conclude is this chapter is that subjective road safety includes more than risk perception. To get a complete picture of subjective road safety, more elements need to be taken into account. It is also important to be clear that objective and subjective road safety coexist in all cases and that both are always present to a greater or lesser extent. This does not mean that they do not influence each other even though the way in which they do so is difficult to predict.

4

Subjective road safety in practice: grey literature review

Grey literature is literature that has not been subject to the normal requirements of scientific publication. In practice, this means that these sources have not been peer-reviewed, but have been validated in some other way (University Library Groningen, 2022).
Grey literature is very important in this study because it is much closer to practice than academic literature. Many policy makers are more exposed to the information that appears in conferences with different interest groups. At the municipal level, much is done on the basis of objectives set at the national or provincial level. Therefore, this literature has a more direct impact on decision-making and subjective road safety processes in municipalities. In this study, the grey literature looks at government documents, government reports and plans, news reports, interest group reports, factsheets and police and news releases.

This chapter examines the second sub-question, as described in Section 1.4. This question reads ”How is subjective road safety defined and measured by local stakeholders and how do they use this information in their activities?” In addition, this chapter contributes to answering the third research question: *“What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?”* Although this question is not fully answered here, reviewing grey literature provides initial insight, leading to a more focused interview, as described in Chapter 2.

This chapter will first focus on the various stakeholders and interest groups showing interest in this topic in Section 4.1. Next, activities taken in this area in Section 4.2 will be considered. Section 4.3 will then look at the data that is currently available and collected by the different groups. After this, Section 4.4 will be dedicated to looking at the definition provided by the different groups.

4.1. Interest groups and stakeholders

There are different organisations dealing with different aspects of road safety in the Netherlands. This section highlights the main parties involved in subjective road safety in municipalities in the Netherlands. These parties can be divided into stakeholders, interest groups and knowledge organisations.

4.1.1. Stakeholders

Stakeholders are the parties that have a say and can make decisions. As described earlier in Chapter 1, responsibility for road safety lies largely with the government. In this case, the responsibility for road safety in the Netherlands lies with the road authorities. The Netherlands has four sizes of road authorities: the national government, the provinces, the water boards and the municipalities. This study focuses on subjective road safety within the municipalities and therefore the municipalities are responsible for this. The municipalities make plans based on the goals and guidelines set by the provinces and the central government. This makes the Ministry of Infrastructure and Water Management's Strategic Plan for Road Safety 2030 (SPV) (Ministerie van Infrastructuur en Waterstaat et al., 2018) a guideline. This plan states that road safety should be approached in an increasingly risk-based manner, which seems to include a focus on subjective road safety. The various provinces and municipalities are each making their own translation of this guideline to translate this vision into policy.

Another influence on the subjective road safety is enforcement. Local enforcement and police are directed by the municipality. Therefore, the municipality is the most important actor in this study.

Within the municipality there is a difference between the municipal council and the municipal executive. In short, the municipal council is elected and forms the college of mayor and aldermen, who are responsible for implementing the decisions of the municipal council. Officials working in the municipalities implement the decisions. The extent to which these decisions are guided by the aldermen may vary.

4.1.2. Interest groups

Interest groups and advocacy organisations are organisations dedicated to the advocacy of a specific social cause. In this study, there are a number of organisations that have an interface with subjective road safety.

The most important interest organisation is Veilig Verkeer Nederland (VVN). VVN is committed to ensuring that people are aware that everyone is a traffic participant and that everyone can easily contribute to safer traffic (VVN, n.d.-b).

Besides VVN, the Fietsersbond also shows interest in this subject. The Fietsersbond champions the interests of cycling in the Netherlands and advocates cycling routes that are both objectively and subjectively safe (Fietsersbond, 2023).

4.1.3. Knowledge organisations

The last category is knowledge organisations. These are bodies that conduct research or provide a bridge between available knowledge and municipalities. These organisations are very important, as policymakers get a lot of information from them.

There are independent knowledge institutes such as SWOV and other research institutes. This is where research is conducted in the field of road safety (SWOV, 2012). There are also institutes that act as platforms to connect researchers in this field, such as Mobilitietsplatform (Mobilitietsplatform, 2014) and Verkeerskunde (Verkeerskunde, n.d.).

Some institutes consist of a collaboration of knowledge organisations, such as the Kennisnetwerk SPV (Kennisnetwerk SPV, n.d.-a). This is a collaboration between SWOV and CROW, commissioned by the Ministry of Infrastructure and Water Management. Its purpose is to make knowledge available for the implementation of the Strategic Plan Traffic Safety 2030 (Ministerie van Infrastructuur en Waterstaat et al., 2018). This constitutes an important source of knowledge for municipalities.

There are also consultancies that conduct research into subjective road safety, often commissioned by a client. Municipalities can also use the knowledge and expertise of these consultancies (Andriesse & Goudappel, 2024).

4.2. Activities of municipalities and interest groups

Actions to affect subjective road safety generally have two purposes. The most obvious is to improve subjective road safety. Although this sounds simple, in practice it is often much more difficult and involves a number of pitfalls.

Secondly, actions can also be taken to address subjective road safety in order to encourage

a change in behaviour that will have a positive effect on objective road safety. Again, caution is needed as the relationship between objective and subjective road safety is not entirely certain as described in Section 3.1.1.

The different types of intervention that are used can be divided into campaigns and infrastructure measures. Municipalities are responsible for policy and physical infrastructure. However, the municipalities also use other means to have an effect. Interest groups do not have the authority to change infrastructure and try to achieve effects through raising awareness and campaigns. The different types of action can be used for both purposes. This section gives examples of both.

4.2.1. Improving subjective road safety

Some municipalities argue that the feeling of road safety is enough to take action (Gemeente Rotterdam, 2019). The danger in these cases is that improving traffic situations or objective road safety does not always result in improved subjective road safety.

It can also be the other way around. Improved subjective safety does not necessarily mean improved objective road safety; it may even have a detrimental effect. An example of this is the construction of pedestrian crossings. Despite the fact that road users, such as the elderly, may feel the need for such a pedestrian crossing (VVN, n.d.-c) this does by no means always make the traffic situation safer. This is because pedestrian crossings are often difficult for drivers to see (SWOV, n.d.). So in this case, false safety occurs which can actually cause more accidents.

Another way to influence subjective road safety is not only through infrastructure measures, but also through understanding and support. Many feelings of unsafety may arise from a lack of understanding and frustration. This can be addressed in a number of ways. An example would be angry neighbours complaining about traffic, parked cars or speeding. Sitting around a table together may reveal underlying problems that have nothing to do with traffic, but which lead to this type of complaint. Another example is that many citizens do not understand the basis on which certain decisions are made. If a citizen is given an insight into the problems associated with the construction of speed bumps or the disadvantages of a zebra crossing, they can understand the decisions and feel less negative about them.

Involving residents in decision-making can reduce misunderstandings about certain infrastructure decisions. Neighbourhood involvement in projects is therefore increasingly used by local authorities, especially for large projects. It gives people the feeling that they are being listened to and that their concerns are being taken seriously. But it can also be complex, as in-

frastructure projects have to take into account many different factors and it is not always possible to satisfy all citizens' wishes (Gemeentepeiler, 2019).

Another approach is to create a sense of responsibility. This can be done, for example, by actively involving residents in road safety projects, such as conducting speed monitoring in the neighbourhood. As a result, people pay more attention to their own speed and learn that the situation may not be as dangerous as it first appears. This can lead to a more reassuring feeling (VVN, n.d.-a).

4.2.2. Influencing behaviour through subjective road safety

One example of an infrastructure change that can be implemented is the creation of a 'living room effect,' known in Dutch as the 'huiskamer effect'. This means that the road becomes visually narrower, causing cars to slow down. This principle thus makes use of the subjective feeling that the infrastructure is less safe (Provincie Noord-Holland, n.d.).

The same happens with shared space. This is a space with minimal traffic calming measures. As a result, subjective road safety is reduced, users pay more attention and fewer accidents occur (Provincie Noord-Holland, n.d.).

Another method is called fear appeal, which is a form of education. This is an attempt to influence behaviour through fear-inducing images. This way of influencing behaviour is not always desirable (TeamAlert, n.d.). Fear appeals can be used in certain campaigns, an example of which is MONO. This campaign shows how dangerous it is to use a smartphone in traffic (Veilig Verkeer Nederland, n.d.-a). This type of approach is not suitable for all population groups and may even be counterproductive (SWOV, 2023).

4.3. Currently available data

Currently, data is already available and gives municipalities insight into subjective road safety. This information is collected by municipalities themselves or comes from external interest groups. This section gives a brief overview of the various data sources currently used.

Veilig Verkeer Nederland (VVN) has a registration point where people can report unsafe traffic situations. In this system, situation-specific cases are categorised by the reporters themselves. The categories used are speed, traffic density, parking or an unclear traffic situation. There is also the option to create a new category. Next, people are asked how (un)safe they feel on a seven-point scale from very unsafe to very safe. Finally, people are asked about their age category. The map with all reports can be viewed publicly (VVN, n.d.-d). Municipalities get an overview of the notifications and can act on them. VVN is now implementing a change where

the focus is more on citizens taking action themselves. The participation point comes later.

In the municipality of Leeuwarden, the safety domain provides support in the field of subjective road safety. According to the implementation programme, responsibility for this lies with the municipality's physical domain (Gemeente Leeuwarden, n.d.-a). Leeuwarden uses a Safety Performance Index (VPI), in which neighbourhood report figures are calculated based on various components from a survey (Gemeente Leeuwarden, n.d.-b). One of these components is traffic. Items about traffic in the resident survey are parking, bicycle parking and traffic annoyances. These traffic annoyances in particular are intersecting with road safety. The source indicates that 72 percent of the residents are occasionally irritated by speeding traffic. Other topics of ergencies are parking, sneak traffic and noise from traffic. However, not all these issues have to result in feeling unsafe. What also stands out is that public safety is a separate item in the residents' survey, which does not include traffic.

In Rotterdam, a risk-based approach mainly uses SPI's and blackspots based on objective traffic figures. However, in the traffic safety model a top three subjectively unsafe locations were added per neighbourhood. These locations were identified using the 'traffic safety pricker,' a survey conducted among Rotterdam residents (Gemeente Rotterdam, 2019).

In Amsterdam, city talks and surveys are conducted. Residents are made aware of these talks through articles, advertisements on local news sites, social media and newsletters. The talks covered a range of topics such as safe school environments, traffic congestion in the city and speed. In total, 20 to 30 people attended each session and an hour and a half was spent discussing the issues (Gemeente Amsterdam et al., 2021).

Looking at the different streams of information used to gain insight into subjective road safety, a distinction can be made between reactive and proactive obtaining of information. This is shown schematically in Figure 4.1. The difference here lies in whether the initiative comes from citizens, or whether the municipality or another party actively requests information. Currently, information is mainly collected in a reactive way.

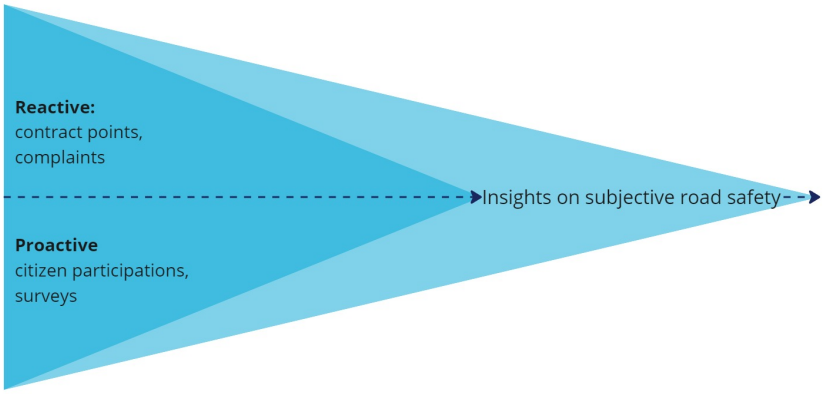

Figure 4.1: Reactive versus Proactive

4.4. Definition of subjective road safety in practice

It is important to examine what municipalities mean by subjective road safety. As can be read in Chapter 3.1, there are a number of elements that play a role in subjective road safety. A 2020 SWOV study has already tried to find out whether municipalities know the difference between objective and subjective road safety (Bax et al., 2020). However, this survey consisted of only one question and the organisation of the results did not give a complete picture.

Below are some translated citations from definitions of subjective road safety as reported by the municipalities. For this, six municipalities are chosen in Section 2.3.2 expanded with the municipalities of Amsterdam and Rotterdam, as they have a lot of interest in this topic. Of these in total eight municipalities, four provide a clear definition. Not every municipality describes a clear definition, so quotes are not available from every municipality. The municipality of Heiloo is currently part of De Buch, a partnership of smaller municipalities in North Holland.

The municipality of Amsterdam:
"Subjective road safety, that is the feeling of (un)safety that people experience when travelling in traffic." (Gemeente Amsterdam et al., 2021)
The municipality of Leeuwarden:
"Subjective safety is the extent to which people feel safe. Subjective safety is a personal matter. For each individual, the boundary lies somewhere different as to whether they feel safe. One person feels unsafe in the city because of loitering youth while another feels unsafe in traffic. Everyone has their own perception of safety in a particular situation or area." (Gemeente Leeuwarden, n.d.-a)
The municipality of De Buch (Heiloo):

"Subjective represents the feeling of safety and objective safety is based on facts (e.g. accident records). For example, an environment may be perceived as unsafe but this is not reflected in road safety figures." (Gemeente Heiloo, Negenman, & Broersen, 2018)
The municipality of De Wolden:
"Subjective road safety can be described as a feeling of insecurity. People feel unsafe for whatever reason, but - fortunately - no accidents happen." (Gemeente De Wolden, 2009)

As the quotes above show, people's feelings are central to municipalities. However, the definitions do not go deep into the subject and generally remain superficial. What also stands out is the tension between subjective and objective road safety. One of the quotes even concludes, wrongly, that accidents cannot happen in subjectively unsafe places. This is a misconception, as a location that is perceived subjectively unsafe in traffic can also be objectively unsafe. The two concepts can coexist. This distinction appears to be unclear to the municipalities.

Besides the definitions used by municipalities, there are also definitions from knowledge institutes and interest groups.
SWOV: *"...personal feelings people have about traffic unsafety or, more generally, to the concern about traffic unsafety for themselves and/or others."* (SWOV, 2012)
Kennisnetwerk SPV: *"Subjective road safety is the personal experience, observation or perception of road safety. This may involve an assessment of the probability of being involved in a crash in given traffic situations. It may also involve the extent to which someone experiences fear and concern about the safety of themselves or others, such as children and partner."* (Kennisnetwerk SPV, 2022)

The knowledge network also discusses the weak relationship between objective and subjective road safety.

VVN itself does not describe a clear definition but refers to the SPV knowledge network.

4.5. Findings from the grey literature

What is notable in this chapter is the difference in the definitions used by the municipality and the knowledge organisations. In the municipality, the definition is mainly focused on feelings. Subjective road safety is not looked at in a cognitive way. This differs from scientific research where much attention is paid to the cognitive part and risk perception. By the knowledge institutes, the definitions are used much more broadly and seem to highlight more sides.

5

Interviews with municipalities

This chapter discusses the results from the interviews. The interviews were analysed using thematic methods as described in Section 2.3. Section 5.1 briefly addresses the practical aspects of these methods and provides information about the process followed. In the following section (5.2) the interview results are presented in the order of the pre-established interview structure, which can be found in Appendix C.4.

Next, Section 5.3 examines a comparison of these results with the knowledge derived from the scientific literature in Chapter 3 and the gray literature in Chapter 4. This is followed by an interpretation of the gathered information.

In this chapter, the specific names of the municipalities have been withheld in accordance with the agreements made with them. In addition, this study does not have data from a large number of municipalities to make meaningful comparisons. The results are therefore presented in this way. Further information about the interview results can be found in Appendix D.

5.1. Performing thematic analysis of the interviews

A thematic analysis was used to extract information and findings from the interviews. The steps taken for this purpose are explained in Section 2.3. This section discusses the results of these intermediate steps.

In order to create the codes used to extract information from the interviews, the content of the transcribed texts was considered. Whenever relevant information for the study was found,

a label or code was assigned to it. Although the interviews were conducted and transcribed in Dutch, the labels were created directly in English to avoid losing the original meaning in a later translation.

The codes were kept short and to the point. Examples of codes used are: 'keeping older people mobile' or 'overcrowding on cycle paths'. Several recurring topics and points emerged during the analysis of the different interviews. Here, an effort was made to maintain consistency in the use of the same codes.

After the first round of code assignment, it is checked whether certain codes have the same connotation; if so, they are merged. The number of codes per interview may vary depending on the content of the interview. In this study, the number of quotations in each interview ranged from 24 to 43 quotations per interview. In total, 101 different codes were assigned. The full list of codes can be found in Appendix D.

After this step, the similarities between the codes were examined and themes were created. The themes were not predetermined and depended on the answers given by the municipalities during the interviews. Nevertheless, five of the seven final themes can be traced back to the pre-established interview structure (Appendix B). The two additional themes found indicate that the study looked beyond the expected themes. This suggests that the coding process was objective and as complete as possible.

The seven themes identified are listed below, along with a brief explanation of what they entail:

- **Definition of subjective road safety as it is understood by the municipalities**
  This theme relates to the definition of subjective road safety as understood by the municipalities. This is initially done by examining the responses to the specific questions on this topic. It is also revisited later in the interviews to explain why certain aspects are included or excluded from subjective road safety.
- **Causes of notifications of subjective road safety**
  This category was created because many municipalities look for the causes of complaints about road safety. For many municipalities this was both difficult to define and an area where they had an opinion but where the follow-up was often unclear.
- **Information, data and investigations already available to municipalities**
  This topic contains information on the data and research that municipalities currently have or use to understand subjective road safety.
- **Groups of road users that stand out in subjective road safety**
  One thing that stood out in the interviews was that many municipalities identified specific

groups of road users in relation to subjective road safety. These are, for example, groups to which the municipalities pay particular attention because of other objectives, or groups from which many complaints come.

- **Municipal goals for subjective road safety**
  This theme includes codes related to the goals municipalities have set for subjective road safety.
- **Resources within municipalities for approaching subjective road safety**
  This theme identifies the resources available to municipalities to conduct research or gain insight into subjective road safety.
- **Municipal needs for approaching subjective road safety**
  This theme deals with the needs of municipalities. It examines what is in demand and what municipalities believe can help them.

The distribution of how often codes from the listed themes are mentioned is shown in Figure 5.1. This figure shows that not all themes come up equally often. This may be because respondents found some questions difficult to answer. It is noticeable that little was said about the needs of the municipality. This may be explained by the fact that municipalities themselves are not always sure how to proceed and do not have a clear answer to this question. It is also apparent that there is a lot to be said about the current information available to municipalities. Section 5.2 discusses the findings by theme in more detail.

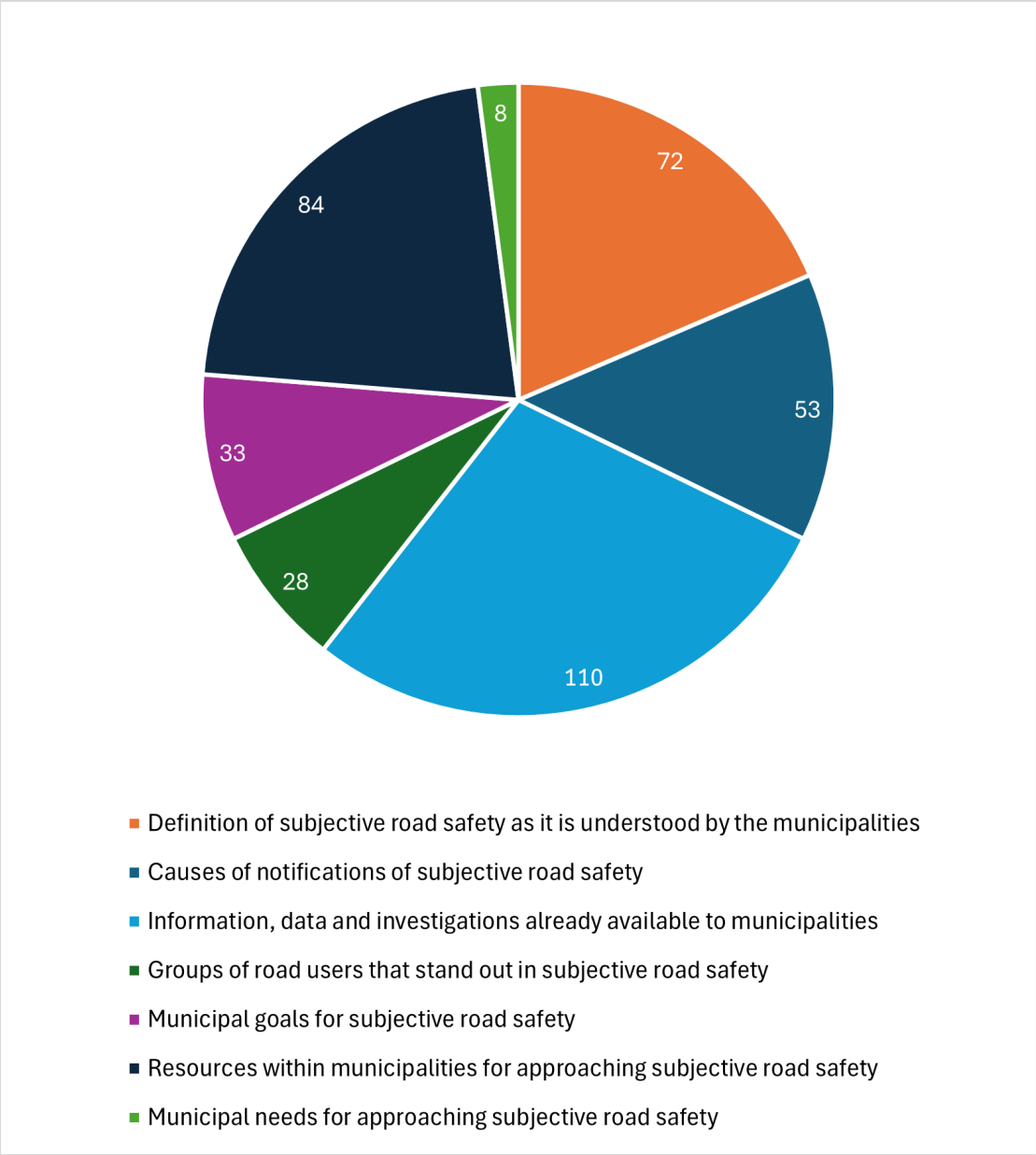

Figure 5.1: Proportion of different themes based on the number of times associated codes were assigned

It was also checked whether all municipalities had something to say about each theme found. Where this was not the case, additional checks were made to ensure that nothing was overlooked in the analysis process. Figure 5.2 shows the proportion of municipalities that talked about the themes found. The y-axis indicates the number of codes mentioned, and the colours represent the different themes into which these codes fall. These colours remain consistent throughout

the report. It can be seen, for example, that the municipality of De Wolden does not mention all the themes. This may be because these themes are less important for this municipality.

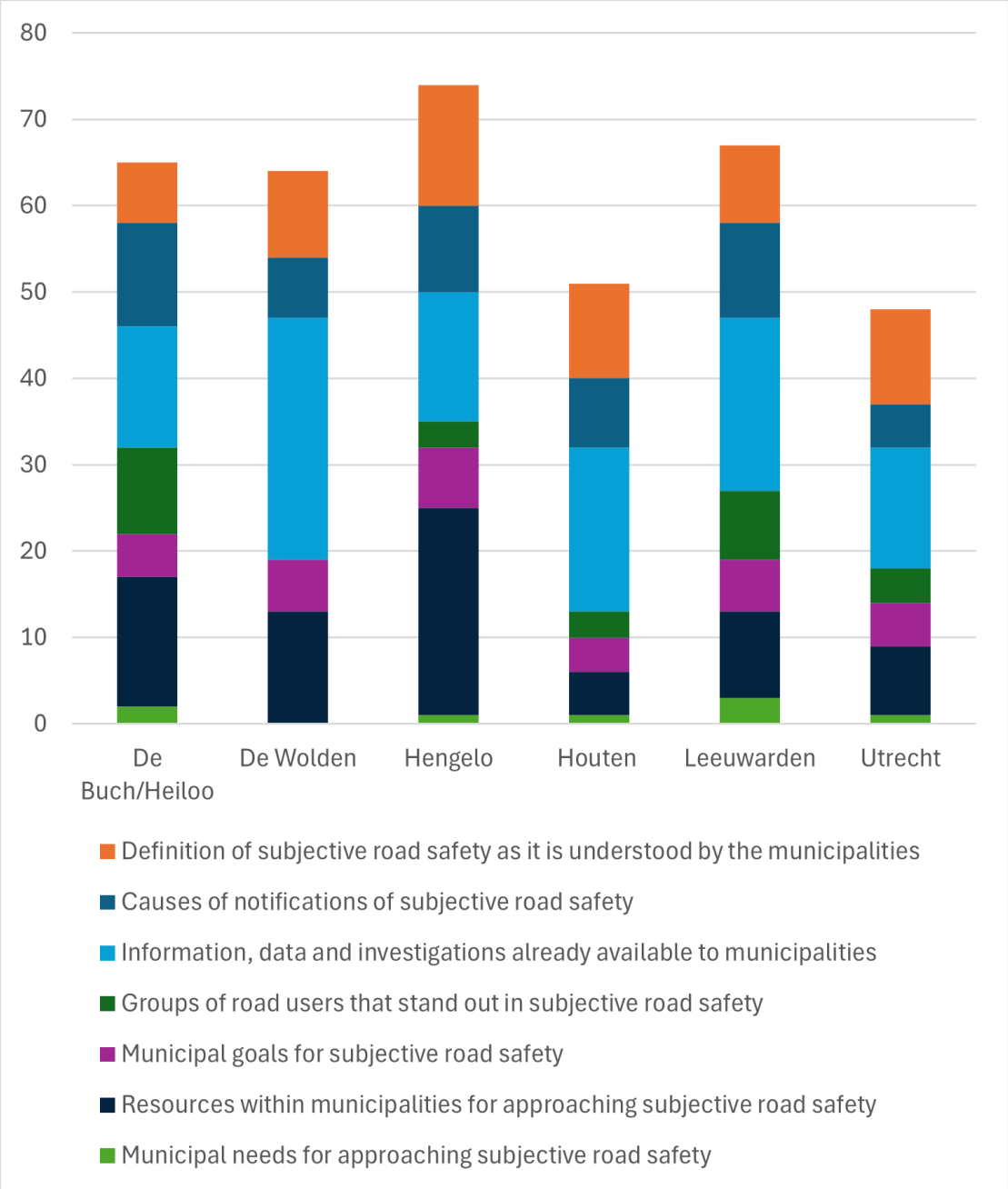

Figure 5.2: Proportion of different themes based on the number of corresponding codes assigned per municipality

Figure 5.3 shows an example of one of the seven themes: 'Groups of road users that stand out in subjective road safety'. The different codes associated with this theme are shown on the left. The x-axis shows how often these codes were mentioned in the interviews. Appendix D shows more figures for the other themes. Due to the privacy of the municipalities, this information is not further broken down by municipality.

To make statements about content, notable issues are analysed. These may be codes that are mentioned noticeably often or sparsely. It helps that the content of the interviews is familiar to the analyser at this stage. Here, a reference back is made to the corresponding text from the interviews to avoid misinterpreting the codes. This is further elaborated in the next section.

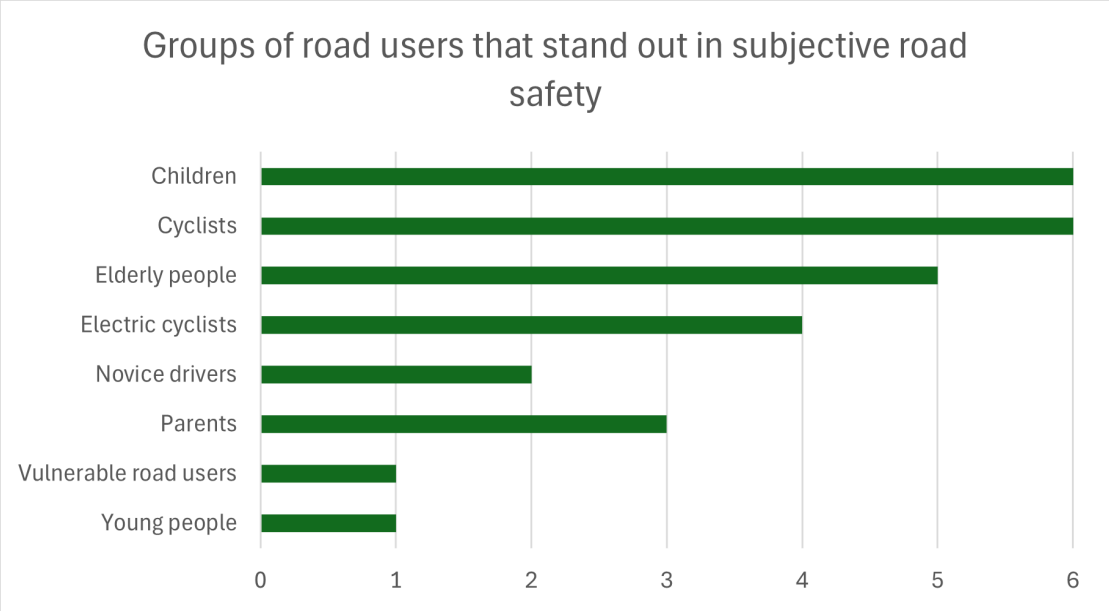

Figure 5.3: Codes belonging to the theme 'Groups of road users that stand out in subjective road safety' and the number of times they were attributed

5.2. Results from the interview analysis

This section describes the results of the interviews by theme. Here, we look at the measure noteworthy or important information for this study. The codes for each theme can be found in Appendix D.

5.2.1. Definition of subjective road safety as it is understood by the municipalities

In the interviews, municipalities were asked for their opinions on the established working definition of subjective road safety. This definition, based on the scientific literature in Chapter 3, reads:
'Subjective road safety refers to the perceived feeling of unsafety that individuals have in traffic, whether they actively participate or not, regardless of the mode of transport'.

All municipalities agreed in principle with this definition, but two additions and one modification were proposed. A municipality suggested adjusting the definition by emphasising that it refers to a resident's or road user's feeling of traffic unsafety. Another indicated that the assessed risk and associated feelings are also important. Yet another municipality's comment was noteworthy because they argued that the feeling of unsafety can exist even when there is nothing objectively wrong. This tension between subjective road safety and the objective situation emerged in all interviews.

The remaining interviews showed that people's feelings and emotions are considered important. This was pointed out several times, with three and four references in two different municipalities. In addition, the individual aspect of subjective road safety was seen as an important feature by all six municipalities. This came up a total of 13 times, with frequent examples of individual complaints in specific situations being difficult to resolve precisely because they depend heavily on one person's feelings.

5.2.2. Causes of notifications of subjective road safety

Although not specifically asked about it in the interviews, many municipalities began to explain why they think people experience a sense of unsafety in traffic. While this has not been researched, it does give a good idea of the situations municipalities face.

As many as 18 times, speed was cited as the cause of feeling unsafe. Reports are often made about vehicles speeding. The feeling that a traffic situation is unsafe due to the experience of speeding occurs in all municipalities.

Interestingly, however, many municipalities respond by carrying out speed measurements. However, these rarely measure a truly excessive speed. So the high speed is perceived as such, without actually being problematic. There are several explanations for this. One example is the use of the V85 by municipalities. The V85 is an SPI and is in line with the risk-based approach described in the Strategic Road Safety Plan (SPV2030) (Ministerie van Infrastructuur en Waterstaat et al., 2018) . The V85 is the speed at which 85% of drivers are below this speed

(Kennisnetwerk SPV, n.d.-b). This also means that although the V85 is below the desired speed limit, there may still be outliers. These extremes can still make residents feel unsafe. Another example is where there is no speeding, but the road layout is outdated. This may mean that cars are not speeding, but the speed may still be higher than desirable when taking into account road width, other road users or visibility. A follow-up step for the municipality in this situation is often difficult. A municipality says that it then checks whether the road layout still matches the permitted speed.

These infrastructural features are another possible cause of feeling unsafe in traffic. This was mentioned four times in the interviews. Examples of such infrastructural features include road width, visibility at intersections and the possibility of crossing the road. A municipality gives an example where a bicycle path was resurfaced. As it was raised slightly higher in relation to the verge, people felt that the path had become narrower. When the verge grew higher, this feeling disappeared. The width of the cycle path had not changed, but people's perception of the width of the cycle path, and hence the perception of road safety, had.
Two other points mentioned as possible causes of feelings of insecurity were mixed traffic and the difference between urban and rural areas. Both points were mentioned four times. Mixed traffic in urban areas often means in practice the mix between cyclists and cars, or mopeds on the cycle lanes. In more rural municipalities, this also involves agricultural traffic, which can create an unsafe feeling.

Finally, general frustration is mentioned by two municipalities as a cause of reports on road safety. This is a bit more difficult to argue, but the point is that if there is frustration in society, there will also be more dissatisfaction with transport safety. This could be because people disagree with upcoming local plans or more national changes, such as the fact that more people had to work from home in the corona years. As a result, more attention was paid to the traffic situation around the home and more complaints were received. This statement is based on the experience of the municipal officials and needs to be further investigated to prove these links.

5.2.3. Information, data and investigations already available to municipalities

Most of the codes from the interviews fall under the theme of information, data and research available to municipalities. A distinction can be made between reactive and proactive information, as explained in Section 4.3. The interviews show that almost all of the information used by municipalities to form their impressions of the subjective road safety is reactive.

Much of this imaging comes from complaints and reports from citizens. This occurred in all six

municipalities and was mentioned a total of 27 times. These complaints can reach the municipality in a number of ways. Many municipalities use an application or external application that allows residents to report an unsafe situation in their neighbourhood. These reporting systems can be managed internally and forwarded by a central department to the appropriate department within the municipality, but they can also be managed externally.

Five times it was mentioned that a map is used where reports are visible. However, it was also mentioned twice that there is a wide distribution of complaints and that there are no clear blackspots as is often the case with accidents.

Other ways in which reports are received are by phone, email, letter, social media or in person. The quality of reports often depends on how they are received, and they are sometimes handled differently depending on how they reach the council. This is partly due to oversight. Simplifying the reporting process can sometimes mean that the content of complaints is less detailed.

It can be taken into account that not every demographic group will approach the municipality in the same way. Young people are more likely to choose a digital way. Complaints by post are more often more formal in nature and are likely to have been sent by older citizens. The accessibility of the municipality may also play a role here. In a smaller municipality where people are more likely to have acquaintances within the municipality, contact can also be made in this way to address their complaint.

Another common method is neighbourhood interviews, often project-related or in response to a report about a situation. Sometimes street interviews or surveys are carried out as part of projects to get a better idea of what is going on.

General population surveys are also carried out proactively, usually on an annual or biennial basis. However, there are still some problems with this proactive form of information collection. The questions are often not standardised, making it difficult to compare results between years and between municipalities. There is also no room for in-depth questions, so the results remain superficial. The results are often broken down by neighbourhood.

Finally, the information from these surveys is not always passed on to the relevant departments, or these departments are not actively involved in formulating the questions.

5.2.4. Groups of road users that stand out in subjective road safety

In five of the six interviews, different groups of road users are mentioned as standing out when it comes to subjective road safety. These are groups that municipalities have expressed interest in and from whom they receive complaints about subjective road safety.

Commonly mentioned groups are children or schoolchildren, cyclists and the elderly. Regarding children or schoolchildren, a municipality notes that, according to them, they do not

always go to school independently anymore. The safety of children on their way to school is also a major concern in two other municipalities. One of those notes that there is a feeling of unsafety due to crowding around schools, caused by parents bringing their children to school by car, while the school is often easily accessible by bicycle.

An other municipality says, it is more general about the congestion on bicycle paths, which bothers parents with children and also elderly people. The elderly are also often mentioned in combination with electric bikes. A link is also quickly made to policy goals aimed at these specific groups. This is further explained in the Section 5.2.5

5.2.5. Municipal goals for subjective road safety

Three municipalities indicated that improving subjective road safety is in itself a goal within their policy. Yet, for two of these three municipalities, the realisation of this goal is still unclear.

Recognisable goals mentioned in the interviews are often not directly linked to subjective road safety. Encouraging cycling is mentioned four times as a goal, for example, and keeping older road users mobile is seen as an important concern by two municipalities. Behind these goals are measures that may make it more attractive for people to continue using bicycles. These respond to the subjective experience of road users, with subjective road safety playing a role, but more in the background.

Another point mentioned is the risk-based approach. Many municipalities indicate that they follow the goals from the Strategic Road Safety Plan (SPV) and build on plans from the provinces.

However, the most frequently mentioned goal is complaint avoidance. This can be seen as a goal in itself: fewer complaints can be interpreted as fewer bottlenecks. Yet the underlying reason for this often seems to be workload, which is discussed further in Section 5.2.6.

5.2.6. Resources within municipalities to approach subjective road safety

The resources available to municipalities for an approach to subjective road safety can be divided into two groups. The first group concerns the resources that municipalities use to address or prevent citizens' feeling of dissatisfaction with road safety. These resources are thus about potentially influencing subjecive road safety.

In addition, the resources of municipalities are limited. In the pre-established structure (Appendix C.4), the first question is mainly about the available resources that municipalities have to gain more insight into subjective road safety. What possibilities are there within a municipality for a better approach to subjective road safety? These answers are presented in terms of limitations and are set out here under the 'limiting factors' section.

Potential for influencing subjective road safety

To address subjective road safety, a municipality can take several actions. The codes mentioned in the interviews can be roughly divided into two approaches: adjusting infrastructure or engaging with citizens to create a better sense of road safety through understanding.

Actual adjustments to infrastructure often require more than just a feeling of unsafety within the municipality. One municipality indicates that a feeling of unsafety can sometimes be enough for an adaptation. Yet priority is usually given to locations where accidents actually occur. Also, when a road is in need of maintenance, a location moves up the list, allowing changes to take place sooner. Political attention, such as the interference of an councillor, can also play a role in prioritising a case.

When infrastructure changes are eventually made, citizens are involved in many municipalities. Various forms of discussions are held with residents of the relevant neighbourhood or district. There is often a point of contact or neighbourhood council with which the municipality engages in talks to explain the course of action. This also involves management of expectations by the municipality.

In individual cases where no infrastructural measures are taken, a personal chat is often held. Municipalities indicate that citizens like to be heard, and that part of the problem is already solved when understanding and explanations are given. This aspect of explanation is mentioned eight times by five different municipalities in the interviews.

Limiting factors

The limiting factors mentioned by municipalities are currently obstacles that prevent them from dealing with subjective road safety. The most frequently mentioned problem is high workload, which was mentioned a total of 14 times. This problem occurs in all municipalities, regardless of their size or the number of employees in the team. Workload also includes the aspects of capacity and budget, which were mentioned five and seven times respectively and are therefore also important.

Budget plays a crucial role, as, for example, insufficient number of personnel is available to increase capacity to reduce workload. In addition, budget affects the measures that can be implemented, which puts pressure on the decisions that can be taken within a municipality.

Limited financial resources also mean that infrastructure modifications, even if they improve the road layout, cannot always be executed right away. Project prioritisation often takes place when infrastructure is in need of maintenance, which was mentioned five times in the interviews.

Budget is also required when external help is brought in. Although most municipalities prefer to do the work themselves, three different municipalities indicate a lack of internal knowledge.

In these cases, experts or consultancies are desired, but budget is also a limiting factor here.

In addition, it is indicated that working on subjective road safety often takes a lot of time. Because the current resources for addressing subjective road safety are highly personal in nature, this takes a lot of time, which further increases the workload.

5.2.7. Municipal needs for approaching subjective road safety

During the interviews, municipalities found it difficult to answer the question of what is needed within the municipality in terms of subjective road safety. The codes showed that relatively few codes were mentioned within this theme, namely seven, and they were also not often repeated.

No exact overlap was found in the answers of the different municipalities, but the answers seem to point in the same direction. Some answers that emerged include:

1. Help in processing notifications
2. Better organisation within the municipality for handling complaints
3. A better overview of all data and dates of notifications coming in through various channels
4. Better internal coordination between municipal departments
5. Clarity in the policy process on how to deal with subjective road safety
6. More guidelines for measuring and assessing subjective road safety
7. A more standardised approach to surveying subjective road safety.

Although responses vary, it is striking that there is a general need for more clarity on the value and processing of subjective road safety. The overarching question emerging from these responses is: how should municipalities deal with all these complaints?

5.3. Discussion of the results of the interviews

In this section, the main points are summarised from the interviews. Following this, these are compared with the findings from the academic literature and the grey literature. It also answers the third sub-question of this study: *what are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?*

5.3.1. In-depth interpretation compared to scientific literature

Municipalities agree with the work definition as established:
'Subjective road safety refers to the perceived feeling of unsafety that individuals have in traffic,

whether they actively participate or not, regardless of the mode of transport'.

In the scientific literature, many different aspects have emerged that can fall under the concept of subjective road safety. Similar to the scientific literature, it is not common practice in municipalities to refer to a fixed definition.

The relationship with objective road safety remains uncertain, and this area is fraught with tension.

5.3.2. In-depth interpretation compared to grey literature

Where is the municipality's priority? Due to limited resources, choices always have to be made. The question is where to focus attention and where to spend the budget for adjustments. Municipalities feel on the one hand that they have insufficient insight into subjective road safety, but on the other, they are reluctant to collect more information. More reports or extra work on processing data is often undesirable.

The available data is mainly reactive and consists mainly of reports and complaints from citizens. Although other means are used, such as questionnaires, surveys and interviews, this is mainly done on a project basis and thus also remains reactive. Some municipalities proactively distribute periodic surveys on general liveability in neighbourhoods, which also include space for questions on subjective road safety. However, these questions do not go deep enough, so municipalities often feel they can do little with them. In addition, cooperation between different departments within the municipality is sometimes lacking, and the fact that the questions in the surveys vary makes comparisons difficult.

In general, municipalities feel the pressure and importance of subjective road safety. However, there is still uncertainty among municipalities. Municipalities are unsure what information is best to collect when they want insight on subjective road safety. This results in a rather general approach that lacks depth. Municipalities also often do not know how this can be set up and used structurally. After this, there is a problem processing all this information. This is time-consuming and means that much energy and manpower is needed to deal with each complaint. This situation makes municipalities reluctant to gather new information, worried it will just add to their workload.

5.3.3. Conclusions from the interviews

Municipalities' priorities are in different areas, but it is important to first identify where the problems actually are. It was initially thought that municipalities were struggling to get a good picture of the status of subjective road safety. While there is certainly room for improvement in that area, this does not appear to be the biggest bottleneck for many municipalities. The real problem lies

mainly in dealing with individual complaints: it is often unclear and time-consuming to determine what to do with each report.

An alternative way of mapping the status of subjective road safety is desirable, but complaints and reports about individual situations will always remain. After all, the municipality remains the first point of contact for citizens and has the responsibility to address these issues. Yet processing these complaints is currently causing problems. It takes too much time to deal with each individual case, at the expense of other work. Moreover, municipalities are often bound by strict budgets, so choices have to be made in other ways. There may be a need for guidelines or handles to deal with these situations, but municipalities still struggle with the question: what to do with this?

To answer the question *"What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?"*, municipal goals are often based on international road safety guidelines. However, specific goals for subjective road safety are unclear or completely lacking. Policies around subjective road safety are highly situation-driven and there are no fixed guidelines for drafting policies yet. Factors such as neighbourhood participation, the street maintenance plan, political pressure and other individual circumstances play a role in policy-making, significantly increasing the workload for municipalities.

The lack of clear frameworks and guidelines causes a lot of time and energy to be spent on processing complaints, while at the same time there is a great lack of strategic approaches that can streamline the whole thing.

6

Recommendations for municipalities on approaching subjective road safety

This chapter discusses the various ways in which municipalities can address subjective road safety concerns. Based on the information from the previous chapters (3, 4 and 5), an initial approach is given with which municipalities can get started. The aim is to take a first step in the right direction.

Furthermore, this chapter starts structuring the approach for municipalities in the field of subjective road safety. This not only improves the processing by municipalities themselves, but also ensures more transparency towards citizens about the making of certain decisions. This can facilitate communication and the justification of decisions. While this chapter offers a valuable step forward based on the previous research, further deepening will be needed to arrive at a more concrete and appropriate plan for municipalities.

A foundation of practical tools is laid in this chapter. First, the different road safety goals of municipalities are described in Section 6.1. Then it discusses in Section 6.2 the tools that municipalities can use to measure subjective road safety, along with relevant characteristics.The link between measurement and different aspects of subjective definitions of road safety is discussed in Section 6.3. Section 6.4 provides a schematic representation of how municipalities approach subjective road safety.

6.1. Road safety goals in municipalities

Within the municipality, goals are often set based on European and national guidelines, as well as the individual wishes and visions of the municipality itself. The more concrete these goals are, the easier it is to take decisions and actions based on these goals.

This section looks at different categories of objectives related to subjective road safety. How these goals are related to each other is important for choosing the right method to measure subjective road safety.

When distinguishing between types of municipal goals, they can be categorised according to their relationship to subjective road safety. The categories to be used are direct, indirect and detached. These categories indicate how subjective road safety can contribute to achieving the objectives. They are intended to make municipalities aware of the underlying question: what exactly does the municipality want to achieve by measuring subjective road safety? The subsections below provide explanations and examples of goals that fit into these categories.

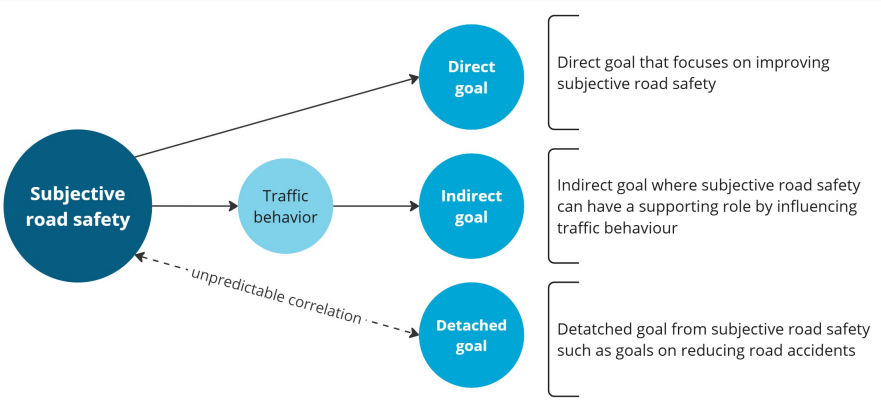

Figure 6.1: Categories of goals in comparison with subjective road safety

Figure 6.1 presents the topic of subjective road safety, along with its relationship to the different types of goals municipalities may have regarding subjective road safety. The arrows indicate how subjective road safety can influence these objectives.

6.1.1. Direct goal

A municipality goal with a direct link to subjective road safety concerns objectives that actually deal with the status of subjective road safety. This could include reducing fear in traffic. Or goals can be set for specific neighbourhoods where people feel unsafe in traffic, with the aim of improving this situation.

6.1.2. Indirect goal

An indirect link relates to goals that are not directly about subjective road safety, but subjective road safety can be used to positively influence this goal. This is mostly done by influencing the behaviour of road users. Due to differing subjective road safety, people also make different choices in traffic and behave differently, as explained in Section3.3.

An example of an objective in this category is encouraging the elderly to use bicycles more often. By creating a sense of safety for the elderly on bicycles and cycle paths, their behaviour can be influenced. This contributes to their long-term mobility and fitness. If this is a goal of the municipality, the subjective road safety of elderly people on bicycles can be looked at.

However, it is important to stress that any change in the behaviour of road users can also affect objective road safety and accident rates. This is something a municipality should handle carefully. In the example mentioned, elderly people who now choose to cycle may be involved in an accident, while without participating in traffic or by choosing a different mode of transport, they might not have been involved in an accident. It is up to the municipality to clearly define what matters to them.

6.1.3. Detached goal

Not all traffic safety goals relate to subjective road safety. Initially, the goals to improve road safety and to aim for zero traffic casualties is discussed in Section 1.1. This is primarily an objective goal. Because the link between subjective and objective road safety is unclear, subjective road safety data is therefore unsuitable for use in these situations. Subjective and objective road safety influence each other but also exist independently (Subsection 3.1.1). A change in subjective road safety can have both positive and negative effects on objective road safety, and the reverse can also be true. For this reason, it is important for municipalities to have clarity on the type of goal they aim to achieve and the data to be used for this purpose.

6.2. Tools to use to measure subjective road safety

This study distinguishes between different ways in which subjective road safety can be measured by municipalities. This division is based on the initiative: does it lie with the citizen or with the municipality? If the initiative lies with the citizen, one speaks of reactive measurement of subjective road safety. If the initiative lies with the municipality, one speaks of proactive measurement.

Currently, reactive methods are mainly used to measure subjective road safety. However, the municipality also has several tools that can be used for proactive measurements. The distinction between these tools is not always clear; some tools were originally developed for municipal

initiative, but can also be used in response to complaints to go deeper into certain situations.

When the municipality is pursuing direct goals, it is very important to use both reactive and proactive tools to get a complete picture. Table 6.1 gives an overview of the different methods municipalities can use to measure subjective road safety. It indicates whether a method is mainly reactive or proactive, and what the other characteristics of these tools are.

Table 6.1: Overview of tools and characteristics

Tool	Type	Usage	Benefits	Downside
Notifications via an online application	Reactive	Citizens can easily report unsafe conditions. Reports covers living environment and sometimes a map is used	Low-threshold	Low-quality notification
Notifications via an external organisation	Reactive	In some cases, when citizens feel unheard by the municipality, they file a complaint here	Weekly updates; National System	Duplicate reports
Contacting the municipality: telephone, email, website, post	Reactive	Citizen seeks contact on an issue; possible ways vary between municipalities	Standard	Limited group takes this action
Neighbourhood contact: person, district agent, neighbourhood representative or neighbourhood council	Reactive	Point of contact in the neighbourhood with whom problems can be discussed and fed back to the municipality.	Reachable in person	Workload
Social media	Reactive; proactive	Can be a point of contact for citizens, can also be used to distribute surveys	Reach other target group	Prone to low quality reports
Periodic citizen surveys	Proactive	Annual or biennial survey of residents on their living environment, often including a section on road safety	Can be unified; can reflect trends; general view; neighbourhood level	Not enough detail; questions not yet standardised
In-depth street interviews	Reactive	In-depth conversations in the neighbourhood or on the street in response to a concern.	More depth, standardizable in specific situations	Workload
Individual discussions	Reactive	Discussions to find out where the problem lies if this is unclear	Personal, in-depth	Workload
Citizen participation groups	Proactive	Groups of citizens who want to participate in neighbourhood improvement	Cooperation; responsibility	Workload
Neighbourhood surveys	Reactive; proactive	In-depth surveys in a neighbourhood, often before or after projects/plans or after an ongoing concern.	Systematically	Workload

Other methods for measuring subjective road safety may emerge in the future. Other tools are already used in science, such as measuring physiological factors. However, this method is currently not a realistic option for several reasons. It is still very expensive and lends itself more to an experimental setting. Nevertheless, there may be other methods in the future that could

provide a solution.

The emergence of AI could help categorise and process complaints, which could reduce some of the workload. This will leave more human attention for the cases that need it. Machine learning could help in analysing information on social media. If this information can be displayed in a compact way, it could also be a valuable source of information for the municipality regarding subjective road safety. An advantage of this is that real-time data is always available.

Of course, there are conditions attached to this kind of new technique. It often takes more time in the beginning to learn something new before it can actually reduce the workload. There must be room for this within the municipality.

6.3. Attention to the definition in measuring subjective road safety

The interviews in Chapter 5 show that the municipalities mainly emphasise the emotional aspects in their definition of subjective road safety. Although the proposed working definition is accepted, the focus remains largely on the emotional aspect, which also raises the most questions and problems.

In Chapter 3, the scientific literature describes that road safety consists of several aspects. By also focusing on these other aspects, communities can develop a more complete picture of road safety. This could contribute to both a better picture and a more effective approach.

This broader view of subjective road safety can help to achieve both direct and indirect goals, as described in Section 6.1. For the direct objectives it is important to improve subjective road safety. This requires highlighting all aspects to get a complete picture. For the indirect goals, it is possible to look more specifically at the current and desired situation.

If a municipality focuses on a direct goal related to subjective road safety, it is essential to collect data both reactively and proactively. Table 6.1 shows that the reactive form often consists of in-depth interviews or surveys. However, the questions in current surveys are often limited and focus mainly on feelings of road safety, which is the emotional side. These surveys could be improved by including other aspects of road safety and formulating specific questions about them. The various aspects from Chapter 3 are described again below. Here, some short remarks are made on how these aspects can be taken into account when collecting information on subjective road safety.

6.4. Data-collection diagram

In this section, the approach that municipalities can take is briefly summarised and shown in Figure 6.2. This is again a simplification and aims to provide initial insight and guidance for municipalities to consider. The blue elements give examples of different possibilities of incentives, goals and tools.

First of all, it is worth noting that many municipalities act based on resolving complaints. This is an external incentive and does not in itself improve road safety. It is important to determine within the municipality what the goals are for that municipality within road safety. This has already been described Section 6.1. It helps the municipality to make goals as concrete as possible. After this, it can be considered whether these goals are direct, indirect or detached. In the case of a complaint, it can be examined where it belongs.

For each goal, it can be determined which information sources are most appropriate to cite in creating a picture of the situation. The different sources also have advantages and disadvantages, so this should be handled carefully. When handled in this way, it can be easier for the municipality to know how to deal with subjective road safety. However, there will always be instances that don't easily fall into categories, creating a desire to diverge from the norm. It can be valuable for a municipality and its citizens to retain room for this, in consideration of the goals.

The steps can also be followed when for example maintenance or major projects are planned. Changes affect subjective road safety and it may therefore be desirable to pay attention to this. When actions are taken to change subjective road safety, care should always be taken that this can have an effect on objective road safety. This is why infrastructural changes in areas where there is nothing objectively wrong are often not desirable (Kennisnetwerk SPV, 2022).

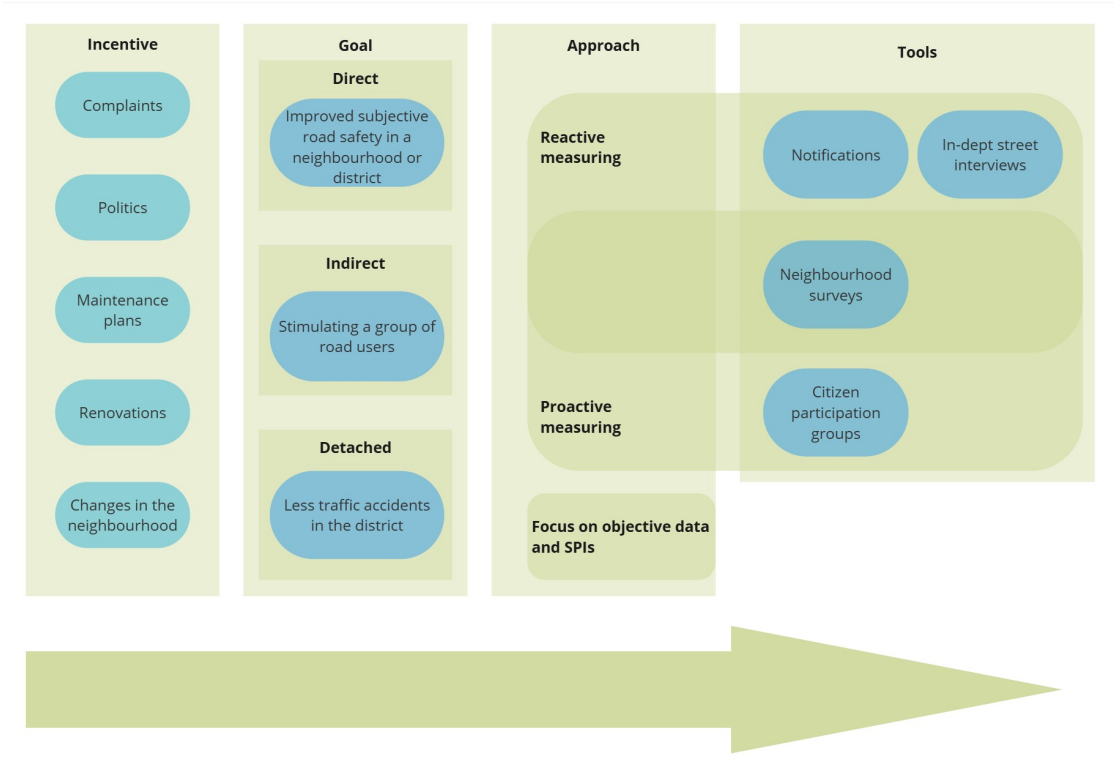

Figure 6.2: Approach for municipalities to start collecting data on subjective road safety

7

Final Conclusions

This chapter contains the discussion and conclusions. Firstly, the discussion is addressed in Section 7.1 where the findings of this study are discussed and interpreted. Section 7.2 describes the conclusion. It begins by answering the main and sub-questions of this study. This is followed by a list of the most important findings of this study.

7.1. Discussion

This discussion looks back at the results of this study. It also looks at whether the findings are reflected in the current literature. It considers the limitations of this study and its implications in both scientific and practical terms. Recommendations for both municipalities and further scientific research will follow.

7.1.1. Interpretation of the results

At the beginning of this study, ways were being looked for to bring more clarity to the concept of subjective road safety. This research has shown that this topic is at the intersection of different disciplines and fields. The scientific literature lacks a clear definition and the aspects covered by subjective road safety are diverse. By taking a more considered approach to defining and including these aspects in scientific research, studies can become more comparable. A transparent and consistent definition makes it easier to determine which aspects should be included in studies, contributing to clarity and scientific value. As a result, studies in this area of research

can be better compared and controlled.

In practice, there is also ambiguity about the definition of subjective road safety among municipalities and interest groups. However, this ambiguity differs from that in the scientific field. While the scientific literature defines the concept too broadly and complexly, in practice the focus is limited to the emotional component, such as the feeling of safety. Other relevant aspects are recognised but are difficult to define or are not sufficiently emphasised in practice research.

Another important difference between science and practice is the method of data collection. In science, data is collected actively, whereas in practice it is mostly collected passively. Municipalities and interest groups rely mainly on complaints and reports submitted by citizens in various ways.

Interviews with municipalities show that it is difficult for them to distinguish between objective and subjective road safety. Municipalities often experience tension between these two dimensions, making the policy-making process complex. This challenge is amplified by the lack of clear goals within municipalities, leading to inefficiency and increased workload. While there is a need for greater clarity in the process, municipalities fear that this will lead to an increase in complaints, which they would prefer to avoid.

7.1.2. Validation with the existing literature

When interpreting the results of this study, it is important to place them in the context of the existing literature. This study shows that, unlike many studies that focus on the cognitive dimension of risk, subjective road safety is about more than risk. Estimated risk does not appear to be the most important aspect of subjective road safety in practice. The emotional side of road safety is perceived as much more important. That this emotional side of subjective road safety is indeed important is also clear from recent research (Uijtdewilligen et al., 2024).

This study also argues that subjective road safety can be used to influence traffic behaviour if it is in line with the goals of the municipalities. Although the study itself did not directly investigate this influence, the conclusions are based on interviews with the municipality and its actions. The research of Uijtdewilligen shows that cyclists' choice of routes can change based on the subjective road safety of those routes (Uijtdewilligen et al., 2024). This form of behaviour adjustment has further implications for road safety. This can affect both subjective and objective road safety, and may also be used by municipalities to their advantage. If subjective road safety improves, people may adapt their traffic choices accordingly. For example, older people may cycle for longer, certain routes may be used more, or people may choose to cycle rather than use a car. In this way, subjective road safety can also have a positive effect on the goals of local municipalities.

7.1.3. Limitations of the study

However, this study has got some limitations. First, a conscious decision was made to exclude studies on subjective road safety in relation to self-driving vehicles. This is because of the many variables and uncertainties that still exist in that area, making these studies less relevant to current practice and to municipalities. Nevertheless, it is notable that many recent papers focus on this topic. Due to this choice, potentially useful new insights may have been missed.

Another point concerns the research method chosen. A qualitative approach through interviews with six different municipalities was deliberately chosen. These municipalities differ in terms of size and location. Nevertheless, with a larger sample of municipalities, the conclusions might have led to more insights, and more statistical statements could be made about the differences between the various categories of municipalities. A follow-up study could focus on differences in subjective road safety between municipal characteristics or population groups. This study was too small to make statements on this. Factors such as culture or the level of connectedness within a neighbourhood, and their impact on self-reliance and responsibility for road safety, are also interesting topics for further research.

7.1.4. Implications of the findings

This section looks at which results are relevant and can be used in the future. This is divided into the implications for science and the practical implications for municipalities and interest groups.

Scientific implications

For the scientific community, the most significant gain from this study lies in clarifying the definition of subjective road safety. This study shows that the definition can be described more specifically and consistently in many scientific studies. By clearly defining what the study focuses on, future studies can better reflect the findings.
Subjective road safety encompasses several aspects, including:

- **Emotional aspects**: The feeling of safety or fear in traffic situations
- **Cognitive aspects**: The assessment of risks and dangerous situations
- **Individual dimension**: The personal perception of road safety
- **Social dimension**: The shared concerns or perceptions within a community
- **Concern for themself**: Concern about one's own safety
- **Concern for others**: Concern about the safety of others, such as children or vulnerable road users
- **Active participation**: The experience of road safety as an active participant

- **Passive observation**: The observation of road safety without direct involvement (e.g. as an observer)

Currently, scientific research largely focuses on the cognitive aspect of subjective road safety, for example by asking about people's risk assessments. This is valuable, but a more integrated approach, including emotional and social dimensions, could lead to a more complete and accurate picture of subjective road safety.

Looking to the future, much research focuses on risk perceptions in relation to self-driving vehicles. Here, the focus is mainly on the cognitive and risk-oriented part of subjective road safety. This research field could also benefit from a broader perspective that includes emotional, social and participatory dimensions. This can not only lead to a better understanding of how people experience autonomous transport, but also contribute to the design of systems that are better suited to human needs and perceptions.

Practical implications

What this study makes clear is that many municipalities need to rethink their objectives in terms of subjective road safety. There is also a need for greater clarity about the concept. Subjective road safety should be seen as a multi-faceted approach to road safety that is not in conflict with objective road safety. Recognising the coexistence of these two dimensions can already contribute to a structured process for dealing with subjective road safety.

It is important for municipalities not to see complaints about subjective road safety only as a means to improve objective road safety. At the same time, these complaints should not be seen as a burden because of the time it takes to deal with them. A clear definition of subjective road safety will allow municipalities to better understand the concept and use it in a more targeted way. This makes it possible to use the concept for purposes to which it can actually contribute and to take structured action, for example to collect additional information when needed.

This study contributes to this by firstly highlighting the differences in definitions and interpretations of subjective road safety. It provides an overview of the different aspects of this concept and shows that subjective and objective road safety coexist in all cases.

In addition, this study makes it clear that municipalities should analyse and categorise their subjective road safety goals as direct, indirect or separate goals. This categorisation makes it easier to determine which data collection method is most appropriate. The study also provides a first insight into possible methods and steps that municipalities can use to collect data on subjective road safety in a better and more structured way.

7.1.5. Recommendations to the municipalities

The main recommendations for the municipality from this study are listed below.

1. **Definition**
   It is essential to have a clear definition of subjective road safety. The proposed working definition can help with this: ”Subjective road safety refers to the perceived sense of unsafety that individuals experience in traffic, whether they are actively participating or not, across all modes of transport”. In addition, it is important to clearly understand the connection with the different aspects of subjective road safety. Remember that every traffic situation has both subjective and objective road safety. These are not mutually exclusive, but influence each other. However, how this mutual influence occurs exactly is difficult to predict.
2. **Determine the municipality’s goals**
   It is important for the municipality to determine its specific goals regarding subjective road safety. Although objective and subjective road safety are not mutually exclusive, municipalities often lack the resources to address both simultaneously. Therefore, it is essential to decide where the focus will be within the realm of subjective road safety. These goals can be categorized as follows:

   Direct goals: These goals focus directly on subjective road safety. For example, when there are many complaints from certain neighbourhoods or road users that the municipality wants to address.

   Indirect goals: These goals do not primarily concern subjective road safety, but improvements in this area can contribute indirectly. For example, a better sense of safety can lead to changes in traffic behaviour.

   Detached goals: In some situations, objective road safety is given priority. For example, when data show accidents taking place at a certain location.
3. **Collecting data**
   After defining the goals, it is important to collect the right data. Use existing passive data, such as complaints received through current channels. If needed, supplement this with actively collected data, for example, through surveys, community conversations, or interviews. When gathering data, make sure to consider the various aspects included in the definition of subjective road safety.

Although this study focuses on subjective road safety, this does not mean that objective road safety does not play a role. As mentioned earlier, these two dimensions of road safety exist

simultaneously and often influence each other. However, this influence is complex and difficult to predict (Kennisnetwerk SPV, 2022). It is crucial to take this into account when using the collected data to develop interventions. At all times, avoid interventions that lead to an increase in casualties and a worsening of objective road safety.

Table 7.1 shows what a municipality should pay attention to in the different possible situations regarding road safety. A minus sign (-) indicates an unfavourable or unsafe situation, while a plus sign (+) indicates a favourable and therefore traffic-safe situation.

Table 7.1: Interventions

Objective Road Safety	Subjective Road Safety	Intervention Needed
-	-	Focus on improving objective road safety. Include subjective road safety as a complementary resource.
-	+	Use proactive methods to find out more about subjective road safety before implementing interventions.
+	-	Use proactive methods to find out more about subjective road safety before implementing interventions. With infrastructure changes, ensure that guidelines are guaranteed in order to avoid negative repercussions on objective road safety.
+	+	No interventions needed.

7.1.6. Recommendations for further research

This section presents the main recommendations for further research. Although there are numerous possibilities for continuing research on subjective road safety, three important and interesting directions have been selected.

In this study, six interviews were conducted to understand the views and visions of different municipalities. While this yielded valuable information, the number of interviews was insufficient to explore in depth the differences between municipalities and the effects of these differences on goals and meanings around subjective road safety.

Interviewing more municipalities could help better understand the diversity in visions and priorities. It would also be valuable to explore possible differences in perceptions between policymakers and citizens. Additionally, comparing subjective road safety in densely populated districts versus low-density neighborhoods could offer insights. For example, questions like ‘Does citizens’ sense of responsibility for their own neighborhood affect subjective road safety?’ or ‘Are there differences in priorities between large and small municipalities in the Netherlands?’ can provide valuable information.

Another important direction for follow-up research is to build on the results of this study. This study resulted in a general recommendation for improving the view on subjective road safety. However, a logical next step for municipalities is the question 'How can subjective road safety be dealt with concretely?' Future research could focus on identifying variables that influence subjective road safety and ways in which municipalities can adjust them to improve safety at the societal level. For this, science will be able to engage with studies that more closely match real-life situations. The differences in subjective road safety for different types of road users within municipalities can also be studied, and whether this changes when an individual chooses a different mode of transport.

Finally, it is vital to understand more about the relationship between objective and subjective road safety. While it is known that these influence each other, there is still much uncertainty about exactly how this interaction occurs. For example, which factors contribute to improving both forms of safety? Now, situations can arise in which measures that improve objective safety actually worsen subjective safety, or vice versa. As long as this relationship is not fully understood, caution will be needed when taking measures that target only one of the two aspects. Only when the interaction is properly mapped can policy measures be designed that optimally improve both objective and subjective road safety. Although this is a complex field of research, it represents a valuable step in effectively improving road safety.

7.2. Conclusions

7.2.1. Answers to the research questions

Figure 7.1 once again shows the overview of the sub-questions of this study and the main research question that is answered by these sub-questions. In this conclusion, the three sub-questions are answered one by one. Then the main question is answered.

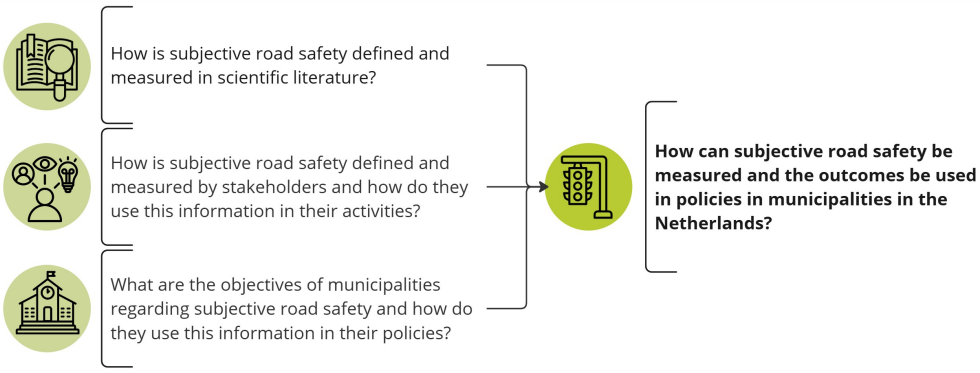

Figure 7.1: Recapitulation of sub- and main research questions

Sub-question 1:

"How is subjective road safety defined and measured in scientific literature?"

This study shows that subjective road safety can coexist with objective road safety. Subjective road safety is a wide-ranging concept with different dimensions. The different aspects of subjective road safety that can be distinguished are emotional, cognitive, individual, social, focusing on oneself or others, actively participating and observing.

Much is written in the scientific literature on risk perception, where the focus is mainly cognitive and thus less diverse than for subjective road safety (Lazarus & Folkman, 1984; Furian, Brandstätter, Kaiser, & Witzik, 2016). What is noticeable is that studies seldom specify which aspects of subjective road safety are included and which are left out.

There are several methods that can be used to get a picture of subjective road safety. Commonly used methods in scientific research include surveys, interviews, machine learning and physiological measures. These studies are often situation-specific and usually conducted in an experimental context. These methods are always proactive, meaning they are initiated by the researcher. A slightly more reactive method of obtaining an image of subjective road safety used in science is the use of machine learning to analyse social media data (Abedi & Sacchi, 2024). In this case, people are not added to an experiment and the data is disclosed by citizens without being asked. However, this techinic is not yet easy to use.

Sub-question 2:

"How is subjective road safety defined and measured by local stakeholders and how do they use this information in their activities?"

The second sub-question has three different parts: the definition, measurement, and use of subjective road safety. When this topic is discussed by stakeholders and interest groups, the definition is by no means always considered. When they do, the emphasis is always on feelings. This shows that the emotional side of subjective road safety is considered important, while it is less concerned with the cognitive part, as is the case with risk perception.

Measuring subjective road safety is mainly done in a reactive way. This means that the initiative for receiving information lies with citizens. The main method currently used consists of incoming reports to municipalities or interest groups. These reports come in through a reporting platform, an application or through another contact point. Sometimes proactive methods are also used, often through a survey or interviews, usually at the neighbourhood level.
Municipalities and action groups undertake various actions related to subjective road safety. These actions can be divided into actions that improve subjective road safety, or actions aimed at influencing behaviour by changing subjective road safety, or vice versa.

Sub-question 3:

"What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?"

The goals pursued by municipalities are often based on national plans and guidelines. However, specific objectives regarding subjective road safety are often unclearly formulated or even completely absent. Nevertheless, municipalities have several reasons to pay attention to subjective road safety, although these reasons and goals are often not defined in concrete terms, making it difficult to implement targeted policies. Municipalities often want to improve subjective road safety to increase citizens' sense of safety and promote willingness to participate in traffic, especially among vulnerable groups.

An important task of municipalities is to respond to residents' complaints about road safety. There are often guidelines stipulating that citizen complaints must be dealt with within a certain time frame. Handling these reports often requires customisation, where personal attention is crucial. At the moment, it is still very difficult for municipalities to prioritise in a structured way, often trying to plan this together with other maintenance plans to get the most out of the budget. The most common actions municipalities take are to change infrastructure or engage in dialogue with citizens to improve the subjective road safety. The municipality then needs conversations to understand why someone feels unsafe in traffic; through a conversation the citizen can better understand the choices and this can also affect subjective road safety. However, the lack of clearly defined goals for subjective road safety makes it difficult to properly ground choices and policy decisions. In many cases, the available budget plays a major role in the final decisions, with the underlying principle being to maintain a good road design.

Main research question:

"How can subjective road safety be measured and the outcomes be used in policies in municipalities in the Netherlands?"

The first part of the main question focuses on measuring subjective road safety. This research shows that in order to effectively exploit the value of subjective road safety, it is first necessary to look at the goals municipalities have regarding this topic. Only then can a choice be made between reactive and proactive measurement methods. Several options are available for this, such as using periodic questionnaires or neighbourhood interviews.

Municipalities in the Netherlands can use subjective road safety when developing traffic policy, provided they are aware of the specific goals they want to achieve and the possible side effects of changes in road safety perception. This concept offers a valuable complement to ob-

jective safety statistics, as it provides insight into another dimension of safety that is important for municipalities to consider.

In addition, subjective road safety can help achieve policy goals by influencing road users' behaviour. When people feel safer on the road, they tend to adjust their behaviour and transport choices accordingly. However, municipalities should carefully consider how to integrate subjective road safety into their policies. Combining subjective data with objective safety statistics provides a broader and more nuanced picture of road safety, leading to better informed policies. It is important to avoid situations appearing subjectively safer, while objectively they are more unsafe. The use of subjective road safety as a measure should therefore always be considered in conjunction with objective road safety indicators.

7.2.2. Conclusion of the study

The answers to the research questions were a first step in clarifying the concept of subjective road safety. By creating more understanding in this area, we can work towards more positive subjective road safety. Ultimately, it is important that people can get from A to B safely, without road casualties, as is the case with objective road safety, and feel subjectively safe in traffic.

This study shows that subjective road safety is more than just emotional feelings or people's perception of risk. For a complete picture of subjective road safety, the following aspects should be included: emotional, cognitive, individual, social, concern for self, concern for others, active participation and passive observation. To properly capture these aspects, both reactive and proactive methods can be used to measure subjective road safety. The difference between these methods lies in who takes the initiative to collect the data. The choice of method depends on the goal a municipality wants to achieve in terms of subjective road safety. The three types of goals relevant here are direct, indirect and detached. It is important to consider the possible effects of intervention on objective road safety. Optimal policies can only be developed when further research provides greater clarity on the interaction between objective and subjective road safety. These policies can then ensure that people not only feel safe on the roads, but also that the number of road deaths and injuries is minimised.

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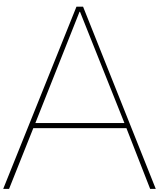

Research paper

Approach for Dutch municipalities to gain insight into subjective road safety

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Abstract

This study investigates how Dutch municipalities can measure and use subjective road safety. A literature review was conducted, analyzing 31 scientific sources. In addition, gray literature and practical differences were examined, involving 13 different parties. Interviews were also held with six municipalities to discuss their perspectives on the definition of subjective road safety, the data they currently have, their goals regarding subjective road safety, the resources available for further measurements, and their most pressing needs.
The study found that there is still significant ambiguity within municipalities regarding the definition of subjective road safety. For many municipalities, the individual's perception of safety plays a central role. Furthermore, there is confusion about the relationship between objective and subjective road safety. Municipalities need more concrete goals to make informed decisions about whether to measure subjective road safety reactively or proactively. Policies can be developed based on these goals, but it is crucial that objective road safety is not compromised. Using subjective road safety as a measure to gain insight into objective road safety is not advisable, as the relationship between these two dimensions is not yet fully understood. While they coexist and influence each other, they function independently.

1 Introduction

Throughout the Netherlands, municipalities receive reports and complaints of unsafe traffic situations. In September 2023, a European study revealed that four out of ten Amsterdam residents feel unsafe in traffic (NOS nieuws, 2023).

The Ministry of Infrastructure and Water Management aims to ensure people can safely navigate traffic (Ministerie van Infrastructuur en Waterstaat, 2010). Mobility is very important in the Netherlands since almost everyone participates in transport. To make this a reality, longer-term road safety targets are being set at European and national levels. The EU's road safety vision comes from Sweden's 'Vision Zero'. This states that the goal should be zero deaths and injuries on the roads, as any loss of life is morally unacceptable. In the Netherlands, to implement the EU road safety vision, the Strategic Plan for Road Safety 2030 (SPV 2030) has been implemented at the national level (Ministerie van Infrastructuur en Waterstaat et al., 2018).

Still, the number of road deaths has increased over the last few years despite the tightening of safety goals (Mulders et al., 2023). The SPV has a risk-based approach based on objective safety performance indicators such as road injury and fatality data. In addition, the SPV mentions subjective road safety in which, for example, complaints about road safety can be used as a signal to investigate the risks of a traffic situation.

Subjective road safety impacts the traffic system (see for example (Lupas, 2023)). However, current scientific literature has not studied subjective road safety through a practice-oriented approach. It is unclear how subjective road safety can contribute to the risk managed approach and thereby reduce road casualties, which is also considered objective road safety. It is difficult to form a picture of subjective road safety, let alone implement well-founded policy on it due to the lack of insight. This research is centered on municipal roads, as over 60% of the fatalities occur on road types for which municipalities are responsible. On top of that, those are the places where most of the feelings of unsafety and dissatisfaction are experienced. Subjective road safety can therefore be of additional value in these places.

This study addresses the ambiguity surrounding subjec-

tive road safety for municipalities and aims to provide insights in how subjective road safety can be used to achieve better road safety. We do so by addressing the research question 'How can subjective road safety be measured and the outcomes be used in policies in municipalities in the Netherlands?'. Three sub-questions are adopted to answer the main question. 1) How is subjective road safety defined and measured in scientific literature? 2) How is subjective road safety defined and measured by stakeholders and how do they use this information in their activities? 3) What are the objectives of municipalities regarding subjective road safety and how do they use this information in their policies?

Our findings suggest that there are differences in the definitions of what is understood by subjective road safety, and these are often not specified. The measurement methods used in scientific research are largely not applicable in practice. In practice, reactive measurements are predominantly used. Municipalities can improve their approach by paying more attention to their goals related to subjective road safety. Based on these goals, they choose between the use of reactive and proactive measurement methods or a combination of those.

Section 2 provides more insights into the methods of this research. Then, the definitions of and possibilities to measure subjective road safety, together with the results from the interviews are provided in Section 3. This will be followed by the discussion and conclusions in Section 4.

2 Methodology

We employed a literature review and interview approach to understand how subjective road safety can be used to improve general road safety. First, the literature review is set out. Next, the interview approach will be provided.

2.1 Literature review

To define subjective road safety a literature review was executed. The literature review encompasses scientific literature as well as grey literature.

Scientific literature was collected through the search engine Scopus by using six search terms. This led to 591 papers. Screening of the title and backward and forward snowballing resulted in a set of 168 papers. Next a selection was made based on the abstracts. Only papers with relevance to this research were included, literature considering self-driving vehicles and IA were excluded. This led to a set of 31 papers.

Grey literature can provide a better impression of how society views the concept of subjective road safety. An overview was created of the different parties and organisations interested in subjective road safety. This led to 14 parties. For each of these parties the definition will be investigated.

2.2 Conducting the interviews

Interviews were held to on the one hand gain insights into the motivations of municipalities to monitor subjective road safety. On the other hand we wanted to understand what means municipalities have to implement an investigation on this subject.

Interviews were being held with municipalities. The choice was made based on four characteristics. First, the municipality had to have already been involved in subjective road safety. We considered this by searching on google for any mention of a municipality in relation to subjective road safety, giving us a set of 20 municipalities. After a discussion with the Dutch interest group of municipalities, VNG, we added 5 other municipalities. Thus, providing us with a set of 25 municipalities actively interested in subjective road safety.

Next, the characteristics of urbanization, size and location are taken into account. The categorisations are made by Statistics Netherlands. The category of size of municipality has been adjusted as in (Bax, Uijtdewilligen, Kint, & Commandeur, 2020) which is more in scale with the size of this study. See tables 1, 2 and 3 to understand the different categories for these characteristics.

Table 1: Degree of urbanisation of the municipality

Code	Description
1	Area address density of 2 500 or more
2	Area address density from 1 500 to 2 500
3	Area address density from 1 000 to 1 500
4	Area address density from 500 to 1 000
5	Area address density of less than 500

Table 2: Size of municipality

Code	Description
1	less than 20 000 inhabitants
2	20 000 to 50 000 inhabitants
3	50 000 to 100 000 inhabitants
4	100 000 inhabitants or more

We then selected 10 municipalities with a good spread amongst these different characteristics. Six of these municipalities responded to our interview request. The characteristics of these six municipalities can be found

Table 3: Localisation of municipalities

Code	Country sections	Provinces
1	Northern Netherlands	Groningen, Fryslân, Drenthe
2	Eastern Netherlands	Overijssel, Flevoland, Gelderland
3	Western Netherlands	Utrecht, Noord-Holland, Zuid-Holland, Zeeland
4	Southern Netherlands	Noord-Brabant, Limburg

in table 4. The interviews were held with the municipal traffic officials.

Table 4: Characteristics of the interviewed municipalities

Municipality	Urbanisation (code)	Municipality size (code)	Location (code)
Heiloo	3	2	3
Henglo	2	3	2
Houten	2	3	3
Leeuwarden	2	4	1
Utrecht	1	4	3
De Wolden	5	2	1

We chose a semi-structured interview approach as it allows the interviewees to deviate to other points of interest without losing sight of the purpose of the interview and research. The interviews were conducted in March 2022 through an online video call. The interview protocol can be found in appendix C. In the interviews, the topics that where addressed included the definition of subjective road safety, the research and data currently available to the municipality, the municipality's goals regarding subjective road safety, the resources available to the municipality, and the municipality's needs. To process the interviews, the interviews were transcribed and then a thematic analysis was conducted. For this, 101 codes were assigned to the text which were divided into seven different themes.

3 Results

This section discusses the results of the study. We first discuss the definition of subjective road safety and how it is articulated in the scientific and grey literature. We look at the methods used to measure subjective road safety in science and in practice. Finally, the results from the interviews with the municipalities are provided.

3.1 Definitions of subjective road safety

In the scientific literature, subjective road safety is often referred to as either perceived safety or perceived risk in parallel. Subjective road safety can be divided into several aspects. The aspects of subjective road safety found are:

- Emotional: This means get feeling without having a reason for this (Lazarus & Folkman, 1984).
- Congintive: The more rational part that is influenced by experiences and external factors (Lazarus & Folkman, 1984).
- Individual: Subjective safety is something one feels personally.
- Societal: Subjective safety is also subject to societal trends and cultural differences (Lund & Rundmo, 2009).
- Concern for oneself: Someone may feel unsafe themselves.
- Concern for another: A person may worry about another in traffic, like parents worry about their children (Sørensen & Mosslemi, 2009; Elvik, Kolbenstvedt, & Strangeby, 1999).
- Active participating in traffic: People have a feeling of unsafety while participating in traffic.
- Passive observation traffic: Someone can feel fear and anxiety about traffic without an event happening (Vlakveld, Goldenbeld, & Twisk, 2008).

Risk perception is only the cognitive moment (Sjöberg, 2000), which is why it is important to make a clear distinction in science whether this is what is being studied or one or more aspects of subjective road safety.

In practice, we looked at the definitions used by municipality and interest groups. Certainly not all stakeholders define the term when they discuss subjective road safety. When they do, three components stand out among municipalities. Much emphasis is placed on the feeling of insecurity, and thus and emotional side of subjective road safety (Gemeente Amsterdam et al., 2021). The individual aspect is also given a lot of attention (Gemeente Leeuwarden, n.d.-a). Finally, it is the tension between objective and subjective safety that is striking. We have found that some municipalities only speak about subjective road safety when objectively nothing can be found here that can cause unsafety (Gemeente Heiloo, Negenman, & Broersen, 2018; Gemeente De Wolden, 2009).

The definition used by knowledge organisations includes more different aspects of subjective road safety. For example, the kennisnetwerk SPV defines subjective road safety as: *"Subjective road safety is the personal experience, observation or perception of road safety. This*

may involve an assessment of the probability of being involved in a crash in given traffic situations. It may also involve the extent to which someone experiences fear and concern about the safety of themselves or others, such as children and partner" (Kennisnetwerk SPV, 2022). Interest group Veilig Vekeer Nederland (VVN) refers to this definition (VVN, 2022).

3.2 Measuring subjective road safety

In the scientific research, much research is done in the form of experiments. Also, before-and-after studies are frequently the form in which research is conducted. This is because they often focus on specific elements that change and how they are affected. Such as infrastructure (Møller & Hels, 2008; Zakowska, 1995), weather or visibility conditions (Nygårdhs & Fors, 2010) or personal characteristics.

The methods used for scientific research are all proactive, in other words, the initiative for collecting information lies with the researchers. Methods used in science to get a perspective on subjective road safety include: Surveys (Uijtdewilligen, Baran Ulak, Jan Wijlhuizen, & Geurs, 2024), Interviews (Lee & Kim, 2021), Machine learning (Abedi & Sacchi, 2024) and Physiological traits such as monitoring eye movement or heart rate (Gadsby, Tsai, & Watkins, 2022). A combination of these methods can also be used.

In contrast to the scientific literature, the methods used by municipalities and interest groups for gaining insight are actually mainly reactive. This means that the initiative mainly lies with the citizen. Therefore, the most common way of obtaining information is through complaints. Many municipalities receive these complaints in addition to the regular contact points, via a website or application. Interest group Veilig Verkeer Nederland also has a registration point where people can in their experience report unsafe situations and places on a map of the Netherlands.

Other ways used to gain insight are periodic surveys on the living environment, these can often be viewed at neighbourhood level but here there is not much room for in-depth questions as this survey covers more topics (Gemeente Leeuwarden, n.d.-b). In Rotterdam, a combination is made between objective figures and subjective data. Blackspots from accident data were used, as well as locations rated as unsafe on a map in surveys. From these, a top three of unsafe locations was compiled for each neighbourhood (Gemeente Rotterdam, 2019). Another way is neighbourhood interviews, where there is more individual attention and here citizens can often give more depth and explanation. By asking further questions, causes can be better found and a more focused look at the problem (Gemeente Amsterdam et al., 2021).

3.3 Interview results

There were seven themes that emerged from the Interviews. These are addressed in the order listed below. The seven themes are :

- Definition of subjective road safety as it is understood by the municipalities
- Causes of notifications of subjective road safety
- Information, data and investigations already available to municipalities
- Groups of road users that stand out in subjective road safety
- Municipal goals for subjective road safety
- Resources within municipalities for approaching subjective road safety
- Municipal needs for approaching subjective road safety

The municipalities universally agree with the definition presented: *Subjective road safety refers to the perceived feeling of unsafety that individuals have in traffic, whether they actively participate or not, regardless of the mode of transport.* Citizens' feelings are the most important thing for municipalities. The tension between objective and subjective road safety is also cited: the feeling of insecurity while objectively nothing is wrong.

Municipalities indicated that speed is very often pinpointed as a cause of subjective road unsafety. In response, municipalities take speed measurements. These often show that objectively there is hardly anything to be concerned about. This makes it difficult for municipalities to respond. For municipalities, this again results in the tension between objective and subjective road safety. Other causes cited are the infrastructural road layout, the difference between urban areas and rural areas and mixed traffic such as agricultural vehicles on the road.

The vast majority of the information that municipalities have on subjective road safety comes from the complaints they receive. There are various ways these complaints can reach the municipality: telephone, email, postal mail, social media or in person. Municipalities often have a reporting system, on which citizens can report unsafe situations about public spaces. These systems sometimes also use a visual map. There are also external parties that facilitate a reporting system. Besides

this reactive way of receiving information, some municipalities also look for information proactively. This is done through questionnaires, interviews or neighbourhood consultations. The questionnaires can be periodic and then deal with the overall public space or more focused on neighbourhood or district new for more in-depth information. These more proactive methods are also sometimes used in response to numerous reports to gain more clarity in the situation but can also be used in response to other incentives such as plans for infrastructural alterations in the neighbourhood.

Municipalities have a focus on certain groups of road users. These groups often report feeling unsafe in traffic. Groups that come up frequently are: parents and schoolchildren, (electric) cyclists and the elderly.

Municipalities have not set concrete goals on subjective road safety although half of them indicate that subjective road safety is important in the municipality. There are goals that are not directly linked to subjective road safety but could benefit from it. An example mentioned four times is the encouragement of cyclists. Also, reducing complaints is desirable for municipalities because processing is a lot of work.

Municipalities have several options for measuring subjective road safety. Yet there are limitations that make it difficult to deal with subjective road safety. These limitations are workload, capacity and budget. The budget limitation results in the fact that choices and trade-offs always have to be made. Dealing with subjective road safety takes a lot of time because it often involves individual cases.

Municipalities indicate that more clarity is needed in the area of subjective road safety. They point out the need for a better organisation for handling complaints, as well as more standardisation and structure. There is also a demand for some guidance on how to measure subjective road safety.

4 Discussion

In this research we have looked at the possibilities for Dutch municipalities to measure and use subjective road safety. Other scholars have previously shown that subjective road safety can influence what route cyclists take (Uijtdewilligen et al., 2024). This shows that subjective road safety can be used by municipalities to achieve their goals.

We have identified the possibilities for Dutch municipalities to measure and use subjective road safety by exploring the adopted definitions. The first thing we have found is that there is a lot of unclarity regarding the definition of subjective road safety. It is a wide-ranging concept with different dimensions. The current scientific literature focuses on risk perception, showing a cognitive focus. This provides a narrow perspective on subjective road safety.

Stakeholders do not always define their views on subjective road safety. However, if they do, they describe subjective road safety mainly by emphasizing possible feelings. This shows the more emotional side of subjective road safety. Having no clear definition and common language makes performing a precise measurement or implementation hard. It reduces the usability of the concept of subjective road safety.

In current scientific research, many types of methods are adopted to investigate subjective road safety consisting of, amongst others, surveys, machine learning, and physiological measures. Although many types of methods are being used the research remains situation-specific and is often performed in an experimental context. This makes the research hard to generalize and hard to implement the findings or recommendations for municipalities. Stakeholders measure subjective road safety by using incoming reports. This is often a reactive method. Still, sometimes proactive methods can be identified such as surveys or interviews.

We have seen that definitions of subjective road safety are often unclear or lacking and the measurements adopted do not fully align with current scientific research or are not usable for municipalities as they focus on reactive measurements. On top of this, the goals pursued by municipalities regarding road safety often omit the subjective road safety part. Mostly, goals regarding this topic are absent or unclear. The fact that goals are lacking makes it difficult to properly ground choices and policy decisions and allocate budget to enhance subjective road safety.

Subjective road safety can play a role in the policies of municipalities in the Netherlands at present. Therefore, in this research, we have chosen to exclude studies on subjective road safety in relation to self-driving vehicles. Many uncertainties exist in this area, making these studies less relevant to the current practices of municipalities.

We have deliberately chosen to discuss subjective road safety with different municipalities in the Netherlands. Although we have tried to achieve a spread in our sample by differentiating in location and population size, our sample size was too small to provide insights into differences or relationships between subjective road safety and municipal characteristics, population groups, culture, or the degree of connectedness of a neighborhood. To enhance the usability of subjective road safety for municipalities and obtain a better grasp of how sub-

jective road safety can play a role in road safety future research can follow up on this study. It is recommended that the studies have a strong connection to the real world to provide the best input.

5 Conclusion

Subjective road safety can be measured by both proactive and reactive methods, depending on the kind of goal a municipality has about subjective road safety. This study offers a first step in clarifying the concept of subjective road safety. It highlights that subjective road safety encompasses more than just emotions or risk perceptions, such as the aspects emotional, cognitive, individual and social, concerns about oneself or concerns about another, actively participating or passively observing. By using reactive and proactive measurement methods and taking into account the interaction between subjective and objective road safety, municipalities can develop targeted policies that both increase feelings of safety and reduce road casualties.

To conclude, municipalities in the Netherlands can use subjective road safety when developing traffic policies. The concept offers valuable additional information to complement objective safety statistics. Subjective road safety data can provide a nuanced picture of road safety leading to better informed policies. It can also aid in influencing the behavior of road users. Still, municipalities should be careful in adopting subjective road safety to identify objective road safety. The concepts coexist and influence each other, but their precise relationship is not well understood. To maximize the value subjective road safety provides, municipalities need to be aware of the road safety goals they want to achieve and understand how subjective road safety corresponds to these goals.

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B

Orienting and exploratory conversations

At a the beginning of the project, many orentative conversations were held to get a good picture of the field. There were also specific conversations with municipalities to get a vision for conducting the interviews and talks with parties to identify good contributors for the interviews in this study.

Table B.1 documents all interactions with external facilitators throughout the thesis-project. The key details include participants (anonimised), date, organization, and the type of conversation.

Table B.1: Meetings with other parties

Meetings			
Participants	**Date**	**Organisation**	**Type of conversation**
xxx xxx	15-11-2021	SWOV	Orientation in general
xxx xxx	22-11-2021	SWOV	Orientation in general
xxx xxx	12-1-2022	Municipality Edam-Volendam	Orientation of municipality
xxx xxx	31-1-2022	Municipality Landsmeer	Orientation of municipality
xxx xxx	1-2-2022	TU Delft	Orientation in general
xxx xxx	2-2-2022	SWOV	Orientation in general
xxx xxx	7-2-2022	Polis Network	Orientation on method
xxx xxx	15-2-2022	VNG	Search for participating municipalities
xxx xxx	23-2-2022	VVN	Search for participating municipalities
xxx xxx	2-3-2022	Municipality Leeuwarden	Interview with municipality
xxx xxx	3-3-2022	Municipality Utrecht	Interview with municipality
xxx xxx	4-3-2022	Municipality Hengelo	Interview with municipality
xxx xxx	4-3-2022	Municipality De Wolden	Interview with municipality
xxx xxx	9-3-2022	Municipality De Buch	Interview with municipality
xxx xxx	10-3-2022	Municipality Houten	Interview with municipality
xxx xxx	29-3-2022	Municipality Utrecht	Orientation on methods
xxx xxx	10-10-2024	VVN	Reflection on methods

C

Interview background information

C.1. Characteristics of municipalities

Location of the municipalities

Figure C.1: Country sections

Table C.1: Localisation of municipalities

Code	Country sections	Provinces
1	Northern Netherlands	Groningen, Friesland, Drenthe
2	Eastern Netherlands	Overijssel, Flevoland, Gelderland
3	Western Netherlands	Utrecht, Noord-Holland, Zuid-Holland, Zeeland
4	Southern Netherlands	Noord-Brabant, Limburg

Size of municipality

Table C.2: Size of municipality

Code	Description
1	less than 20 000 inhabitants
2	20 000 to 50 000 inhabitants
3	50 000 to 100 000 inhabitants
4	100 000 inhabitants or more

Degree of urbanisation of the municipality

Table C.3: Degree of urbanisation of the municipality

Code	Description
1	Area address density of 2 500 or more
2	Area address density from 1 500 to 2 500
3	Area address density from 1 000 to 1 500
4	Area address density from 500 to 1 000
5	Area address density of less than 500

Municipality with prior experience of subjective road safety

The list is compiled by a google search with the term ”subjective road safety in municipality” on 14 February 2022. About 50 hits were searched which means that the search went up to the fifth page. This resulted in 20 different municipalities. The last five municipalities were added after a discussion with VVN and VNG about municipalities that are interested in this topic.

Table C.4: Shortlist of municipalities with prior knowledge of subjective road safety and characteristics

Municipality	Country section	Location (code)	Municipality size (code)	Urbanisation (code)
Amsterdam	West-Netherlands	3	4	1
Apeldoorn	Eastern Netherlands	2	4	2
Barneveld	Eastern Netherlands	2	3	4
De Wolden	Northern Netherlands	1	2	5
Eindhoven	Southern Netherlands	4	4	1
Goirle	Southern Netherlands	4	2	3
Haarlemmermeer	West-Netherlands	3	4	2
Heerlen	Southern Netherlands	4	3	2
Heiloo	West-Netherlands	3	2	3
Hengelo	Eastern Netherlands	2	3	2
Houten	West-Netherlands	3	3	2
Koggenland	West-Netherlands	3	2	5
Landsmeer	West-Netherlands	3	1	3
Leeuwarden	Northern Netherlands	1	4	2
Lochem	Eastern Netherlands	2	2	4
Nederweert	Southern Netherlands	4	1	4
Ommen	Eastern Netherlands	2	1	4
Ridderkerk	West-Netherlands	3	2	2
Rotterdam	West-Netherlands	3	4	1
Sittard-Geleen	Southern Netherlands	4	3	2
Uitgeest	West-Netherlands	3	1	3
Utrecht	West-Netherlands	3	4	1
Venlo	Southern Netherlands	4	4	2
Zaanstad	West-Netherlands	3	4	2
Zuidplas	West-Netherlands	3	2	3

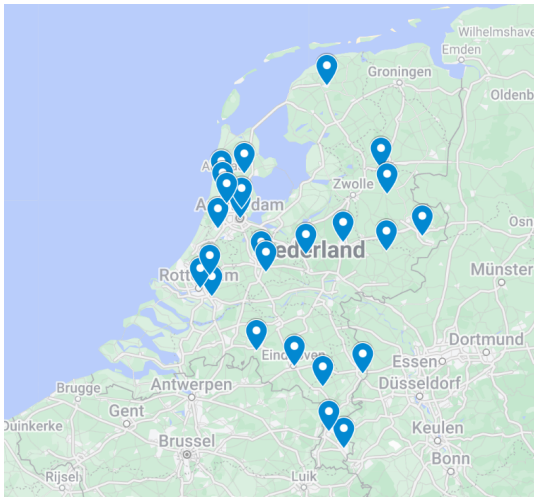

Figure C.2: Locations of shortlisted municipalities with prior knowledge of subjective road safety

C.2. Selected municipalities

Before publication, all personally identifiable information from the dataset must be anonymised.

Table C.5: Municipalities contacted

Contact person	Date of appointment	Municipality	Note
XXX XXX	2-3-2022	Leeuwarden	
XXX XXX	3-3-2022	Utrecht	
XXX XXX	4-3-2022	Henglo	
XXX XXX	4-3-2022	De Wolden	
XXX XXX	9-3-2022	De Buch (Heiloo)	
XXX XXX	10-3-2022	Houten	
XXX XXX	16-3-2022	Goirle	no-show at the appointment
XXX XXX		Nederweert	no response after contact
XXX XXX		Rotterdam	no contact
XXX XXX		Amsterdam	no contact

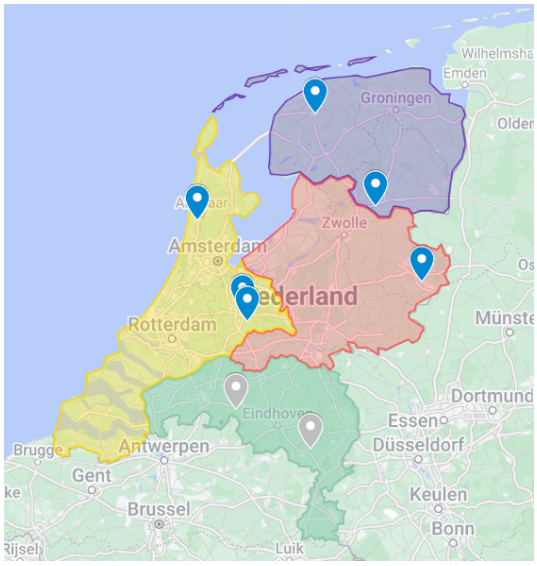

Figure C.3: Locations of selected municipalities

C.3. Informed consent

Geïnformeerde toestemming (Dutch)

U wordt uitgenodigd om deel te nemen aan een onderzoek naar de subjectieve verkeersveiligheid in gemeenten in Nederland. Dit onderzoek wordt uitgevoerd door Anne de Hoop van de Technische Universiteit Delft in samenwerking met SWOV Instituut voor Wetenschappelijk Onderzoek Verkeersveiligheid en het Kennisnetwerk SPV.

Het doel van dit interview is om inzicht te krijgen in de bevindingen van de gemeenten over subjectieve verkeersveiligheid, wat er binnen gemeenten op dit moment wordt gedaan en welke doelen en middelen gemeentes hebben rond subjectieve verkeersveiligheid. Het interview zal ongeveer 45 minuten in beslag nemen. De data zal gebruikt worden voor het schrijven van de master thesis van Anne de Hoop. U wordt gevraagd om antwoord te geven op vragen rond het onderwerp subjectieve verkeersveiligheid vanuit het perspectief van de gemeente waar u werkzaam bent.

Door deel te nemen aan het interview met SWOV, accepteer ik het volgende:

- Ik heb schriftelijke informatie over het onderzoek gelezen en begrepen.
- Ik ben in de gelegenheid gesteld om vragen over het onderzoek te stellen.
- Ik heb voldoende tijd gehad om goed over deelname aan het onderzoek na te denken.
- Ik ben me ervan bewust dat mijn medewerking geheel vrijwillig is.
- Ik begrijp dat ik op elk moment zonder opgaaf van redenen mijn deelname aan het onderzoek kan beëindigen zonder dat dit voor mij nadelige consequenties heeft.
- Ik begrijp dat mijn gegevens en onderzoeksresultaten vertrouwelijk behandeld worden.
- Ik ga akkoord met het maken van een opname van geluid via het videobel-programma Teams. Als gewenst, kan ik zelf de videocamera uitzetten. Ik ontvang na het interview een schriftelijk verslag ter correctie. Daarna wordt de opname gewist. De naam van mijn gemeente maakt onderdeel uit van het verslag en de naam van de gemeente kan worden opgenomen in het onderzoeksrapport.
- Ik begrijp dat mijn emailadres wordt gebruikt voor terugkoppeling van het interviewverslag en de resultaten na afloop van het onderzoek. Hierna wordt mijn emailadres gewist.
- Ik weet dat ik bij vragen contact kan opnemen via: anne.de.hoop@swov.nl en/of charlotte.bax@swov.nl (xxx-xxxxxxx).

Indien u vragen, opmerkingen of klachten heeft, kunt contact opnemen met Anne de Hoop: anne.de.hoop@swov.nl

Wanneer u instemt met dit interview bevestigd u dat u de bovenstaande informatie begrepen heeft en accepteert.

Informed consent (English)

You are invited to participate in a study on subjective road safety in municipalities in the Netherlands. This research is being conducted by Anne de Hoop from the Technical University of Delft in cooperation with SWOV Institute for Scientific Traffic Safety Research and the Kennisnetwerk SPV.

The purpose of this interview is to gain insight into the observations of municipalities on subjective road safety, what is currently being done within municipalities and what goals and means municipalities have around subjective road safety. The interview will take about 45 minutes. The data will be used to write Anne de Hoop's master thesis. You will be asked to answer questions on the subject of subjective road safety from the perspective of the municipality where you work. By participating in the interview with SWOV, I accept the following:

- I have read and understood the written information about the study.
- I have been given the opportunity to ask questions about the study.
- I have had enough time to think properly about participating in the study.
- I am aware that my cooperation is entirely voluntary.
- I understand that I can terminate my participation in the study at any time without giving any reasons and without any adverse consequences for me.
- I understand that my data and research results will be handled with confidentiality.
- I agree to record audio via the Teams video calling programme. If desired, I can turn off the video camera myself. I will receive a written report after the interview for correction. After that, the recording will be deleted. The name of my municipality will be part of the report and the name of the municipality may be included in the research report.
- I understand that my email address will be used for providing feedback on the interview report and results after the study is completed. After this, my email address will be deleted.
- I know that if I have any questions, I can get in contact via: anne.de.hoop@swov.nl and/or charlotte.bax@swov.nl (xxx-xxxxxxx).

If you have any questions, comments or complaints, please contact Anne de Hoop: anne.de.hoop@swov.nl

By agreeing to this interview, you confirm that you have understood and accept the above information.

C.4. Structure of the interviews

Introduction

- Introduce myself and the topic of my research: ”Subjective road safety in Municipalities.”
- Discuss the possibility of recording the conversation for processing purposes, with the assurance that it will be deleted afterward.
- Confirm the estimated duration of the interview (approximately 45 minutes).
- Ask about the daily responsibilities within the municipality.

1. Working definition of subjective road safety

- Define subjective road safety: ”Subjective road safety refers to the perceived sense of unsafety that individuals experience in traffic, whether they are actively participating or not, across all modes of transport”
- Ask for the interviewee’s thoughts on this definition or how they would describe subjective road safety.

2. Current investigations

- Discuss the scale of the municipality’s efforts in mapping subjective road safety.
- Explore the methods used to gather information and assess the satisfaction with these methods.
- Inquire about citizen engagement methods such as discussions, phone calls, complaint forms, emails, and online applications.
- Ask if there are citizen participation surveys addressing subjective road safety.

Example questions:

- *How would you describe the current state of data collection regarding subjective road safety in your municipality?*
- *Can you elaborate on the methods employed to gather information on subjective road safety, and how satisfied are you with these approaches?*

Current perceptions of subjective road safety

- Present the figure illustrating the proactive and reactive nature of data flow to the municipality.

- Inquire about the municipality's experience with both forms of information and which one dominates.
- Explore the department primarily responsible for processing this information.

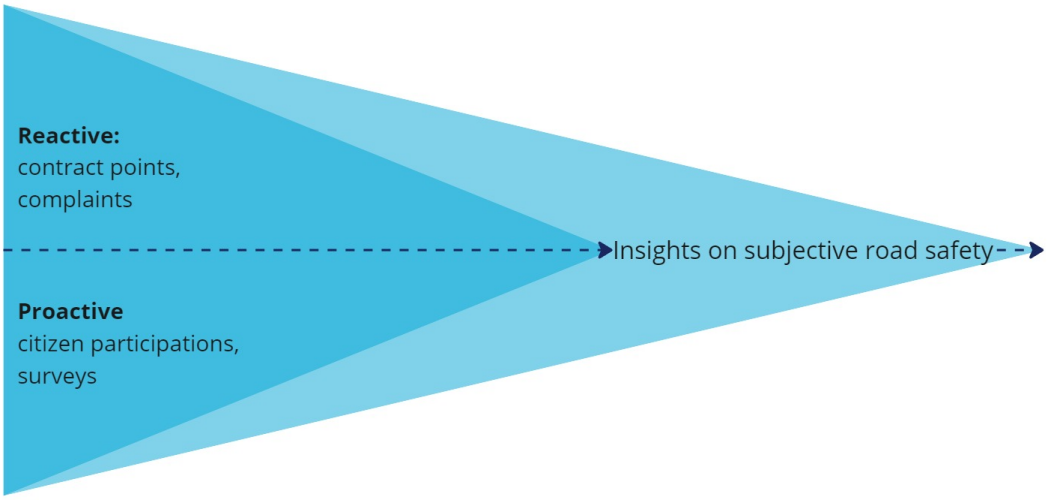

Figure C.4: Reactive versus Proactive

3. Goals

- Explore the municipality's goals regarding road safety.
- Discuss the role of subjective road safety in these goals.
- Investigate whether subjective road safety is considered a standalone goal.
- Discuss integration into mobility plans and differentiation between proactive and reactive goals.
- Explore the desired insight into subjective road safety.
- Discuss the potential use of available information.

Example questions:

- *How do the municipality's goals align with the concept of subjective road safety?*
- *In what ways is subjective road safety integrated into broader municipal objectives and future mobility plans?*
- *What specific insights does the municipality aim to gain from subjective road safety data?*
- *How is the information on subjective road safety utilized, especially in response to complaints or during election campaigns?*

4. Resources

- Explore the resources allocated by the municipality for data collection and surveys.
- Inquire about the department responsible for conducting such investigations.
- Discuss how citizens contribute input and if there's a preference between proactive and reactive methods.
- Explore the involvement of external agencies in conducting research.

Example questions:

- *What resources, including funding, personnel, and expertise, does the municipality allocate for data collection on subjective road safety?*
- *How is citizen input solicited, and is there a preference between proactive and reactive methods?*
- *Have external agencies been engaged in assisting the municipality with data collection on subjective road safety?*

5. Needs

- Explore the perspective on the implementation of subjective road safety within the municipality.
- Identify desired data and useful information for the municipality.
- Discuss the types of questions that can be used to gather relevant information.
- Inquire about satisfaction with the current approach, both reactive and proactive.

Example questions:

- *How does the municipality plan to involve the community in addressing subjective road safety concerns?*
- *What specific data is deemed most valuable for addressing subjective road, and are citizens satisfied with the current approach?*

Conclusion

- Revisit the definition of subjective road safety for reflection.
- Allow space for any additional questions or comments from the interviewee.
- Inquire about any specific needs or preferences.
- Explain the next steps in the process, including sending an initial draft for verification and providing the option for a final report and audio file.

Closing

- Thank the interviewee for their time and insights.
- Confirm the conversion of the recorded interview to an MP3 format.
- Offer to share the final report upon completion, if desired by the interviewee.

D

Interview results

D.1. Codes used

This appendix contains the details on the interview results. For privacy reasons, the interview transcripts have not been released. However, the codes derived from these interviews are included. These codes can be found in Table D.1, where they are arranged in alphabetical order. The table also shows the theme to which these codes were later assigned and the number of times they were allocated to a text in the two remaining columns of the table. Further explanation on the themes is provided later in this appendix.

Table D.1: Overall list of codes from the interviews

Codes	Themes	#
A person makes many reports	Causes of notifications of subjective road safety	1
Active participation	Definition of subjective road safety as it is understood by the municipalities	2
As few complaints as possible	Municipal goals for subjective road safety	1
Behavioural measure	Resources within municipalities for approaching subjective road safety	1
Better organisation within the municipality	Municipal needs for approaching subjective road safety	1
Better overview of available data	Municipal needs for approaching subjective road safety	2
Cause analysis	Resources within municipalities for approaching subjective road safety	1
Change in questions	Information, data and investigations already available to municipalities	1
Check that the road layout is correct	Municipal goals for subjective road safety	1
Children	Groups of road users that stand out in subjective road safety	6
Citizen participation	Information, data and investigations already available to municipalities	3

Tabel D.1: Overall list of codes from the interviews (continued)

Codes	Themes	#
Clarity in where subjective road safety stands for policy-making	Municipal needs for approaching subjective road safety	1
Cognitive estimating risk	Definition of subjective road safety as it is understood by the municipalities	3
Complaints	Information, data and investigations already available to municipalities	27
Complaints by phone	Information, data and investigations already available to municipalities	1
Concern for oneself of another	Definition of subjective road safety as it is understood by the municipalities	0
Contact people in the neighbourhood	Resources within municipalities for approaching subjective road safety	2
Cooperation between province or state		1
Crowded	Causes of notifications of subjective road safety	1
Crowding on cycle lanes	Causes of notifications of subjective road safety	0
Cyclists	Groups of road users that stand out in subjective road safety	6
Difference between rural and urban areas	Causes of notifications of subjective road safety	4
Difference in demand for the municipality		1
Difference in priority how a notification arrives	Resources within municipalities for approaching subjective road safety	1
Division at neighbourhood scale	Information, data and investigations already available to municipalities	3
Elderly people	Groups of road users that stand out in subjective road safety	5
Electric cyclists	Groups of road users that stand out in subjective road safety	4
Emotion and frustration in perception	Definition of subjective road safety as it is understood by the municipalities	13
Encourage cycling	Municipal goals for subjective road safety	4
Expectations management	Resources within municipalities for approaching subjective road safety	1
External app	Information, data and investigations already available to municipalities	1
Feeling safe in public spaces	Municipal goals for subjective road safety	2
Financial priority by maintenance	Resources within municipalities for approaching subjective road safety	5
Financial priority to objective road safety	Resources within municipalities for approaching subjective road safety	1
Frustration	Causes of notifications of subjective road safety	5
Goals or priorities not clear	Municipal goals for subjective road safety	4
Guidelines for subjective road safety	Municipal needs for approaching subjective road safety	1
Help with processing	Municipal needs for approaching subjective road safety	1
In own street or neighbourhood	Causes of notifications of subjective road safety	5
In-depth conversations with citizens	Information, data and investigations already available to municipalities	10
In-depth street surveys	Information, data and investigations already available to municipalities	4

Tabel D.1: Overall list of codes from the interviews (continued)

Codes	Themes	#
Individual perception	Definition of subjective road safety as it is understood by the municipalities	13
Infrastructural features	Causes of notifications of subjective road safety	8
Internal coordination	Municipal needs for approaching subjective road safety	1
Interviews with residents	Information, data and investigations already available to municipalities	2
Investigation from another departmen	Information, data and investigations already available to municipalities	2
Involvement		2
Keeping elderly people mobile	Municipal goals for subjective road safety	2
Limiting factors		24
Limiting factors: Budget	Resources within municipalities for approaching subjective road safety	7
Limiting factors: Capacity	Resources within municipalities for approaching subjective road safety	5
Limiting factors: High workload	Resources within municipalities for approaching subjective road safety	15
Limiting factors: No in-house knowledge	Resources within municipalities for approaching subjective road safety	3
Limiting factors: Takes a lot of time	Resources within municipalities for approaching subjective road safety	3
Living environment complaints	Information, data and investigations already available to municipalities	3
Map display	Information, data and investigations already available to municipalities	5
Missed link within the municipality	Information, data and investigations already available to municipalities	1
Mixed traffic	Causes of notifications of subjective road safety	4
Nationally standardised surveys	Municipal needs for approaching subjective road safety	1
Neighbourhood board	Resources within municipalities for approaching subjective road safety	2
Not concentrated in location, diffuse	Information, data and investigations already available to municipalities	2
Notifications	Information, data and investigations already available to municipalities	1
Notifications without content	Resources within municipalities for approaching subjective road safety	1
Novice drivers	Groups of road users that stand out in subjective road safety	2
Parents	Groups of road users that stand out in subjective road safety	3
Parking	Causes of notifications of subjective road safety	2
Passive observation	Definition of subjective road safety as it is understood by the municipalities	5
Periodic resident survey	Information, data and investigations already available to municipalities	5
Political motivation	Resources within municipalities for approaching subjective road safety	7
Poor visibility	Causes of notifications of subjective road safety	2
Potential for influencing subjective road safety	Resources within municipalities for approaching subjective road safety	9
Potential for influencing subjective road safety: Explanation and understanding	Resources within municipalities for approaching subjective road safety	8
Potential for influencing subjective road safety: Reassuring citizens	Resources within municipalities for approaching subjective road safety	1
Priorities	Resources within municipalities for approaching subjective road safety	2
Project-related	Information, data and investigations already available to municipalities	7

Tabel D.1: Overall list of codes from the interviews (continued)

Codes	Themes	#
Province as guide	Municipal goals for subjective road safety	1
Questionnaires via socialmedia	Information, data and investigations already available to municipalities	2
Reporting system	Information, data and investigations already available to municipalities	4
Research carried out by a consultancy firm	Information, data and investigations already available to municipalities	4
Research costs money	Resources within municipalities for approaching subjective road safety	1
Resident platforms	Information, data and investigations already available to municipalities	2
Risk-based approach	Municipal goals for subjective road safety	4
School example		4
Self-reliant citizens		1
Sense of safety for the citizen	Municipal goals for subjective road safety	1
Shared space	Causes of notifications of subjective road safety	1
Should be a higher priority	Municipal goals for subjective road safety	1
Specific goal to improve perception of road safety	Municipal goals for subjective road safety	3
Speeding	Causes of notifications of subjective road safety	18
Strain with objective road safety	Definition of subjective road safety as it is understood by the municipalities	9
Surveys lack depth	Information, data and investigations already available to municipalities	6
Tension between objective and subjective traffic safety	Definition of subjective road safety as it is understood by the municipalities	6
Through an interest group	Information, data and investigations already available to municipalities	5
Too easy to complain	Causes of notifications of subjective road safety	1
Tools for understanding subjective road safety		3
Tools for understanding subjective road safety: Measuring speed	Information, data and investigations already available to municipalities	3
Town council	Resources within municipalities for approaching subjective road safety	1
Traffic behaviour	Municipal goals for subjective road safety	1
Traffic density	Causes of notifications of subjective road safety	1
Vulnerable road users	Groups of road users that stand out in subjective road safety	1
Want to avoid more complaints	Municipal goals for subjective road safety	8
Want to be heard	Resources within municipalities for approaching subjective road safety	4
Widely supported	Resources within municipalities for approaching subjective road safety	3
Working definition	Definition of subjective road safety as it is understood by the municipalities	10
Working definition: Addition to the definition	Definition of subjective road safety as it is understood by the municipalities	2
Working definition: Adjustment of definition	Definition of subjective road safety as it is understood by the municipalities	1
Working definition: Agree with definition	Definition of subjective road safety as it is understood by the municipalities	8

Tabel D.1: Overall list of codes from the interviews (continued)

Codes	Themes	#
Working definition: Disagree with the definition	Definition of subjective road safety as it is understood by the municipalities	0
Working group	Information, data and investigations already available to municipalities	6
Young people	Groups of road users that stand out in subjective road safety	1

D.2. Groups from the codes

The codes assigned to the interviews were divided into seven themes or groups. The distribution of the number of times these codes were mentioned in the interviews is shown in Figure D.1.

A figure for each theme (D.2, D.3, D.4, D.5, D.6, D.7) is then shown, showing the different codes within that theme, as well as the number of times they were mentioned in the interviews. The number of mentions may give an indication of the importance these codes may have for a municipality, but this should be interpreted with caution. That is because the importance of a code and the number of times it is mentioned need not be directly related. But for the purposes of completeness, the numbers are included here.

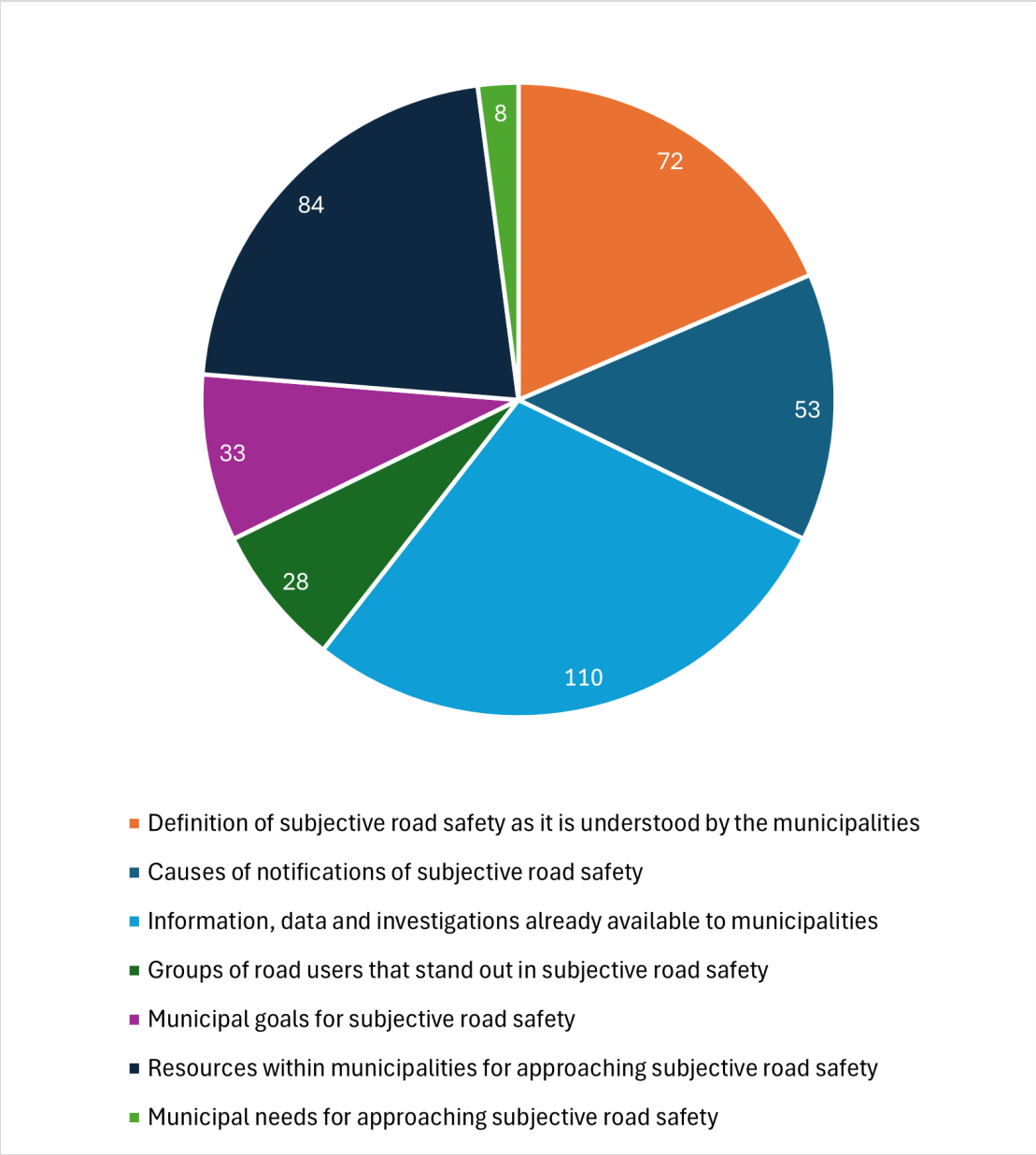

Figure D.1: Distribution of number of codes used by theme

Note that the horizontal axis in the Figures D.2, D.3, D.4, D.5, D.6, D.7 and D.8, indicating how many times the code is mentioned, is not the same in the different figures. This is also because municipalities had more to say about certain topics. This also makes these axis numbers the best to compare within the themes.

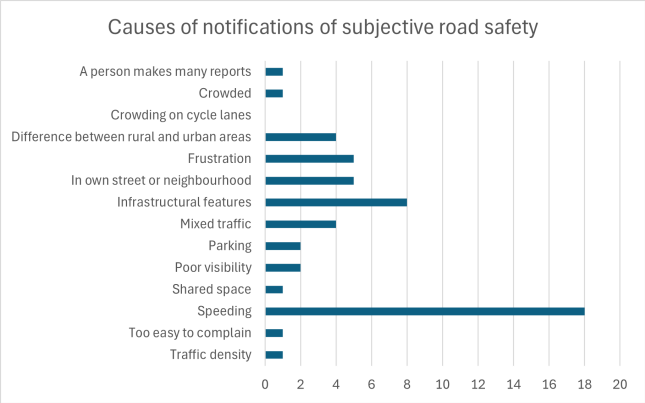

Figure D.2: Codes and number of times mentioned in theme: Causes of notifications of subjective road safety

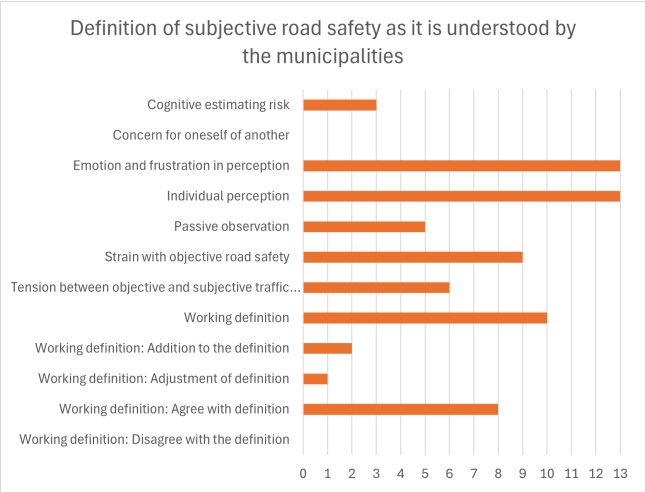

Figure D.3: Codes and number of times mentioned in theme: Definition of subjective road safety as it is understood by the municipalities

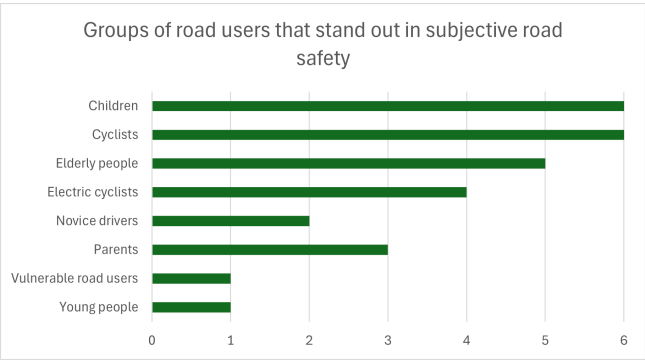

Figure D.4: Codes and number of times mentioned in theme: Groups of road users that stand out in subjective road safety

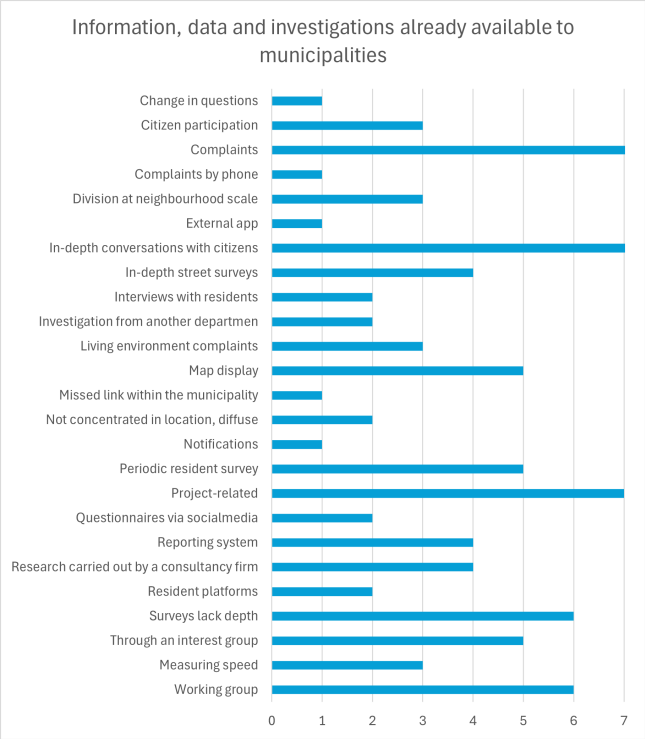

Figure D.5: Codes and number of times mentioned in theme: Information, data and investigations already available to municipalities

Figure D.6: Codes and number of times mentioned in theme: Municipal goals for subjective road safety

Figure D.7: Codes and number of times mentioned in theme: Municipal needs for approaching subjective road safety

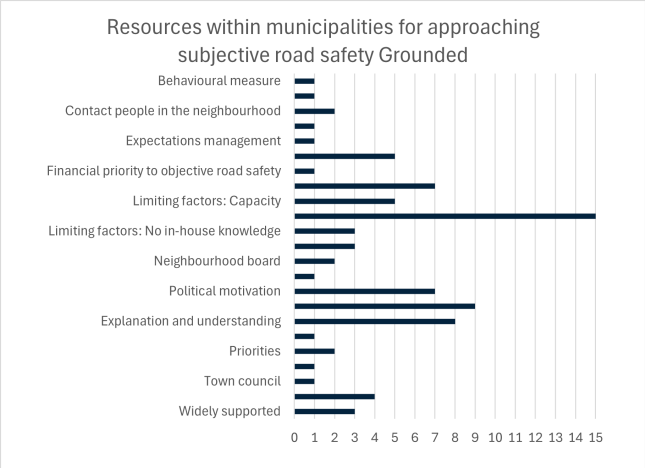

Figure D.8: Codes and number of times mentioned in theme: Resources within municipalities for approaching subjective road safety

D.3. Codes per theme per municipality

Table D.2: Overview of codes and themes

Municipality / Theme	De Buch/Heiloo	De Wolden	Hengelo	Houten	Leeuwarden	Utrecht	*Total number of codes per theme*
Definition of subjective road safety as it is understood by the municipalities	7	10	14	11	9	11	**62**
Causes of notifications of subjective road safety	12	7	10	8	11	5	**53**
Information, data and investigations already available to municipalities	14	28	15	19	20	14	**110**
Groups of road users that stand out in subjective road safety	10	0	3	3	8	4	**28**
Municipal goals for subjective road safety	5	6	7	4	6	5	**33**
Resources within municipalities for approaching subjective road safety	15	13	24	5	10	8	**75**
Municipal needs for approaching subjective road safety	2	0	1	1	3	1	**8**
Total number of codes per interview	65	64	74	51	67	48	**369**

Table D.2 shows how often codes were used per theme and interview. The difference with the total number of codes used (378) is that some codes were not assigned to a theme. These codes did not belong in a category and were later considered not important enough to create an extra theme.