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Wheelchair pedestrians assert participation and normality but compensate more for mobility barriers: interviews and go-along study in the Netherlands towards inclusivity and justice☆

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ABSTRACT

Wheelchair pedestrians have long been known to be a vulnerable road user group. Existing traffic policies and research typically address their needs from a functional or practical perspective. In contrast, this study applied an inclusive design and justice perspective to understand the lived experiences of wheelchair pedestrians in traffic situations, and to elicit their needs, preferences, and meanings. We conducted semi-structured one-on-one interviews with 11 wheelchair pedestrians and go-along observations with six of them at an unsignalized crossing in the Netherlands. For the Dutch urban context, our results confirm previously found travel experiences, such as planning ahead, coping with crowdedness, being extra vigilant, taking detours when facing obstacles, and avoiding crowded situations. We also found that participants preferred clear traffic situations: good visibility from a low vantage point, other traffic users adhering to traffic rules, and clarity of who can use which path. Our study adds new insights that could improve road and transport design (processes). These insights include their assertion of participation and normality, and their strategies to manage extra challenges, such as difficulties in controlling speed (too slow/too fast), risks of getting trapped due to their physicality, and their ensuing extra compensation behaviour. These issues call for new requirements and solutions to be designed and evaluated through real-world and simulated participatory systemic processes in road and transport design, to support equity and safety.

1. Introduction

Wheelchair pedestrians' community participation has been linked to a sense of motivation, competency, and self-efficacy, and via these aspects, to health status and psychological and physical well-being (Harris et al., 2015; Smith et al., 2016; Venkataram, 2023). For older powered wheelchair pedestrians, mobility has been described as a core aspect of the life continuum, impacting their identities, both past and present, and a key issue for equity of access and social inclusion (Labbé et al., 2020). At the same time, they face more barriers than younger wheelchair pedestrians (Harris et al., 2015). For older people, mobility has been shown to contribute to quality of life by facilitating desire for independence, control, status maintenance, inclusion, normality, and travel for its own sake

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(Musselwhite & Haddad, 2010). It can be expected that this importance is similar for wheelchair pedestrians, many of whom are also older adults. Larrington-Spencer (2025), in an autoethnographic study, connects the ability to follow desire lines (i.e., preferred, short routes) as a wheelchair pedestrian to liveability and experience of citizenship (cf. Gaete-Reyes, 2015). Yet accessibility and desired travel are often separated in the literature. For example, the National Association of City Transportation Officials provides guidance for designing travel environments for all abilities (NACTO, 2017/2025), yet only includes desire lines in guidelines for general pedestrians (NACTO, 2013/2025). This prompts our research into how wheelchair pedestrians' desired participation in travel is supported and what their experiences are. A key aspect of the experience of vulnerable road users is their safety and their perception of safety in traffic. The latter affects their willingness to participate in travel and their overall experience of it.

1.1. Wheelchair pedestrians' road safety

There are approximately 80 million wheelchair users (around 1% of the population) globally (WHO (World Health Organization), 2023), and the proportion is expected to increase due to population ageing. Kraemer and Benton (2015) estimated that the pedestrian mortality rate in fatal crashes in the US is 36% higher for wheelchair users than for the general population, with almost half of these crashes occurring at intersections, of which over a third were without traffic control devices (unsignalized).

The Dutch context seems similarly relevant for such research, since the urban fabric is often dense, there is a high percentage of cyclists, and many bike lanes (Goel et al., 2022). Sidewalks are used by ambulant pedestrians, wheelchair pedestrians, cyclists, roller users, and more (e.g., Berge et al., 2022; Steenbruggen et al., 2012). At road crossings, they all interact with each other and with motorized traffic such as cars, mopeds, and motorbikes.

Overall, the Netherlands is one of the ten safest traffic countries globally (Rosen et al., 2025), with decades of concerted effort invested into preventive measures, as mentioned in a recent review of traffic safety in the Netherlands (Wegman et al., 2022), that however omits mentioning traffic participants with disabilities. Direct injury or fatality comparisons between general pedestrians and wheelchair pedestrians, like in Kraemer and Benton's (2015) US study, are not readily available. Estimating mobility aids in the Netherlands at 200,000 (SWECO, 2025), with half in daily use, and comparing this with an estimated 11.5 million daily traffic participants (80% of persons aged 18+, who themselves comprise 80% of the 18 million inhabitants; CBS, 2024), then we can very roughly estimate wheelchair users to be approximately 1% of traffic participants, similarly to the global proportion reported by WHO (2023). VeiligheidNL (2024) reports that between 2018 and 2022, an average of 38 persons, or approximately 5% of total traffic fatalities, were users of motorized mobility aids, against 1% of traffic participants, with the number nearly doubling between 2013 and 2023 (KiM, 2024). Three quarters of the 38 fatalities were men, and over half were over 80 years old (VeiligheidNL, 2024). Over half of the fatalities resulted from accidents without others involved, around one third from crashes involving other vehicles, and 14% from crashes with static objects. There is no data on intersections.

1.1.1. Improving wheelchair pedestrians' road safety

Recent and long-term developments seek to improve road safety (European Commission: Directorate-General for Mobility and Transport, 2020) and the situation of people with disabilities via better provisions through the 2006 UN Convention on the Rights of Persons with Disabilities (UNCRPD United Nations, 2006). In the Netherlands, policies and practices have traditionally largely removed people with disabilities from public space (Reindl et al., 2022), and attention to them is relatively recent.

Although the Netherlands has long embraced Safe System policies (Wegman et al., 2022), accessibility demands have only recently been added to new developments like shared space concepts (CROW, 2023). Shared space concepts entail removing curbs to reduce speed and foster a socially regulated traffic environment. However, they have been met with mixed responses from disabled communities due to feeling more exposed and less safe (Houtzager & De Vos, 2025; Imrie, 2012).

In line with the NEN-EN 17210 (2021) and NEN 9120 (2025) legislation, Dutch municipalities are now establishing Local Inclusion Agendas (Houtzager & De Vos, 2025) to involve citizens in matters in the public domain, and the methodologies for this remain under development. To contribute to these efforts, there is an urgent need for a better understanding of the needs of these groups in traffic situations. It has been noted that even with accessibility legislation in place, inattention to disability can and does persist (Ross et al., 2024). This study aims to support efforts to reduce this gap with relevant insights. To our knowledge, no academically published study in the Netherlands has investigated mobility experiences in community participation in a contextual way and from wheelchair pedestrians' perspectives.

1.2. An inclusive design and justice approach to research with wheelchair pedestrians

We adopt Bianchin and Heylighen's (2018) justice-based approach to inclusive design based on legal and moral philosopher Rawls' theory of justice as fairness. It entails the principles of equality and equal opportunity as well as facilitating the needs of those most disadvantaged when inequalities arise, as similarly argued in Martínez-Buelvas et al. (2024) as a transport justice approach. Heylighen and Bianchin (2018, p. 31) apply these principles to the dilemma that public situations must accommodate diverse and sometimes conflicting needs. Applying Rawls' principles, they recommend addressing the dilemma on the scale of a social context rather than that of specific designs and identifying and prioritising who is likely to be worst off in that social context. The focus should be on "*the degree in which (these) agents can convert a resource—in other words, a city, a neighbourhood, a building, a space—into a functioning (…) (e.g., walkability, freedom of movement, accessibility), but also meaning making (e.g., hominess, stigma)*" (Heylighen & Bianchin, 2018, p. 31; cf. Ross et al., 2024). Nonetheless, there are also examples when specific designs have been found to address conflicting needs (such as pebbled or grooved concrete to both provide a curb cut and signal the presence of a curb for blind pedestrians; Hamraie, 2017, p. 118).

Methodologically, we adopt their recommendation to directly involve those worst off in whole journeys as a social context, in relation to specific situations (inclusive design aspect), and to elicit their experiences of whether the situations are fair (justice aspect) (Bianchin & Heylighen, 2018; Heylighen & Bianchin, 2013), as similarly advocated by Holmes (2018) and others championing inclusive design approaches (e.g. Clarkson & Coleman, 2015; Lamirande et al., 2022; Park & Chowdhury, 2022; Reindl et al., 2022).

Furthermore, our approach is aligned with the UN Convention on the Rights of Persons with Disabilities (UNCRPD United Nations, 2006) postulate that *"persons with disabilities should have the opportunity to be actively involved in decision-making processes about policies and programmes, including those directly concerning them"*. The EU legislation for accessibility and usability of the built environment NEN-EN 17210 (2021) and NEN 9120 (2025) is based on UNCRPD and supports Universal Design and its adage 'nothing about us, without us'. Our approach also aligns with the social model of disability in that it acknowledges that societal barriers cause disability (Oliver, 2013) and with the biopsychosocial model of disability (Hunt, 2024) in that it is cognisant of the cumulative experiential effects of physical disability, environmental barriers, and lived experience.

1.3. This study: aim and research questions

We aim to contribute to the improvement of the accessibility of public space by generating knowledge on wheelchair pedestrians' traffic experiences in specific situations across their whole journeys. Our main research question is: what are wheelchair pedestrians' safety needs, experiences, and preferences in navigating traffic scenarios, particularly road crossings? While Dutch data on the safety of unsignalized road crossings are unavailable, their risk is well documented in US studies (Kraemer & Benton, 2015). Consequently, such crossings form part of the focus of this study. Within this broader question, we enquire how wheelchair pedestrians make travel choices, navigate road crossings, perceive safety in this process, and we articulate their traffic safety needs and experiences. We focus mainly on perceived safety rather than safety-critical occurrences because we are interested in studying their whole journeys rather than isolated accidents.

This paper is structured as follows: in section 2 we inventory wheelchair pedestrians' known experiences and perceived safety, and the conditions and situations they encounter in participating in traffic in urban areas. We cluster this knowledge into four themes that are relevant to the wheelchair pedestrians' perspective. Sections 3 and 4 present an in-situ qualitative study that aims to add to this knowledge through in-depth research with 11 wheelchair pedestrians, comprising interviews, go-along and observation. We analyse the data in parallel with aligning it with the literature. In section 5 we discuss the contributions of the findings of this research and the implications for road and transport design and research.

2. Related work on wheelchair pedestrians and (vulnerable) pedestrians' travel experiences and perceived safety

This section reviews factors previously identified to influence wheelchair pedestrians' experiences and perception of safety in traffic situations. In some cases, findings from vulnerable pedestrians and pedestrians with disabilities generally are included, if the studies did not clearly specify where findings pertained to wheelchair pedestrians. These aspects inform the set-up of the interview questions and situations to be addressed in our study. We classified these factors into four themes: (1) Own behaviour (e.g., caution and careful travel choices), (2) Other road users (e.g., number and behaviour), (3) Temporary conditions (e.g., time of day, weather, obstructions), and (4) Infrastructure characteristics (e.g., sidewalk quality, crossings, traffic) (Sections 2.1–2.4). The overview of these aspects, without claiming to be a complete literature review, provides a basis for understanding the key factors in wheelchair pedestrians' lived experiences, as well as possible gaps in our current understanding.

Most studies employ a survey- or literature-based approach, in some, complemented by in-depth (group) interviews. Increasingly, studies use inclusive observation-based and/or immersive approaches (e.g. Gaete-Reyes, 2015; Hammond & Musselwhite, 2013; Pecchini & Giuliani, 2015; Prescott et al., 2021; Shoman & Imine, 2023; Sun & Lau, 2021; Wang et al., 2024), alongside two that employ an autoethnographic approach (Larrington-Spencer, 2025; Osman & Porkertová, 2023).

2.1. Influence of own behaviour on travel experience and perceived safety

Pedestrians with disabilities frequently report feeling at risk due to aspects related to their own behaviour and situation (such as fatigue), and to adapt their behaviour due to desired routes or risks they perceive (such as avoiding certain places). To **ensure their own safety**, people with disabilities avoid walking alone at night due to insufficient light and avoid dangerous places (Flynn et al., 2023; Verlinghieri et al., 2022) and wear reflective clothing or take other measures to make themselves visible (Webber et al., 2021). They take longer routes to avoid crowding, rush hour, shared spaces, bad weather and tricky surfaces (Harris et al., 2015; Lawson et al., 2022), as well as being overlooked and excluded from navigating easily (Rasoulivalajoozi et al., 2025; Velho, 2019). This and having to manoeuvre, for example around obstacles such as trees, results in **fatigue, anxiety and frustration** (Harris et al., 2015; Rasoulivalajoozi et al., 2025; Flynn et al., 2023 (for people with disabilities generally)). This is compounded by fears of injury or embarrassment from falling out of or with the wheelchair (Rasoulivalajoozi et al., 2025). Some are also conflicted about their own role, resenting their wheelchair use for aesthetic or comfort reasons or feeling like a burden when there are no provisions for them (Rasoulivalajoozi et al., 2025). These heightened experiences result in developing their own problem-solving techniques or strategies (Velho, 2019). They also **pay heightened attention while navigating**.

Wheelchair pedestrians are apprehensive, nervous and extremely cautious at road crossings, particularly unsignalized ones, only crossing when drivers are completely stopped (Pecchini & Giuliani, 2015). When encountering autonomous vehicles, they check whether these recognize them as pedestrians (Asha et al., 2021). They carry out potentially dangerous manoeuvres such as swerving

into the street to avoid obstacles on the sidewalk (Harris et al., 2015; Gaete-Reyes, 2015) but still choose direct paths (desire lines, Larrington-Spencer, 2025). Older people and those with disabilities may break traffic rules to follow desire lines but also express annoyance with other traffic users breaking the rules and a desire for mutual understanding and considerate behaviour (Wang et al., 2024). They carefully weigh **choices when and where to travel**. This is due to fears about routes, e.g. due to low vision and risk of attacks (Verlinghieri et al., 2022, reporting on people with disabilities generally). It results, for example, in sticking to known routes and paths, particularly in shared spaces, to manage anxieties (Hammond & Musselwhite, 2013, reporting on vulnerable traffic participants). People with disabilities and particularly wheelchair pedestrians report choices marked by worries about availability and (dis-) comfort of transportation modes such as public transport (Flynn et al., 2023; Rasoulivalajoozi et al., 2025). People with and without disabilities desire more and easier combinations of travel modes (Flynn et al., 2023). Wheelchair users grudgingly use specialised transport to reduce exhaustion (Parent, 2018).

2.2. *Influence of other road users on travel experience and perceived safety*

Wheelchair pedestrians and people with disabilities have been reported to be affected in their perception of safety by other road users. This applies particularly to crowding, but also to **other road users' behaviours** such as excessive speed, which can lead to risks and conflicts. Wheelchair pedestrians are bothered by over-crowding (Gaete-Reyes, 2015; Shoman & Imine, 2023; Sun & Lau, 2021) and have reported experiences of other motorists not stopping or only stopping when there is a second person with the wheelchair pedestrian (Geoerg et al., 2019) or treating wheelchair pedestrians as invisible (Gaete-Reyes, 2015). Conversely, some studies report that other pedestrians show consideration and slow down when there are wheelchair pedestrians (Pecchini & Giuliani, 2015). Wheelchair pedestrians feel that pedestrians obstruct them in their path, particularly in shared space (Shoman & Imine, 2023), and **encounter excessive speed, recklessness or distractedness** of cyclists or e-scooters (Pecchini & Giuliani, 2015; Shoman & Imine, 2023; Wang et al., 2024) and being on the receiving end of those road users' ableist attitudes, triggering distressing emotions (Gaete-Reyes, 2015).

2.3. *Influence of temporary conditions on travel experience and perceived safety*

The issues found so far are compounded by temporary **conditions** such as nighttime (Lawson et al., 2022), bad weather seasons and poor weather conditions (Borisoff et al., 2018; Harris et al., 2015), hindering wheelchair pedestrians from participating or prompting them to brace for these conditions. **Changes in traffic rules** introduce uncertainty too, such as the introduction of shared space (Wang et al., 2024). Older people and those with disabilities mention trying to mitigate the unpredictability of their travel by seeking the **presence of other people** (e.g. Verlinghieri et al., 2022). They encounter and have to tackle unpredictable **obstacles** such as street furniture (Lawson et al., 2022; Venkataram, 2023; Verlinghieri et al., 2022), improperly parked micro mobility devices or cars (Hammond & Musselwhite, 2013; Venkataram, 2023), architectural barriers, tree roots, garbage bins, traffic signs, bushes, advertisement banners (Larrington-Spencer, 2025; Pecchini & Giuliani, 2015; Ross et al., 2024; Shoman & Imine, 2023). They also face hard-to-predict risks and experiences of physical injury while in **specialised transport** (Wretstrand et al., 2004) or due to uneven road surfaces (e.g. Gaete-Reyes, 2015) as well as usability issues and discomfort in **public transport** (Flynn et al., 2023; Rasoulivalajoozi et al., 2025). Due to the unpredictability of these aspects, wheelchair pedestrians and others with vulnerabilities or disabilities often undergo these conditions and face risks, but also in some cases avoid travel.

2.4. *Influence of infrastructure aspects on travel experience and perceived safety*

Unsuitable or insufficient pedestrian infrastructure makes travel unattractive, fatiguing or impossible for people with disabilities and wheelchair pedestrians (Harris et al., 2015; Venkataram, 2023). Older wheelchair pedestrians experience more barriers than younger ones (Harris et al., 2015). The issues are numerous: stairs, broken, narrow, too steep or missing curb cuts, curb cuts not at any corner or into ongoing traffic, too narrow sidewalks/ bike lanes/ refuge islands, gaps in surfaces such as drain grates (Hammond & Musselwhite, 2013; Harris et al., 2015; Larrington-Spencer, 2025; Park & Chowdhury, 2022; Pecchini & Giuliani, 2015; Ross et al., 2024; Sharifi et al., 2017; Shoman & Imine, 2023; Sun & Lau, 2021; Venkataram, 2023; Verlinghieri et al., 2022). The same goes for ramps/slopes: without railing, with a slick surface, too narrow, too steep, without sufficient landing space, or too long (Harris et al., 2015; Rasoulivalajoozi et al., 2025). Right angles and dense environments require more distance and time for manoeuvring, particularly for motorized wheelchair pedestrians (Sharifi et al., 2017). Not all public transport stops are accessible, leading to longer trips as a wheelchair pedestrian (Osman & Porkertová, 2023). People with disabilities have been reported to **avoid shared space** with detours of up to 30 min (Lawson et al., 2022). They prefer and seek out **well-lit streets** (Lawson et al., 2022; Verlinghieri et al., 2022), value **reachability of desired locations** for participation, such as shops, places of worship, education and cultural centres, education or work (Osman & Porkertová, 2023; Pecchini & Giuliani, 2015), and feel excluded by inferior provisions like being forced to use a back entrance rather than a general entrance (Müller et al., 2024). Lack of close-by accessible transport stops can also lead to further trips as a wheelchair pedestrian (Osman & Porkertová, 2023). The **state of repair** of infrastructure is also important: cracked / uneven pavement, poor asphalt condition or unpaved, uneven road surface, feeling it through device, potentially leading wheelchair pedestrians to switch to the smoother road and thus being exposed to greater risk (Gaete-Reyes, 2015; Harris et al., 2015; Prescott et al., 2021; Shoman & Imine, 2023; Venkataram, 2023). **Crossing characteristics** such as too few crossings, poor or insufficient street lighting, lack of signals or signals not allowing enough time to cross also lead to exposure to risks or detours (Harris et al., 2015; Osman & Porkertová, 2023; Peden et al., 2004; Shoman & Imine, 2023). Lastly, the characteristics of the **wheelchair itself** are part of

infrastructure from wheelchair pedestrians' perspective and can lead to discomfort and burdens on travel, for example cushion discomfort or wheelchair weight reducing manoeuvrability (Rasoulivalajoozi et al., 2025).

2.5. Summarizing related work and gap

The literature reveals that wheelchair pedestrians report many mixed experiences and perceived risks. Partly, due to their own behaviour, such as fatigue or cautiousness. The interaction with other road users also influences perceived safety, such as crowding and excessive, conflicting, or unpredictable differences in speed between traffic participants. Temporary aspects also affect the wheelchair pedestrians' experiences and perceived safety, such as the time of day or temporary obstructions. There is already an awareness in the field that more needs to be done on the infrastructure level to support more vulnerable traffic participants such as wheelchair pedestrians, since they are less able to compensate in dangerous situations than other pedestrian traffic participants. Since little contextual research exists in the Netherlands, these topics inform the focus of our study. The review of the literature revealed that over the last decade or so, there has been a gradual increase in published real-world studies, participatory studies and occasional autoethnographic studies. We draw on these to develop our approach with which we seek to apply an inclusive design and justice perspective.

3. Method

Our study design builds on known characteristics of wheelchair pedestrian travel and aims for a research set-up that includes relevant infrastructure and allows participants to describe, enact, and recall their experiences as well as desired situations. This section explains our approach, procedure, and data collection.

3.1. Study approach: interviews and field observations

To realise an inclusive design and justice approach and start from the perspective of wheelchair pedestrians, we align with a body of research that applies in-depth immersion in real traffic contexts (e.g., Wang et al., 2024). In this, we were reflective of our own positionality as non-wheelchair researchers (Kezar, 2002; Mohler & Rudman, 2022) and adopted the following strategies to respect participants' experience. These included: 1. clearly communicating our research goal of identifying ways to improve public space; 2. eliciting the wheelchair pedestrians' own experience in context and their thoughts on experienced and preferred traffic situations. We acknowledge the likely diversity of wheelchair pedestrians' experiences (Kezar, 2002). Heylighen and Dong (2019) additionally caution that empathic research approaches must also account for embodied physicality, which means acknowledging the limits of obtaining accurate and relevantly complete information about someone else's lived experience. This led us to include go-along in our research: a researcher accompanying a wheelchair pedestrian on a portion of a journey to understand their lived experience, with commentary from them. We additionally generated materials that enabled them to reflect on past journeys to consider their lived experience over time.

3.2. Procedure

Our study consisted of four parts, including (1) a sensitizing preparation that commenced a week in advance of the other parts, (2) a semi-structured one-on-one interview (part 1) in combination with (3) go-along field observations at a road crossing in Delft, The Netherlands, and (4) continuation of the interview directly after (part 2). The third author (hereafter: the interviewer) carried out all practical parts of the research (sections 3.2.2–3.2.4) except recruitment and discussed their experiences with the other authors between sessions. After the first part of the interview, the interviewer and participant travelled together to the intersection for the observation, then returned to the original interview location to complete the interview. Each session lasted about 120 min. The study was performed between June and September 2023.

3.2.1. Participant sampling and recruitment

We aimed to reach a mixed group of wheelchair pedestrians who moved independently in public space, varying in gender, age, and type of wheelchair (e.g., manual, electric). Initially, we planned to recruit participants through institutional channels and through organizations that represent or advocate for people in wheelchairs. However, there was no local advocacy group of wheelchair pedestrians in Delft at the time of the research, and national advocacy groups were unable to name contacts in this city. This led us to recruit most participants by intercepting them on the street near the research site (cf. Sun & Lau, 2021). This ensured proximity, reduced burden, and allowed potential participants to judge their own comfort and safety with the research context. On the street, the first author asked if they would be interested in joining the study and gave them our contact details, after which they were free to contact us by email or phone to confirm their participation. From the moment they got in touch, they interacted with the interviewer who informed them that participation was voluntary and that they could withdraw from the study at any point in time. The participants were offered a gift voucher worth 40 euros as compensation. Ethical approval was given by the Human Research Ethics Committee of the TU Delft (nr. 3470).

3.2.2. Sensitizing (part 1)

After reading the consent form (which they later signed physically or through audio recording when they arrived for the interview)

and before the interview, participants were asked to take photos of traffic locations they encountered over one week, similar to a photovoice approach (e.g., Wang et al., 2024). We asked them to send us approximately five to ten pictures with a short explanation. The pictures should be of locations that they find relevant or visit often. For example, a spot that feels safe or unsafe, or where the participant can point out what they do to navigate a traffic intersection. This process has been termed 'sensitizing' and it serves to engage participants and motivate them to think and reflect about the topic in advance from the perspective of their own experience (Sleeswijk Visser et al., 2005).

3.2.3. *Interview (parts 2 and 4)*

The participants were invited for interviews at the university campus, which also included an observation portion.

Fig. 1 shows how the participants could reach the interview location from different directions from the city of Delft (green small-dotted lines), and the path that the interviewer then took together with them to the observation location and back (orange dashed line). The sensitizing (section 3.2.2) covered the city of Delft, which extends to surrounding areas outside of the picture. The photos that the participants themselves took were mostly located around Delft. The pictures that we provided to the participants to reflect further on traffic situations showed a diversity of crossing situations throughout the Netherlands (Appendix A2).

Once the participants had arrived at the interview location, the interviewer asked them about their trip, and placed the participants' own printed sensitizing photos (Appendix A3) on the table to prompt them to pinpoint, recognize, and recollect their thoughts or ideas with the photos. Due to the proximity from which the participants were recruited, these photos most likely included locations through which they had travelled to come to the interview itself. These photos were discussed first to learn more about why they were chosen and what is important about them. To provide more potential inspiration, the interviewer then presented a set of photos of a variety of traffic crossings from TU Delft campus and Dutch newspapers (i.e., AD, Gemeente Amsterdam, Trouw; see Appendix A2) as further supporting materials. From these, the interviewer asked the participants to pick two crossings that related to their own experience and describe how they would experience them. Moreover, when participants wanted to describe any specific traffic situation they had experienced that was not represented by any of the materials present, the interviewer used Google Maps Street View to look jointly with them at that situation in detail. This helped the researcher to understand the situation but also encouraged the participant to describe their experience in more detail.

A semi-structured interview guide supported the interviews (parts 2 and 4) (see Appendix A1). Part 2 had a duration of about 20 min and contained a set of introductory questions, followed by a discussion about the collected photos from the preparatory activity. Further questions and optional prompts covered their travelling experience in general, where they travelled and whether alone or with others, their perceived safety in traffic, whether they would like to travel more, how they navigated, whether they planned a route and how they dealt with travelling to a new place, how they felt while travelling, how independent they were during travelling, whether they felt there were any safety issues, how they felt about the time it took to travel and whether they ever took detours, fair treatment from other traffic users, future wishes, and the use of their mobility aid. After the observation (part 3) and returning to the interview room, the part-4 interview lasted about half an hour and the participants were asked how they navigated the crossing, whether this was similar to the way they usually navigated crossings, their reasoning in choosing their actions, their impressions, and any further thoughts about (perceived) safety. Some additional prompt questions had been prepared and were asked where relevant, such as how safe they felt in traffic and when they felt less safe, what influenced their perception of safety in traffic, whether they avoided any

Fig. 1. Green, small-dotted line: the various paths of max 1.5 km the participants could take to the interview location. They could either come as wheelchair pedestrians from the surrounding city of Delft (e.g. from the city centre or train station extending from the top left of the image). Or by bus or car, in either case stopping close to the interview location. Orange dashed line: the route the interviewer travelled with participants to the crossing and back, ca 1.5 km each way. (Image: Google Maps).

places, whether they wanted to be noticed or not, whether they themselves were ever distracted (e.g. by phone use) or broke rules, and how they felt about fairness in traffic. Lastly, they were asked about what should be different, what they would need to feel safe while travelling, and what an ideal road crossing would look like to them. This was then followed by some information questions about their wheelchair type and why, and demographic questions.

3.2.4. Go-along observation (part 3)

After the initial interview, the participants and the researcher moved as pedestrians to an observation location, an unsignalized road crossing on a through road. This journey took 10–15 min. The journey to the crossing was part of the research and led to both observations of the interviewer (e.g., about obstacles in the path) and statements from participants. The selected crossing is on the Schoemakersstraat and the Van der Burghweg in Delft (see Fig. 2). The Schoemakersstraat is a through road with an estimated daily motor vehicle volume of 3000 based on the volume during observation and a maximum speed of 50 km/h for cars. In consultation with the pilot participant, we selected this crossing because it has similar risks to situations in many countries. There are two options to cross the road, either to take the *short path, a likely desire line,* which includes some bumps and only a shallow curb cut, or to take the *long path, a detour* in the bike lane with full curb cuts. In the foreground, indicated by white lines, are the shallow curb cuts: the curb is 11 cm on the right side, and 8 cm on the left. In the background, there is a second unsignalized four-leg intersection with full curb cuts. From the side roads, cars, bicycles, and mopeds turn into the through road. Pedestrians also turn into the road or cross to and from the bus stops. Bike lanes run along both sides between the sidewalk and the road. Both main road crossings have a midblock section (also called a refuge island).

Once arrived at the crossing, the researcher asked the participants to travel to the bus stop on the other side. The participants were not steered in their choice of route; they were only asked to cross the road safely and in a way in which they would normally do. The researcher did not cross with them but remained in place to observe with full attention and to look out for traffic safety. Participants were encouraged to think out loud during the observation (Boren & Ramey, 2000). For safety reasons, we did not conduct the observation at a crowded time, but the road crossing situation was realistic enough to allow participants to recall such situations. Afterwards, the researcher asked questions about their behaviour and experiences during this activity. This observation portion took around 10–20 min, followed by 10–15 min of pedestrian journey back to the interview location. These go-along journeys also allowed the researcher to experience and compare the journey towards that crossing among participants. The insights from the travel to and from the location, the observations at the location and the participants' comments are presented in the themes in the results section below.

4. Results

4.1. Participants

In total, 11 wheelchair pedestrians participated in our study. The first and second pilot participants were colleagues and the third participant was a student at the same institution. None of these had a power relationship to the researchers. Seven participants were recruited by the first author through street intercepts near the study site, and one additional participant was recruited via another participant.

The researchers determined the location for the observation together with the pilot participant, but the interview with this participant took place online due to illness, and no field observation could be conducted. The second pilot session included a go-along observation. Both pilots were included in the data because they contained valuable insights, and only minor adjustments were made to the research setup after the second pilot session.

Of the four female and seven male participants, three used a mobility scooter, three used an electric wheelchair, and five used a manual wheelchair. One participant with a manual wheelchair had a stretched leg. The participants were between 19 and 74 years old.

Fig. 2. The observation location was a crossing at Schoemakersstraat in Delft (image: Google Maps Streetview, coordinates: 51°59′52.1"N 4°22′48.3"E). Foreground, at the crossing path indicated by white markings: high curbs with only small cuts (curb is 11 cm on the right, 8 cm on the left). Left and right: bike lanes between sidewalk and road. Side roads from left and right with full curb cuts on their crossings, from which vehicles and pedestrians turn into the road. Background, another main road crossing with full curb cuts. Next to the bus stop on the left there is a curb on the direct route between bike lane and bus stop.

Seven interviews took place at and around the university campus and included a go-along observation, six of these at the comparison crossing (Fig. 2) and one at a crossing closer to the interview location. Four of these seven participants used extra mobility support during this observation: one motorized hand-bike, one manual hand-bike, one smart-drive motor at the back of a manual wheelchair, and one participant was pushed by the researcher part of the way.

One interview took place online. Three interviews took place at participants' own homes upon their request. One of these interviews included a shorter observation at a street location close to the participant's home, and the participant cancelled the go-along observation planned to take place later at the crossing due to bad weather. The other two participants did not take part in any go-along observation: one was unable to go outside without a support person, and one was uncomfortable travelling to the TU Delft campus because of the distance.

We anonymised the participant data through aliases. The aliases are functional and consist of three letters and an optional fourth one. The first letter refers to the gender, either male (M) or female (V). The second letter corresponds with age range, split up into three categories: young, 18–25 (J), adult, 26–59 (V), and 60+ (O). The third letter describes the type of mobility aid, either a manual wheelchair (H), an electric wheelchair (E), or a mobility scooter (S). The fourth letter is optional and consists of a, b, or c, and serves only to differentiate between repeated combinations. Table 1 shows the participants' characteristics and remarks on their participation in the overview.

Table 1
Overview of participants.[a]

Participant alias [a]	Gender	Age category	Type of mobility aid	Remarks
MVHa	Male (M)	Adult (V)	Manual (H)	-No observation, but online consultation on tough traffic situations in the campus vicinity, leading to the selection of the observation crossing.
MJE	Male (M)	Young (J)	Electric (E)	**-Obs:** takes detour. Slows down to drive carefully across bumps in the sidewalk. One small risky situation with a car: when he had right of way, he just went ahead, although a scooter was also approaching, making the situation complex.
MOSa	Male (M)	Older adult (O)	Mobility scooter (S)	-1 min video showing him navigate the crossing Within that time, 2 trucks, 3 cars and 1 cyclist travel one way, 3 cars other way. **-Obs.:** First takes detour, to go back, direct route. Struggles to mount curb, briefly stops on road (risky), watches for car, reverses, small run-up, mounts curb, gets compressed then launched slightly out of seat as he mounts. See also fig. 4.
VVHa	Female (V)	Adult (V)	Electric handbike (E)	-Has a straightened leg **-Obs.:** While traversing a cobbled square, mentions she feels every little ridge on the ground while travelling in her wheelchair. Crossing: takes detour there and back. One small risky situation with a car, she waves cordially. 2:21 min of video showing her navigate the crossing. Within that time, 1 scooter, 9 cars, 2 cyclists travel one way, 2 vans and 9 cars other way, 2 cars turn into the road, 1 scooter and 1 pedestrian cross.
MVHb	Male (M)	Adult (V)	Manual handbike (H)	Eye-tracking, still photos from eye-tracking obtained. **Obs.:** Direct path, wheelies, no cars. Says second curb (on return path) feels higher. (Says that after 3 beers he would have taken the safer detour). On the way back from the crossing, cannot get around an obstacle on the sidewalk and must enter the road.
VVHb	Female (V)	Adult (V)	Manual (H)	Interview at her own house upon her request. Wheelchair was temporary due to a temporary leg injury Short **obs**ervation, not at the crossing.
MVHc	Male (M)	Adult (V)	Electric and Manual (E) (SmartDrive)	**Obs.:** direct path, wheelies, cars give him right of way. Steep curb down: risk of hitting footrest, so wheelie, risk getting stuck, much arm strength needed. (Fig. 3). On the way to crossing: mentions finding the ridged tiles bothersome. Parked bicycles block the sidewalk for him, must take bicycle lane. Must do a wheelie to get back up on the sidewalk.
MOSb	Male (M)	Older adult (O)	Mobility scooter (S)	**Obs.:** Detour. Back: direct path, briefly stopping on road (risky). Does it again, detour again and direct back. Gets right of way once from a delivery van, then *taken* right of way immediately by the same driver. Mentions high curb bike lane. On the way to crossing: groans lightly during the trip along an even sidewalk, mentions finding it uncomfortable.
VOS	Female (V)	Older adult (O)	Mobility scooter (S)	Interview at her own house upon her request. Short **obs**ervation in her own neighbourhood upon her request. 5 photos from this observation: a curb at a crossing, 2 pedestrian midblock crossings, a shared space cycle path, a shared space pedestrian street.
MOE	Male (M)	Older adult (O)	Electric (E)	Interview at his own house upon his request. No observation.
VOE	Female (V)	Older adult (O)	Electric wheelchair (E)	Interview at her own house upon her request. No observation due to bad weather on the day of the research and lack of support person.

[a] Participant aliases are codes consisting of the letters M/V for gender, J/V/O for age, H/E/S for type of mobility aid. In case there are participants with similar characteristics, a/b/c is used in addition to distinguish between them.

4.2. Data analysis

The interviewer audio-recorded the entire interaction with all participants, including the conversation at the interview location, the trip to the crossing during which both travelled alongside each other (if it took place), the crossing itself, the trip back, and the concluding interview. We asked two participants to video record their crossing activity from the first-person view, using eye-tracking equipment 'Pupil Invisible Glasses' from Pupil Labs (https://pupil-labs.com/). However, this only yielded data from one participant, MVHb. The data were only meaningful in connection with the participant's statements and the researcher's observations (the video is included as supplementary material to illustrate the crossing experience). The interviewer video recorded two participants, MOSa and VVHa, as they navigated the observation crossing. Screenshots of this are in Appendices B1 and B2, and an observation from MOSa is shown in Fig. 5. The author team analysed this data in conjunction with the interviewer's observation notes and the participants' statements. Altogether, we collected rich qualitative information like participants' thoughts and intentions (Patton, 2002; p. 340) as well as their experiences, their own perspective (Blomberg & Karasti, 2012), and the interviewer's observations.

The author team analysed the data using a six-phase approach of inductive thematic analysis, in which the themes are data-driven and do not use a pre-existing coding frame (Braun & Clarke, 2006). It consists of: 1) familiarizing oneself with the data; 2) generating codes; 3) clustering codes into themes; 4) reviewing themes; comparing them with themes known from the literature in a parallel process, 5) defining and naming themes, and 6) reporting.

In the data familiarisation step, the interviewer transcribed the entire sessions using an open-source AI tool called 'Whisper' (https://replicate.com/openai/whisper), then reviewed each file while listening to the audio recording to correct any mistakes and note relevant voice and facial expressions (e.g., looking angry or sounding sad, as remembered). The author team reviewed the video footage and made notes of observations. The interviewer annotated the videos and combined them with observation notes for inclusion in the analysis. The participants' explanations from the sensitizing activities and what they said about their prior trip to the interview location were included in the analysis. While we had asked the participants to rate traffic situations according to perceived safety (Appendix A1), this data was *not* included in the analysis because the interviewer noticed that the participants struggled to make these ratings meaningfully. However, we did include the participants' reflections on the rating categories in the analysis.

In the coding step, the interviewer first coded all the transcripts (open-coding, in-vivo) using ATLAS.ti software. The codes consisted of quotes of one or several sentences or observations. The second and third author (interviewer) then independently coded two transcripts and compared them to the earlier coding results. Once they had developed a shared understanding of the codes, the interviewer coded all transcripts and the second author then checked them. The interviewer then transferred the codes to post-its in an online whiteboard environment (Miro) and printouts from Miro for easier handling. This step generated about 1500 codes.

The first, second and third author (interviewer) conducted the third, fourth and fifth analysis steps in three joint sessions. During this phase, about 50 quotes were discarded because they related only to local specific issues and did not contribute to the research topic. The team clustered the remaining codes into four main themes and 29 sub-themes in several iterations and in comparison with the literature. The interviewer then translated the final four themes and relevant quotes from Dutch into English for reporting purposes and paraphrased a few codes to improve readability.

During the sixth step, reporting, all four authors made further comparisons with literature and generated the final clustered, defined and named themes.

4.3. Themes resulting from sensitizing, interview and observation

4.3.1. Theme A: Asserting travel participation and relating to others

This theme describes how wheelchair pedestrians participate in traffic and assert this participation, and how they relate to other road users. Participants expressed the desire for equal treatment and equitable access to traffic systems and described the ambiguities and mixed experiences of their position in this. While they encounter some respect and support, other road users often affect their experience of safety and fairness in traffic negatively.

4.3.1.1. Own positioning/ Assertion of normality. Some participants strongly presented the attitude that they 'would not be stopped', indicating that they would always try to go where they want to go, no matter the difficulties that current traffic systems potentially bring. Differences in wheelchairs, own strength, disabilities, and likely personalities come with different choices and levels of (in) dependence. Participants described both their dependence and independence in traffic. Yet 9 of the 11 participants, sometimes repeatedly, mentioned wanting to participate *normally* in public life and in travel. Their relationship with safety is not just passive: they also challenge the conditions affecting their safety with courage. They show strength and active engagement with their intersectional position as a wheelchair pedestrian, a citizen, a traffic participant, a participant in public life, and, through necessity, an activist. MVHc and VVHa mentioned deliberately projecting confidence and independence towards other traffic participants to assert positivity, normality and to command respect. In the observation, the interviewer saw both MOSa and VVHa fixate the car driver with their eyes at the crossing to command respect, then assert positivity by cordially acknowledging the driver's yielding of way (see screenshots in Appendix B).

"When I have somewhere to go, I won't let anything stop me" (MJE).

"So yeah, I travel quite some kilometers. I'm in the city a lot, even if it's just to get some fresh air. I try to get out every day." (VOS).

The tension between asserted normality and the participants' awareness of their position as wheelchair pedestrians is illustrated by the way they navigated the observation crossing. Of the 6 participants who traversed it (see Table 1), 2 participants chose the direct

route, incurring some risky situations like gaining speed from coming down a curb, or only just keeping balance while doing a wheelie up a curb or mounting it with a mobility scooter. Two participants chose the detour via the second crossing in the background, thus applying extra caution, and 2 participants took the detour one way and the direct route coming back. Their comments indicate that the direct route is the desire line, and the detour the route of extra caution. Fig. 3 shows the direct route (desire line) indicated with a yellow and dark blue line. It involves traversing insufficiently cut curbs (with 11 and 8 cm curb remaining). To reach the second street crossing shown in the background, which has curb cuts, wheelchair pedestrians must use the bike lane and take a longer detour (longer orange line). Red crosses mark risky situations observed during the crossings of six wheelchair pedestrians.

4.3.1.2. Fairness. About half the participants expressed that they think their position in traffic is unfair, in some cases related to how other road users treat them and, in some cases, related to the design of traffic situations. A third of the participants expressed that they feel like they are treated differently in traffic compared to other road users. However, a third of the participants indicated that they do feel like they are treated fairly in traffic. About half felt like they are being treated similarly as other road users. The topic of fairness had been part of our interview questions, which is why all participants gave an answer to this.

4.3.1.3. Being able to trust in others. Some participants mentioned that other road users were often nice to them and often willing to help. A third of the participants mentioned that other people are always willing to help them when they need help [in traffic situations]. For example, in public transport, or when there are (unexpected) stairs.

4.3.1.4. Lack of understanding and feeling misunderstood. Incomprehension was a subtheme that emerged through the many examples of participants receiving (angry) comments in traffic, as well as general misunderstanding about disabilities. Especially the mobility scooter users among the participants seemed to experience lots of cursing from others. These participants indicated that they are more cautious and reluctant to speak up now, when other traffic users disobey traffic rules.

"If I honk at someone for driving through a pedestrian crossing – [hence not giving right of way] – I get a big mouth for it in return" (MOSa).

4.3.1.5. Impacted by and critical of others' behaviour when they break the rules. Most participants mentioned that the behaviour of other road users has a significant impact on their perception of safety in traffic. For some participants, the behaviour of others in traffic is even the biggest aspect in feeling safe or not, more important than, say, infrastructure or crowdedness. Half of the participants also expressed the explicit desire to have all road users comply with traffic rules, indicating that this is not the case right now. Their argument is that when everyone complies with traffic rules, it would be the safest. The participants gave many examples of other road users breaking traffic rules, often to the annoyance of participants. For example, other road users going through a red light, or taking over both on the left and the right-hand side. But also, cyclists that shoot right past wheelchair pedestrians, or other road users that move crisscross through each other.

"If everyone would comply with the rules, [all] crossings would be perfect as they are" (MOSb).

"I think [this] crossing is dangerous, because everyone goes through the red light" (MOSa).

4.3.1.6. Impacted by and critical of others' incompatible behaviour: in a rush, distracted or unaware. Many participants were troubled specifically by cyclists and scooters that moved in ways they felt were irresponsible. Cyclists are viewed as incapable of taking wheelchair pedestrians into account, for instance, by cycling next to each other no matter the amount of space.

"Cyclists and pedestrians simply don't take you into account" (VVHb).

"So many pedestrians suddenly decide to go right or left without looking – I've had someone land on my lap, they and I had a scare. I think they learned from it. Nothing I can do about it. Unless I go very slow. It's not solvable – perhaps with separate lanes."(MVHc).

For some, scooters are even worse, due to their high speed and extra weight in combination with irresponsible behaviour.

"It is not normal that delivery bikes and scooters drive through people at breakneck speed" (MOSa).

Other road users often seem to be distracted and rushed in traffic, according to the participants. Being distracted is often paired with the use of mobile phones en route. Being rushed results in other road users breaking traffic rules when they are near the participants, sometimes almost causing accidents in doing so.

Observation: A scooter [hastily] passes by MJE on the righthand side while he crosses. [during observation].

4.3.1.7. Not wanting to be a nuisance to others. MJE, MVHc, VVHb expressed that they do not want to be a nuisance to others during travel. Due to the width of wheelchairs and mobility scooters, narrow roads mean a wheelchair pedestrian easily blocks the road for other traffic participants. Participants indicated that they prefer to prevent this, even if this means they must go for a more uncomfortable or longer option.

"I don't want to block the entire path – I think that would be asocial" (MJE).

But also, they sometimes deliberately forced their right of way.

4.3.1.8. Trying to influence others' behaviour. Some participants mentioned developing strategies to assert their rights towards others and inform them about wheelchair pedestrians' position. For example, MVHc mentioned that disabled parking spots are sometimes taken by people who don't need them, leading him to develop strategies to inform others about his position. He kept cards in his car to leave behind for cars that are parked in a disabled spot without a visible disabled parking permit. The cards ask to either show the

permit or to park somewhere else, explaining that he had to traverse a longer distance as a wheelchair pedestrian because the spot is taken.

4.3.1.9. Wanting their opinions [on infrastructure] to be heard and seen. Participants did not think wheelchair pedestrians are always considered in the design of infrastructure, which they feel is the municipality's responsibility. Some discontent was expressed about the municipality of Delft in this regard. Some participants' opinion is that the municipality prioritizes cyclists and ignores pedestrians, both in the design of infrastructure and the regulation of traffic (meaning police surveillance and penalties).

4.3.2. Theme B: Strategies to mitigate extra burdens during travel

This theme relates to strategies that the participants have built up over time in order to cope with traffic and travelling, and shows their whole journey perspective.

4.3.2.1. Vigilance and management strategies. All participants described personal strategies to ensure their safety in traffic. Most prominently mentioned were being extra vigilant in traffic, sticking to traffic rules and making sure you are clearly visible and noticeable to other road users. For instance, by adding yellow reflecting elements to their mobility aid.

To manage problems that they would often encounter during their journeys, the participants described two additional ways of managing. Firstly, checking out the route to a new or unknown destination before going, to avoid impossible routes or difficulties on the way. This is not true for all participants though. Some downplayed checking anything beforehand, stating that they will always find their way. Secondly, participants often take a detour, as we also saw in the observation. When aware of inconveniences on a certain route, participants often choose to take a detour to avoid any trouble or to be more comfortable.

4.3.2.2. Alone or together. Travelling alone or together influences the participants' willingness to take risks in traffic. Most of them prefer to travel together with another person instead of by themselves. When travelling alone, more caution is taken. Even more so when encountering a difficult situation in traffic. When encountering an unexpectedly difficult situation in traffic, participants sometimes choose to take a detour when they are by themselves. Whereas if they were travelling together, they would take the risk because they have a safety net. VOE declined an outdoor observation portion due to expected bad weather on the agreed day, which also meant she had not made arrangements with the support person who usually accompanies her.

"When I am by myself, I would not get off at a sidewalk when it has a curb that technically I could just about manage" (MJE).

4.3.2.3. Being in touch with railway and train station operators to mitigate barriers. Participants described a dependence on working elevators in train stations and on assistance getting in ('instaphulp'),[1] support by a person, for entering Intercity trains in the Netherlands provided by the NS (Dutch national railways). Without a working elevator or assistance, wheelchair pedestrians are not able to enter or leave a train station, or to board or get off an Intercity train. Only the new Sprinter trains are at ground level, enabling wheelchair pedestrians to enter and leave independently. Participants describe these ground-level trains as much nicer. Participants are in touch with the operators of relevant train routes and train stations, but consider entering or leaving a train station as difficult in general, due to badly maintained sidewalks, stairs, and (broken) elevators to enter or exit a station.

"I once got a call from the [railway operator] that one of the broken elevators on my route was working again. Unfortunately, this was no use to me, because it would only allow me to travel one-way and not back home due to the other broken elevator on the other side." (MVHc).

4.3.2.4. Negotiating about extra burdens in tram and bus. Participants describe Dutch trams as accessible for wheelchair pedestrians since they are at ground level. Most buses also have no height difference between the pavement and the bus at the bus stops, making them accessible for wheelchair pedestrians as well. However, when there is a height difference, wheelchair pedestrians depend on negotiating with the bus drivers, who are required to deploy a special ramp to assist a wheelchair pedestrian to enter the bus. Unfortunately, not all bus drivers seem to be aware of this ramp, or they may claim not to have time to use it.

"A busdriver once suggested that I could just get out of the wheelchair and carry my wheelchair into the bus together with my daughter" (VVHa).

4.3.2.5. Managing around the schedule of specialised transport (Regiotaxi). A common mode of transport for wheelchair pedestrians is the Regiotaxi service, a specialised transport service provided through social services in the Netherlands (Zorgwijzer, n.d.). The organization of the Regiotaxi service is handled per municipality. Experiences with the Regiotaxi vary: some participants have positive experiences, while others have negative experiences. The Regiotaxi service picks up multiple passengers along the route and drops them off in an order that is most convenient for the driver, making it difficult to predict exact arrival and departure times. Participants noted that this variability complicates scheduling appointments, as they often arrive earlier or later than planned. Three participants expressed a preference not to rely on the Regiotaxi, partly due to these planning challenges. The participants developed strategies to deal with this variability of the Regiotaxi. One participant, for instance, asks the Regiotaxi to drop her off further away from her

[1] See for example the video by Lot van Baaren about her experience with the NS Reisassistentie service, https://www.youtube.com/shorts/MoFnABOtC_c

destination when she notices she will be there early, so she can delay her arrival time by navigating the final bit as a wheelchair pedestrian. She does so because she finds it impolite to arrive earlier than expected, for example at a friend's party:

"If I will arrive somewhere much too early, I let the Regiotaxi drop me off a little further away from the destination, so that it is less noticeable to others that I was so early." (VVHa).

4.3.2.6. Preference for using a car over public transport. Most participants have negative feelings towards public transport due to the many negative experiences that they have had with it. Public transport is thus avoided when possible; other types of transport are preferred. As one participant stated:

"From the moment that I had a car I never used public transport again" (MOSb)

4.3.3. Theme C: Managing the extra burdens of tough conditions

This theme relates to the participants' anticipation and evaluation of many difficulties during travel, based on their earlier experiences. Some of these difficulties are due to permanent elements, such as infrastructure, whereas others are more temporary. These situations can affect their route choices and make travel more comfortable or even possible.

4.3.3.1. Slippery, wet, and dark conditions outside. In the case of snow or slipperiness, most participants do not go outside, as they do not consider it safe. For some, it is even impossible to go outside, as their wheelchair physically cannot move forward on slippery surfaces. Rain is considered uncomfortable and impractical, so nearly all participants prefer to stay inside when it rains.

When it is dark outside, some participants indicated that they cannot properly see the edges of the sidewalk and bike lane and are afraid to bump into them. Well-lit streets are preferred as they increase the feeling of safety, especially at crossings.

4.3.3.2. Buildings could be more wheelchair friendly. Participants mentioned that many buildings are not wheelchair friendly, mostly because of unsuitable entrances. Often wheelchair pedestrians cannot enter these buildings at all, for example due to stairs, leading to frustration. In some cases, stores have narrow aisle paths, making it impossible to pass through with a wheelchair due to the width.

4.3.3.3. Elevators are tight and inconvenient. Participants generally experience elevators as tight and inconvenient. VVHa was for example unable to visit an office, as she did not fit into the elevator with her stretched leg. She experiences all elevators as slow and annoying. MVHc did not fit into a regular elevator at the place he was visiting, thus he had to use the freight elevator. This made him feel unwelcome.

4.3.3.4. Parking rules vary. Participants who have their own car had many comments about parking. In most places, there are disabled parking spots and participants do not need to worry about parking in a convenient place. However, when going somewhere new, they often need to check how parking is regulated in that municipality. Parking rules differ per municipality, for example whether the parking spot is paid, or whether you need an additional permit. Participants experience this as annoying. Rules also tend to change every few years. This means the pre-checking of parking is never really finished.

"Experience has taught me that I have to figure it [parking in a new place] out beforehand. And yes, [sigh] it taught me that". (MVHc).

4.3.3.5. Curbs: discomfort, risk of getting stuck in the road, risk of falling. Sidewalks were the most-mentioned problematic physical infrastructure due to missing or insufficient curb cuts. Depending on the type of wheelchair and level of physical strength, a curb can cause them unexpectedly to get stuck en route. Those who have strong upper bodies and a manual wheelchair can do 'wheelies' [i.e. lifting the front wheels] to go up or down a curb when there is an insufficient curb cut (we observed MVHb and MVHc do so), to avoid risks of footrests hitting the road. This however creates a potential situation of insecurity and risk, for example if the curb proves too high. In the observation, MVHc did a wheelie at the desire line curb, but the different heights meant he nearly lost balance (Fig. 4).

During the observation, MOSa, using a mobility scooter, first got stuck in the road due to too high a curb (11 cm), was exposed to oncoming traffic, then with a run-up, mounted the curb. In doing so, his body was first compressed when the front wheel hit, then lifted out of his chair when the back wheel hit (Fig. 5). See also Appendix B1 for screenshots of the sequence. Although he said that this had not affected him much, he said at another point of the interview that road surfaces and bumps caused him back pain.

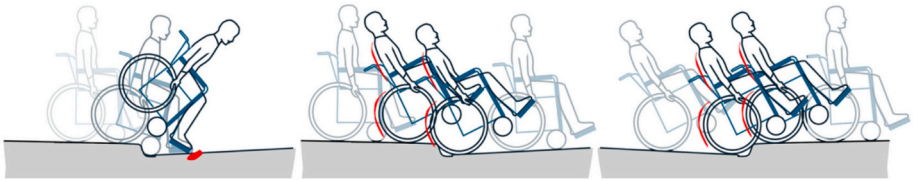

Fig. 4. MVHb and MVHc both chose the direct route and made wheelies up and down curbs. MVHc states this is based on experience with getting stuck with the footrest (left picture). Attempting a wheelie up the curb requires taking a run-up first, and then either succeeding, or losing balance and risking falling. When MVHc balanced for the wheelie, the wheelchair got caught in the rain gutter and caused imbalance and risk of falling backwards or forwards. Wheelchair illustration based on Tilley (2001).

Fig. 5. A risky moment after having entered the road: being unable to re-mount the higher curb on the other side and getting stuck on the road, exposed to oncoming traffic. After this happened to MOSa, he took a run-up and mounted the curb forcibly. This first compresses the front of the body, then presses the body into the seat, and then launches the body out of the seat and the mobility scooter's back wheels into the air. See also Appendix B1.

4.3.3.6. Road textures: discomfort and pain. Textures of roads, slanted roads and narrow paths were mentioned as inconvenient. Uneven road textures can cause inconveniences for wheelchairs, as they cause a wheelchair to vibrate or shake. Most of the time this is simply inconvenient or uncomfortable, but in some cases, it can be painful or dangerous as well due to exhaustion, for example when wheelchair pedestrians have multiple physical conditions. VVHa, MJE, MVHc, MOSa and MOSb, who all successfully navigated the entire journey including the observation crossing, all mentioned physical discomfort and pain from the surfaces during the go-along portion of the study. MJE has a sensitive spine due to injury:

"I usually have to make sure to keep my head fairly upright. Usually that works fine, but if I go fast over a bump in the pavement, that can be … well, not nice." (MJE).

4.3.3.7. Slopes: weighing uncertainty and risk. A road or ramp with a steep slope requires extra strength to tackle and brings challenges for wheelchair pedestrians. Too high an upward slope can be dangerous: if you don't balance successfully, you might fall backwards, similar to what is shown in Fig. 4. In some cases, participants take a run-up to try to ensure they make it. In other cases, participants mention being unable to see the other side of a high slope, for example a bridge,[2] and don't know for sure whether they are able to safely exit the bridge – and are thus left to take the chance, or not, of traversing it. Participants said they often chose to take a detour around a slope rather than risk it.

4.3.3.8. Road width: inconvenience, risk. Narrow roads or paths are inconvenient because wheelchairs are wider than most road users [cyclists, scooters, and pedestrians]. Participants expressed that they don't want the wheelchair to stick out on the road, as cars could hit them. They also don't want to be a nuisance to others by blocking the way, but sometimes there is no other option, leaving them to manoeuvre uncomfortably and at risk.

"On the narrow sidewalk by the tram stop, my stretched leg sticks out beyond the sidewalk and into the tram's path." (VVHa).

"When I am travelling on the narrow street next to the waterway (because the sidewalk is too narrow to even use), cars cannot pass me anymore." (MJE).

4.3.4. Theme D: Fast and unpredictable situations

This theme relates to the unpredictable situations that wheelchair pedestrians can encounter while they are travelling. They face risks arising from unpredictable (combinations of) conditions in traffic situations, such as encountering a tough traffic situation or obstacles in the road. This last theme illustrates that despite the vigiliance, assertion and management strategies that wheelchair pedestrians employ to manage the extra burdens they face in traffic, its speed and complexity still pose significant risks for them that go beyond their ability to compensate for their disadvantaged situation.

4.3.4.1. Managing different speeds. The participants mentioned the ambivalence of their appropriate place in traffic as a problem. Wheelchair pedestrians in the Netherlands have the choice between the sidewalk or the bike lane but must not drive faster than 6 km/h when on the sidewalk (SWOV, 2021). However, participants are often either slower than cyclists on the bike lane or faster than pedestrians on the sidewalk. This complicates the choice between the two: either feeling like a nuisance on the bike lane, but able to go full speed, or having to hold back speed on the sidewalk while additionally navigating often bumpy terrain, which can lead to injury and exhaustion. These extra burdens make it harder to make fast decisions when these need to be taken for safety. In shared spaces of which there are some in the centre of Delft, they mention the speed and lack of consideration of cyclists (see also 4.3.1.6.)

4.3.4.2. Clarity and rules. The participants gave many examples of traffic situations that they experienced as tough no matter how they tried to manage them. Especially situations around getting the right-of-way and taking a left turn. Participants also often mentioned crossings of the type of our observation crossing (Fig. 3). Pedestrians have the right of way there, but cars do not always give it as we

[2] Dutch pedestrian bridges are often arched, see for an example: https://maps.app.goo.gl/qMLnaTEtkyrHiss8A

Fig. 3. The observation location (same as Fig. 2, with author-drawn lines). On the left and right: bike lanes between sidewalk and street. Foreground, at the crossing path indicated by white street markings: high curb with only a small cut: curb is 8 cm at the left side and 11 cm at the right side. Direct path (desire line): yellow (in front) and dark blue line (second from front). Background: street crossing with curb cuts on the far side. To reach the bus stop on the left side of the street from the right side using real curb cuts, wheelchair pedestrians must use the bike lane and take a long way around (longer orange line). Both crossing locations have a midblock section or refuge island. Red crosses: risky situations observed during the crossings of six wheelchair pedestrians. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

also noticed during the observation. In the case of crossings with refuge islands, wheelchair pedestrians can end up getting trapped there. To reduce risk, they mostly wait until they clearly get the right of way before going (eye contact with cyclists (MVHc) or drivers (MOSb), cars slowing down). The participants stated a preference for clear rules as is the case with traffic lights. In larger crossings with left-turn (bicycle) lanes, wheelchair pedestrians can end up surrounded by other drivers and in a vulnerable position. Combining that with not being able to turn one's head to see other traffic or needing both arms to properly move or operate the wheelchair and not being able to indicate direction, makes taking a left turn scary for some participants.

"I already feel disabled enough – so I'm not going to throw myself into oncoming traffic at a pedestrian crossing (to get the right of way)" (MOSb).

"I would rather take a detour and travel towards the closest traffic light to cross (rather than pre-sort for a left turn on a bicycle path)". (MJE).

4.3.4.3. Split second choices. The way risky situations arise was illustrated at the observed traffic crossing (Fig. 3). The interviewer observed that the participants made the decisions on which path to choose very fast, sometimes within a split-second:

(Researcher: "Had you also considered to take the detour?") "Yes, for a split second. (But then) I thought, yes I can manage this. It's just the shorter route. I was looking at it carefully though … I thought, I can try to do it as safely as possible. But I thought it would work. If I'd already had three beers, I would not have done it. Then I would have estimated the risk differently. But now I did not hesitate." (MVHb).

Observation VVH: for a split-second she checks the direct route and its curbs before deciding not to trust it and choosing the detour to go there and back. If lighting conditions had happened to not shown the curbs well, she may not have been able to see the insufficient curb cuts and might have chosen a route that would have been painful and risky for her. (See Appendix B2 for screenshots of this observation).

4.3.4.4. Managing physical specifics during fast situations. Wheelchair pedestrians' lower vantage point than other road users makes them less visible to others and can also result in seeing less than others or lacking overview in traffic. For instance, when there is a planter on the roadside that is equally tall or taller than a wheelchair pedestrian. As mentioned, most participants have trouble turning their heads due to limited range of movement, making it even harder to see all traffic. During the observation, one participant manoeuvred their wheelchair left and right to look for oncoming cars at the crossing, and others also mentioned limitations in turning their head. Additionally, participants mentioned their own speed as a limiting aspect. They often react or manoeuvre slower than road users around them, or slower than they desire to be. This in turn can affect a wheelchair pedestrians' choice of route, as there are traffic elements that they want to avoid; for instance, pre-sorting to go left on a busy street.

"Not being able to react quickly because I am too slow, plays a role in my [perception of] safety" (VVHb).

4.3.4.5. Crowdedness. Crowdedness was also prominently mentioned as a factor in such situations. Participants experience crowdedness as inconvenient, unpredictable, and sometimes as unsafe, because it results in having less overview of traffic situations. The lower vantage point of wheelchairs also plays a role here. Crowdedness is not always visible: the observation crossing looks calm enough. However, based on the number of vehicles passing during the 1- and 2-min video clips we obtained, (Table 1, participants), this road can be assumed to have around 3000 vehicles Average Daily Traffic, and fast or crowded situations can occur unexpectedly.

4.3.4.6. Unexpected obstacles. Obstacles that are normally not there or not supposed to be there, often come as a surprise to the participants. These obstacles can block their way, meaning they either must go around the object, take a detour, or go back where they came from and choose an entirely new route. This may mean travelling back up an entire street if it is blocked at the end, for example due to works on the sidewalk. It may also mean they get stuck entirely and cannot proceed, or that they must enter the road to manoeuvre around obstacles, which we observed several times. Participants indicated that the most obstacles blocking their way occur on the sidewalk. Some examples of obstacles that were mentioned are: (road safety) poles, parked bicycles, sharing scooters, planters, trashcans, and vegetation. In the case of planters and vegetation, participants also said that those obstacles can unexpectedly block their vision and hence make it harder to assess whether crossing a road is safe.

"I am unable to exit a sidewalk just like that (due to curbs), so when a sidewalk is blocked, I have to go back to where I entered the sidewalk to take another path". (VOE).

"I've sometimes had piled-on series of small bad luck situations… so I'll cut my losses and go back a whole way." (MVHa).

"I got halfway down that road, then I had to turn back." (MOSa).

5. Discussion

Our research initially set out to investigate wheelchair pedestrians' experiences and perceived safety. The results added insights into their assertion of normality and participation, the strategies they employ towards their whole journey aims, and the speed at which situations can unfold.

The study makes four contributions: one methodological contribution and three substantive contributions.

- Firstly, it advances a behaviour- and justice-oriented methodology for studying wheelchair mobility in situ. Employing an inclusive design and justice perspective, this behaviour orientation is interpreted in terms of wheelchair pedestrians' preferences, experiences and meanings of citizenship in connection with moment-to-moment perceptions, actions and adaptations in traffic environments – an area with limited empirical coverage.
- Secondly, it provides rich behavioural and elicited evidence on wheelchair pedestrians' experience and navigation of traffic situations: asserting participation, normality and relating to others.
- Thirdly, it presents evidence of wheelchair pedestrians' whole journey perspective, and their extra efforts and strategies to mitigate extra burdens during their journeys.
- Lastly, it highlights conditions that strain and exceed wheelchair pedestrians' abilities to compensate, and links these to systemic shortcomings in transport and urban design.

5.1. An inclusive design and justice approach to researching wheelchair pedestrians' experiences

Our inclusive design and justice research approach allowed us to refine themes already known in the literature and add new interpretive depth. By combining sensitizing, interviews, and go-along with in-situ video observations, the research captured both the experiential and behavioural dimensions of wheelchair travel as they unfold moment-to-moment. Our research approach created a bridge between the sometimes very fast and contextual experiences while travelling (go-along and observation, (cf. Wang et al., 2024)) and participants' ownership and interpretation of these experiences, which we elicited via sensitizing and interviewing. Our approach included a sensitizing activity not commonly used in transportation research (Sleeswijk Visser et al., 2005), in that it facilitates participants in accessing and exploring aspects of their personal contextual experiences in their own time and environment. This sets them up to enter the research as 'reflective practitioners' (Schön, 2017) of their own experience (cf. Sleeswijk Visser et al., 2005) and prioritizes their own embodied experiences.

The inclusive design aspect of our approach focuses on specific design elements and pinpoints where wheelchair pedestrians can or can no longer participate in the provisions for travelling in public space. An example is the design of unsignalized crossings. They were difficult for many wheelchair pedestrians. Our approach revealed the specific risks for them such as obstacles resulting in uncontrolled situations and the stress that arises from these, and the sequence of how dangerous situations can arise (e.g., split-second decisions and being propelled from too high a curb cut into the street). Our approach also revealed their suggestions for improvement, such as more space to accommodate longer reaction times.

The justice aspect of our approach elicits and prioritizes the meanings that wheelchair pedestrians connect with their travel as a social context, as well as their strategies and ways of managing and carrying extra burdens. Relevant meanings identified in this research are, for example, assertion of participation, normality, independence, and perceived and actual safety (cf. Heylighen & Bianchin, 2018). By eliciting these meanings, our approach adds wheelchair pedestrians' voice to the behavioural emphasis that is more prevalent in the literature (e.g. Pecchini & Giuliani, 2015; Prescott et al., 2021) and also aligns with studies focused on equity

from whole journey perspectives (such as Velho, 2019, Larrington-Spencer, 2025; Verlinghieri et al., 2022; Osman & Porkertová, 2023; Pecchini & Giuliani, 2015; Park & Chowdhury, 2022).

The documentation of our approach (section 3.2 and the appendices) offers starting points for replication and iteration in studying vulnerable road users and their experiences in close alignment with the streetscape level of infrastructure.

5.2. Evidence of asserting participation in travel and relating to others

Our findings provide rich evidence from elicitation and observation on how wheelchair pedestrians assert participation and claim normality in travelling and relating to others (Theme A). We highlighted wheelchair pedestrians' management of interactions with other road users, in which they prefer not to be conspicuous or a burden to others. They deliberately put confident and positive behaviour forward to command respect and maintain the meanings of normality and independence. This contrasts somewhat with previous findings that depict wheelchair pedestrians as mostly fearful (Rasoulivalajoozi et al., 2025; Flynn et al., 2023). However, the participants' wish to be independent and participate normally in life and travel aligns with meanings of identity and citizenship found in (auto-)ethnographic reports such as Musselwhite and Haddad (2010), Labbé et al. (2020), Verlinghieri et al. (2022), Velho (2019), Gaete-Reyes (2015) Larrington-Spencer (2025), and Osman & Porkertová, 2023). They depict mobility as a core aspect of wheelchair pedestrians' lives, tied to their past and present identities and their feelings about equity of access and social inclusion. An example of this meaning of identity is being able to select a preferred route, or desire line (cf. Larrington-Spencer, 2025), as we showed at the observation crossing, especially if that choice is easily available to others. The participants described that as ‘normal’ travel, in contrast to experiences such as those with the Regiotaxi, which they experienced as singling them out and cumbersome, or those with sidewalks that were blocked or under construction, causing them to have to back up and take sometimes long detours. Our study shows that wheelchair pedestrians develop behavioural strategies to influence others' behaviour in a positive way, such as projecting confidence, paying extra attention and sticking to traffic rules (or sometimes defiantly not). This management of others to support their adjustment to ‘normal’ has been described previously (e.g. Hartblay, 2020). The participants wanted urban planners to see and hear their extra efforts more.

5.3. Evidence of strategies to mitigate extra burdens during travel

Our results add insight into wheelchair pedestrians' extra efforts and strategies to mitigate extra burdens (Theme B): being extra prepared (or defiantly not), courageous, cautious (cf. Asha et al., 2021; Pecchini & Giuliani, 2015), virtuous, and resilient. These findings largely align with existing literature on whole journey perspectives: wheelchair pedestrians' efforts and challenges during their journeys and the need of assurance of arriving (e.g. Velho, 2019; Larrington-Spencer, 2025; Verlinghieri et al., 2022; Osman & Porkertová, 2023; Pecchini & Giuliani, 2015; Park & Chowdhury, 2022). To manage uncertainties like the risk of getting stuck (e.g., due to broken elevators) or the complexity of using specialised transport (Regiotaxi) (Parent, 2018), we saw wheelchair pedestrians employ strategies such as planning and communicating ahead, travelling with others to feel safer, avoiding public transport, taking detours, adapting the planning of their day, or switching to their own car (cf. Verlinghieri et al., 2022; Lawson et al., 2022, Harris et al., 2015). We also saw how general provisions like ground level train doors reduce this extra burden considerably.

Most wheelchair pedestrians reported weighing the decision whether to travel every time, particularly when travelling to a new destination, as has been reported previously (e.g. Harris et al., 2015; Park & Chowdhury, 2022; Verlinghieri et al., 2022; Flynn et al., 2023; Rasoulivalajoozi et al., 2025). When travelling on the road, they made sure to be clearly visible, considering that they are physically lower while sometimes travelling faster than expected. They acquired a great deal of expertise to achieve their integrative aim to arrive. Our results direct attention to the extra effort they put into strategies to manage their whole journeys, and the decision processes that go into each step of their journeys. Our findings align with Park and Chowdhury's (2022) recommendation to consider the whole journey chain, supporting its preparation but also everything that happens while en route.

5.4. Evidence of extra burdens that strain and exceed wheelchair pedestrians' abilities, linked to systemic shortcomings in transport and urban design

Our research adds evidence of how, despite the plans and strategies that wheelchair pedestrians have developed, they still face multilayered, increased risks. Our findings show how tough conditions (Theme C) create burdens for wheelchair pedestrians and sometimes strain and exceed their capabilities to manage and mitigate them. Known issues we also found included streetscape elements like (insufficient) curb cuts, path widths, detours from the desire line, surface textures, and slopes, contested or unpredictable parking rules, conditions like the weather and the dark, and built environment elements like unsuitable building entrances and inaccessible elevators (Venkataram, 2023; Harris et al., 2015; Verlinghieri et al., 2022; Park & Chowdhury, 2022; Shoman & Imine, 2023; Ross et al., 2024; Larrington-Spencer, 2025; Hammond & Musselwhite, 2013; Venkataram, 2023; Sun & Lau, 2021; Sharifi et al., 2015; Rasoulivalajoozi et al., 2025; Osman & Porkertová, 2023; Müller et al., 2024; Prescott et al., 2021; Gaete-Reyes, 2015; Peden et al., 2004). Five of our eleven participants declined to participate in the observation (two only in a reduced, modified way), even though all were recruited while participating independently in public life. This seems to align with earlier research that disability leads to less participation (e.g., Prescott et al., 2021).

Navigating with vulnerabilities like a straightened leg or instability of the spine poses even more demands to avoid losing sight, balance, and control of situations due to differences in balance or increased sensitivity. Such issues also limit the wheelchair pedestrians' capabilities of mitigating blocked paths with detours due to increased pain from physical conditions and uneven road surfaces

(cf. Gaete-Reyes, 2015).

When travel speed and fast and unpredictable situations are added to these conditions (Theme D), the burdens are exacerbated. While our participants said and showed that they pay extra attention while navigating and stick to traffic rules to stay safe, traffic situations or elements can still be surprising and sometimes exceed their capabilities to manage them, including in shared spaces. Wheelchair pedestrians are hampered from overseeing situations due to their low vantage point, and are faced with added challenges due to split-second changes in traffic (such as cyclists or cars suddenly appearing or changing direction), unclear rules, objects unexpectedly coming up on the path, prompting them to choose paths that put them in the way of traffic. Encountering such obstacles has been similarly described in the literature (Venkataram, 2023; Lawson et al., 2022; Verlinghieri et al., 2022; Hammond & Musselwhite, 2013; Shoman & Imine, 2023; Pecchini & Giuliani, 2015; Larrington-Spencer, 2025; Ross et al., 2024). Sometimes reduced physical ability such as not being able to turn the head reduces sightlines or requires extra manoeuvring to achieve overview. Our research highlights how sight lines can vary dynamically in fast interactions that happen at road crossings.

Our findings add evidence to the situated nature of wheelchair pedestrians' travel, including decisions to take detours or the desire line as illustrated in the observed case (Fig. 3). The participants' attempts to maintain independence and safety repeatedly conflict with infrastructure and operational practices that implicitly prioritise other road users. The mechanisms we documented – such as the occurrence of forced (potential) encounters with traffic in the road (cf. Gaete-Reyes, 2015), exclusion from desire lines (cf. Larrington-Spencer, 2025), and high-speed encounters and decision-making, provide actionable evidence for urban planners and accessibility regulators enquiring into more inclusive mobility environments. For example, while desire lines have been described as conceptually trivial (Wozniak et al., 2025), they become an equity issue in connection with travel of people with disabilities. This is particularly salient when considering the extra, often fatiguing physical effort wheelchair pedestrians invest in taking detours, while also often experiencing greater physical fragility than pedestrians in general.

5.5. Implications and future work for research, policy, and practice

5.5.1. Management of infrastructure

Our research confirmed relevant streetscape aspects found in the literature that affect wheelchair pedestrians during their journeys, such as uneven road surfaces, bins, parked micro-mobility devices or cars, roadworks on sidewalks or insufficient curb cuts, temporary conditions such as the dark or bad weather, other road users, infrastructure and accessing buildings.

Our research frames these as aspects adding extra burdens to wheelchair pedestrians' own efforts to assert participation and manage normality, and outside of their control to modify. We have shown how these aspects cause prolonged trips and significant detours, and in turn fatigue, potential for physical injury, and risk of exposure to traffic. Even small unevenness, when experienced over longer stretches, can cause pain and fatigue.

5.5.2. Questioning the 'normal' in travel time and space

Our findings have highlighted how traffic situations can exceed the perceptual and physical capabilities of wheelchair pedestrians. Even with extra vigilance, caution and preparation, wheelchair pedestrians cannot compensate for unexpected risk situations, for the potential consequences of a split-second desire line choice and for the rapid and unpredictable behaviour of drivers and cyclists. As a result, their compensations are not sufficient to achieve the 'normal' that they seek. Pecchini and Giuliani (2015) note that technical approaches on specific streetscape elements alone cannot redress oppressive conditions.

Prioritising those who are 'worst off' would mean prioritising the wheelchair pedestrians' desire line. For the observation crossing we studied, this could mean, for example, questioning its status as a through road and instead lowering vehicle speed and aligning it with 'crip time' (Mery Karlsson & Rydström, 2023). The time that wheelchair pedestrians need in that context is then the starting point for design, challenging the binary notions of 'normal' or 'not normal', 'disabled' or 'able' (Mery Karlsson & Rydström, 2023). Since their mobility-assisted bodies' shapes and dimensions extend beyond the space available for pedestrians, while having reduced sight lines, this also means reconsidering the allocation of space (Osman & Porkertová, 2023).

A possible practical translation of this could be to view the space not just as functional, where those most capable of speed travel as fast as possible, but as an opportunity to diversify the meaning of 'normality'. Planners and municipalities could for example embrace notions of slow mobility (Pink et al., 2025), making travel slower for some and prioritising the desires of those currently most disadvantaged. This could include making it faster for them and designing for their desire lines. The North American National Association of City Transportation Officials' (NACTO, 2013/2025) guideline on Midblock Crossings gives an example directly applicable to these ideas: a midblock crosswalk positioned at a desire line, with a pedestrian peninsula as a pinchpoint to create a buffer between cars and pedestrians. Combined with a car stop line some distance from the crosswalk, this creates more time and space for wheelchair pedestrians to oversee a developing traffic situation, and signals to cars to slow down through vertical elements (such as trees). For wheelchair pedestrians, this creates predictability, resting places and safety from getting stuck and more safe space to take the time to oversee the situation.

From this perspective of challenging the 'normal', the wheelchair pedestrians' almost unanimous insistence on 'normal' travel can be interpreted not as a desire to be like others, but as a desire to be able to enact their citizenship fully, as anyone else could. Not being able to follow a desire line is a challenge to the 'normal' that is available to others – in this view, it hampers embodied citizenship (cf. Gaete-Reyes, 2015). It indicates insufficient equity compared to those who are able to do so. The design of public space is a civic task rather than a technical task. Supporting wheelchair pedestrians' assertion of their wish to participate requires whole-journey support. They currently invest substantial extra efforts to realise normality of participation.

5.5.3. Planning for a whole journey perspective and participation

Addressing the design of public space as a civic task supports the UNCRPD's directive for participation. Addressing the conditions affecting wheelchair pedestrians affects not just their mobility but their life, education, employment, and risk of poverty (e.g. Osman & Porkertová, 2023). There is a need for better planning, support of detection, reporting and repair to support whole journey perspectives of wheelchair pedestrians. This applies to streetscape elements as well as public transport provisions in ensuring reliable operation of infrastructure such as elevators. Reindl et al. (2022) point out the salience of the challenge in the Netherlands, where policies of the past decades largely removed people with disabilities from public space. It is an enforcement issue (Houtzager & De Vos, 2025) but also a design issue and a perspective issue (Guerra-Santin et al., 2024; Pink et al., 2025; NEN-EN 17210, 2021; NEN 9120, 2025 (based on UNCRPD)).

Applying a justice perspective and viewing the public space within which people travel as a social context implies that the needs of the different stakeholders would need to be considered together. Policy and road and transport design could seek to emphasise support and diversity by focusing both on specific groups and on their position in an overall social context. Tackling this complexity requires a systems design approach, which has long been recognised as a necessity for travel planning (Peden et al., 2004; Wegman et al., 2022). Systems-level approaches should connect both integration and innovation (Veeneman et al., 2020) within transport systems. In these, the needs and preferences of those currently 'worst off' (Heylighen & Bianchin, 2018) – wheelchair pedestrians and others with functional impairments of any kind - would be prioritised within the overall system rather than seen as an exception or add-on. The approaches could be reflective of the complexity and change that this entails (Van der Bijl-Brouwer & Malcolm, 2020). Initial design and systems-oriented example projects of this kind exist (Van Hoven et al., 2024; Wijayaratna & da Rocha, 2025), although their broader effectiveness has not yet been assessed.

5.5.4. Participatory processes

In the Netherlands, Local Inclusion Agendas have been introduced (Houtzager & De Vos, 2025) in response to the introduction of the UNCRPD. They mandate the formation of local lived experience panels in municipalities, in alignment with NEN-EN 17210 (2021, section 4.5) / NEN 9120 (2025, section 1), which, on the advice of disability advocates, recommend involving stakeholder representatives continuously. However, how these panels can function best in relation to urban planning processes is still being explored.

We suggest that participatory processes can be utilised to address this. Our research was deliberately positioned ahead of any specific planning process, so that it could identify needs for such processes freely. Wheelchair pedestrians and representatives of disability organizations should be able to demonstrate and contribute the types of experiences we have identified to other stakeholders during all phases of planning processes, rather than running the risk of getting disregarded in requirements documents. The benefits of such stakeholder direct exposure have long been demonstrated and continue to be developed further (e.g., Kowaltowski et al., 2024). New technologies such as apps can support consulting wheelchair pedestrians in planning and research projects. Examples of recent efforts are Van Hoven et al. (2024); Wilson et al. (2024); Ypenga et al. (2023). Our participants preferred not to show their struggles in daily life, instead projecting independence and confidence. This means that without dedicated efforts, problems likely remain underreported because wheelchair pedestrians seek to compensate for them themselves. Therefore, more effort should be made to elicit wheelchair pedestrians' and reflections on their travel experiences and their travel-related wishes, expertise, and strategies, as well as those of others who are currently disadvantaged.

Such efforts may also require establishing new connecting roles between stakeholders in traffic planning. The close connection between citizenship, experiences and streetscape elements that we have demonstrated is a challenge for the translation of insights into technical interventions, potentially requiring the development of new roles (e.g. Groeneveld et al., 2013, from the field of health research).

A key civic issue is also to address the conflicting requirements that can arise from different functional impairments. An oft-cited example is blind pedestrians' needs for tactile street markings and clear separation from car traffic, conflicting with wheelchair pedestrians' needs for smooth surfaces and full curb cuts (cf. Imrie, 2000). Negotiation and compromise is inevitable in new stakeholder processes.

5.5.5. Simulations could reduce research burdens for wheelchair pedestrians

Our results have some implications for new design and research approaches to streetscape elements. We showed the importance of flagging up micro-scale elements such as uneven road surfaces, risks of (uncontrolled) changes in speed and physical vulnerabilities such as having to keep the head straight to avoid injury or having a stretched leg in wheelchair pedestrians' travel experience and safety. Despite our efforts to accommodate participants, we observed pain, small panic and risk moments, fatigue and more during relatively short trips. Simulation-based studies offer a promising avenue in this regard, as they could reduce the burden and risks on participants and allow rapid iterations and testing of design solutions (cf. Asha et al., 2021). Early Virtual Reality studies in this direction are being conducted, for example simulating uneven road surfaces Lindner and Bogenberger (2023) and the embodied dynamics during travel (Feng et al., 2021) but further development is needed. Future work could address aspects such as balance difference (e.g., unevenness due to a stretched leg), road surface inclines and changes in them, wanted or unwanted changes in speed and desire lines that affect the likelihood of acceptance of detours. Continuous direct input and participation from road traffic participants with disabilities should always remain a crucial part of these processes to mitigate biases and translation errors that can occur through automation, and to ensure that complexity is not reduced at the expense of equity.

5.6. Limitations

5.6.1. Participant pool

Some limitations in the transferability of our findings might arise from our participant pool, in that it focused on wheelchair pedestrians who navigate independently in traffic situations in public. This was due to our recruitment method, partly due to necessity. This and our small sample size have both been flagged by Park and Chowdhury (2022) and Schweiger and Sharifi (2025) as common limitations in this field. Our research aligns with these authors, and the new NEN 9120, to call for a more direct integration of studies like these in road and transport design projects. However, Asha et al. (2021) and Larrington-Spencer (2025) argue that even single-participant experiences are real and relevant, and our six observations showed relevant issues that have also been found in the literature, as well as issues that have received less attention so far, such as the specific role of desire lines. One point to note is that own behaviour 'mistakes' such as distraction featured less in our findings than in the literature on pedestrians generally (Beitel et al., 2018; Gkekas et al., 2020; Loukaitou-Sideris et al., 2014; Papadimitriou et al., 2013). Our participants mostly stated being extra vigilant while out. This finding might apply to wheelchair pedestrians' navigation in traffic generally, but it might also be influenced by the observational situation being an exceptional rather than routine moment for them, leading to heightened alertness. Distraction due to fatigue is likely an issue for wheelchair pedestrians too.

5.6.2. Data capture

Even though the study had been piloted and we obtained useful audio data from all participants, there were several data failures, and not all crossings were video recorded (although they, and the go-alongs, were all audio recorded). Video footage from eye-tracking glasses was obtained from only one participant. It reveals where they are looking and is informative in combination with an audio-captured explanation from the participant. Chest-worn video devices are not advised since their direction of capture may result in lost data. In one case where we tried it, the footage showed mostly the sky. A video operator should additionally capture a traffic situation from a distance, to reveal the relationship between different traffic participants and capture dynamic situations. We obtained valuable footage from two participants this way. Screenshots from this footage are shown in Appendix B.

6. Conclusions

This study examined the experiences of wheelchair pedestrians in traffic situations through qualitative empathic design research focused on road crossings. Our findings show how wheelchair pedestrians actively assert their participation in mobility in public environments and claim the meaning of normality, consistent with earlier findings. We confirm that wheelchair pedestrians expend extra efforts to claim that meaning and to be independent and safe. Their assertion of participation suggests future research on both a detail level and on a systems-perspective level that addresses how travel contributes (or detracts from) embodied citizenship, and that emphasizes diversity and support more generally.

By applying an inclusive design and justice approach, we highlighted the value of focusing on those 'worst-off' to investigate the conditions for equity and support embodied citizenship that move beyond binary notions of ability. For the Dutch context, our study confirmed previously reported travel experiences such as planning ahead, being extra vigilant, and applying coping strategies such as taking a longer route when facing obstacles, and avoiding crowded situations.

Wheelchair pedestrians expressed a strong preference for clarity in traffic situations, including good visibility from a low vantage point, other traffic users adhering to traffic rules, and clear rules on who can use which path. Our study adds new insights that could improve road and transport design (processes). These include considering specific risks such as difficulties in controlling speed (too slow/too fast) when navigating obstacles, sightlines, difficulties aligning their dimensions with those of their surroundings (e.g., because of an extended leg), and the compensation that wheelchair pedestrians themselves do up to the point where this fails. Addressing these issues calls for new requirements and solutions to be designed and evaluated through real-world participatory systemic desgn and evaluation processes in road and transport design, to advance equity and safety in transport systems.

CRediT authorship contribution statement

Stella Boess: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Suzanne Hiemstra-van Mastrigt:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Noortje Kwakernaak:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Conceptualization, Methodology. **Yan Feng:** Writing – review & editing, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of generative ai and ai-assisted technologies in the writing process

Statement: During the preparation of this work the author(s) used AI Whisper to transcribe data. Additionally, the author(s) used ChatGPT to organise some of the points in the discussion for better readability. After using these tools/services, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

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

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2026.103562.

Data availability

Data will be made available on request.

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