Walking as an approach to the socially-ecological transformation of inclusive urban mobility systems: An explorative case study involving disabled people in Berlin

Horn, Julian

WZB

Berlin Social Science Center

Julian Horn

Walking as an Approach to the Socially-Ecological Transformation of Inclusive Urban Mobility Systems

An Explorative Case Study Involving Disabled People in Berlin

Discussion Paper

SP III 2024–602

June 2024

Research Area
Digitalization and Societal Transformation

Research Professorship & Project
Digital Mobility and Social Differentiation

WZB Berlin Social Science Center
Reichpietschufer 50
10785 Berlin
Germany
www.wzb.eu

Julian Horn

Walking as an Approach to the Socially-Ecological Transformation of Inclusive Urban Mobility Systems

Discussion Paper SP III 2024-602

Wissenschaftszentrum Berlin für Sozialforschung (2024)

This study was carried out with the support of the DLR Institute of Transport Research as part of the EXPERI project.

Abstract

Walking as an Approach to the Socially-Ecological Transformation of Inclusive Urban Mobility Systems

by Julian Horn

The worsening climate crisis calls for restructuring mobility systems and urban infrastructure. One goal of the socio-ecological transformation in the mobility sector is to promote walking. Measurements of pedestrian friendliness are summarised under the term walkability or walkability index, but they mostly lack the perspectives of people with disabilities. To address this gap, five mobile interviews with disabled people in Berlin were conducted to identify specific barriers, perceived safety risks, and well-being, which have remained unconsidered in recent measurements. Curb ramps, ground conditions, tacticle walking surface indicators, parking cars, other road users, and noise were the most important factors that should be integrated into further concepts of walkability indices. The study also shows how disabled people are discriminated against by urban infrastructure and how this affects their mobility and well-being.

Keywords: Walkability, Walkability Indices, Inclusion, Mobility of disabled people, Barriers, Urban Infrastructure

Acknowledgement

Special thanks to all interview participants: Katrin Müller, Miss Eckert, Mr Bolle, Mr Kubis, and Tascha Bendzuk. Some of the interviewees are members of the association 'Barrierescouts' [Barrier scouts]. They are part of the association 'Sozialhelden' [Social Heroes] and have been doing valuable work to break down barriers and fight ableism for many years.

Self–Reflection of the Author

I, the author of this study, am a white, able–bodied man with German citizenship who benefits from many privileges when I move unrestrictedly through the urban space of Berlin. Keeping this in mind and reflecting on how this background might influence the interpretation of the results is, in my view, a challenging but indispensable task of social science. The motivation for the topic arose from professional connections to mobility research and interest in breaking down barriers and combating ableism.

Table of Contents

1 Introduction

1.1 Relevance of the Topic

The worsening climate crisis requires profound, timely, and systemic changes that reach deep into specific areas of life and social infrastructure. In its latest report, the Intergovernmental Panel on Climate Change (IPCC) placed a special focus on system transitions to mitigate climate change (Shukla et al. 2022). The IPCC identifies urban and rural infrastructure and mobility as particularly relevant areas for system transition (Shukla et al. 2022). Urban transport accounts for one-quarter of all the transport emissions in Europe. Almost all of them are attributed to road transport, of which 58% are due to passenger transport (Moradi und Vagnoni 2018, S. 232). This confirms the urgent need for action in this area.

As a partial response to these challenges and to force the urgent need for socio-ecological transformation in urban infrastructure and mobility systems, active mobility such as cycling and walking is increasingly becoming the focus of science, politics, and civil society (Pozoukidou und Angelidou 2022). Encouraging walking brings several benefits to urban environments. It conserves resources, reduces emissions, and results in lower noise levels (Guzman et al. 2022, S. 1). Developing pedestrian-friendly infrastructure leads to increased pedestrian traffic, and promotes economic, recreational, and cultural activities (Guzman et al. 2022, S. 1). When developing strategies to increase pedestrian friendliness and a more inclusive design of mobility systems, cities are guided by scientific findings from current mobility research. For example, it has been repeatedly proven that the built environment is one of the strongest factors that influence pedestrian friendliness in cities (Guzman et al. 2020; Koo et al. 2022).

1.2 Research Gap and Structure of the Study

One tool to measure and support pedestrian friendliness in cities is the measurement of walkability or the walkability index. It measures pedestrian friendliness on the basis of various influencing variables. These can include pavement conditions, lighting, greening, and many other factors (Maghelal und Capp 2011, S. 6). Despite the vast number of studies and various forms of the walkability index, there is very little to no differentiation of the different personality structures of individuals in the rubric of walkability. The existing literature reveals a research gap examining the perspective of people with disabilities in relation to the walkability or walkability index. This research gap was recently addressed by Shields et al. (2023). The authors examined more than

25 key studies on the walkability index and criticised that most studies do not strongly differentiate pedestrians by gender, age, or ability.
In Germany, 10% of the total population live with a disability. The reasons for the lack of focus on the perspectives of disabled people and the identified research gap, even with such a high number of affected people, cannot be discussed in this study. Nevertheless, low-barrier and inclusive urban infrastructure would also help other groups of people, for example, people with children's scales or children.
This study aims to investigate the extent to which the perspectives of people with disabilities are considered in the evaluation of walkability in cities. As the walkability index serves as a benchmark for the promotion of active mobility, it is important to consider these perspectives for the socio-ecological transformation towards an inclusive mobility system.
This leads to the following main research question, differentiated into three sub research questions:

> **Q1:** To what extent are the perspectives of people with disabilities considered in existing concepts of walkability indices to promote an inclusive socio-ecological transformation of emission-reduced mobility systems?
> **Q1.1**: What barriers and perceived safety risks are people with disabilities exposed to when travelling in public spaces by wheelchair or on foot?
> **Q1.2:** How do these factors influence their well-being when moving through urban infrastructure?
> **Q1.3:** To what extent are barriers, perceived safety risks, and well-being considered in recent assessments of pedestrian friendliness based on the walkability index?

To achieve the aim of this study and answer the research questions, mobile interviews were conducted with five disabled people in Berlin. Various routes in everyday life are travelled and accompanied. The results were interpreted using qualitative content analysis and visualised using maps.
The study is structured as follows. The second chapter provides the theoretical framework around walkability and different walkability indices and summarises the current state of walkability research with disabled people.
The third chapter introduces the mobile interview method and discusses it against the background of existing literature. The fourth chapter presents the results of the interviews and illustrates the routes using maps.
The fifth chapter interprets the results and discusses them in the context of existing literature. The discussion of the main findings (5.1) is followed by section 5.2, making suggestions for an inclusive walkability index to science. The last chapter presents political guidance (6.1.1), further scientific recommendations (6.1.2) and concludes by summarising the main findings of the study (6.2).

2 Theoretical Framework and State of Research

2.1 Walking as a Part of Active Mobility

More than one-third of adults worldwide suffer from insufficient physical activity. This is directly related to the increasing mortality rates of cardiovascular disease, cancer, diabetes, and other physical impairments (Hallal et al. 2012). Walking is one of the healthiest activities for the population and could counteract these problems. (Guzman et al. 2022, S. 1).
Simultaneously, the growing climate crisis is forcing the mobility sector to shift away from fuel-based transport towards sustainable active mobility, such as cycling or walking (Moradi and Vagnoni 2018: 232; Shukla et al. 2022). In addition, cities are under high pressure to not further promote land reclamation or strive for it (NABU [Nature Conservation Union] 2022). In Berlin, 58% of urban street spaces are dedicated to parking or driving cars, but only 17% of all trips are made by cars (Creutzig et al. 2020, S. 716). Automobiles are one of the least space-efficient modes of transport (Creutzig et al. 2020, S. 716).

The promotion of walking is a promising strategy to tackle the increasing problems of motorised transport that cause air pollution, CO2 emissions, noise, and spatial injustice (López-Lambas et al. 2021: 2). Strategies to facilitate walking in an urban environment also have a positive impact on equal opportunities, as walking is accessible and affordable for all, regardless of age, availability of a car, or social status (López-Lambas et al. 2021, S. 2).
Improving the built environment and pedestrian infrastructure increases pedestrian traffic and multiplies economic[1] (Volker und Handy 2021), cultural and leisure activities (Guzman et al. 2022, S. 1). Developing walkable and barrier-free streets encourages walking trips, which is crucial for improving urban liveability and society's welfare (Guzman et al. 2022, S. 1). Studies have shown that the built environment is a determining factor for encouraging or deterring walking (Guzman et al. 2020; Larrañaga et al. 2016; Koo et al. 2022).

What is considered pedestrian-friendly and which influencing factors play a fundamental role are currently the subject of a large amount of research worldwide, especially in the Global North. The next section of this chapter is dedicated to theories on walkability and the walkability index.

1 This aspect could offer conflicts in consumption-centred and partially in exuberance living Western societies but cannot be discussed further at this point.

2.2 Measuring Walkability and Walkability Index

2.2.1 Measuring Walkability on Different Levels

In recent research, two different concepts of walkability indices have emerged: microscale and macroscale approaches. Microscale approaches prioritise micro-level physical features with a narrow spatial scope in the operationalisation of walkability (Shields et al. 2023: 24). These approaches evaluate the walkability of a street or a specific area.
These studies reflect an interest in the creation of specific neighbourhoods or streets that promote and increase walking and foot traffic in two ways. On the one hand, by enhancing the environment on a human scale and on the other hand by enticing people to walk further than they originally planned (Shields et al. 2023, S. 24). These approaches aim to assist urban planners and policymakers in improving certain specific urban districts by redistributing, reconstructing, or rearranging facades, entrances, parking arrangements, street furniture, such as benches, or crosswalks with curbs (Shields et al. 2023, S. 24).
Macroscale (or mesoscale) approaches generally use a high level of aggregation and focus more on the objective characteristics of the built environment (Guzman et al. 2022: 2). Ewing und Cervero (2010) summarised five urban built environment characteristics (the 5 D's), which are crucial for assessing the walkability of an area:

(1) **Diversity** describes land-use heterogeneity. A higher land use mix encourages more walking trips (Guzman et al. 2020, S. 6).

(2) **Design** refers to road connectivity through intersection density. Frank et al. (2007) found a positive correlation between the number of intersections in a specific area and number of walking trips.

(3) **Density** refers to the number of commercial places or population in a specific area which is positively correlated with higher pedestrian activity (Adams et al. 2014; Larrañaga et al. 2016).

(4) **Distance** to public transport measures the distance to the closest public transport station and

(5) **Destination Accessibility** refers to the accessibility of different 'everyday stations', such as shopping facilities, educational institutions, and places to spend time, such as parks.

Both approaches are useful and important for measuring walkability. The weakness of the macroscale approach is the assumption that built environment factors are homogeneous within units of analysis. Differences in sidewalk quality, pedestrian barriers, security, and the perception of these attributes were not captured (Guzman et al. 2022: 2). Sarmiento et al. (2021) showed that built environment factors and sidewalk quality can differ within units of analysis, even block by block. In the urban centres of countries in the Global South, the condition of pedestrian infrastructure sometimes acts as a barrier to walking (Larranaga et al. 2019), and other aspects such as safety and security can influence the number of walking trips (Arellana et al. 2020).

As the focus of this study is on exploring the variables mentioned above from the perspective of people with disabilities, the next section goes into more detail regarding the microscale approach.

2.2.2 Key Figures of Microscale Walkability Indices

A comprehensive study by Maghelal und Capp (2011) in which 25 different indices were examined, revealed 85 different factors influencing walkability. These are assigned to specific categories such as 'Distance', 'Sidewalk' (connectivity, width, etc.), 'Roads', 'Intersections', 'Pedestrian Support Facilities' (i. e. sidewalk buffer), 'Quality of Safety' (traffic security, personal security) and a few others. Many of the indicators used in the current walkability indices can also be found in Maghelal and Capp's list.

Moura et al. (2017) developed an alternative framework for measuring walkability. It focuses more on the individual perception of pedestrian friendliness and is based on five factors: pedestrian infrastructure must be 'Convivial', 'Comfortable', 'Connected', 'Convenient', and 'Conspicuous'.
Shields et al. (2023, S. 33) conducted a comprehensive literature review of different walkability indices and commented that the study by Moura et al. added significant value to the evaluation of pedestrian friendliness. Shields et al. distinguished between different types of pedestrian groups. The needs of adults, children, seniors, and people with disabilities vary greatly, and have a decisive influence on the evaluation of walkability.

Current studies try to take these aspects into account and focus more on the diversity of people using pavements. Carvalho und Freeman (2018) developed a walkability index based on previous indices, which considers the individual needs and experiences of pedestrians. The authors developed a set of 27 indicators listed in table below.

Table 1: Different Walkability Variables; Source: Carvalho and Freeman 2018

Categories	**Indicators**
Accessibility	Sidewalk Width, Sidewalk Condition and Tactile Pavement, Topography, Unevenness of Sidewalks, Visual Attractiveness
Attractiveness	Visual Permeability, Afforestation, Cleanliness, Pollution
Connectivity	Block Size, Access to Public Transportation, Bicycle Infrastructure
Comfort	Seating, Protection from Weather, Rain Infrastructure
Public Security	Pedestrian Flow, Lighting
Road Safety	Conflict between Pedestrians and Vehicles on Sidewalks, Buffers, Street Width, Speed Limit
Land Use	Mixed-Use Land, Distance from Green Areas
Crossroads	Access to Crosswalks, Number of Streets in an Intersection, Crosswalks Signal

Although many indices consider individual needs, the literature lacks attention to ethnic and racial diversity. Shields et al. (2023, S. 31) criticise that objective measurements of 'Ethnic Minority Density' complemented by 'Pedestrian Classification' of differences in public would not capture real differences in cultural uses of diverse urban street spaces. The objective of simply passing through could raise conflicts with shopping crowds or people socialising on the street (Shields et al. 2023, S. 31).

Bartzokas-Tsiompras und Photis (2020) have shown that migration background has a decisive influence on walkability and access to pedestrian-friendly neighbourhoods. The authors studied 447 neighbourhoods in Berlin and found a negative correlation between community ethnic diversity and walkability.
Previous research has shown the need for a stronger focus on considering different requirements or groups of pedestrians. First approaches in research examine walkability from the perspective of certain groups of people, such as elderly people (Horak et al. 2022), children (Bucko et al. 2021; Molina-García et al. 2020), people with a migrant background (Bartzokas-Tsiompras und Photis 2020) or disabled people (Gan et al. 2022; Campisi et al. 2021).

Nevertheless, many studies do not differentiate pedestrians by gender, age, and ability, nor do they incorporate socioeconomic and affective factors, such as social norms and diversity (Shields et al. 2023, S. 36).
This study attempts to fill this research gap and specifically include the perspective of people with disabilities. The last section of this chapter explains why this group was chosen for this study and discusses the recent state of research on the walkability of disabled people.

2.3 People with Disabilities as a Marginalised Group

2.3.1 Disability as a Social Construction

There are approximately 7.8 million disabled people living in Germany by the end of 2021 (Federal Statistical Office 2022). This corresponds to nearly 10% of the total population. Approximately 34% of this group is over 75 of age. There is a positive correlation between increasing age and the incidence of disability; however, this is not the sole cause. More than half of the group (7% of the total population) feel that their disability hinders their mobility (infas 2018, S. 99).
The Convention on the Rights of Persons with Disabilities (CRPD) of the United Nations contains a large number of special regulations tailored to the life situation of people with disabilities and came into force in 2008 (United Nations 2007). The CRPD led to adjustments to the German Passenger Transport Act. According to this, all local public transport should have been barrier-free (Federal Ministry of Justice 2023). However, disability associations criticise that only every second railway station in Germany has been converted to be fully barrier-free (Social Welfare Association 2023).

The example of public transport shows that, although barrier-free access and inclusion have long been considered as human rights, people with disabilities are still structurally disadvantaged. They face more barriers in everyday life, are affected by ableism[2], and are thus marginalised. Studies worldwide prove the structural disadvantage, exclusion and discrimination of disabled people (Ma und Mak 2023; Pettersson et al. 2022).
These injustices are continuously reproduced because the majority of society still has a long outdated ‘medical’ view of disability. In the disability studies, the ‘Medical Model’ describes a view of disability as the direct result of a physical or mental impairment (‘deficit’) that needs to be eliminated with medical-therapeutic treatment methods (Egen 2020, S. 23–24; Schöne 2022, S. 16–22).

This view reduces people to this ‘deficit’ and supposedly sets non-disabled people as the norm. According to this model, disability is an objectively describable, negative characteristic of a person like a stigma, behind which all other characteristics pale. Disability is seen as a fateful and personal misfortune that must be overcome individually, hence the alternative term ‘Individual Model of Disability’ (Egen 2020, S. 23–24).

---

2 Disability rights activist Andrea Schöne defines ableism as a closed system of thought and behaviour that manifests itself in different forms within a society. Non-disabled people are privileged and have structural and social advantages over disabled people (Schöne 2022: 9-10).

The contrast of the 'medical model' is the 'social model' of disability. In this model, disability is not the result of medical pathology, but the result of social organisation, which creates barriers to participation. This results in the slogan: "You are not disabled, you become disabled". This model does not apply solution strategies to individuals, but to society (Egen 2020, S. 11). If a certain place is not accessible to a person using a wheelchair, it is often not due to a person's physical constitution but to a defective lift or the lack of a ramp.

2.3.2 Disabled People in Walkability Research

Built Environment

This structural discrimination and ableism are also reflected in urban mobility systems. Adapting to this is one of the main difficulties faced by people with disabilities (Nizomutdinov 2022, S. 582). The accessibility of urban environment infrastructure has a direct impact on the quality of life of people with disabilities, as they are often forced to plan routes in advance because of possible barriers (stairs, large height differences, etc.) (Nizomutdinov 2022, S. 582).
Rosenberg et al. (2013) interviewed 35 people with different disabilities using a variety of mobility assistive devices (moad) including canes, walkers, manual and powered wheelchairs to gain a better understanding of how the built environment impacts neighbourhood-based physical activity among people with disabilities.

One major barrier of the built environment is the lack of curb ramps in many places because it can force people to walk or wheel on (busy) streets. Curb ramps are also in poor condition or too steep to pass safely without the risk of falling or dropping out of the wheelchair (Rosenberg et al. 2013, S. 274). Another aspect is the lack of parking spaces for people with disabilities, who are close to a specific destination and usually offer more space for leaving and entering the car with an moad more easily (Rosenberg et al. 2013, S. 274).
Moad's require flat, smooth ground conditions. Sidewalk quality, width of the sidewalks, and lack of sidewalks were also documented as barriers. Parked cars in driveways that block the sidewalk and cyclists driving on them are barriers and potential risks (Rosenberg et al. 2013, S. 274).

Sociophysical and Sociopsychological Factors

Gan et al. (2022, 43) developed the so-called 'Wheelability Scale'. The researchers proved that sociophysical and sociopsychological dimensions play a crucial role in the walking/wheeling experience. The presence of other people having conversations, chatting, or smiling at each other may appear unrelated to walkability, but for many people with disabilities this may make a difference. Regarding the authors, this is what makes a street a "comfortable social space" (Gan et al. 2022, 43). Journeying beyond homes may require considerable physical, psychological, and logistical effort for disabled people (Gan et al. 2022, 44).

Different Disabilities Lead to Different Barriers

Prescott et al. (2020) emphasised the importance of not seeing people with disabilities as a homogeneous group. The authors reviewed 37 articles on factors that affect the ability of people with disabilities to walk or wheel to certain destinations in their community.

People with visual impairments use auditory cues from traffic and construction, haptic sources such as food smells, grass, and echolocation to orient themselves (Prescott et al. 2020, S. 651). The amount of ambient noise in the environment (loud construction or car traffic) could (negatively) influence auditory feedback. Regardless of the information source used, people with visual impairments were able to incorporate distances into their cognitive maps during their journey (Prescott et al. 2020, S. 651).
The authors found that an important goal of any journey for people with visual impairments, regardless of familiarity, involves safely and effectively crossing the streets. This becomes more difficult with increased vision loss. It is more difficult for people with visual impairments to complete crossings safely and in a timely manner. As a result, they take greater risks than sighted people at crosswalks because they tend to have a more difficult time determining traffic patterns and starting the crossing in a timely fashion (Prescott et al. 2020, S. 658).

The described issues of the built environment (surface quality, presence and quality of curb ramps, steps, path width, slope, etc.) are common for **people with mobility impairments** and are influenced by the use of moad. Most journeys include crosswalks, and people with mobility impairments may seek ways to avoid them. This may explain why people with mobility impairments travel 15% more than the shortest route[3] (Prescott et al. 2020, S. 660).
Longer routes make trips more complex, expose people with mobility impairments to more risk, and reduce trip enjoyment. This may deter them from participating in their communities (Prescott et al. 2020, S. 660).

There is a paucity of research on **people with hearing impairment**. One possible explanation for this is that their navigational experiences may appear

[3] This extra time, which must be spent for further distances is also referred as 'crip time' (Schöne 2022: 42).

equivalent to those of the general population without hearing impairments because of their access to visual information (Hersh et al. 2010). However, Pecchini und Giuliani (2015) found that auditory feedback can provide significant cues when the vision is limited. High fences, walls, and other obstacles can block the view of driveways and force people to rely on auditive information. Being able to hear traffic, especially if cars appear in different directions, can make travel safer (Pecchini und Giuliani 2015, S. 23).

To point out the complexity of disabilities and accessibility, the term 'barrier-poor' is sometimes used in disability research. The term is intended to draw attention to the fact that, even if formal criteria for fulfilling accessibility are met, accessibility is not yet necessarily ensured for all people.
In summary, the categories of 'Well-being', 'Barriers and Safety', and 'Needs and Solutions' were identified as the main factors influencing the walkability of people with disabilities.

2.4 Berlin as a Research Location

3.6 million people live in Berlin. Every Berliner travels an average of 3.5 kilometres per day (Mobility in Cities 2019). Walking is the most important mode of transport in Berlin. In 2019 approximately one third (30.8%) of all journeys were made on foot. For distances less than one kilometre the value was 77% (TU Dresden 2019).
Around 340,000 disabled people live in Berlin, which corresponds to just under 10% of the city's total population (Office for Statistics Berlin - Brandenburg (Amt für Statistik Berlin - Brandenburg) 2023).
In mid-2018, the Berlin Mobility Law came into force. It prescribes measures that give bicycles and public transport priority over car traffic in Berlin's transport planning. The purpose of the law is to develop a safe and barrier-free transport system geared toward the mobility needs of the city (Berlin Senate 2018).

In 2021, a section with a pedestrian traffic plan has been added. Although the city has committed to the UN Convention on the Rights of Persons with Disabilities, it is repeatedly criticised for its accessibility. By law, all 175 underground stations in the city must be barrier-free by 2022. Currently, 34 are not accessible without any steps. The same applies to seven train [S-Bahn] stations. Presumably, the entire underground network will not be barrier-free until 2028 (Latz 2023).

3 Methodological Approach

3.1 General Description of the Procedure

A mixed methods approach was used, to answer the research questions. As the research field of the walkability index in relation to disabled people is still relatively small, the focus of this study is on a qualitative explorative study. Thus, new aspects of the walkability index can be exploratively collected and discussed. Mobile interviews involving people with disabilities were conducted for this purpose. The results were evaluated and processed using qualitative content analysis.
In the second step, the results were analysed with qualitative visualisations using a Geographical Information System (GIS) Program. In the following section, the mobile interview method is explained and briefly discussed. The section 3.3 describes the qualitative GIS analysis. The last section of the chapter describes the concrete procedure, the selected sample, and details of the interview guide.

3.2 Theoretical Background of Mobile Interviews

The method of mobile interviews was based on several emerging forms of 'mobile ethnography' (Sheller und Urry 2006), which came up with the 'new mobility paradigm' (Sheller und Urry 2006, 2016). This paradigm assumes spatial mobility as a social normality. It is based on different strands of social science theory and further assumes that mobility and movement are not seen as deviations from the normal state, but rather as the basis and prerequisite for a society (Manderscheid 2019, S. 1361).

Manderscheid (2019, S. 1361) summarised these current of emerging research methods as 'mobile methods', which all have in common that researchers follow their research objects and so are mobile with them, in order to understand movements and stasis between human and material actors. There is a broad body of literature on several versions of mobile interviews.
Erturan und van der Spek (2022, S. 293) summarised the following terms from recent literature: 'Guided Walk', 'Walking Interviews', 'Commented Walk' or 'Go-along'. In this study, the term 'Mobile Interviews' is used because some of the participants use a wheelchair.

All methods have in common that researchers move together with the interviewees, conducting (semi-) structured interviews at the same time and observing the participants in the context of the space (Erturan und van der Spek 2022, S. 293). According to Kusenbach (2003, S. 463) , this makes the method unique because researchers observe participants' spatial practices in situ[4], and thus have access to their experiences and interpretations of their environment at the same time. It is also possible that hidden details or memories related to certain places can be captured, in contrast to regular interviews. Sheller und Urry (2006, S. 218) describing walking with people can be seen as "form of deep engagement in peoples worldviews" (Sheller und Urry 2006).

To keep the bias of the results as low as possible, Kusenbach (2003, S. 464) points out that interview situations should be as authentic as possible. In a concrete example of a walk-along interview, the interviewer should accompany the participant on a route from daily life, ideally at the usual time. Merriman (2014, S. 175–177) criticised the trend of upcoming mobile methods. According to the author, the assumption that these methods are enabling researchers to witness events 'first-hand' bringing closeness, immediacy and proximity which is often associated with an authentic experience is often overvalued.

It can be inferred that, as will be seen later, in some situations, mobile methods are the only possible way to collect new data. This has also been recognised in the social sciences. Social science researchers use all types of mobile methods listed above to gain different insights into mobility practices. Morris et al. (2019) conducted go-along interviews with 25 training groups to analyse the emerging trend of organised running groups in the UK and to explain why women in particular are disproportionately more often members of such groups.
Wong (2018) conducted 13 mobile interviews with visually impaired people in San Francisco. The author wanted to understand the relationship between the built environment, behavioural, and social processes and how these factors affect the individual mobility of people with visual impairments.

Parent (2016) is a disabled researcher trying to point out the intersection between mobility and critical disability studies. The author conducted 'wheeling interviews' with 23 disabled people in Montréal and New York City to theorise wheeling with a wheelchair as a mobile practice and to disturb how society thinks about walking.

This variety of research approaches illustrates the advantages and meaningfulness of this method. After briefly explaining the theoretical background of mobile interviews and their advantages, the next section deals with qualitative data analysis using the GIS.

[4] The term 'in situ' translated from Latin means "in the immediate place" or "in the original position".

3.3 Qualitative Mapping with GIS

The results of the mobile interviews were then used for qualitative analysis and visualisation using GIS. Geographer Kwan (2012b, S. 959) describes a fundamental methodological problem that exists when researching the effects of area-based characteristics on individual behaviour. The 'Problem of Uncertain Geographic Context' (PoUGC) (Kwan 2012b) describes the problem of local effects based on individual behaviour being geographically delimited by contextual units (e.g. neighbourhoods) and thus deviate strongly from the actual true geographic context. To address the PoUGC, methods and approaches should consider the complexity of the spatial and temporal configuration of the individual context.
Kwan (2012a) proposes a person-specific, individual-based analysis of geographic context, based more on where people go and the routes they choose. The author sees qualitative GIS analysis is a possible method for addressing the PoUGC.

Qualitative GIS science has grown rapidly and expanded in the last decade. This approach combines the representation of place, qualitative enquiry, and information technology (Pavlovskaya 2016, S. 1).
According to Cope und Elwood (2009, S. 174), qualitative GIS mapping offers the possibility of looking at a piece of space and helps understand that social interactions and places constantly influence and change each other. However, there are still ways to build on previous knowledge that comes from daily routines or familiarity. Qualitative GIS mapping has the power to reflect these routines and patterns, and ultimately capture them on a map. Researchers have recognised these advantages, and the methodology of qualitative GIS analysis is becoming increasingly relevant (Cope und Elwood 2009).

Franke et al. (2017) investigated how familiarity and time influence the travel behaviour of older adults, using a mixed-methods approach of qualitative geo-referenced interviews and quantitative data sets on the built environment. Wridt (2010) used qualitative GIS data from 32 children in a Denver suburb to investigate the social and structural factors shaping their physical activity.
Battista und Manaugh (2019) conducted walking interviews with 30 residents from a low-income neighbourhood in central Montreal to investigate walkability from a pedestrian perspective. They particularly focussed on social and personal factors which mediate the interaction between pedestrians and walkable places in public.

Marquart et al. (2021, S. 4) found that personal perceptions can be captured even better when additional wearable sensors that can measure noise and air pollution are worn during mobile interviews.

This section briefly introduced the method of qualitative GIS with examples. The last section of this chapter dedicates the framework conditions and procedure of the conducted interviews.

3.4 Framework Conditions and Conduct

Five mobile interviews were conducted at different locations in Berlin to collect the data. The results were analysed according to Mayring's (2019) content analysis. For a better illustration, qualitative maps were created using GPS data. The following sections describe the procedure in detail.

3.4.1 Preparing and Conducting the Interviews

The recruitment of participants for the mobile interviews was done via e-mail requests to different organisations. For example, the association 'Sozialheld*innen' [Social Heroes], which campaigns for greater participation and accessibility for people with disabilities or 'Cooperative Mensch' [Cooperative Human], which supports disabled people in their social participation. The interviews were conducted with five people in different districts in the city of Berlin during May 2023. The quality criteria of objectivity, validity, and reliability were ensured through a pre-test with a person who did not participate in the study.

Mobility differs greatly according to the type of disability. Prescott et al. (2020, S. 660) stressed the need for more research that incorporates the diversity of mobility impairments. To obtain the widest possible range of perspectives, people with different disabilities were chosen deliberately. In a preliminary interview, participants were informed about the method and procedure and were asked general questions about their daily travel routes. The pre-interviews also served to stimulate and accustom participants to the interview situation.

The interviewees chose the time and route themselves. Thus, the distances covered corresponded to the everyday routes of the interviewees. The routes were recorded using GPS. Semi-structured interviews were conducted on this route. The interview guide was based on the research questions and further developed in an iterative process. It covers the subareas of 'Well-being', 'Barriers and Safety', and Needs and Solutions. The questionnaire was not too large to allow room for spontaneous insertions in certain situations. From a practical perspective, the interview guide also served as a moderation guide for the interview. The interviews were recorded and later transcribed into text.

3.4.2 Evaluation of the Results

The transcribed interviews were analysed according to Mayring's qualitative content analysis and the evaluation software MAXQDA. The methodology of qualitative content analysis was developed by Phillipp Mayring in 1980. Since then, it has found various forms and applications in social sciences. The aim of the analysis is to gain new insights to answer the research question from the available material by summarising and interpreting the content (Mayring und Fenzl 2019, S. 633).

The procedure is strictly rule-governed and based on a few basic principles. The material should be placed in a 'communication model' (Mayring und Fenzl 2019, S. 636) in which text production situations, text effects, and text producers are elicited. According to Mayring (Mayring und Fenzl 2019, S. 636), in this respect, it is not only a matter of pure text analysis, but also of drawing conclusions beyond the text. Regarding the evaluation of the conducted interviews, attention was paid to the context in which certain statements were made, the manner in which the interviewees made the statements, and which environmental factors played a role (e. g., other background noises, other road participants, etc.).

For the evaluation, certain text passages were assigned to certain categories (codes), which were summarised and interpreted. For the evaluation, a combined variant of deductive and inductive category formation was used (Mayring und Fenzl 2019, S. 637). The main categories from the interview guide, 'Well-being', 'Barriers and Safety' and 'Needs and Solutions', were initially used as deductive categories. After the first coding run, further (sub-)categories were inductively developed in a second coding pass. After this, the main category 'Barriers and Safety' was spitted up into 'Safety', 'Barriers and Obstacles' and 'Environment'.
The recorded GPS data were fed into the GIS software for further analyses. Based on the corresponding time stamps from the interviews, the qualitative maps shown in Section 4.2, with photos and quotes on the most relevant barriers or other situations, were created.

After discussing and explaining the methodological approach in this chapter, the next chapter presents the interview results. The chapter begins with an overview of the sample.

4 Results

4.1 General Information about the Interviews and Sample

Five interviews were conducted in different locations in Berlin. The table shows the sample with the location of the interview, how long people are already living in that area, information about a moad, and how long they have been using it.

Table 2: Overview of the Sample

	Place of the Interview	Mobility Assistive Device / Disability	Has been using a moad since (years)	Route Length (km)	Living in that Area since (years)
Person A	Westend	blind; uses a white cane	30	1.7	5
Person B	Hellersdorf	uses a hand wheelchair	42	2.1	33
Person C	Weißensee	attention deficit hyperactivity disorder and deaf in one ear	-	3.1	17
Person D	Wedding	uses a wheelchair with electronic drive	2	4.4	2
Person E	Moabit	uses a wheelchair with electronic drive	9	5.4	7

People who have only been using a certain moad for a short time or have recently moved to a new area have a different mobility behaviour than people who are already experienced in using a moad and know their neighbourhood. To obtain reliable results, only people who have been living in their current place of residence for a longer period of time and are experienced in using moad were selected.
The next five sections reflect individual experiences and the interview results. Every section begins with the map of the travelled route with different barriers, perceived safety risks or positive aspects.

Figure 1: Route of Person A; Source: Own Data/ DLR

4.2 Results of the Individual Interviews

4.2.1 Person A

Person A is blind and has used a white cane when moving through public space for 30 years. He/She lives in his/her neighbourhood for five years. He/She walked a typical route from different stations of his/her everyday life. From home to a park, further to a bakery, to a bus stop, and back home again. The participant walked a total distance of 1.7 kilometres.
Person A reported that he/she feels safer in areas he/she knows than in unfamiliar surroundings and that he/she has to concentrate constantly when moving through public spaces. A few metres from his/her home, person A encounters an e-scooter (1)[5], which is in the middle of the pavement, and collides with his/her white cane. The person comments: "Yes, this is a good example. It's just disturbing; they're just disturbing. They are increasingly getting in the way. It's not always so easy not to run into them and it throws me off my bearings."

He/She continues walking along a four-lane main road. Person A first reports that he/she is now used to the noise of the road because he/she has lived there for more than 20 years and no longer finds it bad. At a later stage, however, the person also reports that it is sometimes difficult for him/her to locate or hear the location signal[6] of the traffic lights because of road noise.
The person reports a case in which he/she did not walk straight across the traffic light crossing. He/She could not hear the clacking sounds due to car noise, as cars were still moving fast in one direction on the other side of the road. The person concluded: "That can quickly become dangerous. And especially on Spandauer Damm it's not really safe because of all the car traffic."
After the person had passed the beer crates of a beverage store standing on the pavement (2), the person wanted to go to the bus stop. However, owing to the lack of tacticle walking surface indicators (twsi), the person was unable to locate the bus stop and walked past it (3).

Afterwards, the person wanted to show a positive counter-example, as the twsi for boarding the bus were installed on the other side of the roadway. However, the twsi led to the curb of a terminal station where boarding the bus was not possible (4). The person remembered shortly afterwards that the bus stop was 10

---

5 The numbers in brackets refer to the numbers in the map highlighting individual barriers (orange) or positive aspects (green).

6 The location signal [Auffindsignal] is located at pedestrian traffic lights and is usually a slow knock or ‘tack’-sound (tack-tack-tack) and helps people with visual impairments to find the traffic light post. It should normally be heard from about 5 metres away.

metres away. On the way back home, the person had to cross another traffic light where the acoustic signal marking the green phase was missing (5). The person could only cross the traffic light with assistance.

Figure 2: Different Floor Coverings of the Walkway; Source: Own Picture/ DLR

On the way back, person A still reports that he/she often orientates between two different surfaces on the pavement to avoid going off the path (see Figure 2). If the surfaces are not different, the person is oriented toward the edge of the pavement.

In general, it became clear from the interviews that the condition of the ground plays an extremely important role in the person's orientation. The person reports that he or she can no longer use the white cane if the pavement is covered with too many leaves or snow and states "For me, it would therefore be important that the pavements are cleared as much as possible". As positive aspects of his/her environment, the person mentioned the installed twsi at a bus stop as well as the acoustic orientation sounds of the traffic lights.

Figure 3: Route of Person B; <u>Source:</u> Own Data/ DLR

4.2.2 Person B

Person B had used a hand wheelchair since he/she was a child. He/She lives in that area for 33 years. The route was from the person's home to a supermarket, then to a drugstore, and back home. The length of the route was 2.1 km. The person first reported that one does not have to walk far to encounter barriers. In his/her neighbourhood there are a lot of cobblestones "where you can't go with a hand wheelchair. However, I cannot use an e-wheelchair because of my back. Also, I do not like e-wheelchairs because you have to concentrate so much on your surroundings and where you are going."
The first barrier was a ledge at a bridge crossing (1), where it was difficult to cross. The person comes down a few metres from a lowered curb, which is blocked by a car (2): "Yes, it is often blocked here. People do not give it much thought."

After about ten minutes, the person passes a path that he/she classified as "not barrier-free, because it's always going up and down here" (3). Higher curbs and edges sometimes cause the person to tip over with the wheelchair. He/She reports that she once tried to sue the district for damages, but without success. Furthermore, the person reports that smooth and even paths would help him/her, but at the same time he/she knows that this is not feasible because the district has no money.

After half an hour, the person first drives onto the cycle path to cross a road junction, because the pavement is lowered better there (4). "It is easier for me to ride on the cycle path here because the curb is much lower than for the pedestrian path. I always have to look out for cars (from the right) and cyclists (behind and in front)." At the moment of crossing, a cyclist passed by and overtook person B.

The person further stated, that sometimes it also happens that cyclists ride on the pavement: "Once a cyclist almost knocked me down on the pavement."
In general, person B still reported that street noise does not bother him/her so much, but e-scooters do, because "you have to drive around them more often when they are on the pavement". He/She also no longer feels as safe as he/she used to: "I used to go to Alexanderplatz (city centre) or something like that, but now I do not dare. I see an increase in the propensity to violence in the world."
As positive aspects along the way, person B described a fountain in front of the drugstore (5) and the greenery next to some pavements.

Figure 4: Route of Person C; <u>Source:</u> Own Data/ DLR

4.2.3 Person C

Person C walked 3.1 km from home to a playground, through a park, to a citizens' office, and back home again. He/She lives in his/her home for 17 years. He/She has an Attention Deficit Hyperactivity Disorder and is deaf in one ear. Person C is also part of the advisory organisation 'Barrier Scouts', which advises cities, organisations, and companies on accessibility and inclusion. He/She could therefore report from the own perspective of a person affected, but also assess obstacles for other people with disabilities[7]. At the same time, this expertise also leads to the person sometimes feeling depressed: "Actually, I am fine, but because I am affected and my interest, I see an incredible number of barriers. I just can't block that out and it is often depressing."
The first barrier is the lack of signage for a higher playground (1). The wheelchair-accessible entrance with a ramp is on the other side, which is not obvious. One would think that there is no wheelchair access at all, because the person was standing at the main entrance of the playground. By coincidence, a person in a wheelchair passes by and person C comments: "If the man didn't know his way around here now, he wouldn't be able to know that there is another ramp around the back."

Person C further remarked that the playground and the access have only recently been rebuilt. He/She complains that there was only a tiny note for suggestions and criticism, which quickly disappeared. There was no real opportunity to express criticism, make suggestions, or seek citizen participation.
After approximately 20 minutes, person C passes a crossing to a park (2). The person comments on the crossing firstly that it has a very short green phase and secondly that this is the only crossing to the park and the adjacent culture centre [Kulturhaus]: "You always have to walk here to the crossing to get over there or towards the city centre, but it's really far away. There are also many restaurants and other things. And it's also dangerous, because sometimes people don't have the strength to take the long detours."

In the park, person C reports on the barriers and problems on the ground (3) in the park, "which were difficult or impossible to overcome with a hand wheelchair. Maybe you can find detours, but the unevenness of the ground is a big problem."
The situation where a man is shouting in the park not far from person C, he/she comments that it wouldn't bother him/her and that the person might have an obsessive-compulsive disorder: "I don't think it's bad, I even think it's good that something like that is visible and not tabooed."

[7] To distinguish whether person C is affected by a barrier him/herself or can determine it based on his/her expertise, the barriers were marked differently on the map.

Back on a major high street, person C reports that moving through public space is very exhausting: "I actually have to have this management of synchronising myself with my surroundings all day long, around the clock, even if I am just walking to the bakery or something. This requires a significant amount of energy. I have to be 100% attentive at all times, otherwise my life is sometimes in danger and that can't be the starting position."

Person C describes a construction site on the way home (5) as "annoying" and comments: "A lot of things are concentrated here [...] and people are really in danger here. [...] It is good that something is changing, but citizens must also be involved, and the process must be clear and comprehensible. And the lack of barriers and traffic safety must be ensured for everyone."
Person C also finds the noise exhausting because her disability makes it difficult for him/her to concentrate on conversations: "Well, I don't hear anything on one side, where you are walking, and on the other side there is the street noise. So, I have noise on one side and nothing on the other."

After about an hour, the person comes to a large, "very noisy" intersection (6), which is located between a hospital with an old people's home and the park with a lake. He/She reports that people often do not dare to go down here to the Weißensee because there is "so much rush hour traffic" and that trams come from two different directions. "You can't imagine it, but for such psychological or physical reasons people don't want to walk over here."

The penultimate barrier is a "quite dangerous" road crossing (7) where, according to person C, people have already died. He/She further comments that if, for example, people with assistance dogs are walking here, they could be frightened by the trams and cars passing very close by and might jump in front of the cars.
Arriving on person C's street, which has just been converted into a cycle lane, there is a "huge gap" in front of the curb at a newly constructed pedestrian crossing (8), which could be a major barrier for people with wheelchairs.
As positive aspects, on the one hand, the person mentioned the barrier-free access to the culture centre at the park. On the other hand, he/she considers construction sites that contribute to an improvement in accessibility as positive and finds it good that "something is happening at all". At the same time, person C believed that barriers are often not reduced by construction sites.

Figure 5: Route of Person D; <u>Source:</u> Own Data/ DLR

4.2.4 Person D

Person D has used an electronic wheelchair for about two years and travelled from his home to a supermarket, a discount store, and back again. He/She is living in the neighbourhood for two years. Person D encountered the first barrier after approximately seven minutes (1). A "high curb" where the person always has to take a running start to be able to drive over it and where it always "rattles a bit" and "you can be glad that you don't lose anything or break anything". According to person D, it is also difficult if the wheelchair is not fully loaded, as it can then get stuck or one has to look for another place to drive up. However, it is not always easy to determine.

In general, person D reports that it is "okay" to move around the city and gets by so far. She/he would describe the area as "75% wheelchair friendly". In the district of Neukölln, where the person had previously lived, it was much worse and he/she was always dependent on help with the use of a hand wheelchair.
It also took a while before person D dared to travel slightly further away from home. This was mainly because, in other areas, he/she "did not know the people and did not know what barriers might be there". In this area, person D already knows which roads "work well".

Person D has got used to street noise and generally only wishes for a bit more consideration from people on the pavement. Especially when they are sometimes on the move with the e-scooters, "because you really have to watch out that you do not get knocked over." After about 20 minutes the person arrived to another high curb (2) and a delivery ramp use (3) that has been built over the footpath. When this is down for delivery, it is difficult for person D to get under it because he/she also "can't really get out into the street."
As a positive example, the person mentioned a small square in front of the entrance to the supermarket.

Figure 6: Route of Person E; Source: Own Data/ DLR

4.2.5 Person E

The last person (E) has been using an electronic wheelchair for nine years and has lived in that area for seven years. He/She has travelled to the occupational therapy surgery, to the supermarket, along the river and back home.
After about two minutes, person E passes an e-scooter (1) and comments that they are a "catastrophe", a nuisance and that he/she often has to swerve onto the cycle path because of them, which can be dangerous.

After slightly more than five minutes, a person passes a walkway without pavement slabs (2). Theoretically, the person could drive over, but would then "break their back" because the wheelchair had no suspension.
A few metres further on, person E must pass a "very high ledge" (3), on which person E has already got stuck once and could not move on. The person does not manage to pass the ledge and receives minimal assistance. At this intersection, the person also reported that he/she had already been "rammed by a lorry" because the lorry driver did not see the person.
After reaching the supermarket, person E comes to a "dangerous spot" (4) where the path is a "catastrophe" and the person does not dare to go there because he/she has been stuck there before. The person decides to turn around. The person comments on this passage, as well as at several other points during the interview, that people with disabilities are "not considered" and that politicians "don't give a shit" about them.

Like person B, person E also swerves onto a cycle path at the next point to get further (5). He/she describes the spot as "really dangerous" because he/she does not have a good overview from the wheelchair. He/she is "bothered by the cars" because they restrict his/her view and he/she cannot see over them. The person is quite relaxed about the surrounding acoustics and says that he/she is already used to car noise and that he/she has become accustomed to it.
At a pedestrian crossing (6), the person takes a diversion because the ramp is "too steep after the cobblestones" and if he/she is unlucky "the wheelchair can touch down and the connecting cable of the wheelchair can fly out." A few metres further, person E must turn back again because a shelter for temporary power cables completely blocks the footpath (7). As the next obstacle and at a later point in the interview, a parking car is blocking the way and person E has to drive around (8).

At two partly quiet narrow spots (9), pedestrian and cyclist paths have been merged due to road works, which person E judges to be "very dangerous" because many cyclists "race" there anyway.
Further obstacles existed on the way to and along a riverside path that led along the Spree River. First, a lowered curb (11) is missing, which requires the person

to divert across the street. Furthermore, ramps (13) are missing in two places, so the person cannot cross the river here. Person E complained about this because it denied him/her a short way to the train [S-Bahn] station (15).
Moreover, between these locations, cyclists would use this path as a "race track", which can be dangerous for person E because he/she sometimes cannot see cyclists coming from behind (14). At the same time, the person described the riverside path as "very nice, quiet and relaxing" and that “you don't notice anything of the city” (12). Other positive aspects mentioned by the person were one the one hand, two curbs that were lowered after reconstruction (10). On the other hand, a wide pavement with sufficient greenery and the predominantly helpful younger fellow citizens.

5 Discussion

5.1 Evaluation of the Main Findings

After describing the individual results from the interviews in the previous chapter, this chapter discusses the key findings in relation to the current literature and research questions. The first section summarises the main barriers, perceived safety risks, and adaption mechanisms and discusses the perceived exclusion of people with disabilities. The second section will make suggestions and discuss, what aspects should be integrated to develop a more inclusive walkability index.

5.1.1 Main Barriers

High Curbs, Gaps and Elevations

One of the most relevant barriers in public spaces for participants were high curbs, edges, gaps, or other elevations. For the interview participants who used a wheelchair, it was difficult, only possible with assistance, or impossible to overcome them. If the obstacle could not be overcome, the person had no choice but to turn back and find another way (person E).
One of the most common barriers were poorly lowered curbs, which must be overcome at intersections or road crossings to continue the route on the pavement. Studies have shown that poorly lowered curbs increase the risk of injury to people in wheelchairs because of the risk of tipping backwards or falling out of the wheelchair (Bennett et al. 2009, S. 17; Carlsson und Lundälv 2019). In Sweden, the most common reason (34%) for single accidents with a wheelchair is typically poorly lowered or damaged curbs (Carlsson und Lundälv 2019, S. 486). Person B also reported having tipped backward once (person B).
Curbs that were not lowered led interviewees swerving into the cycle lane to make the crossing easier (person A & E). This, in turn, leads to an increased risk of accidents owing to additional interactions with other road users such as cyclists. The section 'Car Traffic and Other Road Participants' (p. 45) will discuss this aspect in more detail.

Participants using a wheelchair with an electric drive tended to negotiate higher curbs than people using a manual wheelchair. The interviews revealed that the choice of a suitable wheelchair plays a crucial role for people with disabilities and is thus reflected in their mobility.
Person D, after changing from a hand to an e-wheelchair, was no longer dependent on being pushed by a person and created more independence.

However, person B cannot use an e-wheelchair for health reasons. Person B has never liked driving an e-wheelchair anyway because "you constantly have to avoid barriers or places at high speed" (person B).

Blach Rossen et al. (2012) asked people about their choice of e-wheelchairs. The study revealed that when choosing the right e-wheelchair, the interviewees felt in a dilemma between “the need of a wheelchair to do occupation outside, and one to manage occupation indoors” (Blach Rossen et al. 2012, S. 403). Smaller electronic wheelchairs are more manoeuvrable and practical inside, but are not built for the barriers or activities outside.
When the wheelchair broke down, participants had to wait for a long time to repair and relied heavily on help from others. Person D reported a defect in the middle of an intersection where the person had to stop and depended on the help of passers-by.
Whether curbs, gaps, or other obstacles can be overcome depends on the wheelchair type, which is chosen by the person concerned for different motives and reasons.

Ground Conditions

For all the interview participants, the ground condition played a central role when moving through public spaces. The reasons for this result were very different.

First, in some places, poor and uneven ground conditions (such as cobblestones) meant that certain places could not be reached, and could only be reached with great difficulty or with help (person B).
Kapsalis et al. (2022) reviewed 48 studies to investigate the factors that influence accessibility in public places for people using moad. They identified the inadequacy of narrow, uneven, or sloping pavements as a key factor in the accessibility of places for people using moad. As with high curbs, sloppy, uneven, or rough pavements have led to accidents, usually tip-over accidents, in which users suffer minor, moderate, severe, or even fatal injuries (Kapsalis et al. 2022, S. 10).

Second, health aspects also play a key role. Two of the interviewees reported that they avoided or had to avoid uneven surfaces because they caused back pain (person B & E). Person E reported that even driving on the small-scale cobblestones is "bad" for him/her and it sometimes causes him/her pain in the shoulder, because it "shakes so much" (*ibid*) with the unsprung wheelchair.
Duvall et al. (2016) studied the health risks and comfort of wheelchair users moving on pavements in different cities in the USA. The authors found that both uneven and rough pavements or pavements that slope to one side can cause uncomfortable vibrations or mild pain for wheelchair users.

Lariviere et al. (2021) have examined 35 studies on manual wheelchair users with regard to the exposed vibrations and come to the similar conclusions. Users of hand wheelchairs are exposed to excessive vibrations, particularly in public spaces, which are considered harmful to the human body. In addition, vibrations can be triggered by high curbs, other edges, and obstacles (Lariviere et al. 2021, S. 471). Studies have shown that these bumps can cause neck problems and have a significant negative impact on muscle fatigue. Not only broken or uneven pavements but also rough materials such as aggregate concrete can cause this negative impact (Kapsalis et al. 2022, S. 10; Lariviere et al. 2021, S. 472).

Third, the interview with person A showed that the ground can serve as one of the central orientation points for people with visual impairment. In places where no twsi provided orientation, person A used his/her white cane to orient him/herself on the line between two different footpath surfaces (see Figure 2, p. 27).

Existing literature confirms these findings. Studies have shown that ground conditions and obstacles on footpaths are the strongest factors influencing the mobility behaviour of people with visual impairments (Frazila und Zukhruf 2018, S. 4; Kim und Sohn 2020, S. 738).
While uncleared pavements can make it very challenging and difficult for wheelchair users to manoeuvre wheelchairs (Henje et al. 2021, S. 6–7), it is not possible for person A to orient himself/herself with the white cane. Since "everything feels the same", person A can no longer distinguish between different floor coverings.

It is widely documented that snowfall and poorly cleared pavements have an impact on walking activity (Abenoza et al. 2019), walking speed (Willberg et al. 2023) as well as already mentioned an impact on the manoeuvrability of the wheelchair (Henje et al. 2021, S. 6–7) and is thus a barrier for both able-bodied people and people with disabilities.

While well-cleared pavements would help all people, the pavement of the walkway showed a potential conflict of interest between two people: while person A used the middle line between two different pavements for better orientation, the small cobblestones (Figure 2, p. 27) led to back pain for person E. Recent literature describes and discusses similar conflicts.
Bentzen et al. (2020) studied walkways with twsi and their interactions with people using different moad in the USA. For more than half of the participants, crossing the guiding bars involved effort or caused instability, regardless of the direction in which the guiding bars were laid. For all participants, it was more difficult to cross bars laid perpendicular to the direction of their travel. For wheelchair users, crossing perpendicularly caused more instability on average than crossing parallel bars (Bentzen et al. 2020, S. 416–417). The authors also

found that the unevenness of twsi can negatively influence the fatigue stage (Bentzen et al. 2020, S. 416–417).

Construction Sites

Three of the five participants felt that roadwork had a negative impact on their mobility. Person C passed several construction sites and said that after the completion of the construction work, barrier-free access has often not improved, and accessibility and road safety are often not provided during construction. Person E could only overcome one barrier with assistance and one barrier not at all, both of which were caused by a construction site.

During the interviews, the impression of accessibility was strongly neglected, especially at construction sites. Similar obstacles and barriers occurred, such as higher edges and uneven paths. These confronted participants with the challenges and safety risks described above. Henje et al. (2021) made similar observations when they accompanied 13 powered wheelchair users in Sweden.
In October 2019, there were 2419 construction sites on Berlin's road network, which is 5400 kilometres long (Berlin Newspaper 2019).
This corresponds to a roadwork density of approximately one construction site every two kilometres. Even though this figure includes roadworks that only affect the road, person E's interview showed that they could also have an impact on adjacent pavements.

Although roadwork is a relevant barrier to many people's daily mobility, it has only been studied very poorly, especially for people with disabilities. Blanchard et al. (2022) found that some temporary obstacles, such as small construction sites on pavements, rubbish bins, or e-scooters, may not be consciously noticed by able-bodied people but can be a barrier for people with disabilities. According to the authors, their impact on the mobility of people with disabilities also differs from the permanent barriers described above because they can occur suddenly and unexpectedly (Blanchard et al. 2022, S. 477).

Noise

In no other topic area was the range of answers as wide as in the topic of noise. The statements generally referred to the noise produced mainly by cars and ranged from "have got used to it" (person A & D) to that it "sucks because it is so exhausting to have to shout at each other" (person C).
Although person A said that he/she is used to street noise, at a later point in the interview, he/she said that the noise makes it difficult to orient his/herself, for example, when finding the location signal of a crossing with a traffic light. The acceptance and "getting used to it" of car noise reflects the path dependency of a

car-centred mobility system, which is broadly documented in the literature (Manderscheid 2022, S. 87; Scherf et al. 2018, S. 8; Urry 2004; Geels 2012).
Noise pollution has been widely studied. Many studies have shown negative health effects due to annoyance, sleep disturbances (Münzel et al. 2018) or other factors (Li et al. 2018; WHO 2018). However, other studies have limited the research results and pointed to heterogeneity and certain restrictions on the research results (Zare Sakhvidi et al. 2018).

Thus, while many studies have focused on the health effects of noise, consideration of noise as a potential barrier for people with visual impairment has been understudied. Mediastika et al. (2022) conducted walking interviews with nine visually impaired people on pavements in Indonesia[8]. The pavements and intersections with traffic lights are equipped with acoustic signals and twsi.
The acoustic environment offered the participants some orientation as to whether they were too far or close to the traffic, and thus to possible danger zones. Although it had some influence on direction, comfort, and safety, traffic noise was not found to be the main problem when walking on pavements (Mediastika et al. 2022, S. 124).

These results contradict the issue identified in the interview with person A that traffic noise drowns acoustic assistance signals. The German Association for the Blind and Visually Impaired [Deutscher Blinden- und Sehbehindertenverband] also points out the problem of "general traffic noise" (XIII Straßenverkehr 2023) for people with visual impairments.

Tacticle Walking Surface Indicators

Despite the possible conflicts with wheelchair users already discussed above, both the current literature (Bentzen et al. 2020, S. 410) and the statements of person A confirm that twsi are a helpful support for orientation in public spaces for people with visual impairments. In one situation, it was not possible for person A to locate the bus stop, because no twsi were present. A few metres further, there were twsi pointing towards a bus stop. However, this was only a terminal stop, where it was not possible to board the bus.

Parking Cars

Some of the interviewees either encountered (person B & D) or reported (person A) the barrier of incorrectly parked cars at footpath crossings during the walk. While person A reports that it takes him/her away from his/her usual route and

---

[8] Although the traffic and mobility systems of Indonesia and Germany are structured differently, the fact that the pavements have been equipped with similar standards as in Germany offers good comparability.

that he/she has to re-orientate him/herself, parked lowered curbs sometimes lead to detours or the fear of no longer being able to "drive up in the usual place” (person E) and without a diversion across the road.
Brown et al. (2020) examined the problem of incorrectly parked cars in their study of five major American cities and found that out of 2631 parked motor vehicles observed, one quarter (24.7%) impeded access to other participants. Nearly one percent (0.8%) blocked crosswalks or pedestrian curb ramps (Brown et al. 2020, S. 7). Both the experiences of the interviewees and the results of recent research suggest that incorrectly parked cars can be a barrier, especially for people with disabilities, and can negatively affect their travel behaviour.

Missing Access and Other Barriers

During the interview, person E passed two spots that he/she could not access because of missing ramps on the stairs. One of the crossings is the access to a train station [S-Bahn], which person E can only reach via a major diversion. It has been proven several times that step-free or barrier-free access to people with disabilities leads to unnecessarily long detours (Arai et al. 2022; Stock 2023).
Further barriers were encountered by person A in the form of beer crates on the pavement. Since these barriers are not present the whole time and can pop up randomly (i.e. e-scooters or wrongly parked cars), they are described as temporary barriers.
In their study on temporary barriers for people with disabilities Blanchard et al. (2022) point out the problem of lacking research on this topic and developed a framework to overcome these research gaps, which section 6.1.1 will further discuss. The next section discusses the major perceived safety risks of the participants.

5.1.2 Perceived Safety Risks

Traffic Lights and Road Crossing

One of the biggest perceived safety risks for the interviewees are road crossings and intersections, with or without traffic lights. In Berlin in 2018, there were 2196 pedestrian traffic lights. Approximately half of them were barrier-poor because they fulfil the three criteria of a barrier-free traffic lights. The most important criteria are a lowered curb, twsi for orientation with a white cane, push buttons for requesting acoustic and location signals. Person A crossed both low-barrier traffic lights, which he/she could pass independently, and old traffic lights that were not yet equipped, which he/she could not cross without assistance.

The lack of acoustic support for traffic lights has emerged as a central problem in the literature. Christofa et al. (2017) concluded that push-button-activated signals are the most effective treatment for visually impaired pedestrians "may have been overstated" (Christofa et al. 2017, S. 3). In many situations, visually impaired pedestrians fail to find the push button, or even worse, try to attempt a crossing during a walking period.

Liao (2013, S. 14) found other problems that people with visual impairments face at traffic lights. There is often a lack of knowledge about which traffic lights have an audible walk signal and confusion about alerting tones and traffic noise. Furthermore, participants reported that taking direction at the starting position and keeping direction while walking was sometimes problematic at traffic lights without location signals. This difficulty was also reported by person A.

Gamache et al. (2019) have compiled a comprehensive literature review on pedestrian-friendly infrastructures for people with disabilities by 41 articles. Participants with visual impairments preferred traffic lights with a pedestrian phase on recall, because they did not have to find a push button to activate walking signals (Gamache et al. 2019, S. 419). They further concluded that people with visual impairments only use push buttons when they know that they are there and where they can find them (Gamache et al. 2019, S. 419).
This is also why in urban planning and research, technology-based approaches such as automatic pedestrian detection are increasingly being discussed and planned to ensure greater safety for all road users (M. C. Ghilardi et al. 2018).
Another important aspect to ensure the safe crossing of pedestrian traffic lights is the sufficient length of the green phase. Person C complains at one point that the green phase is "very short" (person C).

The length of the green phases at pedestrian traffic lights in Berlin is based on the guidelines for traffic lights, which apply nationwide. It specifies a clearing speed[9] [Räumgeschwindigkeit] of 1.2 metres per second.

Insufficient crossing time has already been documented by Rosenberg et al. (2013, S. 274) and Arango und Montufar (2008). Gamache et al. (2019, S. 419) reviewed the research on appropriate green phase and clearing speeds and found that most studies recommend a clearing speed of 0.8-1 m/s so that all people can safely negotiate traffic lights at different speeds.

Person C further noted that if the crossing density or crossing opportunities are too low, people sometimes simply walk across the road without choosing a traffic light or crossing, which can lead to dangerous situations.
Person C also passes a crossing that leads across a four-lane road with two tram tracks inside, but does not have traffic lights. The person reports that several people have died there. This aspect illustrates once again the importance that pedestrian friendliness of urban infrastructure cannot only be measured by whether existing traffic light systems have been converted to be barrier-free, but also whether there are sufficient crossing possibilities and whether they are equipped with barrier-free traffic lights.

Crossings without traffic lights as passed by person C lead to traffic fatalities and a high risk for people without disabilities. Crossing a four-lane road with two tram tracks without traffic lights and acoustic signals can pose even greater challenges and dangers for people with visual impairments.

Car Traffic and Other Road Participants

Interviewees reported dangerous situations that would arise through interactions with other road users, such as cars, cyclists, pedestrians, or e-scooter users. Person C reported dangerous situations often occurring when traffic gets stuck due to road work. Other road users then drive in a very "angry and aggressive" (person C) manner. Sometimes, car drivers drive over pavements. In recent research, aggressive driving behaviour has been identified as one of the main causes of accidents and is considered a substantial risk factor for collisions and crashes (Su et al. 2023).

However, not only are cars a potential risk factor for the interviewees. Person E reported cyclists as a source of danger in two places for different reasons: On the one hand, cycle- and footpaths are merged even in narrow places - mostly due to road works. According to person E, cyclists "still race" (person E) there. On

9 The clearing speed [Räumgeschwindigkeit] describes the minimum speed that must be travelled to clear the road in time for other road users (e.g. cars) after switching to the red signal.

the other hand, person E often cannot hear cyclists, which can lead to dangerous situations on some paths where pedestrians and cyclists share the way (see Figure 7).
As described above, person B also had to use the cycle path in places to cross some intersections. Wheelchair users are often exposed to higher danger because they have to use the roadway due to the lack of lowered curbs (Henje et al. 2021, S. 4). The perceived risk of accidents also increases when construction works merge cycle- and footpaths, or when wheelchair users are forced to use cycle paths, has not yet been considered in research.

Figure 7: Cycle– and Footpath at Spree River; Source: own picture/ DLR

Person E reported a collision with a lorry at an intersection because he/she was overlooked. Although the cause of this accident is not clear and interviews can generally only be used to assess perceived safety risks, recent literature clearly indicates an increase in actual safety risk in the described situations. Carlsson und Lundälv (2019) identified a strong need for research on these aspects because in ageing societies, the need for electronic wheelchairs, for example, will increase. In Sweden, the number of accidents involving electronic wheelchairs or motorised mobility scooters tripled between 2007 and 2016 (Carlsson und Lundälv 2019, S. 486–487). Collision events occurred predominantly at junctions and intersections (70%) and in two-thirds (67%) of the cases of cars, lorriess, or buses where involved (Carlsson und Lundälv 2019, S. 486–487).

E-Scooters

Although the interviews and recent studies show that car traffic seems to be the biggest source of risk in road traffic, almost all interviewees (4) mentioned e-scooters as barriers or potential risk factors. E-scooters in use are a source of perceived danger for accidents and incorrectly parked barriers that must be detoured. For person A, this barrier can bring risks because it can take her/him “out of [...] [her/his] orientation". Person D complains about e-scooter users “racing” along the pavement. In some situations, people must be careful not to be knocked down.

Surprisingly, the most recent studies on e-scooters could not confirm the negative picture that emerged from the interviews. Brown et al. (2020) evaluated 865 parked e-scooters in five major American cities. Not even one in 100 scooters (0.8%) blocked the pavement (Brown et al. 2020, S. 6). However, the authors have also limited their findings. The results cannot necessarily be transferred or generalised to other cities (Brown et al. 2020, S. 8). Conversations with the Organization ‘Disability Rights Oregon’ revealed that people who use moad "face a host of obstacles on urban sidewalks" (Brown et al. 2020, S. 6).

Lloyd (2023) accompanied e-scooter users in ride-along interviews to determine how they behave with other road participants and what potential risks arise. Contrary to the perceptions of the interviewees, the author did not saw any "egregious conflicts between e-scooterists and co-movers" (Lloyd 2023, S. 18). Pedestrians and e-scooter users are aware of each other in a subtly coordinated manner. However, the author also emphasises that this subtle coordination is not transparently available to empirical study which might explain the strength and frequency of negative reactions and feelings regarding e-scooters (Lloyd 2023, S. 18), also seen in the interviews. The perspective of people with disabilities regarding e-scooters has not yet been researched.

5.1.3 Adaptation Mechanisms

Another important aspect that could be observed in all interviews are certain adaptation mechanisms that people with disabilities have developed and used when moving in public spaces. Person C describes people with disabilities as "resilient strategists". Other participants "found their ways" (person D) or "always had to adapt a little to the environment" (person E).
Person B and E used the lowered curbs of a cycle path to cross a road junction safely, putting themselves at risk of conflicts with cyclists. Person C often wears headphones when cycling because the road noise is so "extremely stressful". Since many interviewees had been using their tools for a long time, it can be assumed that further adaptation mechanisms have developed, even beyond those observed.

Recent disability studies have proved these adaptation mechanisms. People with disabilities sometimes visit places that are not barrier-free and often exceed their physical limits (Schöne 2022, S. 71). Stock (2023) showed how adaptation mechanisms are organised at a higher level. The website 'Broken Lifts' shows all defective lifts in Berlin's train and underground stations. It is a helpful tool for disabled people when using public transport. The open-source-based 'Wheelmap'[10], shows and rates the accessibility of public buildings. This map will be extended to the entire public space in future projects. The map should show ground conditions (e.g. cobblestones, gravel, etc.), accessibility of public spaces (parks, squares, etc.), and lighting of different areas.

Politics and science can learn from these overarching adaptation mechanisms and consider them in the development of urban infrastructure. Section 6.1 will discuss this aspect in further detail. After this section looked at individual and collective adaptation mechanisms, the next two sections will try to find an approach to the second research question by discussing the impact on participants' well-being.

5.1.4 Perceived Exclusion and Lack of Participation

People with disabilities experience ableism, discrimination, and exclusion (see section 2.3). Participants confirmed this finding. Person E has the feeling that politicians do not think about people with disabilities and they "don't give a shit" (person E) about them. For person C disabled people are not considered and their needs are not taken into account in urban planning. Many people with disabilities live in person C's district because of several social institutions or

[10] The websites 'Wheelmap' and 'Broken Lifts' are both run by the association 'Sozialhelden', which has been developing solutions for more accessibility and inclusion for many years.

workshops for disabled people. The lack of accessibility there "is not only discriminatory, but a scandal" (person C).

Studies have shown that many people with disabilities share these experiences and feelings (Egen 2020; Ma und Mak 2023). Pettersson et al. (2022) investigated how users of wheeled mobility devices experience exclusion and discrimination due to inaccessibility in urban infrastructure. The results are in line with the findings of this study, as people with disabilities are also demanding to be recognised, understood, listened to, and are thus struggling for equal access and social participation to live a life as others do (Pettersson et al. 2022, S. 6).

Finally, these studies show that, as explained in Section 2.3.1, the individual-medical view of disability still seems to prevail in society. Our urban infrastructure ultimately reflects only an ableist and discriminatory society.
The interviews conducted in this study support these findings. Person E could not access a train station [S-Bahn] because only one entrance had stairs without a ramp. The supposedly 'non-disabled majority society' has defined as a 'norm' that human bodies must be able to climb stairs. Those who cannot do so deviate from the 'norm' and are discriminated against and excluded.

Ma und Mak (2023, S. 4) summarise that a large part of the barriers discovered have arisen because of ableist social structures. Society and urban infrastructure have been designed for non-disabled people based on the perceived social norms of body characteristics (Ma und Mak 2023, S. 4).
Environmental inaccessibility carries social values and expresses the non-acceptance of people with disabilities. Even worse, witnessing people with disabilities to negotiate inaccessibility may visualise and substantiate the stereotypes of wheelchair users as dependents, beneficiaries of constant help-seeking, and prone to risks and danger (Ma und Mak 2023, S. 15) .

An important result of this study is in line with the findings of Pettersson et al. (2022, S. 6): paying attention to the experiences of people with disabilities would enhance our understanding of the consequences of inaccessibility.
This group will remain marginalised if they are continuously not listened to or taken into account in research, politics, or other parts of society. This also illustrates the advantage of the mobile interview method in which these perspectives are captured.

5.1.5 Positive Aspects

Although the focus of the interviews was on barriers and perceived risks in public spaces, all interviewees reported aspects positively affecting their well-being.
Two of the interviewees (person B & E) perceived greening as positive. A wide body of literature confirms that greening has a positive impact on well-being and health (Bell et al. 2008), life satisfaction (Ambrey und Fleming 2012) and, happiness (Smyth et al. 2011). Marquart et al. (2022, S. 9) showed that passing greenery, even pure lawns, have a strong positive influence on pleasant travel.
Noise is usually related to noise from motor traffic rather than other factors (Marquart et al. 2022, S. 9).
The term 'quietness' seems to be more related to car-free zones and natural environments than to objectively measured noise levels (Marquart et al. 2022, S. 10). Although no objective noise level was measured in the interviews, the findings of Marquardt et al. seem to be in line with those of this study. Person E for example perceives the path along the Spree, far from any car traffic, as "nice and quiet" (person E) and commented: "You've heard the noise on Turmstraße? When I want peace and quiet, I drive this way".

Figure 8: Blue Spaces as a Positive Influencing Factor to the Well-being of Person B; Source: Own Picture/ DLR

As further positive aspects, person E mentioned curbs that have already been lowered owing to road reconstruction or wide pavements. For person B, urban blue spaces had a positive influence on well-being because he/she "loves fountains" (person B).

5.2 Suggestions for an Inclusive Walkability Index

The discussion thus far provides answers to the first two research questions. On the one hand, high curbs, gaps, uneven paths such as cobblestones are barriers that challenge people with disabilities or make it impossible for them to cover certain distances. On the other hand, non-barrier-free traffic lights, crossings without traffic lights, or other road users (e-scooters, cars, and cyclists) increase the risk of accidents.
This leads people with disabilities developing certain adaptation mechanisms with which they try to avoid or overcome barriers (see 5.1.3). Nevertheless, these barriers and dangers usually result in many disabled people having a smaller radius of movement from their homes than people without disabilities (Schreuer et al. 2019, S. 8).

These aspects are consistent with the findings of this study. Person E could not access several locations because of the lack of ramps on the stairs. Person D reported preferring to stay in the immediate vicinity because of unknown barriers in other places.
Disabled people tend to travel shorter distances on foot or in wheelchairs than able-bodied people (Nizomutdinov 2022, S. 582). A positive correlation between barrier-free built environments and longer travel distances has been widely documented in recent studies (Frazila und Zukhruf 2018, S. 3; Schreuer et al. 2019, S. 2).

It can be assumed that a smaller mobility radius should not necessarily be considered negative. Concepts such as the 15-minute city even aim to reduce the mobility radius (Willberg et al. 2023). However, in the currently existing car-centred urban spaces, a reduction in the mobility radius leads to exclusion, discrimination, and low participation in city life (Schreuer et al. 2019, S. 2).
However, many studies fail to explain details or only use individual factors, such as the passage width of footpaths (Vale et al. 2013), for their calculation of walkability. This section addresses this research problem and answers the last research question, whether or not these aspects are already reflected in existing walkability indices or not.

Many of the findings were consistent with previous research on the walkability of disabled people. In addition, the interviews revealed other barriers or safety risks, which received little or no consideration in research (Table 3), particularly regarding the development of a walkability index. Therefore, this part is explicitly addressed to researchers in order to develop a more inclusive walkability index.

The table below shows the resulting aspects of this study, which should enhance existing walkability indices. It shows the results of the interviews as well as aspects from the literature that have not yet been included in the context of the walkability index. The factors were assigned to the categories 'Built Environment', 'Traffic and Safety' and 'Other'. The questions in the last column explain these aspects in greater detail.

Table 3: Additional Aspects for an Inclusive Walkability Index based on Own Research

	Factor	Questions/ Aspects
Built Environment	Construction Works	Is accessibility also ensured at temporary construction works?
	Sufficient Curb Ramps	Are curbs so well flattened that they are easily accessible with any type of mobile assistive device?
	Ramps at Stairs	Are staircases also equipped with ramps so that people using moad can also access them?
Traffic & Safety	Free Floating Vehicles	Do Free Floating Vehicles (E-Scooters, Bikes, etc.) drive or park on the path and thus pose an obstacle or a safety risk?
	Cyclists	Are cycle- and footpaths well separated from each other and do not pose a mutual safety risk?
	Noise (also in Maghelal und Capp 2011)	Is street noise having (negative) influence on the well-being, the quality of walkability or cause additional risks?
	Barrier-free Traffic Light Systems	Are traffic lights equipped with all important support signals (location signal, green phase signal, etc.) that make it possible for everyone to cross a traffic light safely?
	Crossing Time (also in Rosenberg et al. 2013)	Is the green phase for crossing pedestrian lights long enough so that people using moad can cross in a safely and relaxed manner?
Other	Temporary Obstacles (Blanchard et al. 2022)	To what extent do temporary obstacles (e-scooters, dustbins, etc.) influence pedestrian friendliness?

For the **Built Environment** category, construction sites have not yet been considered obstacles in the walkability index. One could argue that these are only of short duration. However, in reality, construction sites can last for several years. The longest construction site (in terms of distance) in the district of Neukölln (Berlin) on Karl-Marx-Strasse, for example, has been ongoing since 2008. It will not be completed before 2024 after 16 years of construction (Berlin Morning Post 2019). Even when a construction site is completed, another may form nearby.

Lowered curbs or curb ramps have already been considered in some indices, and the focus is mostly on quantity. However, the results showed that even lowered curbs could still be a barrier for people using moad. The indices have not yet made any statement about whether certain paths are not accessible because, for example, a ramp is missing in a staircase.

In the **Traffic and Safety category**, there were still gaps, mainly concerning the interaction of other road users. Merged cycle- and footpaths owing to construction sites or moving e-scooters on footpaths pose perceived safety risks. Noise has also been included in several walkability indices. However, these results provide a new perspective on the noise. Although it is rather unpleasant for people without disabilities to walk along a noisy street, loud traffic can drown out important acoustic signals for blind people and pose an additional safety risk.

Traffic lights must be equipped with all important auxiliary signals that enable people to cross the road safely. The length of the green phase must be chosen such that all people, regardless of their crossing speed, have the opportunity to cross safely and without stress. Temporary obstacles (waste bins, e-scooters, etc.) have not yet been considered in the walkability indices. However, for person A they formed barriers on the footpath.
This section provides suggestions for the expansion of an inclusive walkability index. The last part of the discussion critically reviews the results and considers possible limitations.

5.3 Limitations

As already described, people with disabilities are not a homogeneous group. It is important to consider as many types of needs as possible. Probably facing very different barriers than a person who uses a wheelchair was pointed out by person C.
In this study, five people with different disabilities were interviewed. They shed light on possible barriers to the everyday mobility of disabled people. However, it is not possible to draw conclusions regarding all people with disabilities. Each person deals with barriers differently, and what is a potential safety risk or barrier for one person is not necessarily the same for another.

Another point of criticism that weakens the results lies in the characteristics of mobile interviews. Although participants choose routes from their everyday routines, the reality of life in an interview situation cannot be reproduced or observed in exactly the same way. This criticism ties with the critic of Merriman (2014, S. 175–177), as explained in Section 3.2.
Two of the interviewees mentioned in the preliminary interview that they could "think of a few good examples" they would like to show. If the chosen route reflected a daily route of participants is questionable.
However, even though the routes chosen may not have been 100% in line with the target research design of everyday routes, they could still reveal barriers and situations that people with disabilities encounter in Berlin.

6 Conclusion

6.1 Recommended Actions

After the previous chapter discussed the results against the background of existing research, proposed aspects for an inclusive walkability index and mentioned possible limitations, this chapter derives possible conclusions. The chapter will discuss political recommendations for action, point out some need for further research, and close with a summary of the most important findings of this study.

6.1.1 Political Guidance

Improving the Built Environment

Section 5.2 elaborated on aspects that should be considered when developing an inclusive walkability index. These were mainly derived from the barriers or safety risks that arose during the interviews. These aspects serve as a good basis for the formulation of political recommendations to promote accessibility and increase pedestrian friendliness for disabled people.
The main issues for the built environment were the lack of dropped curbs, ground conditions, construction works, parking cars, missing barrier-free access to higher destinations with stairs, and missing tactile walking surface indicators.

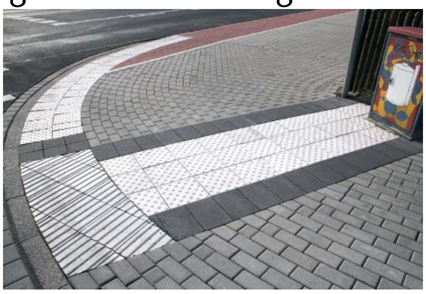

Figure 9: Pedestrian Crossing with Sufficiently Lowered Curb and TWSI; Source: Basamentsteine Böcke GmbH

It is recommended that curbs be lowered to improve the accessability of people using moad. Figure 9 shows a sufficiently lowered curb for both cyclists and pedestrians with tactile walking surface indicators. This extension should serve as a good model for intersections in Berlin's urban areas.

The Berlin Senate already recognised some of the problems and was already rebuilding a few intersections. However, it is emphasised that a complete barrier-free conversion is unrealistic because of a lack of financial resources, shortage of personnel, and limited capacity among construction companies (Berlin Senate 2023b).
Instead, the Senate cites some ‘positive examples’ where pedestrian crossings have been rebuilt at low cost and without much effort. Figure 10 shows an

example. Prohibition zones were also erected at these crossings to prevent illegal parking at pedestrian crossings.

Marking alone does not always prevent parking at a pedestrian crossing, as shown in the interview with person E. In this respect, the establishment of safe pedestrian crossings should go beyond merely marking pedestrian paths. This should include the erection of bollards, which would prevent cars from parking illegally.


Figure 10: Recently Redesigned Intersection with Pedestrian Crossing Markings; Source: Berlin Senate

The Senate asserts that currently insufficient resources (financial, personnel, construction) make it impossible to carry out a complete reconstruction of all intersections and crossings in the short term (Berlin Senate 2023b).

Instead, isolated model projects are promoted within the framework of the Mobility Act (Berlin Senate 2023a). In March 2020, it was decided that all traffic lights should be converted to barrier-free (German Association for the Blind and Visually Impaired 2023).

In the reconstruction of cycle lanes, the curbs are lowered, and extra pedestrian crossings are installed. This is initially positive. However, person C showed that even after a recently redesigned cycle lane with additionally lowered curbs, pedestrian friendliness does not necessarily increase for all people because of the gap of several centimetres between the curb and the road. This could pose a challenge for hand wheelchair users. Accessibility should be checked when implementing such measures.

The same applies to construction sites. As in the example of the lowered curbs, the theses posed in section 5.1.4 are confirmed. Barrier-free access seems to play a subordinate role, and is often not considered at all on construction sites.

Person E could not pass several ways, including an access to a train station [S-Bahn], because the stairs were not equipped with ramps. This is another example of the exclusion and discrimination of people with disabilities, as described in section 2.3. To reduce discrimination and promote inclusion, all stairs should be equipped with ramps or lifts. If long ramps are difficult to implement owing to building regulations, other solutions such as ‘stepped ramps’ may be possible. Tatano und Revellini (2023) make comprehensive proposals for solutions with ramps.

Section 5.1.1 comprehensively explained the central role of ground conditions when moving through public spaces for people with disabilities. From the perspective of accessibility and to prevent health damage from vibrations, policies to improve ground conditions should be sought and implemented. The expansion of twsi should be further promoted.

Mitigating Safety Risks

One of the main perceived safety risks was the interaction with other road users such as bikes (person E), e-scooter riders (person D & E) or cars (person E). Gössling und McRae (2022) investigated the perceived safety of active mobility users in Berlin. The results highlight the importance of separating cyclists from motorised and pedestrian traffic. The separation of individual traffic modes and the protection of 'weaker' traffic participants should be promoted and understood as the goal of a safe mobility system. Ultimately, all road users will benefit from this. The Berlin Mobility Act, with its Pedestrian and Cycling Plan, provides a good first basis for achieving these goals.

E-scooters and their (inappropriate) use, such as driving or parking on pavements, pose a safety risk, particularly for disabled people. The relatively new form of micromobility is a constant source of discussion in society, politics, and science. In Paris, these problems led to a majority speaking out against e-scooter rental. E-scooters will be banned in the city (Tagesschau [Daily News] 2023). In Germany, the city of Augsburg has set up fixed parking zones for e-scooters (Krog 2023).

Based on the results of this study, no comprehensive and unambiguous recommendations can be made regarding how to deal with e-scooters. However, policymakers should be aware of the dangers and hurdles of free-floating vehicles (e.g. E-scooters) and discuss solution approaches from other cities.

Learning from Existing Knowledge

Section 5.1.3 showed how people with disabilities adapt to inaccessible and ableist urban mobility systems. For this purpose, initiatives developed the open-source 'Wheelmap' or the platform 'BrokenLifts'. This helps people with disabilities assess buildings, lifts, places, surfaces, or parks according to their accessibility. These data are also valuable for city planners and politicians. Knowing at a glance where certain barriers are located helps create transparency and can provide useful information on where barriers need to be mitigated.

In addition, policymakers should involve people with disabilities in urban planning. This requires facilitating access to citizen participation. Section 5.1.4 indicates that people with disabilities are not yet sufficiently considered in urban planning or are able to join participation formats. Person C even hypothesised that the perspective of people with disabilities is not necessarily desired in urban planning.

It is equally important to bring the perspectives of people with disabilities into urban planning institutions to break down barriers and prevent them from arising in the first place. The 'Pedestrian Traffic Committee ' is mainly responsible for the development of the Pedestrian Traffic Plan in the city of Berlin. Organisations, such as 'Foot Association' [Fuß e. V.] or the 'German Association for the Blind and Visually Impaired' [Allgemeiner Blinden- und Sehbehindertenverein Berlin], are also part of the committee and contribute to the perspectives of disabled people.

Although perspectives are already partially considered in higher-level planning committees, there is still a lack of barrier-free access at the local level for public participation. Strategies on how people with disabilities can become more involved in participation formats should be developed. Even simple measures can aid in this regard. For example, invitations to participation formats should always be available in simple language and audio files.

6.1.2 Further Research

Section 5.2 has made proposals for an inclusive walkability index. Therefore, researchers should consider when designing walkability indices. However, these suggestions are not yet complete. This exploratory study aimed to collect initial suggestions for an inclusive walkability index. However, the results were based only on the perspectives of five people. Further research is needed to quantitatively validate these results. For example, the identified factors can be included in a walkability index to test their suitability.
As described above, people with disabilities face various barriers (person C; Schreuer et al. 2019, S. 8). Further research is needed to consider other perspectives of people with disabilities, such as those with nonphysical mobility disabilities.

For Berlin, there is only one study that applied a walkability index for the city (Bartzokas-Tsiompras und Photis 2020). It is based only on four variables: population and crossing density, proportion of land-use mix, and transit stop density. There is a need for research to apply a larger walkability index and gain more information about the pedestrian friendliness of a city.
The Dutch Mobility Agency Goudappel scientifically developed a 'Walkability Tool' with different variables. It is intended to record walkability in a simple and accessible manner. Such concepts can serve as the basis for empirical surveys in other cities.

One recommendation for politicians is to involve people with disabilities more in the planning and development of urban spaces. The same applies to science. Only a few studies included disabled people. Research should not be done "about them" but rather "with them".
It is recommended that people with disabilities be more involved in the knowledge-production process. Research results from able-bodied people can be valuable but are always subject to certain assumptions, prejudices, perspectives, or biases.
After giving recommendations to science and politics, the last section of this chapter will summarises the most important findings of this study and answers the research questions in conclusion.

6.2 Summary

This study explored the question of what barriers and perceived safety risks people with disabilities face in Berlin and to what extent these aspects are already integrated into the current concepts of walkability indices.
Five mobile interviews with disabled people revealed on the one hand that this group is particularly hindered in their daily mobility by high curbs, elevations, poor ground conditions, construction sites, noise, parked cars, and lack of access to certain areas.

However, they are exposed to safety risks such as non-barrier-free traffic lights or intersections, other road users such as cars or cyclists, and e-scooter users. People with disabilities have developed adaptation mechanisms at the individual and collective level to better navigate in urban infrastructures. They generally feel disadvantaged, marginalised, and experience discrimination in urban areas. Positive factors were car- and noise-free paths, greenery, and water.

Section 5.2 derived suggestions for researchers from the results by comparing them with existing walkability indices. Factors improving the inclusiveness of walkability indices are sufficient and well-developed curb ramps, ramps on stairs, and barrier-free construction sites. For perceived safety and traffic, aspects such as other road users (cycling and e-scooter users), noise, and barrier-free crossing options should be considered.
Possible limitations of the study are existing biases in route selection and the small sample size, where not all aspects could be investigated.

In addition to the proposals to science presented in Section 5.2, the last chapter discussed recommendations for action in politics and science. The most important recommendations for policymakers are the development of barrier-free intersections and crossings with sufficiently lowered curbs and tactile guidance systems, consideration of barrier-free construction sites, and the development of ramps on stairs.

The stricter separation of different road users minimises (perceived) safety risks. Policymakers should involve people with disabilities in urban infrastructure planning, and learn from their collective and individual knowledge.

Further research is needed on the quantitative validation of the results and the application of a more comprehensive and, inclusive walkability index for Berlin. Furthermore, studies that include people with disabilities in the research process are underrepresented. Researchers should involve people with disabilities in the process of knowledge generation.

To ultimately drive the urgently needed socio-ecological transformation of urban infrastructure, it will be important in the future to take greater account of the perspectives of people with disabilities and to make concepts such as the walkability index more inclusive.

7 References

Abenoza, Roberto F.; Liu, Chengxi; Cats, Oded; Susilo, Yusak O. (2019): What is the role of weather, built-environment and accessibility geographical characteristics in influencing travelers' experience? In: *Transportation Research Part A: Policy and Practice* 122, S. 34–50. DOI: 10.1016/j.tra.2019.01.026.

Ambrey, Christopher; Fleming, Christopher (2012): Public Greenspace and Life Satisfaction in Urban Australia. In: *Urban Studies* 51. DOI: 10.1177/0042098013494417.

Arai, Yuko; Kusakabe, Takahiko; Niwa, Yukari; Honma, Kentaro (2022): Evaluation of wheelchair accessibility in train stations using a spatial network. In: *Asian Transport Studies* 8. DOI: 10.1016/j.eastsj.2022.100067.

Arango, Jorge; Montufar, Jeannette (2008): Walking Speed of Older Pedestrians Who Use Canes or Walkers for Mobility. In: *Transportation Research Record* 2073, S. 79–85. DOI: 10.3141/2073-09.

Bartzokas-Tsiompras, Alexandros; Photis, Yorgos (2020): Does neighborhood walkability affect ethnic diversity in Berlin? Insights from a spatial modelling approach. In: *EJG* 11 (1), S. 163–187. DOI: 10.48088/ejg.a.bar.11.1.163.187.

Battista, Geoffrey A.; Manaugh, Kevin (2019): Generating walkability from pedestrians' perspectives using a qualitative GIS method. In: *Travel Behaviour and Society* 17, S. 1–7. DOI: 10.1016/j.tbs.2019.05.009.

Bell, Simon; Hamilton, V.; Montarzino, Alicia; Rothnie, H.; Travlou, P.; Alves, Susana (2008): Greenspace and quality of life: A critical review. In: *Transforming urban spaces*.

Bennett, Sean; Kirby, Ronald Lee; Macdonald, Blair (2009): Wheelchair accessibility: descriptive survey of curb ramps in an urban area. In: *Disability* *and rehabilitation. Assistive technology* 4 (1), S. 17–23. DOI: 10.1080/17483100802542603.

Bentzen, Billie Louise; Scott, Alan C.; Wall Emerson, Robert; Barlow, Janet M. (2020): Effect of Tactile Walking Surface Indicators on Travelers with Mobility Disabilities. In: *Transportation Research Record* 2674 (7), S. 410–419. DOI: 10.1177/0361198120922995.

Berlin Morning Post (2019): Karl-Marx-Straße in Neukölln - Umbau wird noch Jahre dauern. In: *Berliner Morgenpost*, 04.05.2019. Online verfügbar unter https://www.morgenpost.de/bezirke/neukoelln/article217080647/Karl-Marx-Strasse-in-Neukoelln-Umbau-wird-noch-Jahre-dauern.html, zuletzt geprüft am 10.07.2023.

Berlin Newspaper (2019): Verkehr in Berlin: So viele Baustellen gibt es auf Berlins Straßen. In: *Berliner Zeitung*, 12.10.2019. Online verfügbar unter https://www.berliner-zeitung.de/mensch-metropole/verkehr-in-berlin-so-viele-baustellen-gibt-es-auf-berlins-strassen-li.33823, zuletzt geprüft am 07.06.2023.

Berlin Senate (2018): Berlin Mobility Law. Online verfügbar unter https://gesetze.berlin.de/bsbe/document/jlr-MobGBErahmen.

Berlin Senate (2023a): Modellprojekte für den Fußverkehr. Online verfügbar unter https://www.berlin.de/sen/uvk/mobilitaet-und-verkehr/verkehrsplanung/fussverkehr/fussverkehrsprojekte/modellprojekte/, zuletzt aktualisiert am 25.05.2023, zuletzt geprüft am 11.07.2023.

Berlin Senate (2023b): Sichere Kreuzungen. Online verfügbar unter https://www.berlin.de/ba-mitte/politik-und-verwaltung/aemter/strassen-und-gruenflaechenamt/planung-entwurf-neubau/sichere-kreuzungen-1236832.php, zuletzt aktualisiert am 21.06.2023, zuletzt geprüft am 10.07.2023.

Blach Rossen, Camilla; Sørensen, Bodil; Würtz Jochumsen, Bente; Wind, Gitte (2012): Everyday life for users of electric wheelchairs - a qualitative interview study. In: *Disability and rehabilitation. Assistive technology* 7 (5), S. 399–407. DOI: 10.3109/17483107.2012.665976.

Blanchard, Enka; Duvivier, David; Kolski, Christophe; Lepreux, Sophie (2022): Towards a Framework for Detecting Temporary Obstacles and Their Impact on Mobility for Diversely Disabled Users. In: Heidi Krömker (Hg.): HCI in Mobility, Transport, and Automotive Systems, Bd. 13335. Cham: Springer International Publishing (Lecture Notes in Computer Science), S. 475–488.

Brown, Anne; Klein, Nicholas J.; Thigpen, Calvin; Williams, Nicholas (2020): Impeding access: The frequency and characteristics of improper scooter, bike, and car parking. In: *Transportation Research Interdisciplinary Perspectives* 4. DOI: 10.1016/j.trip.2020.100099.

Bucko, Agnes G.; Porter, Dwayne E.; Saunders, Ruth; Shirley, Lynn; Dowda, Marsha; Pate, Russell R. (2021): Walkability indices and children's walking behavior in rural vs. urban areas. In: *Health & place* 72. DOI: 10.1016/j.healthplace.2021.102707.

Campisi, Tiziana; Ignaccolo, Matteo; Inturri, Giuseppe; Tesoriere, Giovanni; Torrisi, Vincenza (2021): Evaluation of walkability and mobility requirements of visually impaired people in urban spaces. In: *Research in Transportation Business & Management* 40 (24). DOI: 10.1016/j.rtbm.2020.100592.

Carlsson, Anna; Lundälv, Jörgen (2019): Acute injuries resulting from accidents involving powered mobility devices (PMDs)—Development and outcomes of PMD-related accidents in Sweden. In: *Traffic Injury Prevention* 20 (5), S. 484–491. DOI: 10.1080/15389588.2019.1606910.

Carvalho, Lucila; Freeman, Cristina Garduño (2018): CmyView: Learning by Walking and Sharing Social Values. In: Nina Bonderup Dohn, Susan Cranmer, Julie-Ann Sime, Maarten de Laat und Thomas Ryberg (Hg.): Networked Learning: Reflections and Challenges. Cham: Springer International Publishing, S. 167–186.

Christofa, Eleni; Ganz, Aura; Knodler, Michael A.; Wolfgram, Joshua; Fournier, Nicholas (2017): Visually Impaired Pedestrian Safety at Roundabout Crossings. Unter Mitarbeit von University of Massachusetts at Amherst. Dept. of Civil and Environmental Engineering und University of Massachusetts at Amherst. Online verfügbar unter https://rosap.ntl.bts.gov/view/dot/34548.

Cope, Meghan; Elwood, Sarah (Hg.) (2009): Qualitative GIS. A mixed methods approach. Los Angeles, London, New Delhi, Singapore, Washington DC: SAGE.

Creutzig, Felix; Javaid, Aneeque; Soomauroo, Zakia; Lohrey, Steffen; Milojevic-Dupont, Nikola; Ramakrishnan, Anjali et al. (2020): Fair street space allocation: ethical principles and empirical insights. In: *Transport Reviews* 40 (6), S. 711–733. DOI: 10.1080/01441647.2020.1762795.

Duvall, Jonathan; Sinagra, Eric; Cooper, Rory; Pearlman, Jonathan (2016): Proposed pedestrian pathway roughness thresholds to ensure safety and comfort for wheelchair users. In: *Assistive Technology* 28 (4), S. 209–215. DOI: 10.1080/10400435.2016.1150364.

Egen, Christoph (2020): Was ist Behinderung? Abwertung und Ausgrenzung von Menschen mit Funktionseinschränkungen vom Mittelalter bis zur Postmoderne. Bielefeld: transcript (Medical humanities (Transcript (Firm)), Band 7).

Erturan, Arzu; van der Spek, Stefan Christiaan (2022): Walkability analyses of Delft city centre by Go-Along walks and testing of different design scenarios for a more walkable environment. In: *Journal of Urban Design* 27 (3), S. 287–309. DOI: 10.1080/13574809.2021.1988543.

Ewing, Reid; Cervero, Robert (2010): Travel and the Built Environment. In: *Journal of the American Planning Association* 76 (3), S. 265–294. DOI: 10.1080/01944361003766766.

Federal Ministry of Justice (2023): Personenbeförderungsgesetz [Passenger Transport Act].

Federal Statistical Office (Hg.) (2022): 7,8 Millionen schwerbehinderte Menschen leben in Deutschland. Online verfügbar unter https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/06/PD22_259_227.html, zuletzt aktualisiert am 22.06.2022, zuletzt geprüft am 27.06.2023.

Frank, Lawrence; Kerr, Jacqueline; Chapman, Jim; Sallis, James (2007): Urban form relationships with walk trip frequency and distance among youth. In: *American journal of health promotion : AJHP* 21 (4 Suppl), S. 305–311. DOI: 10.4278/0890-1171-21.4s.305.

Franke, Thea; Winters, Meghan; McKay, Heather; Chaudhury, Habib; Sims-Gould, Joanie (2017): A grounded visualization approach to explore sociospatial and temporal complexities of older adults' mobility. In: *Social Science & Medicine* 193, S. 59–69. DOI: 10.1016/j.socscimed.2017.09.047.

Frazila, Russ Bona; Zukhruf, Febri (2018): Exploring physical attributes of walkability from perspective of blind pedestrians. In: *MATEC Web Conf.* 147. DOI: 10.1051/matecconf/201814702002.

Gamache, Stéphanie; Routhier, François; Morales, Ernesto; Vandersmissen, Marie-Hélène; Boucher, Normand (2019): Mapping review of accessible pedestrian infrastructures for individuals with physical disabilities. In: *Disability and rehabilitation. Assistive technology* 14 (4), S. 410–422. DOI: 10.1080/17483107.2018.1449018.

Gan, Daniel R. Y.; Mahmood, Atiya; Routhier, François; Mortenson, W. Ben (2022): Walk/Wheelability: An Inclusive Instrument Pair for Participatory Age-Friendly Research and Practice. In: *The Gerontologist* 62 (1), e39-e47. DOI: 10.1093/geront/gnab079.

Geels, Frank W. (2012): Automobility in transition? A socio-technical analysis of sustainable transport. New York: Routledge (Routledge studies in sustainability transitions, 2).

German Association for the Blind and Visually Impaired (Hg.) (2023): Die Blindenampel | ABSV. Online verfügbar unter https://www.absv.de/die-blindenampel, zuletzt aktualisiert am 23.05.2023, zuletzt geprüft am 23.05.2023.

Gössling, Stefan; McRae, Sophia (2022): Subjectively safe cycling infrastructure: New insights for urban designs. In: *Journal of Transport Geography* 101. DOI: 10.1016/j.jtrangeo.2022.103340.

Guzman, Luis A.; Arellana, Julian; Castro, William Felipe (2022): Desirable streets for pedestrians: Using a street-level index to assess walkability. In: *Transportation Research Part D: Transport and Environment* 111 (10). DOI: 10.1016/j.trd.2022.103462.

Guzman, Luis A.; Peña, Javier; Carrasco, Juan Antonio (2020): Assessing the role of the built environment and sociodemographic characteristics on walking travel distances in Bogotá. In: *Journal of Transport Geography* 88. DOI: 10.1016/j.jtrangeo.2020.102844.

Henje, Catharina; Stenberg, Gunilla; Lundälv, Jörgen; Carlsson, Anna (2021): Obstacles and risks in the traffic environment for users of powered wheelchairs in Sweden. In: *Accident; analysis and prevention* 159. DOI: 10.1016/j.aap.2021.106259.

Hersh, Marion; Ohene-Djan, James; Naqvi, Saduf (2010): Investigating road safety issues and deaf people in the United kingdom: an empirical study and recommendations for good practice. In: *Journal of prevention & intervention in the community* 38 (4), S. 290–305. DOI: 10.1080/10852352.2010.509021.

Horak, Jiri; Kukuliac, Pavel; Maresova, Petra; Orlikova, Lucie; Kolodziej, Ondrej (2022): Spatial Pattern of the Walkability Index, Walk Score and Walk Score Modification for Elderly. In: *IJGI* 11 (5), S. 279. DOI: 10.3390/ijgi11050279.

infas (2018): Mobilität in Dutschland 2017 - Ergebnisbericht.

Kapsalis, Efthimis; Jaeger, Nils; Hale, Jonathan (2022): Disabled-by-design: effects of inaccessible urban public spaces on users of mobility assistive devices - a systematic review. In: *Disability and rehabilitation. Assistive technology*, S. 1–19. DOI: 10.1080/17483107.2022.2111723.

Kim, Hyungkyoo; Sohn, Dongwook (2020): The urban built environment and the mobility of people with visual impairments: analysing the travel behaviours based on mobile phone data. In: *Journal of Asian Architecture and Building Engineering* 19 (6), S. 731–741. DOI: 10.1080/13467581.2020.1779727.

Krog, Stefan (2023): Augsburg: Ab jetzt gelten die Abstellzonen für E-Scooter in der Innenstadt. In: *Augsburger Allgemeine*, 30.05.2023, zuletzt geprüft am 12.07.2023.

Kusenbach, Margarethe (2003): Street phenomenology: The go-along as ethnographic research tool. In: *Ethnography* 4 (3), S. 455–485. Online verfügbar unter http://www.jstor.org/stable/24047846.

Kwan, Mei-Po (2012a): How GIS can help address the uncertain geographic context problem in social science research. In: *Annals of GIS* 18 (4), S. 245–255. DOI: 10.1080/19475683.2012.727867.

Kwan, Mei-Po (2012b): The Uncertain Geographic Context Problem. In: *Annals of the Association of American Geographers* 102 (5), S. 958–968. DOI: 10.1080/00045608.2012.687349.

Lariviere, Ophélie; Chadefaux, Delphine; Sauret, Christophe; Thoreux, Patricia (2021): Vibration Transmission during Manual Wheelchair Propulsion: A

Systematic Review. In: *Vibration* 4 (2), S. 444–481. DOI: 10.3390/vibration4020029.

Larranaga, Ana Margarita; Arellana, Julián; Rizzi, Luis Ignacio; Strambi, Orlando; Cybis, Helena Beatriz Bettella (2019): Using best–worst scaling to identify barriers to walkability: a study of Porto Alegre, Brazil. In: *Transportation* 46 (6), S. 2347–2379. DOI: 10.1007/s11116-018-9944-x.

Latz, Christian (2023): Unterirdischer Zeitplan: Berlins U-Bahn wird erst 2028 vollständig barrierefrei. In: *Der Tagesspiegel*, 07.07.2023. Online verfügbar unter https://checkpoint.tagesspiegel.de/telegramm/2SbExk2rWrQpNuCW5BjiFw?utm_source=tagesspiegel&utm_medium=hp-teaser&utm_campaign=berlins-u-bahnhoefe-fruehestens-2028-barrierefrei, zuletzt geprüft am 18.07.2023.

Li, Yuan; Guan, Dabo; Tao, Shu; Wang, Xuejun; He, Kebin (2018): A review of air pollution impact on subjective well-being: Survey versus visual psychophysics. In: *Journal of Cleaner Production* 184, S. 959–968. DOI: 10.1016/j.jclepro.2018.02.296.

Liao, Chen-Fu (2013): Using a Smartphone Application to Support Visually Impaired Pedestrians at Signalized Intersection Crossings. In: *Transportation Research Record* 2393 (1), S. 12–20. DOI: 10.3141/2393-02.

Lloyd, Mike (2023): Problems on the pavement?: A study of E-scooterists amongst co-movers. In: *Applied Mobilities*, S. 1–21. DOI: 10.1080/23800127.2023.2214751.

López-Lambas, M. Eugenia; Sánchez, J. Manuel; Alonso, Andrea (2021): The walking health: A route choice model to analyze the street factors enhancing active mobility. In: *Journal of Transport & Health* 22. DOI: 10.1016/j.jth.2021.101133.

M. C. Ghilardi; G. Simões; J. Wehrmann; I. H. Manssour; R. C. Barros (2018): Real-Time Detection of Pedestrian Traffic Lights for Visually-Impaired People. In:

2018 International Joint Conference on Neural Networks (IJCNN). 2018 International Joint Conference on Neural Networks (IJCNN), S. 1–8.

Ma, Gloria Yuet Kwan; Mak, Winnie W. S. (2023): Maintenance of ableist society for wheelchair users: roles of medical model of disability and witnessed negotiation for accessibility. In: *Disability & Society*, S. 1–26. DOI: 10.1080/09687599.2023.2209277.

Maghelal, Praveen; Capp, Cara Jean (2011): Walkability: A Review of Existing Pedestrian Indices. In: *URISA Journal* 23 (2), S. 5–19.

Manderscheid, Katharina (2019): Mobile Methods. In: Nina Baur und Jörg Blasius (Hg.): Handbuch Methoden der empirischen Sozialforschung. Wiesbaden: Springer Fachmedien Wiesbaden, S. 1361–1370.

Manderscheid, Katharina (2022): Soziologie der Mobilität. Bielefeld: UTB; transcript (utb Soziologie, 5581).

Marquart, Heike; Stark, Kerstin; Jarass, Julia (2022): How are air pollution and noise perceived en route? Investigating cyclists' and pedestrians' personal exposure, wellbeing and practices during commute. In: *Journal of Transport & Health* 24 (12). DOI: 10.1016/j.jth.2021.101325.

Marquart, Heike; Ueberham, Maximilian; Schlink, Uwe (2021): Extending the dimensions of personal exposure assessment: A methodological discussion on perceived and measured noise and air pollution in traffic. In: *Journal of Transport Geography* 93 (2). DOI: 10.1016/j.jtrangeo.2021.103085.

Mayring, Philipp; Fenzl, Thomas (2019): Qualitative Inhaltsanalyse. In: Nina Baur und Jörg Blasius (Hg.): Handbuch Methoden der empirischen Sozialforschung. Wiesbaden: Springer Fachmedien Wiesbaden, S. 633–648.

Mediastika, Christina E.; Sudarsono, Anugrah S.; Kristanto, Luciana (2022): The sound perceptions of urban pavements by sighted and visually impaired people – a case study in Surabaya, Indonesia. In: *Journal of Urbanism: International*

Research on Placemaking and Urban Sustainability 15 (1), S. 106–129. DOI: 10.1080/17549175.2020.1834436.

Merriman, Peter (2014): Rethinking Mobile Methods. In: *Mobilities* 9 (2), S. 167–187. DOI: 10.1080/17450101.2013.784540.

Molina-García, Javier; Campos, Sergio; García-Massó, Xavier; Herrador-Colmenero, Manuel; Gálvez-Fernández, Patricia; Molina-Soberanes, Daniel et al. (2020): Different neighborhood walkability indexes for active commuting to school are necessary for urban and rural children and adolescents. In: *The international journal of behavioral nutrition and physical activity* 17 (1), S. 124. DOI: 10.1186/s12966-020-01028-0.

Moradi, Afsaneh; Vagnoni, Emidia (2018): A multi-level perspective analysis of urban mobility system dynamics: What are the future transition pathways? In: *Technological Forecasting and Social Change* 126, S. 231–243. DOI: 10.1016/j.techfore.2017.09.002.

Morris, Stephanie; Guell, Cornelia; Pollard, Tessa M. (2019): Group walking as a "lifeline": Understanding the place of outdoor walking groups in women's lives. In: *Social science & medicine (1982)* 238. DOI: 10.1016/j.socscimed.2019.112489.

Moura, Filipe; Cambra, Paulo; Gonçalves, Alexandre B. (2017): Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. In: *Landscape and Urban Planning* 157, S. 282–296. DOI: 10.1016/j.landurbplan.2016.07.002.

Münzel, Thomas; Schmidt, Frank P.; Steven, Sebastian; Herzog, Johannes; Daiber, Andreas; Sørensen, Mette (2018): Environmental Noise and the Cardiovascular System. In: *Journal of the American College of Cardiology* 71 (6), S. 688–697. DOI: 10.1016/j.jacc.2017.12.015.

NABU [Nature Conservation Union] (2022): Stadtnatur statt Versiegelung! Positionen und Forderungen des NABU-Landesverbands Berlin für die Zukunftsstadt Berlin.

Nizomutdinov, Boris (2022): Development of a method for constructing social routes for people with limited mobility. In: Luís Amaral, Delfina Soares, Lei Zheng, Mário Peixoto und Cristina Braga (Hg.): 15th International Conference on Theory and Practice of Electronic Governance. ICEGOV 2022: 15th International Conference on Theory and Practice of Electronic Governance. Guimarães Portugal. New York, NY, USA: ACM, S. 582–584.

Office for Statistics Berlin - Brandenburg (Amt für Statistik Berlin - Brandenburg) (2023): Schwerbehinderte Menschen in Berlin und Brandenburg. Online verfügbar unter https://www.statistik-berlin-brandenburg.de/k-iii-1-2j, zuletzt aktualisiert am 18.07.2023, zuletzt geprüft am 18.07.2023.

Parent, Laurence (2016): The wheeling interview: mobile methods and disability. In: *Mobilities* 11 (4), S. 521–532. DOI: 10.1080/17450101.2016.1211820.

Pavlovskaya, Marianna (2016): Qualitative GIS. In: Douglas Richardson, Noel Castree, Michael F. Goodchild, Audrey Kobayashi, Weidong Liu und Richard A. Marston (Hg.): International Encyclopedia of Geography: People, the Earth, Environment and Technology. Oxford, UK: John Wiley & Sons, Ltd, S. 1–11.

Pecchini, Dario; Giuliani, Felice (2015): Street-Crossing Behavior of People with Disabilities. In: *Journal of Transportation Engineering* 141 (10). DOI: 10.1061/(ASCE)TE.1943-5436.0000782.

Pettersson, Cecilia; Baudin, Katarina; Hedvall, Per-Olof (2022): The struggle for access - a qualitative document study of how people using wheeled mobility devices experience exclusion and discrimination. In: *Disability and rehabilitation. Assistive technology*, S. 1–9. DOI: 10.1080/17483107.2022.2107094.

Pozoukidou, Georgia; Angelidou, Margarita (2022): Urban Planning in the 15-Minute City: Revisited under Sustainable and Smart City Developments until 2030. In: *Smart Cities* 5 (4), S. 1356–1375. DOI: 10.3390/smartcities5040069.

Prescott, Mike; Labbé, Delphine; Miller, William C.; Borisoff, Jaimie; Feick, Robert; Mortenson, William Ben (2020): Factors that affect the ability of people with disabilities to walk or wheel to destinations in their community: a scoping review. In: *Transport Reviews* 40 (5), S. 646–669. DOI: 10.1080/01441647.2020.1748139.

Rosenberg, Dori E.; Huang, Deborah L.; Simonovich, Shannon D.; Belza, Basia (2013): Outdoor built environment barriers and facilitators to activity among midlife and older adults with mobility disabilities. In: *The Gerontologist* 53 (2), S. 268–279. DOI: 10.1093/geront/gns119.

Sarmiento, Olga L.; Useche, Andrés F.; Rodriguez, Daniel A.; Dronova, Iryna; Guaje, Oscar; Montes, Felipe et al. (2021): Built environment profiles for Latin American urban settings: The SALURBAL study. In: *PloS one* 16 (10), e0257528. DOI: 10.1371/journal.pone.0257528.

Scherf, ChristianVE; Knie, Andreas; Ruhrort, Lisa (2018): Erloschene Liebe? Das Auto in der Verkehrswende: Soziologische Deutungen.

Schöne, Andrea (2022): Behinderung & Ableismus. 1. Auflage. Münster: Unrast (unrast transparent - linker alltag, Band 6).

Schreuer, Naomi; Plaut, Pnina; Golan, Lihi; Sachs, Dalia (2019): The relations between walkable neighbourhoods and active participation in daily activities of people with disabilities. In: *Journal of Transport & Health* 15 (31). DOI: 10.1016/j.jth.2019.100630.

Sheller, Mimi; Urry, John (2006): The New Mobilities Paradigm. In: *Environ Plan A* 38 (2), S. 207–226. DOI: 10.1068/a37268.

Sheller, Mimi; Urry, John (2016): Mobilizing the new mobilities paradigm. In: *Applied Mobilities* 1 (1), S. 10–25. DOI: 10.1080/23800127.2016.1151216.

Shields, Rob; Gomes da Silva, Edmar Joaquim; Lima e Lima, Thiago; Osorio, Nathalia (2023): Walkability: a review of trends. In: *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 16 (1), S. 19–41. DOI: 10.1080/17549175.2021.1936601.

Shukla, P.R.; Skea, J.; Slade, R.; Al Khourdajie, A.; van Diemen, R.; McCollum, D. et al. (2022): IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Online verfügbar unter https://www.ipcc.ch/report/ar6/wg3/about/how-to-cite-this-report/.

Smyth, Russell; Nielsen, Ingrid; Zhai, Qingguo; Liu, Tiemin; Liu, Yin; Tang, Chunyong et al. (2011): A study of the impact of environmental surroundings on personal well-being in urban China using a multi-item well-being indicator. In: *Population and Environment* 32 (4), S. 353–375. DOI: 10.1007/s11111-010-0123-z.

Social Welfare Association (2023): Barrierefreiheit im Verkehr. Positionspapier.

Stock, Robert (2023): Broken elevators, temporalities of breakdown, and open data: how wheelchair mobility, social media activism and situated knowledge negotiate public transport systems. In: *Mobilities* 18 (1), S. 132–147. DOI: 10.1080/17450101.2022.2057810.

Su, Z.; Woodman, R.; Smyth, J.; Elliott, M. (2023): The relationship between aggressive driving and driver performance: A systematic review with meta-analysis. In: *Accident Analysis and Prevention* 183. DOI: 10.1016/j.aap.2023.106972.

Tagesschau [Daily News] (2023): Pariser stimmen für Verbot von E-Scooter-Verleih. In: *tagesschau.de*, 03.04.2023. Online verfügbar unter https://www.tagesschau.de/ausland/europa/paris-e-scooter-verbot-101.html, zuletzt geprüft am 12.07.2023.

Tatano, Valeria; Revellini, Rosaria (2023): An alternative system to improve accessibility for wheelchair users: The stepped ramp. In: *Applied Ergonomics* 108. DOI: 10.1016/j.apergo.2022.103938.

TU Dresden (Hg.) (2019): Mobility in cities. Online verfügbar unter https://tu-dresden.de/bu/verkehr/ivs/srv, zuletzt aktualisiert am 17.07.2023, zuletzt geprüft am 17.07.2023.

United Nations (2007): Convention on the Rights of Persons with Disabilities.

Urry, John (2004): The 'System' of Automobility. In: *Theory, Culture & Society* 21 (4-5), S. 25–39. DOI: 10.1177/0263276404046059.

Vale, David S.; Saraiva, Miguel; Pereira, Mauro (2013): Active accessibility: A review of operational measures of walking and cycling accessibility. In: *JTLU*. DOI: 10.5198/jtlu.2015.593.

Volker, Jamey M. B.; Handy, Susan (2021): Economic impacts on local businesses of investments in bicycle and pedestrian infrastructure: a review of the evidence. In: *Transport Reviews* 41 (4), S. 401–431. DOI: 10.1080/01441647.2021.1912849.

WHO (2018): Environmental noise guidelines for European Region. Copenhagen: WHO Regional Office for Europe.

Willberg, Elias; Fink, Christoph; Toivonen, Tuuli (2023): The 15-minute city for all? – Measuring individual and temporal variations in walking accessibility. In: *Journal of Transport Geography* 106. DOI: 10.1016/j.jtrangeo.2022.103521.

Wong, Sandy (2018): Traveling with blindness: A qualitative space-time approach to understanding visual impairment and urban mobility. In: *Health & place* 49, S. 85–92. DOI: 10.1016/j.healthplace.2017.11.009.

Wridt, Pamela (2010): A Qualitative GIS Approach to Mapping Urban Neighborhoods with Children to Promote Physical Activity and Child-Friendly Community Planning. In: *Environment and Planning B: Planning and Design* 37 (1), S. 129–147. DOI: 10.1068/b35002.

XIII Straßenverkehr (2023). Online verfügbar unter https://www.dbsv.org/xiii-stra%C3%9Fenverkehr.html, zuletzt aktualisiert am 08.06.2023, zuletzt geprüft am 08.06.2023.

Zare Sakhvidi, Fariba; Zare Sakhvidi, Mohammad Javad; Mehrparvar, Amir Houshang; Dzhambov, Angel M. (2018): Environmental Noise Exposure and Neurodevelopmental and Mental Health Problems in Children: a Systematic Review. In: *Current Environmental Health Reports* 5 (3), S. 365–374. DOI: 10.1007/s40572-018-0208-x.