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Barrier-Free Mobility: Public Transport Accessibility as a Determinant of MaaS Implementation in Poland

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Abstract

Ensuring accessible and inclusive urban mobility systems remains a key challenge for contemporary cities, particularly in the context of passengers with disabilities whose mobility strongly depends on the accessibility of public transport systems. At the same time, the concept of Mobility-as-a-Service (MaaS) is increasingly promoted as a framework for integrating different transport services through digital platforms. However, existing research on MaaS has predominantly focused on technological and organisational aspects, while the role of physical accessibility of public transport infrastructure in shaping cities' readiness to implement MaaS solutions remains underexplored.

This study aims to assess the readiness of selected Polish cities to implement the MaaS concept from the perspective of public transport accessibility. A two-level accessibility assessment framework was applied, examining both the accessibility of public transport stop infrastructure and accessibility experienced during public transport journeys. The analysis is based on participant observation conducted in five Polish cities belonging to the Union of Polish Metropolises. Accessibility indicators were evaluated using a binary approach and aggregated into several accessibility dimensions.

The results reveal substantial differences in accessibility conditions between cities and between stop infrastructure and in-vehicle accessibility. The findings highlight that the effective implementation of MaaS requires not only digital integration of mobility services but also consistent accessibility standards across the entire public transport system.

Keywords: urban mobility; Mobility-as-a-Service; public transport; transport accessibility; urban transport policies

1 Introduction

Passenger transport is one of the most important areas of urban functioning. It enables the physical movement of people for various purposes, allowing them to meet their daily needs. This is particularly important from the perspective of people with disabilities, whose mobility is largely determined by the level of accessibility of transport systems. In recent years, a user-oriented approach has increasingly been adopted, in which the priority is to ensure the possibility of safe movement within the city using different modes of transport for all user groups, including people with disabilities. Their needs and expectations differ from those expressed by people without disabilities. Currently, in cities around the world, the dominant mode of transport is the private car, which is often the most accessible form of transport for people with disabilities. However, the excessive number of cars in urban areas contributes to congestion, emissions of particulate matter and exhaust gases, noise pollution, and the degradation of urban infrastructure (Lopez-Aparicio et al., 2025). Another challenge is the relatively low accessibility of public transport, resulting from the underdeveloped road and transport infrastructure (Lowe et al., 2022). The implementation of sustainable mobility principles aims to address these problems by balancing environmental, economic, and social objectives (Niemets et al., 2021).

One of the manifestations of sustainable urban mobility is the concept of Mobility-as-a-Service (MaaS). It represents a new approach to urban mobility, assuming the full integration of transport services within a single mobile application (Sakai, 2019). From the perspective of people with disabilities, MaaS may become a tool for reducing barriers in everyday mobility, thereby improving their quality of life. At the same time, the improper

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design of MaaS solutions may deepen existing inequalities and further increase the marginalisation of these individuals. Despite growing interest in MaaS, most existing studies focus on the technological and organisational aspects of MaaS systems, such as digital platforms, service integration, and business models. Relatively little attention has been given to the impact of the physical accessibility of public transport infrastructure and vehicles on cities' readiness to implement MaaS solutions. This gap is particularly evident when it comes to passengers with diverse mobility needs, including people with disabilities, who are highly dependent on the accessibility of the underlying transport system to benefit from MaaS. The main objective of the study was to examine the level of readiness of Polish cities to implement the MaaS concept in the context of adapting public transport stops and vehicles to the needs of people with disabilities. This objective stems from a research gap related to the limited number of Polish publications on the implementation of MaaS and the insufficient consideration of people with disabilities within the MaaS context.

The remainder of the article is organised as follows: first, the literature on the mobility challenges faced by disabled people and the concept of MaaS is reviewed. This is followed by a description of the methodology and the two-level accessibility assessment framework applied in the study. The subsequent sections present the empirical results and conclusions.

2 Literature review

2.1 Challenges in mobility for people with disabilities

High-quality urban living depends on mobility and accessibility. However, people with disabilities often experience limited mobility due to their impairments and shortcomings in the transport system. People with different types of disabilities make fewer trips on average and travel shorter distances than people without disabilities (Park & Chowdhury, 2018), and the most frequently chosen mode of transport is the private car (Mijailović et al., 2024). This may contribute to the intensification of urban problems associated with the excessive number of cars, including congestion and air pollution. Difficulties in travelling not only lead to social exclusion but are also associated with a reduction in the potential activity space (Casas, 2007). People with disabilities can reach only selected places and services, which results in reduced living space and access to resources.

People with disabilities do not constitute a homogeneous group. Several categories can be distinguished: (1) people with difficulties in standing or walking, (2) people using a wheelchair or mobility aids such as a cane, (3) people with hearing or visual impairments, and (4) people with intellectual disabilities (Casas, 2007). Disability is associated with limitations in an individual's activities and restrictions in participation in community life. Women with disabilities are particularly vulnerable to exclusion, as they are less likely than men to drive private cars and more often require assistance from others when travelling (Mijailović et al., 2024). People with disabilities more often experience stressful situations related to prejudice. Consequently, some individuals deliberately avoid travelling by public transport or even leaving their homes (Mogaji et al., 2023).

The mobility of people with disabilities varies greatly. People with hearing and visual impairments travel significantly less frequently over long distances (Casas, 2007), which makes accessing services difficult. In contrast, people with intellectual disabilities, particularly those experiencing heightened anxiety, more often choose small private cars (Sharma et al., 2026). People with disabilities more often choose their own car for short-distance travel, while longer journeys are more frequently undertaken using public transport (Park & Chowdhury, 2018). It should also be noted that people with disabilities are more sensitive to travel time and are more mobile when travel time does not exceed 11 minutes (Mitropoulos, Karolemeas, et al., 2023). The mode of transport is also important. People with disabilities prefer direct journeys (Mogaji et al., 2024). This is mainly due to infrastructural barriers occurring at transfer hubs, difficulties in understanding or finding information, and concerns about excessive interactions with other users. It should also be noted that people with disabilities more frequently use mobile applications and journey planners (Rickly et al., 2021), which allows better preparation for the journey. People with disabilities face numerous barriers in public transport. Figure 1 shows the most significant barriers, which can be categorised as environmental, infrastructural, socio-cultural, or transport-related.

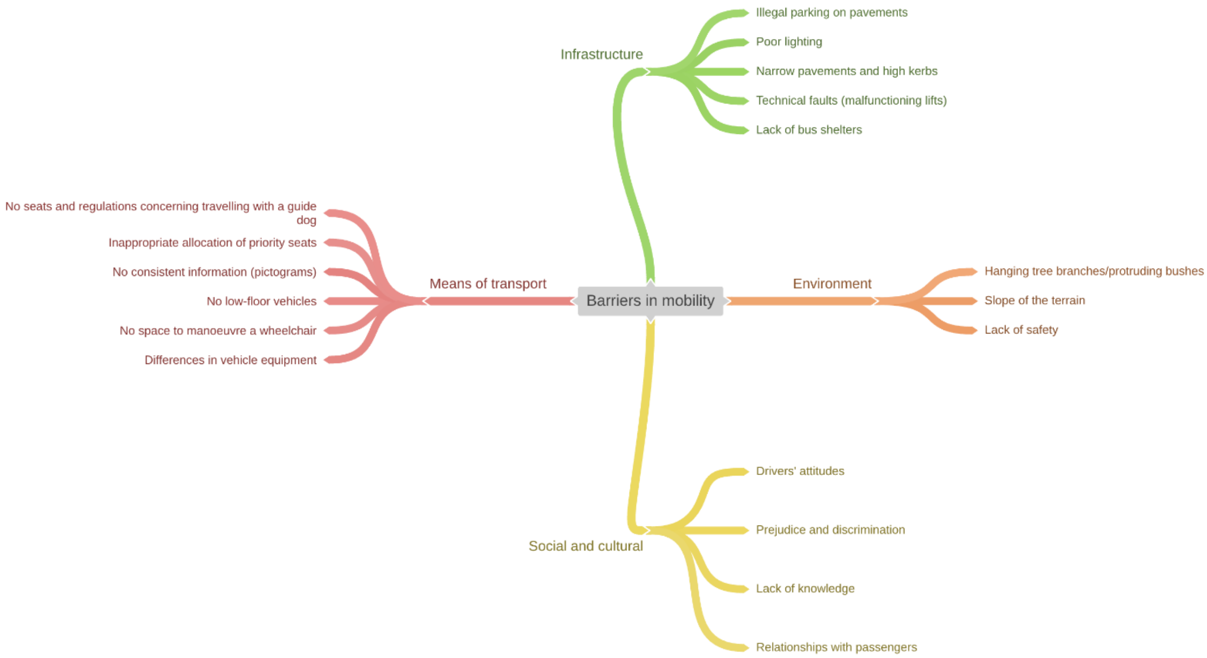

Figure 1. Barriers to mobility for people with disabilities
Source: own elaboration based on literature review.

Limitations in travelling contribute to the lower mobility of people with disabilities. It is necessary to undertake remedial actions aimed at increasing the accessibility of public transport. These actions may involve increasing the independence of people with disabilities by facilitating the undertaking of paid employment (Casas, 2007), inclusive design of vehicles and public spaces (Sharma et al., 2026), increasing flexibility in travel, including multimodal journeys (Mijailović et al., 2024), implementing digital solutions and mobile applications for travel planning for people with disabilities (Mogaji et al., 2023) as well as by initiating social campaigns concerning people with disabilities and their needs in the context of travel (Rickly et al., 2021). The role of municipal authorities and public transport operators is to increase the participation of people with disabilities in the life of local communities, which can only be achieved through the development of more accessible and sustainable public transport systems in cities.

2.2 The MaaS concept as a solution for improving accessibility

A sustainable and accessible urban transport system should offer users multiple modes of transport within transparent fare structures, while simultaneously providing access to real-time information and well-developed infrastructure (Okraszewska et al., 2018). However, achieving full transport integration also requires measures related to the development of transport policies and strategies. An example of such integration in urban transport systems is the MaaS concept, which was first described in 2014 (Aba & Esztergár-Kiss, 2024; Sakai, 2020). Initially, it was defined as a comprehensive mobility service enabling, among other things, journey planning and ticket purchasing within mobility packages. At that time, the user-oriented nature of the concept was also emphasised (Pangbourne et al., 2020), while this definition overlooked other stakeholders, including municipal authorities, operators and transport providers, IT companies, and ticket distributors. Therefore, researchers subsequently focused on further refining the conceptual framework of MaaS.

Currently, MaaS is increasingly described as a new approach to urban mobility. It involves providing high-quality transport services to users through a mobile application that enables journey planning based on real-time data, ticket purchasing, and ride booking (König et al., 2016). MaaS remains user-oriented; however, increasing attention is also being paid to the role of other stakeholders in the implementation and operation of the system (Enoch & Potter, 2023). As a result, MaaS is becoming a platform accessible to users with different needs and expectations, which is especially important at the system planning stage. Equally important is the business model underpinning MaaS solutions. Some companies remain reluctant to join MaaS ecosystems to join the system due to the unclear distribution of revenues and relatively high costs (Athanasopoulou et al., 2022). MaaS aims to implement the principles of sustainable urban mobility, which is often emphasised in its definitions (Mulley, 2017). The implementation of MaaS alone will not make the urban transport system sustainable, as it depends on the travel behaviour of users.

The use of MaaS solutions requires the establishment of closer cooperation among stakeholders, primarily municipal authorities, operators, and transport providers. In decentralised systems, this may be more difficult due to the large number of entities involved (Ho & Tirachini, 2024). Moreover, decision-making processes in cities are usually lengthy and often burdened with excessive bureaucracy (Mavrogenidou & Papagiannakis, 2024). This means that, from an organisational perspective, the process of preparing and implementing the MaaS concept is both time-consuming and costly. It also requires consideration of the needs of different user groups, including people with disabilities. Each user group has slightly different needs and expectations, as well as concerns. MaaS is based on the use of digital solutions, which may pose a challenge for older people and for individuals with visual and mobility impairments (Hasselwander & Bigotte, 2022). Another problem may be ensuring the security of users' personal data. Therefore, investments in the development of digital infrastructure as well as physical infrastructure become necessary.

Within MaaS ecosystems, the integration of various transport modes, both public and shared, plays a fundamental role. Public transport should be characterised by a high level of service quality, the indicators of which include punctuality, direct connections, and accessibility (Agrawal et al., 2015). Transport accessibility refers to the possibility for potential users to use transport services regardless of their physical ability or place of residence. For people with disabilities, accessibility constitutes a key determinant of the use of public transport in everyday travel. Accessibility can be considered here in two ways: in the context of infrastructure (roads, sidewalks, stations, and transfer hubs) and in the context of vehicle design and equipment. The implementation of MaaS assumes ensuring a high level of accessibility (Mitropoulos, Kortsari, et al., 2023). Its indicators include the presence of facilities for people with special needs, such as ramps, accessible lifts, wide sidewalks, low curbs, clear pictograms, voice announcements, and low-floor vehicles. A low level of infrastructure development usually also means the absence or limited availability of such solutions, thereby contributing to the systemic exclusion of people with disabilities (Casas, 2007).

3 Methods

Assessing the readiness of Polish cities to implement MaaS from the perspective of public transport accessibility required an in-depth analysis of how public transport systems operate in selected Polish cities. Achieving this goal required the use of a qualitative research method – participant observation in five cities belonging to the Paweł Adamowicz Union of Polish Metropolises (UMP). The UMP comprises a total of 12 of Poland's largest cities. Since the observation method is largely subjective, public transport evaluation questionnaires were used. Two questionnaires were prepared: one to evaluate public transport stops and one to evaluate public transport journeys. Both questionnaires were entered into MS Forms to facilitate data collection in the field. The questionnaires included a set of variables used to assess selected elements related to the accessibility and functionality of public transport stops as well as the conditions experienced during public transport journeys. These indicators formed the basis for the systematic observation and evaluation of accessibility features relevant for passengers with disabilities. The study applied a two-level accessibility assessment framework, encompassing both the accessibility of public transport stop infrastructure and accessibility experienced during public transport journeys. The field research was conducted between July and September 2025 in selected Polish cities (Bydgoszcz, Gdańsk, Lublin, Warsaw, and Rzeszów).

Selected elements related to the accessibility and functionality of public transport stops were assessed using participant observation conducted at selected stops in the analysed cities. Accessibility indicators were categorised under four headings: passenger comfort and inclusive stop infrastructure accessibility, passenger information accessibility, physical accessibility of stop infrastructure, and pedestrian access and safety. The passenger comfort and inclusive stop infrastructure category included elements such as the availability of resting facilities, different types of seating (benches with or without backrests and armrests), leaning rails or standing supports, sun protection or shading, integrated stop lighting, street lighting, and CCTV surveillance. Passenger information accessibility referred to the availability of printed timetable boards, electronic timetable displays, real-time passenger information systems, continuous and on-demand voice announcements, as well as infrastructure supporting visually impaired passengers, including tactile elements and high-contrast accessibility markings. Physical accessibility of stop infrastructure included barrier-free surfaces, step-free access, adequate sidewalk width enabling wheelchair manoeuvring, access ramps, and raised boarding curbs facilitating easier boarding. The pedestrian access and safety category covered elements related to the surrounding pedestrian environment, such as marked pedestrian crossings, signalised crossings, audible pedestrian signals, roadside safety barriers, and protective barriers separating bicycle paths.

Accessibility of public transport stops was assessed using participant observation conducted at selected stops in the analysed cities. Each accessibility indicator was coded using a binary approach (YES = 1; NO = 0), reflecting the presence or absence of a given accessibility feature. Category scores were calculated as the proportion of positive observations within each group of indicators included in the analysed accessibility dimensions, and the overall stop accessibility score for each city was obtained as the arithmetic mean of the four accessibility dimensions. The number of observed stops was similar across the analysed cities (8 observations per city), which ensures comparability of the results and limits potential bias resulting from differences in sample size.

Selected elements related to vehicle accessibility and passenger information systems were assessed during public transport journeys using participant observation. Accessibility indicators were categorised under three headings: passenger information accessibility, vehicle boarding accessibility, and on-board passenger space accessibility. The availability of real-time delay information before the journey, real-time information boards at stops, on-board displays, and voice announcements of upcoming stops were included in the passenger information accessibility category. Vehicle boarding accessibility refers to door opening buttons, buttons adapted for passengers with disabilities, the kneeling function, and boarding devices such as ramps or lifts. On-board passenger space accessibility included designated wheelchair spaces, priority seating, spaces for strollers, handrails, accessibility markings (e.g., pictograms and contrasting colours), and interior lighting.

Accessibility during public transport journeys was assessed using participant observation conducted during trips in selected Polish cities. Each accessibility indicator was coded using a binary approach (YES = 1; NO = 0), reflecting the presence or absence of a given accessibility feature. Category scores were calculated as the proportion of positive observations within each group of indicators, and the overall accessibility score for each city was obtained as the arithmetic mean of the three accessibility dimensions. The number of observed journeys was similar across the analysed cities (11–12 observations per city), which ensures comparability of the results and limits potential bias resulting from differences in sample size.

Although a larger number of public transport stops and journeys were observed during the field study, only cases ensuring methodological comparability between the analysed cities were included in the final dataset. The selection focused on stops and journeys that represented similar functional roles within the urban transport system, as well as comparable infrastructural and operational conditions. This approach enabled consistent cross-city comparisons of accessibility features at stop infrastructure and journey levels, while mitigating potential bias arising from differences in network structure, service characteristics, and local transport infrastructure across the analysed cities. By combining stop-based and in-vehicle observations within one analytical framework, the study captures both static and operational dimensions of accessibility, which are often examined separately in previous MaaS and public transport research.

4 Results

The following section presents the results of the accessibility assessment conducted in the analysed cities. In line with the adopted two-level analytical framework, the results are presented separately for public transport stop infrastructure and the accessibility experienced during public transport journeys. This structure enables a comparative evaluation of accessibility conditions across the analysed urban transport systems.

The results of the comparative assessment of public transport stop accessibility in the analysed cities are presented in Table 2. The analysis includes four accessibility dimensions: passenger comfort and stop infrastructure; passenger information availability; the physical accessibility of stop infrastructure; and pedestrian access and safety around the stop. In addition, a synthetic indicator of overall stop accessibility was calculated to enable a comparative ranking of the analysed cities.

Table 2. Assessment of public transport stop accessibility based on stop-based observations

City	Passenger comfort and inclusive stop infrastructure accessibility	Passenger information accessibility	Physical accessibility of stop infrastructure	Pedestrian access and safety	Overall accessibility of public transport stops	Ranking (overall accessibility)
Warsaw	53%	56%	75%	68%	63%	1
Bydgoszcz	53%	47%	83%	63%	61%	2
Gdańsk	53%	52%	60%	53%	55%	3
Lublin	47%	42%	75%	48%	53%	4
Rzeszów	49%	39%	65%	25%	44%	5

Source: own elaboration based on field observations.

The results reveal significant disparities in the accessibility of public transport stops across the analysed cities. Warsaw achieved the highest overall accessibility score (63%), reflecting relatively favourable conditions in terms of physical accessibility of stop infrastructure (75%) and pedestrian access and safety (68%), as well as relatively high levels of passenger comfort and inclusive stop infrastructure accessibility (53%). Bydgoszcz ranked second with an overall accessibility level of 61%, primarily due to the high level of physical accessibility of stop infrastructure (83%), although lower scores were recorded in passenger information accessibility (47%). The level of passenger comfort and inclusive stop infrastructure accessibility in Bydgoszcz was comparable to that in Warsaw (53%), indicating that basic elements of stop infrastructure, such as seating, lighting, and shelters, were widely available. Moderate accessibility levels were observed in Gdańsk (55%), where the results across the analysed accessibility dimensions were relatively balanced. These dimensions included passenger comfort, inclusive stop infrastructure accessibility (53%), and passenger information accessibility (52%). However, the physical accessibility of stop infrastructure (60%) and pedestrian access and safety (53%) remained lower than in the leading cities. Lower values were recorded in Lublin (53%) and Rzeszów (44%). In Lublin, the accessibility of stop infrastructure was relatively high (75%), but lower scores in passenger information accessibility (42%) and pedestrian access and safety (48%) reduced the overall result. Rzeszów achieved the lowest overall accessibility score, primarily due to limited pedestrian access and safety infrastructure (25%), as well as a lower level of passenger information accessibility (39%). However, passenger comfort and inclusive stop infrastructure accessibility remained comparable to that in other cities (49%).

Overall, the findings suggest that, while most of the analysed cities provide the basic elements of stop accessibility, the completeness and consistency of these features vary considerably across urban transport systems. In particular, differences are visible in passenger information systems and the pedestrian safety infrastructure surrounding public transport stops.

The results of the observational analysis of accessibility during public transport journeys are presented in Table 3. The assessment focuses on three dimensions of accessibility: passenger information accessibility, vehicle boarding accessibility, and on-board passenger space accessibility. The values shown in the table represent the share of positive observations recorded during field research conducted in the analysed cities.

Table 3. Accessibility of public transport during journeys based on in-vehicle observations

City	Passenger information accessibility	Vehicle boarding accessibility	On-board passenger space accessibility	Overall accessibility during public transport journeys	Rank
Rzeszów	89%	80%	88%	86%	1
Lublin	77%	78%	90%	82%	2
Gdańsk	82%	65%	95%	81%	3
Warsaw	79%	65%	98%	81%	4
Bydgoszcz	70%	64%	82%	72%	5

Source: own elaboration based on field observations

The results reveal significant variations in accessibility conditions across the analysed cities. Rzeszów achieved the highest overall accessibility score (86%), indicating the most favourable conditions for passengers with disabilities during public transport journeys. Lublin ranked second with an overall accessibility score of 82%, while Gdańsk and Warsaw obtained very similar results (both 81%). These results suggest that accessibility features are generally well implemented across the analysed transport systems, although their availability varies between cities and accessibility dimensions. Cities that achieved higher rankings performed particularly well in the categories related to passenger information systems and on-board passenger space accessibility. In several cases, very high scores were observed in the availability of designated spaces, priority seating, and interior accessibility solutions, with values exceeding 90%. Bydgoszcz obtained the lowest overall score (72%), indicating that accessibility features are present but less consistently implemented across vehicles and services.

It should also be noted that the results for larger metropolitan transport systems, such as Warsaw and Gdańsk, may reflect greater variability in accessibility conditions across vehicles and routes. In contrast, smaller or more operationally homogeneous transport systems may achieve more consistent accessibility standards. These findings indicate that improving boarding accessibility and the consistency of accessibility solutions across fleets could further enhance accessibility during public transport journeys and support the broader implementation of MaaS-oriented mobility systems. A comparison of the results presented in Tables 2 and 3 indicates that higher accessibility of stop infrastructure does not necessarily correspond with higher accessibility during public transport journeys.

5 Conclusions

This study aimed to assess the readiness of selected Polish cities to implement the MaaS concept from the perspective of public transport accessibility for people with disabilities. The analysis applied a two-level accessibility assessment framework, examining both the accessibility of public transport stop infrastructure and the accessibility experienced during public transport journeys. This approach enabled a comprehensive evaluation of accessibility conditions within urban transport systems and provided insight into how different components of the mobility system influence the overall travel experience of passengers with disabilities.

The results reveal significant differences in accessibility conditions between the analysed cities and at the two levels of the transport system. Warsaw and Bydgoszcz had the highest accessibility levels in terms of stop infrastructure, reflecting relatively well-developed stop infrastructure and comparatively favourable pedestrian access conditions. However, the analysis of accessibility during public transport journeys revealed stronger performance in cities such as Rzeszów and Lublin, where accessibility solutions within vehicles were implemented more consistently. These findings demonstrate that well-developed infrastructure at public transport stops does not automatically guarantee equally accessible travel conditions within vehicles. Therefore, accessibility within urban transport systems depends on both the quality of stop infrastructure and the operational characteristics of public transport services.

From a MaaS implementation perspective, the results highlight the need for a holistic approach to accessibility within urban mobility systems. For decision-makers and transport authorities, this implies the necessity of improving stop infrastructure and vehicle accessibility features, particularly in cities where inconsistencies between these elements were observed. Investing in barrier-free stop infrastructure, accessible boarding solutions, clear passenger information systems, and consistent accessibility standards across vehicles can significantly improve the usability of public transport for people with disabilities and other groups with diverse mobility needs, such as older adults, passengers travelling with children, individuals with temporary mobility limitations, and people carrying luggage or equipment. Therefore, improving accessibility conditions across the entire public transport system contributes to the development of more inclusive and user-oriented urban mobility systems.

These findings provide an important perspective for research on MaaS. While MaaS is often discussed primarily in terms of digital integration of transport services, the results of this study demonstrate that the physical accessibility of transport systems remains a fundamental precondition for the effective functioning of MaaS solutions. The observed differences between accessibility at the level of stop infrastructure and accessibility experienced during journeys indicate that MaaS readiness should be assessed not only through digital and organisational integration, but also through the consistency of accessibility standards across the entire public transport system. This perspective contributes to the growing body of research on MaaS by highlighting the importance of integrating accessibility considerations into the evaluation of MaaS readiness in urban transport systems. These findings underline that assessing MaaS readiness requires not only evaluating the digital integration of mobility services but also examining the physical accessibility of urban transport systems. In theoretical terms, the findings suggest that MaaS readiness should be understood as a multidimensional condition shaped not only by digital integration and service coordination, but also by the physical and operational accessibility of the transport system.

The study also has several limitations that should be acknowledged. Firstly, the analysis was based on observational data collected in a limited number of cities and focused on selected aspects of public transport accessibility. Secondly, the assessment relied on participant observation, which, despite the use of structured observation questionnaires, may involve a certain degree of subjectivity. Furthermore, the study primarily focused on infrastructural and operational aspects of accessibility and did not directly incorporate the perspectives and experiences of transport users themselves.

Such improvements are essential not only for inclusive mobility but also for the successful implementation of MaaS-oriented mobility systems. Future research could expand the analysis to additional cities and incorporate the perspectives of users with diverse mobility needs. This would include people with disabilities, older adults, and passengers travelling with children. This would contribute to a better understanding of how accessibility improvements influence travel behaviour and participation in urban mobility systems.

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