The Wheelchair Accessibility of Urban Bus: Physical and Social Aspects

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Abstract. In this aging society, the number of wheelchair users is increasing. As an affordable travel mode for them, the urban bus, a universal public transportation, should pay more attention to its accessibility. This essay explores the multifaceted issues wheelchair users face in accessing urban bus transportation. Multiple studies highlight the current state of urban bus accessibility problems in various cities by categorizing them into physical and social barriers. For the physical barriers, the full experience of wheelchair users taking the bus is discussed separately including moving to and from bus stops, waiting on platforms, boarding and alighting the bus, and moving within the bus to the securement area. It is found that the most common accessible problems of the urban bus include the unfriendly built environment, the platform that lack of information and protection, steep ramps, narrow aisles, and unsafe securement areas. Social barriers such as indifferent attitudes from bus drivers and the general public further complicate mobility for wheelchair users. Recommendations are provided to improve both the physical infrastructure and the social environment including training of bus drivers, ergonomic design, stop renovation, and awareness campaigns, aiming to create a more inclusive and accessible urban bus system for wheelchair users.

Keywords: Universal design; wheelchair user; persons with disabilities; urban bus.

1. Introduction

According to the data from the World Health Organization, there are about 1.3 billion people in the world who are suffering from serious disability, which is one-sixth of the global population [1]. Due to the aging tendency of the population, this rate may grow continually in the near future, and mobility devices are considered by a large number of disabled people in order to improve their daily mobile experience. Mobility aid can include a variety of devices such as wheelchairs, mobility scooters, canes, walkers, and so on, but for the purpose of this paper, only powered and unpowered wheelchairs with three or four wheels will be discussed. In Australia, there are more than 200,000 disabled people using wheelchairs, and in the UK, the number of users is about 880,000 [2, 3]. However, the mobility of disabled people depends on not only the device they use but also the level of accessibility of their day-to-day journeys. In recent years, more and more attention has been paid by many urban governments to wheelchair access to public transportation. In 2023, a multi-million dollar is underway for upgrading Queensland's train carriages in order to enhance some accessibility issues, especially the narrow aisle [4]. Moreover, in 2019, a new metro bus system with a great universal design and a new low-floor bus came into service in Trondheim, Norway [5].

As one of the most marginalized groups in current society, people with disability seem to have no luck enjoying the freedom of walking, climbing, and running as healthy individuals. As the capability of mobility is one of the preconditions of community, they are excluded from society and even face huge difficulties in their day-to-day journeys [6]. Moreover, with the issues of employment and expensive medical services, it might be difficult for them to buy private cars. As a result, it can be said that accessible public transportation is an essential part of urban life for wheelchair users, because, for many of them, public transportation might be the only way to reach social activities, entertainment, health, and employment [7]. Hence, the accessibility of public transportation is critical in contemporary urban planning and design. According to research by Unsworth et al, it can be found that most issues of accessibility happened in metro tram (an inaccessible system) and bus (with board and alight issues) in Victoria and Queensland [8]. Also, compared to the train system, wheelchair

users have to interact with the drivers, and the environment of the bus stops is complex and seldom weatherproof [6]. Moreover, the bus system is usually accompanied by a certain level of uncertainty, such as the different street conditions and the built environment. As the metro tram system is not a globally universal public transportation, this paper will pay attention to the accessibility of urban buses based on different physical and social barriers that are faced by wheelchair users.

2. The Barrier

2.1. Physical Barriers

The accessibility of the urban bus system closely relates to the design of its facilities and space. In this part, different physical barriers will be discussed which will include a full experience of wheelchair users taking the bus.

2.1.1. Moving to or from a bus stop

The issues of entering the urban bus links to a broader context of urban areas. The bus stop doesn't stand by itself. It connected to its surrounding urban fabric including curbs, streets, ramps, and sidewalks. Few studies touch this area at some levels [6, 9, 10, 11], which provides several aspects of this topic for further study. Issues identified included steep ramps, huge level differences, weather factors, long sidewalks, and no accessible device to reach the platform. Almada and Renner found that in urban areas of New Zealand, one of the major issues of wheelchair users is the distance to the bus stop, which is caused by the disconnection between the bus stop and the public street, and in that case, a normal curb might be an inevitable issue [6]. Also, according to the research particularly on the curb ramps in Halifax, Canada, surprisingly, only about half of the curb ramps have clear transfer guidance, and only about one-quarter of them can connect the curb and gutter smoothly and comfortably [11]. Moreover, research that analyzes the accessibility condition of metro buses in Istanbul reports that 69.7% of stations are not accessible at all due to the high and long ramps and high curbs [10]. This metro system has served since 2003 and acted as highly efficient transportation in the city, but the experience of wheelchair users is ignored [10].

From those studies, it can be said that there are still some small details such as curb and ramp that are usually overlooked by the city planners. However, there are few studies on this area and further study should be explored Compared to other public transportation, the urban bus system usually does not have any staff members or volunteers who can help wheelchair users enter the stop. Therefore, it is critical to design a proper method for the threshold between the bus stop and its urban context.

2.1.2. Waiting on the platform

The accessibility of the bus platform is about the actual design of the bus stop. Studies on the experience of wheelchair users on the platform of the urban bus are rarely found [10, 12], which highlights issues such as narrow platforms and long wait times. According to research by Hernandez and Rodriguez comparing the time structure of daily travel time between wheelchair users and non-wheelchair users in Montevideo, the waiting time for wheelchairs is about three times higher than for non-wheelchair users [12]. As this research doesn't give an answer or conjecture for this data, it might be caused by unreachable information, lack of assistance facilities, or just the ignorance of the bus driver. In addition, an observation of bus stops in Melbourne can also reveal some of the problems of the platform design. The picture [Fig. 1] of a bus stop on Lonsdale Street in Melbourne CBD shows that there is nearly no assistance facility to keep wheelchair users stable on sloped street surfaces. In addition, the bus information might be too high for them to read and there is no helping service. Hence, further studies can also focus on the accessibility of service and information, which can pay attention to how wheelchair users get bus information or where they can ask for help. Moreover, the weatherproofing and passive design strategies are another blank field to do research. Wheelchair users may be more likely to suffer from summer sunlight or heavy rain due to relatively high shelter because a person sitting in a wheelchair is normally lower than a person's height.

Therefore, more studies should be undertaken to determine the real need for wheelchair users when they are waiting for the bus.

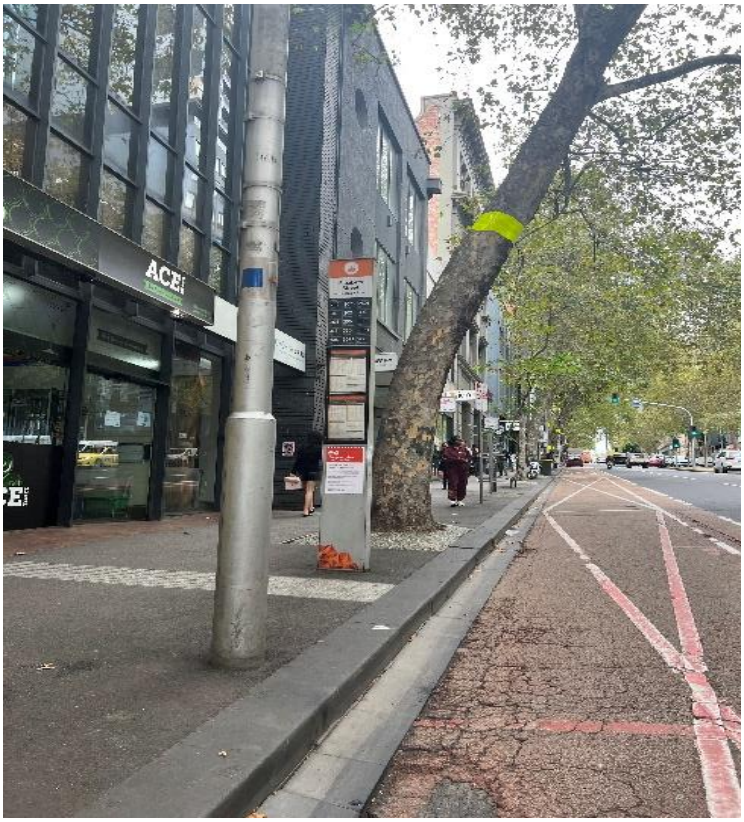

Fig 1. Bus Stop on Lonsdale Street, Self-created.

2.1.3. Boarding and alighting the bus

Boarding and alighting are likely to be the most challenging part of the travel by wheelchair users. D'Souza et al. [7] emphasize that compared to other accessibility issues in urban bus systems, ramp ascent is the most difficult one for non-power wheelchair users. That is also proved by the number of papers that are found related to this topic. Five relevant studies [7, 9, 13, 14, and 15] focus on the bus ramp's design, installation, angles, and user experience. The maximum angles of the ramp are from 8 degrees to 9.5 degrees [7, 9, 13, and 14]. Frost et al. [14] highlight that, when the angle of the ramp slope is larger than 9.5 degrees, the chance of experiencing an accident rises by five times. In addition, driver-operation-mistakes will make the situation even worse, such as deploying the ramp to an obstacle or placing the ramp on the street rather than the sidewalk [15]. Moreover, more incidents happen during boarding than alighting [14, 15], because of the lower control of the ramp approach angle during the boarding [14]. Also, the edge barrier is another problem faced by wheelchair users [9, 15]. According to the research in Novo Hamburgo, the width of both the ramp and the door is too small for safety and mobility, resulting in uncomfortableness [9]. Bad weather conditions can also negatively influence the safety performance of the ramp, especially when it gets wet [15]. According to the research by Frost et al. [15], among 384 American participants, 93.6% of them feel struggling when boarding with a wet ramp.

Hence, considered a very struggling part of wheelchair users' experience, boarding and alighting the urban bus face critical problems such as steep ramps, narrow access, and wet surfaces, which should be considered and reflected by the urban and bus designer.

2.1.4. Moving within the bus to the securement area

The issues within the bus might not be as high-risk as those during the boarding and alighting, but it is more about convenience and comfort. It could be said that the boarding and alighting define the floor of the wheelchair users' experience while moving and staying in the bus define the ceiling.

Several researchers have examined this aspect. Firstly, the fare payment is the first step after boarding, the traditional cash payment will increase the difficulty of payment and counting, or even cause time pressure and anxiety for the passengers [16]. Moreover, it is found that the design of some urban buses does not sufficiently consider the legroom for passengers, and there are overlaps between the legroom and a standard aisle for wheelchairs, especially when the bus is crowded, or the seats are face-to-face [9, 16]. Also, the securement area is not stable and well-designed. Because of the size of the wheelchair and the limited ability of users' upper limbs, some handles, and secure equipment are out of range, which forces users to adapt the equipment rather than the other way around [9]. Another issue is that the interior space is too narrow. D'Souza et al. [7] point out that the internal circulation is the biggest challenge faced by the electric-powered wheelchair users. The factor of this situation might be relatively large size compared to a manual wheelchair and over-sensitive controller for fine-grained adjustments,

Overall, the problems of moving and staying within the bus include fare payment method, reduced legroom, lack of ergonomic design in the securement area, and narrow space, which closely link to the users' experience.

2.2. Social Barriers

Differing from physical barriers, social barriers to bus taking of wheelchair users are more obscure but more important. However, there are only limited studies that mention this barrier. Solving physical barriers just guarantees basic safety and comfort, while social barriers highly influence the social position of disabled people. Discrimination, isolation, and disrespect are always involved in the daily life of wheelchair users and even affect their mental health. This section will discuss three main social barriers: the buggy jostle, the indifferent drivers, and the offish public.

2.2.1. The buggy Jostle

The conflict between wheelchairs and buggies has attracted public attention for serval years [17]. As the only safe place for wheelchair users, sometimes the securement area is occupied by buggies or other things such as shopping trolleys, luggage, or even standing people. An interviewee from research by Velho et al. in London said that the space of securement area is always problematic and people in that area do not even want to move if there is free space elsewhere [18]. Moreover, one participant in a Canadian study states that sometimes wheelchair users are refused boarding an accessible bus by the driver because the securement area is taken by a buggy [19]. Hence, wheelchair users are losing their only safety area on the bus.

2.2.2. Indifferent divers

The attitude of bus drivers can significantly influence the user experience because they can decide whether the buses need to stop for a wheelchair. Still, from some studies, the current situation is not optimistic. Five papers highlight that bus drivers do not want to stop when a wheelchair is on the platform [6, 8, 9, 18, and 19]. The reason for this situation might be the rapid pace of urban life: a long delay by wheelchair is sometimes unbearable for some drivers and passengers [8]. Also, an interesting study by Bareria and Shin finds that assisting wheelchair boarding and alighting may increase the risk of lower back injury among bus drivers [20]. As bus driving is a compulsory sedentary occupation that may cause overweight, hip joint problems, and stiff neck, drivers even less want to assist wheelchair users, which may result in further injury. Overall, the indifferent attitude of bus drivers isolates wheelchair users away from the urban bus system, which also causes anxiety and uncertainty.

2.2.3. The Offish public

The public attitude is also a social barrier that keeps wheelchair users away from the bus. The legroom for other passengers is not enough, resulting in a collision between wheelchairs and other passengers [9, 16], which might cause dissatisfaction and quarrels. Moreover, one participant in a study by Velho et al. complains about the nonfeasance of transport authority, resulting in a loss of

confidence in traveling [18]. Therefore, the public attitude is another influencing factor in wheelchair users' experience.

3. Suggestions

3.1. Physical Barriers

3.1.1. Moving to or from a bus stop

I it is critical to consider whether the bus stop smoothly connects to its built environment. Many aspects should be considered: using smooth road surfaces, low street curbs, and gentle ramps. The research by Bennett et al. gives a systematic analysis method of the urban curb ramps, including alignment, width, slope, gutter, transition, surface irregularities, and drainage grates [11]. Also, the study by Duvall et al. focuses on the relationship between the comfortableness of wheelchair users and the roughness of the road [21]. Those studies can be good references when designing the built environment of urban bus stops. Hence, based on some existing studies, the threshold between the urban bus stop and its built environment needs to be designed by collaborating with relevant units.

3.1.2. Waiting on the platform

At present, the condition of wheelchair users on the platform needs to be paid more attention to. Firstly, the level of weatherproof performance of the stop is critical. Unlike others who can use an umbrella during rainy days, wheelchair users have to use both hands to move the wheelchair, resulting in low resistance against poor weather conditions. Moreover, from the previous problem analysis on the Melbourne urban bus, an ergonomic way to get information and services is another aspect that needs to be considered. Also, the narrow platform width can increase the risk of falling during the waiting time; Evcil and Usal point out that the other elements on the urban bus platform such as public drinking fountains or planters should be standardized rather than randomly placed [10]. Therefore, more studies should be conducted in this area and appropriate funds could be spent on renovating and updating the urban bus stop based on its weatherproofness, services, and width.

3.1.3. Boarding and alighting the bus

The problem of boarding and alighting of the urban bus is closely related to minimizing the slope. According to the ADA Accessibility Standards, the ramp for wheelchairs cannot have more than a 1:12 ratio (8.33%) [22]. However, the angle of the slope, in reality, is influenced not only by this standard but also by the bus driver. The bus should be fully kneeled against the platform so the ramp can easily be placed on it to reduce the angle of the slope. Frost et al. suggest that the bus driver should be well-trained to assist wheelchair users proactively [15]. Thus, promulgating relevant regulations and well-trained bus drivers are two key points of safety boarding and alighting.

3.1.4. Moving within the bus to the securement area

Quicker fare payment, short and wide interior travel path, and ergonomic securement area design can improve the experience of wheelchair users when they are moving within the bus to the securement area. Traditional fare payment might be pretty time-consuming, while electronic fare payment can easily be made with a simple touch. Moreover, a pre-paid payment system is operated in the Select Bus Service in New York City, which can make the payment process even quicker [16]. Furthermore, this kind of payment does not need supervision by the driver, which means that the door can be opened in the middle of the bus, resulting in a shorter interior moving distance. In addition, Unsworth et al. analyze and examine the accessibility of the bus interior for powered mobility aid by using 3D scanning technology [23], which has a great reference significance to rethink how to use cutting-edge to analyze and improve the accessibility of urban buses. It has been mentioned that some participants are unsatisfied with the design of the securement. As there is a lack of study focusing on this aspect. It can be suggested that ergonomic design, flexibility with different types of wheelchairs, and ease of entry are some of the key points that can be further paid attention to. Overall, using

advanced technology to solve and improve the payment system and bus interior space design will be a proper direction for future development.

3.2. Social Barriers

Three aspects of social barriers have been mentioned, but broadly speaking, they are about rules and respect. In 2012, Doug Paulley sued FirstGroup in Yorkshire because he was refused to board a bus because a buggy occupied the securement area. This case speeded up the regulation of the securement area for the priority of wheelchair users in London. As a result, relevant units should draw up more humane regulations. Moreover, it has been mentioned that bus drivers need to be well-trained to operate the bus ramp, but more importantly, they need to learn how to help wheelchair users in a respectful and friendly manner. Also, increasing public awareness campaigns and enhancing feedback mechanisms can let wheelchair users feel like they are a part of society and live in respect. Overall, relevant regulations, friendly service, and raised public awareness play significant roles in helping wheelchairs break social barriers.

4. Summary

In conclusion, this paper has analyzed two main barriers that are faced by wheelchair users when they are taking the urban bus. The study on physical barriers focuses on the full experience for a person with a disability when taking the bus: the bumpy built environment of the bus stop, lack of help and service on the platform, steep and narrow bus ramp, and uncomfortable and unsafe interior design. The social-barrier aspect highlights the several issues that isolate wheelchair users away from society including occupied securement space, rude bus drivers, and offish public. Moreover, corresponding suggestions are made for those barriers. Firstly, it is important to design a bus stop that can smoothly sit in its urban context in order to make wheelchair users easily enter it. Secondly, more government funds should be used on renovating and updating the weatherproofness, services, and width of the urban bus stop. Thirdly, relevant regulations, well-trained bus drivers, and skillful users are needed to ensure the safety of boarding and alighting. Fourthly, using new technology to enhance the payment system and bus interior space. Fifthly, promoting relevant regulations, friendly service, and public awareness can let wheelchair users feel respected.

The paper gives an overall view discussion of the wheelchair accessibility of urban buses in physical and social aspects, which might give a whole reference for civil engineers, city designers, and civil servants to have a better understanding of different key points when they design, renovate or update an urban bus system.

An accessible urban bus system can greatly improve the living quality of wheelchair users and help them be a part of the community. Physical barriers can be solved by modern technology and good design strategies. However, breaking the social barrier is a time-consuming but critical process, which can be a deep topic for future studies.

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