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How individual perceptions of transportation systems influence mode choice for mobility-challenged people: A case study in Dhaka using an integrated choice and latent variable model

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ABSTRACT

This study examines how mobility-challenged persons (MCPs) navigate the limitations of transportation systems, using an integrated choice and latent variable (ICLV) model. Building on the experience of MCPs in a South Asian megacity context, that of Dhaka, Bangladesh, the empirical strategy accounts for perceptions of mode-specific challenges, which arguably vary by mobility impairment. These perceptions are posited as latent variables. Drawing on survey data collected from 400 MCPs living in Dhaka, the latent variables were constructed via a factor analysis of 18 statements about the experienced severity (ranked on a scale from 1 to 5) of mode-specific challenges. Holding socio-demographic and travel-related factors constant, we find that perceptions of mode-specific challenges significantly influence mode choices – while the degree of impairment alone, and related mobility aid needed, do not. Perceived limitations of the walking infrastructure shift MCPs' travel demand towards the bus, whereas bus fare-related issues encourage the use of non-motorized and powered three-wheelers. We recommend that mode choice models include latent variables related to MCPs' perceptions of various modes to more accurately inform universal access policies.

1. Introduction

With over one billion people or about 15% of the world population, people with disabilities (PWDs) are one of the world's largest minorities (World Health Organization, 2022). The Sustainable Development Goals (SDGs) and the Convention on the Rights of Persons with Disabilities (CRDP) urge establishing rights and privileges for PWDs to promote more sustainable, equitable, and inclusive societies (Dempsey et al., 2011; UN-HABITAT, 2016; United Nations, 2006). Specifically, SDG 11.2 calls for universal access to transportation systems so that PWDs and their non-disabled counterparts have equal opportunities to reach desired destinations and participate in society (World Health Organization, 2018; United Nations, 2016).

However, previous research has depicted a grim situation regarding transportation mobility and accessibility for PWDs around the world, mostly due to unfit built environments and ill-adapted transportation systems (Clery et al., 2017; Frye, 2013; Penfold et al., 2008; Rosenberg et al., 2013; Smalley et al., 2013; Sze and Christensen, 2017). Among different groups of PWDs, mobility-challenged persons (MCPs) – defined as those whose walking must be supported by a mobility aid, such as a wheelchair, cane, walking frame, or crutches – are the focus of this article. MCPs undergo specific hardships when availing, on-boarding, and off-boarding transportation modes (Frye, 2013; Hayati and Faqih, 2013). Traveling at all can be so challenging that wheelchair users and other MCPs are known to refrain from making certain trips (Clery et al., 2017). As a result, major inequalities exist between MCPs and non-MCPs in terms of mobility and access to opportunities (Clery et al., 2017; Penfold et al., 2008).

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The difficulties encountered by MCPs are especially acute in emerging economies, where limited financial resources and a dearth of public awareness have long prevented investments in universally accessible transportation systems (Chang, 2010; Danso et al., 2011; Malik, 2017; Penfold et al., 2008; Shafi, 2018). Bangladesh is no exception in this regard. In line with SDG 11.2, CRDP, and other international commitments, the Government of Bangladesh has enacted laws to promote the mobility rights of MCPs and other PWDs. These include the Person with Disability Welfare Act 2001, the Strategic Transportation Plan (STP) 2004, the Persons with Disabilities Rights and Protection Act 2013, and the Road Transport Act of Bangladesh (2013). Yet, adequate measures to truly promote MCPs' mobility in Bangladesh remain to be implemented.

Previous empirical research in Dhaka, the capital of Bangladesh, has shed light on the limitations of local transportation systems for MCPs (Abir and Haque, 2011; Shashank, 2015). Most recently, the authors showed, for example, that walking with supporting devices is especially challenging due to poor pavement conditions; buses are inaccessible to people in a wheelchair for lack of ramps; private taxis and rickshaws are the most viable options, but MCPs typically need a hand to on-board and off-board that bus drivers are not always willing to give (Bhuiya et al., 2022). The goal of this paper is to further examine how MCPs perceive and cope with such mode-specific challenges in Dhaka.

A few studies have explored the relationship between different mobility impairments, at the individual level, and mode choices (Babaei and Hedayati, 2020; Clery et al., 2017; Pocuc et al., 2021; Schmocker et al., 2008). However, it seems important to account for how MCPs perceive mode-specific challenges – where these perceptions necessarily vary depending on the nature of the mobility impairment. More specifically, this paper addresses the following research question: *How does the conjunction of individual mobility impairments and latent perceptions of obstacles related to transportation modes inform MCPs' mode choice in Dhaka?*

Following a literature review, we present the survey data (N=400) and integrated choice and latent variable (ICLV) model used to address this question. In addition to socioeconomic factors, trip attributes, and travel costs, this model includes MCPs' perceptions of different mode-related challenges; these perceptions are posited as latent variables (Chen and Li, 2017; Vij and Walker, 2016). We argue that latent perception variables encapsulate anticipated challenges to avail different transport modes, where MCPs have differentiated experiences of transportation systems' limitations depending on their mobility impairment. The findings show that latent perception variables greatly influence MCPs' mode choice and absorb much of the variance explained by other variables in the model. In Dhaka, we find that perceived obstacles related to different modes shift mode choices from walking and bus to more expensive options like CNGs. After discussing specific policy recommendations for inclusive transportation policies in Dhaka, we conclude that future accessibility research and policy should systematically include individual perceptions of specific challenges associated with different modes when modeling mode choice for MCPs.

2. Literature review

2.1. Factors influencing mode choice

Mode choice in general depends on several factors, among which travel distance and time are known to be most influential across countries (Litman, 2019). For example, several studies from Taiwan, Bangkok, Dhaka, UK, have consistently found that people choose walking for short trips, but the longer the time and distance traveled, the more likely they are to choose motorized modes, such as private cars or public transit (Keyes and Crawford-Brown, 2018; Rahman et al., 2020; Sanit et al., 2010). Age is another key determinant of mode choice. Hu et al. (2013) found a lower propensity to bike or use a private car among the elderly than young people in Changchun, China. Shresta (2016) found a higher rate of public transit use among elderly people than younger/middle-aged people in the UK. Gender, education, and income influence mode choice as well (Shrestha et al., 2016). Chen et al. (2016) found that female and low-income commuters in Fushun, China prefer to travel by bus (Cheng et al., 2016). Based on a study of 45 cities from Asia, Europe, and North America, Dingi and Esztergár-Kiss (2021) concluded that people with a higher level of educational attainment are more likely to use a bus instead of a car. Unsurprisingly, Sharma (2019) found that in India, car ridership is more frequent among higher-income individuals (who can afford to own a car). In contrast, the car share is large across income groups in higher-income countries like the USA, and therefore, private cars consist of a significant proportion of the modal share (Mitra and Saphores, 2018). In the case of emerging new mobility services such as dockless electric bike-share, low-income individuals are more likely to use those services frequently than other income groups (Mohiuddin et al., 2023, 2024).

It can be assumed that all the above-mentioned factors – travel distance/time, age, gender, education, and income – influence MCPs' mode choice. In addition, the nature of MCPs' mobility challenge is an important factor to consider. For example, being in a wheelchair reduces the likelihood of traveling by bus in different contexts, including in South Asian cities (Bascom, 2017; Frye, 2013). Bascom (2017) reported a higher percentage of paratransit use among wheelchair users than non-wheelchair users in Utah, USA. Another set of important factors relates to the characteristics of the transportation service relative to the individual mobility impairment. For example, Deka and Gonjalez (2016) found that PWDs are more likely to use para-transit services because of the door-to-door services they provide by design.

2.2. Perceptions of different modes and their role in mode choice

Several studies around the world have investigated the relationship between people's perceptions of travel modes and mode choice, where perceptions are relative to individual experiences and preferences and are not directly observable. For example, Hu et al. (2015) found that in Nanjing, China, perceptions of reliability and comfort significantly and positively influences the choice of bus as a travel mode. In Los Angeles, USA, Iseki and Taylor (2010) found that people shift to other modes than bus when bus travel is associated with long waiting times in their mind. More recently, Guo et al. (2022) found in another study from China that perceptions of high risks of accidents deter users from walking or using a dockless shared bike for access trips to the metro. Meanwhile, Mohiuddin et al. (2022) demonstrated that road safety perception is positively associated with bike choice for recreational trips, and neighborhood crime perception exerts a negative influence on bicycling choice for grocery trips in Rajshahi, Bangladesh. Al-Ahmadi (2016) found that perception of comfort is an important predictor of mode choice for inter-city business travel in Saudi Arabia. Exel and Piet (2010) highlighted the significant role of perceived travel time in people's choice of car over the bus in the Netherlands. Although these studies have examined the role of mode perceptions in mode choice in different contexts – both developed and developing countries, different trip purposes, different mode, etc. – to the best of our knowledge no study has examined the role of mode perceptions in mode choice for people with disabilities. The perception of the built environment also varies by socio-demographics as Mohiuddin et al. (2022) show that women are more likely to provide a lower perception of different walkability and safety aspects of the built environment than men using Rajshahi, Bangladesh as a case study area. Similarly, mode choice decisions and latent perceptions of individuals with disabilities likely to be shaped differently than individuals without disabilities. It is important to understand how different latent perceptions influence the decision of mode choice of individuals with disabilities.

2.3. Mode-specific problems faced by MCPs

While the role of unobservable mode perceptions remains to be estimated, several observable mode-specific factors are known to influence MCPs' mode choice. For example, whether MCPs can or do take the bus depends on the objective accessibility of the service (Verbich and Ahmed, 2016). Frye (2013), who focused on South Asian cities, found that MCPs avoid making trips by bus because of the lack of a ramp to board, and the lack of space to maneuver or keep mobility aids on board. Furthermore, MCPs are commonly faced with bus staffs' reluctance to allow them to board and, when they do board, often they are verbally abused during the trip (Aarthi, 2019; Dhumgana, 2020; Frye, 2013; Ganesh, 2019; Mampearachchi and Suman, 2014; Morrison et al., 2020; Shafi, 2018).

Individual and mode-specific factors interact in the way they influence MCPs' mobility. Depending on the level of impairment and the mobility aids they use, MCPs experience mode-specific challenges differently. In regard to bus mobility for instance, older MCPs whose legs are especially weak are most challenged by the absence of bus ramps (Imrie, 2000). Wheelchair users experience the absence of bus ramps more acutely than MCPs using a walking frame or crutches (Frye, 2013).

Furthermore, good-quality walking infrastructure is a basic, yet too often unmet requirement to support MCPs' mobility. In many cities worldwide, narrow footpaths are the main impediment to walking for people in need of mobility aids (Chang, 2010; Das and Goswami, 2016; Frye, 2013; Kannan, 2016; Kesik et al., 2012; Tokuda, 2001). Uncut curbs or cut curbs with steep slopes make it difficult for MCPs to shift from the roadway to the footpath (Frye, 2013; Eisenberg et al., 2010). Specifically in Dhaka, Bangladesh, footpaths are so narrow that even a physically fit person cannot walk comfortably. Obstacles like trash bins, landscaping features, or large trees force pedestrians and MCPs alike to make many detours (Abir and Haque, 2011; Sakaki and Gomez, 2018). Cracks in the sidewalks pose a great challenge to MCPs (Ullah, 2019). Motorcyclists plying on the footpath are another great obstacle to MCPs' mobility (The Business Standard, 2021; Ullah, 2019). Bhuiya et al. (2022) showed that such mobility challenges greatly discourage MCPs from walking, while the absence of ramps on buses and the rude behavior of bus staff towards MCPs are key deterrents to their using public buses.

In Dhaka, pull- and CNG auto-rickshaws are the prevalent mobility options available to MCPs. Pull-rickshaws refer to three-wheeled non-motorized vehicles pulled by humans, while CNG auto-rickshaws (locally known as CNGs) are fueled by natural gas. Rickshaws typically provide door-to-door services, although CNG trips can also start and end at CNG stations. Pull-rickshaws are widely used by MCPs for short-distance trips, as an alternative to walking, whereas CNGs are used instead of the bus for longer trips (Islam, 2018). Nevertheless, there are mode-specific challenges associated with pull rickshaws and CNGs as well. Bhuiya et al. (2022) found evidence of unfriendly behaviors from rickshaw pullers and CNG drivers toward MCPs. Drivers are reluctant to carry MCPs' mobility aids or help them get on/off rickshaws and CNGs. It is not uncommon for rickshaw pullers and CNG drivers to charge an extra fee in addition to the usual fare. The excessive height of the platform of a rickshaw and CNG also poses a challenge for MCPs to board (Bhuiya et al., 2022). PWDs in other countries face similar obstacles when using vernacular modes such as rude behavior of keke (powered three-wheelers) drivers in Nigeria (Bombom and Abdullahi, 2015), excessive height of tro tro (mini buses) in Ghana (Odame et al., 2023), and poor design of angkot (mini buses) stops in Indonesia (UKAID, 2022).

2.4. Integrated choice latent variable model for mode choice modeling

Based on the literature review above, we hypothesize that MCPs' mode choice is not only influenced by sociodemographic, trip- and mode-related factors, but also by latent variables revealing MCPs' individual perceptions of mode-specific challenges. This study advances an integrated choice and latent variable (ICLV) statistical modeling approach to account for these perceptions in the analysis of MCPs' mode choice. ICLV is a hybrid choice model which explicitly includes non-directly observable cognitive processes, psychological factors, and latent constructs influencing human behaviors, including the choice of transport modes (Johanson et al., 2006; Vij and Walker, 2016). Several transportation studies have used ICLV modeling techniques to examine mode choice, but never applied to MCPs. For example, based on a sample of the general population of Edmonton, Canada, Habib et al. (2012) investigated the influence of willingness to carpool on mode choice(Habib et al., 2012). Paulssen et al. (2014) in Germany measured the relationships between attitudes toward vehicle ownership, comfort, convenience, and flexibility on commuting mode choice. Li and Sun (2020) in Beijing, China studied the influence of people's perceptions of congestion pricing on mode choice. Recent literature generally confirmed that mode choice is not only dependent on measurable factors, but also on latent factors that are harder to observe, such as safety perceptions and reactions to weather conditions (Liu et al., 2015; Madhuwanthi et al., 2016). Bouscasse (2018) conducted a thorough review of existing literature using ICLV models to explain mode choice. The review showed that most research has been conducted in Western cities, and none of the reviewed studies have considered MCPs as a target group. Our study contributes to addressing these gaps. Within an ICLV framework, we propose to examine how MCPs' mode choices relate to individual perceptions of the limitations of transportation systems in a South Asian megacity.

3. Methodology

3.1. Data collection

We collected survey data from a sample of 400 MCPs receiving physical rehabilitation treatment in Dhaka. We used a convenience sampling strategy to identify and recruit eligible participants, by approaching MCPs at locations that specifically serve their needs, that is, rehabilitation centers. As there is no designated list of all rehabilitation centers in Dhaka, we identified eligible study locations by searching on Google the terms "Rehabilitation Centers in Dhaka, Bangladesh." We found a total of 48 rehabilitation centers that we contacted via phone and email. Eight of them could not be reached for lack of a valid email address or phone number. We shared with the other 40 rehabilitation centers information about our research goals and data collection approach, and we requested permission to conduct the survey on their premises. 19 rehabilitation centers did not respond and 17 declined participation. The remaining 5 institutions accepted to participate in the study, including the Centre for Rehabilitation for the Paralyzed (CRP (2017), the Centre for Disability in Development (CDD) (CDD, 2021a,b), the Physically Challenged Development Foundation (PDF) (PDF, 2017), the Bangabandhu Sheikh Mujib Medical University (BSSMU (2023), and the National Grassroot Disable Organization (NGDO) (NGDO, 2023).

Data was collected in person at the five institutions that gave permission to conduct the survey on their premises, which happened to be some of the largest and most significant rehabilitation centers in Bangladesh. Among these institutions, CRP and CDD are the two largest rehabilitation centers in the country. They serve 84,000 PWDs (around 8% of the total population of PWDs in the country) (CRP, 2022) and 36,000 (around 3.5%), respectively. PDF has more than 5000 beneficiaries in Dhaka (PDF, 2017) and NGDO works directly with the Ministry of Social Welfare and international agencies dedicated to the rehabilitation of PWDs (NGDO, 2023). As for BSMMU, it is the largest hospital of Dhaka and it has one of the best orthopedic departments of the country (Rayna et al., 2021; Huda, 2023). At BSSMU, the survey was conducted in the orthopedic department.

The response rate was 40%. Using a paper-based questionnaire, a sample of 400 MCPs were surveyed, after taking participants' due

consent and confirming eligibility (adult MCPs living in Dhaka). The survey questionnaire focused on regular trips which are made by PWDs, in general, every week. Trips made at least four times per week to a particular place (e.g., workplace, bazaar, children's school) were considered regular trips. Respondents provided information on the primary mode choice for each type of regular trip as well as specific trip-related information including mode, (self-reported) travel time, and waiting time, both at origin and destination. In addition, MCPs were asked to mention other modes they use occasionally as well as socio-demographic characteristics including age, gender, education, monthly income, car ownership, and mobility aid device.

Admittedly, the resulting sample is not statistically representative but random sampling or stratification would be impossible given that there is no official data recorded for all MCPs living in Dhaka. By approaching MCPs at some of the major rehabilitation centers in Dhaka, we were able to overcome some major obstacles faced by disability studies: PWDs are generally difficult to reach and can be reluctant to disclose information about their impairment. The latter may explain why 60% of the MCPs we approached refused to participate in the study. One limitation of our recruitment strategy is that we excluded MCPs who do not frequently visit rehabilitation centers for reasons that may be related to low income, limited access to care or information, light impairment, social norms (e.g., gender norms), or others. Nevertheless, we contend that our data collection approach enabled to optimize the recruitment of eligible participants within the limited resources available for data collection.

3.2. Measurements

3.2.1. Mobility impairment and socio-demographic characteristics

Table 1 presents the sample composition by sociodemographic and mobility impairment category, as measured by the survey. Ordinal scales were used for gender (2 categories), age (3 categories), education (3 categories), income (3 categories), and mobility impairment (3 categories). Mobility aids served as a proxy to rank impairment by level of walking disability. Indeed, the type of device indicates the extent to which MCPs need assistance to walk/move as their legs alone cannot support their weight. The literature has posited wheelchair users as the most disabled in this regard, while users of a walking stick/cane are the least disabled. In-between are users of walking frames and crutches (Bradley and Hernandez, 2011; Cunha, 2020; Leonard, 2021). Hence, the level of disability of wheelchair, crutch/walking frame, and walking stick users were coded as 3, 2, and 1, respectively, in decreasing order of mobility impairment.

The sample included approximately equal shares of respondents using these three types of mobility aids (ranging from 32 to 35%). The share of female respondents was greater (55%) than that of male respondents (45%). The middle-age and middle-income categories included the largest shares of participants. Most participants had at least completed high school.

3.2.2. Perceptions of mode-specific challenges

MCPs' perceptions of four transport modes were measured, including walking, bus, CNG, and rickshaw. MCPs with access to private vehicles reported not using any other modes for regular trips. Since they do not experience the mode-related challenges that severely limit other MCPs' access to transportation services, 16 MCPs that solely relied on private cars were excluded from the study. The resulting sample of 384 individuals was used for the analysis.

Drawing on the literature review, a list of 18 mode-specific challenges faced by MCPs around the world was prepared (Table 2). These challenges relate to riding a bus (5 challenges), walking (5), using a rickshaw (4), and riding a CNG (4). The survey asked MCPs how severe each of these challenges appears to them, on a 1-5-point Likert scale, from Not Severe to Extremely Severe.

Table 2
List of mode-specific problems analyzed in the study.

Mode-specific problems	Literature
Mode: Walking	
Presence of obstacles in the footpath	Canada (Chang, 2010); Malaysia (Frye, 2013); United Kingdom (Imrie, 2000); Iran (Aghaabbasi et al., 2019)
Presence of cracks and undulated surface of footpaths	Cambodia (Frye, 2013); Bangladesh (Ullah, 2019)
Conflict with motorcycle	Bangladesh (The Business Standard, 2021); India (Sumit et al., 2022)
Lack of ramp with standard slope for universal accessibility	Bangladesh, (Bhuiya et al., 2022); United States (O'Hagan, 2021)
Narrow width of the footpath	Canada (Chang, 2010); India (Das and Goswami, 2016; Kannan, 2016); Tanzania (Frye, 2013); Turkey (Kesik et al., 2012)s
Mode: Bus	
Lack of ramp in bus	Nigeria and Indonesia, (Frye, 2013); Ganesh (2019); India (Shafi, 2018); Bangladesh (Bhuiya et al., 2022)
Unwillingness of bus conductors to carry movement-challenged persons	India (Ganesh, 2019); Sri Lanka (Mampearachchi and Suman, 2014), Australia (Neves et al., 2023)
Rude behavior of bus conductors and drivers	India (Aarthi, 2019); Bangladesh (Abir and Haque, 2011); Sri Lanka (Dhumgana, 2020); Russia and Jamaica (Frye, 2013), United Kingdom (Velho, 2019)
Lack of space to maneuver	India (Frye, 2013; Tauhid, 2007)
Lack of space to keep mobility aid	Bangladesh (Abir and Haque, 2011 United Kingdom (Velho, 2019)
Mode: Rickshaw and CNG	
Excessive height of platform	Bangladesh (Bhuiya et al., 2022)
Excessive fare charged by rickshaw puller	Bangladesh (Rahman and Assadekjaman, 2013), India (Thomas, 2021), Pakistan (The Dawn, 2023)
Lack of available space to keep mobility aid	Bangladesh (Bhuiya et al., 2022)
Unwillingness of rickshaw pullers to carry movement-challenged persons	Bangladesh (Rahman and Assadekjaman, 2013)

Table 1
Sample composition by socio-demographic characteristics and mobility impairment.

Variable	Percentage	Coding	Factor and Categories	Percentage	Coding
Gender			Income		
Male	45.4%	0	<25,000 BDT (Lower income)	33.4%	1
Female	54.6%	1	25,000–50,000 BDT (Middle income)	47.3%	2
Age			>50,000 BDT (Higher-income)	19.3%	3
0–25 years (Young)	25.8%	1	Mobility aid (Level of disability)		
25–50 years (Middle Aged)	41%	2	Wheelchair user	31.8%	1
Greater than 50 years (Elderly people)	33.2%	3	Walking Frame/Crutch user	34.3%	2
Education			Walking Stick/cane user	34%	3
Up to Secondary School Certificate (SSC) (≤10 years of schooling)	35.5%	1			
Higher School Certificate (HSC) (12 years schooling)	37.3%	2			
Bachelor or higher (≥16 years of schooling)	27.2%	3			

BDT=Bangladeshi Taka i.e. currency of Bangladesh.

4. Modeling approach

This study employs an ICLV model to analyze MCPs' mode choices while accounting for the mode-specific problems they experience. ICLV is preferred to a more conventional discrete choice modeling (DCM) based on a random utility maximization (RUM) framework. With RUM, the utility function takes in socio-demographic factors and trip costs as inputs, as well as other relevant factors (McFadden, 1986). Ben-Akiva and Boccara (1987) extended the DCM to integrate latent variables. Perception parameters can be integrated as an explanatory variable, using summary measures – such as the mean of the indicators – or following data reduction techniques – i.e., factor scores from the factor analysis (McFadden, 1986). However, multiple studies reported that directly adding attitudinal statements collected through a survey, or pre-estimated factor scores as explanatory variables can lead to measurement error (i.e., at least one independent variable is measured with error) and endogeneity biases (independent variable is correlated with measurement error) (Ashok et al., 2002; Ben-Akiva et al., 2002; Daly et al., 2011).

To address this limitation, Ben-Akiva et al. (2002) advanced an ICLV framework, which combines structural equation models for latent variables (LVs) with measurement models for attitudinal statements. In other words, within an ICLV modeling framework, the effects of socio-demographic variables for example are measured both directly and indirectly. To assess their direct effect on mode choice, socio-demographic variables are included in the utility function of the binary choice model. Their indirect effect, through latent variables, is estimated by the structural equation model. In our ICLV model, the measurement model links LVs to sociodemographic characteristics and response to the attitude statements collected through the survey about perceived obstacles to using different modes, while the structural equation model describes LVs in terms of observable variables (i.e., socio-demographic). LVs are then incorporated into the utility of MCPs to understand their mode choice. The entire framework is described in Fig. 1.

4.1. Extraction of latent variables

An exploratory factor analysis of respondents' ratings of 18 statements about the severity of mode-induced mobility challenges led to the extraction of five factors. Only the factors whose eigenvalue was greater than one were included in the framework. These are posited as the five latent perceptions of MCPs regarding mode-specific challenges (Table 4). Based on the factor loading of the different statements, the five factors were named as follows:

1. Perceived deficiencies in pedestrian infrastructures: This factor encompasses all walking-related problems, absence of bus ramps to shift from walking on the footpath to being on-board, and lack of space on buses to maneuver;
2. Perceived fare-related problems: This factor includes excessive fares charged by rickshaw pullers and CNG drivers, as well as their rude behavior and the unwillingness of bus staff to help MCPs on-board and off-board (where such behavior may be attributed to their inability to charge an extra fee for what they consider an extra service, given that bus fares are fixed in Bangladesh);
3. Perceived lack of space to keep mobility aids on board: Loaded on this factor is the lack of space on both buses and rickshaws;
4. Perceived unwillingness to provide service to MCPs: This fourth factor encompasses the unwillingness to help both rickshaw and CNG drivers;
5. Excessive height of platform of different modes: This factor relates to the problem caused by the high platform of both rickshaws and CNGs.

Table 3 provides more details on how statements regarding mode-related challenges were loaded on these factors, while the whole ICLV modeling framework is shown in Fig. 1.

4.2. Discrete choice model

Equation (1) represents the utility for mode choice of MCPs integrating both observable explanatory variables and a vector of latent

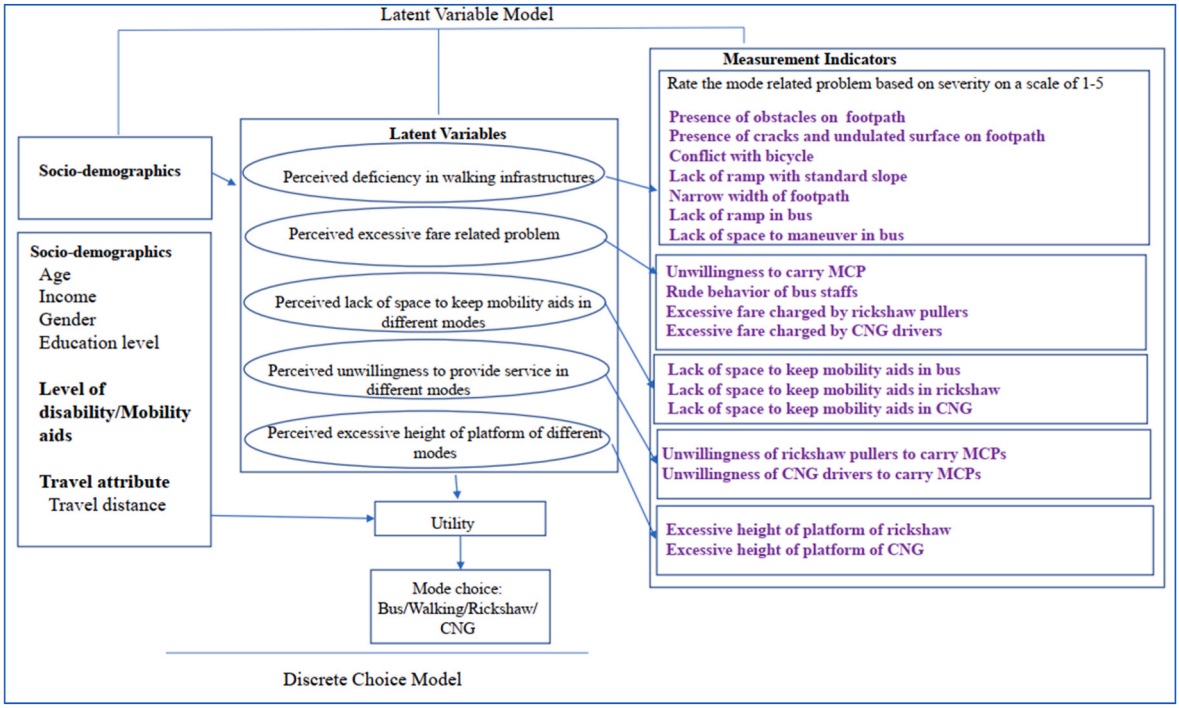

Fig. 1. ICLV modeling framework for mode choice of MCPs.

Table 3
Factor loadings of the different statements from the exploratory factor analysis.

Mode-specific problems	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Lack of ramp on bus	0.672				
Lack of space to maneuver on bus	0.497				
Presence of obstacles on footpath	0.674				
Conflict with motorcycle on footpath	0.369				
Over crowdedness on the footpath	0.131				
Lack of ramp with slope of standard of universal accessibility	0.740				
Narrow width of footpath	0.352				
Presence of cracks and undulated surface of footpaths	0.789				
Unwillingness of bus conductors to carry movement-challenged persons		0.69			
Rude behavior of bus conductors and drivers		0.628			
Excessive fare charged by rickshaw pullers		0.968			
Excessive fare charged by CNG drivers		0.941			
Lack of space to keep mobility aid in bus			0.287		
Lack of space to keep mobility aid in rickshaw			0.941		
Lack of space to keep mobility aid in CNG			0.937		
Unwillingness of rickshaw pullers to carry movement-challenged persons				0.908	
Unwillingness of CNG drivers to carry movement-challenged persons				0.894	
Excessive height of rickshaw platform					0.797
Excessive height of CNG platform					0.602

variables predictors. In this modeling framework, we considered mode choice as a binary choice (i.e., developed four models for mode choice for four modes). It was possible to develop a multinomial framework for the mode choice decision by the MCPs, however, we did not collect travel-related attributes (i.e., travel time, cost, distance, etc.) for each mode for each MCP in the survey. To overcome this data collection limitation, we considered mode choice as a binary decision (choose a specific mode or not) for each mode. The general utility specification of this binary choice for a mode can be described by the following equation.

$$\begin{aligned} u_n = {} & ASC + \beta_1 Age_n + \beta_2 Gender_n + \beta_3 Income_n + \beta_4 Education_n \\ & + \beta_5 Mobility\ Aid_n + \beta_6 travel\ time_n + \beta_7 access\ mode_n + \beta_8 egress\ mode_n \\ & + \Gamma_1\ Perceived\ deficiency\ in\ pedestrian\ infrastructres_n \\ & + \Gamma_2 Perceived\ fare\ related\ problem_n \\ & + \Gamma_3 Perceived\ lack\ of\ space\ to\ keep\ mobility\ aids_n \\ & + \Gamma_4\ Peceived\ unwillingness\ to\ carry\ in\ different\ modes_n \\ & + \Gamma_5 Perceived\ \ excess\ height\ of\ platform\ of\ different\ transport\ modes_n \\ & + \epsilon_n \end{aligned} \tag{1}$$

Where u_n is the utility of a mode as perceived by MCP "n"; ASC is the alternative specific constant; ϵ_n is a random error, which explains unobservable effects; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ are the coefficients of respective explanatory variables; Γ_1 , $\Gamma_2, \Gamma_3, \Gamma_4$ *and* Γ_5 indicate the influence of the latent variables on the utility.

4.3. Structural equation/latent variable models

Equations (2.1) to (2.5) are the structural equations used for the latent variable model. They were developed through a two-step process.

- Step 1: We regressed the factor score of each score on all socio-demographic variables. Then, based on the significant socio-demographic variables in the regression results, we developed the initial structural equation models for the five latent perception variables.
- Step 2: After running the ICLV models, we again inspected the significance of the socio-demographic variables in the initial structural equation model and dropped those variables that were not significant in the structural equation model. Lastly, we reran the ICLV models with a significant set of socio-demographic variables.

$$\begin{aligned} walking\ related\ problem\ perception_n = {} & A_n Gender_n + A_n Income_n + A_n Age_n \\ & + A_n Instrument_n + v_n \end{aligned} \tag{2.1}$$

$$\begin{aligned} fare\ related\ problem\ perception_n = {} & A_n Gender_n + A_n Income_n + A_n Age_n \\ & + A_n Instrument_n + v_n \end{aligned} \tag{2.2}$$

$$\begin{aligned} & lack\ of\ space\ for\ supporting\ instrument\ related\ problem\ perception_n \\ & = A_n Instrument_n + v_n \end{aligned} \tag{2.3}$$

$$unwillingness\ to\ carry\ related\ problem\ perception_n = v_n \tag{2.4}$$

$$excess\ height\ of\ the\ platform\ related\ problem\ perception_n = v_n \tag{2.5}$$

Here, the *A* parameters represent the impact of the socio-demographic variables on latent variables for MCP "n" and the v_n is the stochastic component of the equation (Vij and Walker, 2015).

4.4. Measurement equation model

The measurement equation reveals how the perception statements of mode-specific problems are loaded into LVs. Before entering those perception statements in the model, they were standardized by subtracting the mean. The measurement model equation is provided in equation (3), where D is a vector of parameters representing the sensitivities of the measurement indicators (the selected eighteen mode-specific problems on a scale of 1–5) to the respective five latent variables in the matrix x_n^* derived from equation (2.1)-(2.5) (Vij and Walker, 2016).

$$i_{k,n} = D x_n^* + \eta_n \tag{3}$$

In equation (3), i_k is the *k*th perception statement, x_n^* and η_n indicates the stochastic component of the equation.

5. Results

5.1. Descriptive statistics

MCPs' mode choices for regular trips are either walking, rickshaw, bus, or car. Rickshaw is the most prominent mode, with a 45% modal share, followed by CNG auto-rickshaw (22%), walking – with mobility aids (16%), and bus (14%). A small share of respondents (4%) reported making regular trips by private cars. These respondents were excluded

Table 4
Rank of different mode-related problems in percentage with the average rank value.

Rank	1	2	3	4	5	Average rank
	Not Severe	Not too Severe	Moderately Severe	Very Severe	Extremely Severe	
Walk						
Presence of obstacles in footpath	2%	2%	13%	43%	38%	4.13
Presence of cracks and undulated surface of footpaths	2%	2%	5%	26%	64%	4.49
Conflict with bicycle	2%	5%	27%	28%	39%	3.95
Lack of ramp with standard slope for universal accessibility	1%	1%	13%	26%	58%	4.40
Narrow width of footpath	1%	3%	19%	43%	34%	4.08
Bus						
Lack of ramp in bus	1%	3%	6%	33%	57%	4.43
Unwillingness of bus conductors to carry movement-challenged persons		1%	13%	40%	46%	4.32
Rude behavior of bus conductors and drivers	1%	1%	15%	48%	34%	4.12
Lack of space to maneuver	2%	4%	6%	25%	61%	4.39
Lack of space to keep mobility aid	3%	4%	24%	22%	47%	4.07
Rickshaw						
Excessive height of platform	4%	2%	12%	35%	46%	4.2
Excessive fare charged by rickshaw pullers	1%	1%	15%	36%	48%	4.3
Lack of available space to keep mobility aid	2%	8%	16%	25%	49%	4.13
Unwillingness of rickshaw pullers to carry movement-challenged persons	2%	3%	17%	35%	42%	4.12
CNG						
Excessive height of platform	7%	8%	29%	35%	22%	4.36
Excessive fare charged by CNG drivers	1%	1%	14%	32%	52%	4.17
Lack of space to keep mobility aid	2%	7%	15%	26%	49%	4.14
Unwillingness of CNG drivers to carry movement-challenged persons	2%	2%	17%	36%	43%	3.61

from the analysis.

Table 3 shows the frequency distribution (in percentages) of MCPs' responses regarding the level of perceived severity of different mode-specific challenges. For each challenge, it also shows the average response. The most severe impediments to MCPs' mobility in Dhaka include bad pedestrian infrastructure (cracks in the sidewalks and undulated surfaces), the absence of bus ramps, and excessive fares charged by rickshaw pullers and CNG drivers.

Table 5 shows the coefficient estimates of four ICLV models, one for each mode choice. As described in section 4.3, a significant influence of sociodemographic variables on some mode choice were identified through the ICLV model. Since the focus of this study is to understand the influence of the latent perception on the mode choice, we kept all five latent perception variables in the model whether they were significant or not. Also, we kept the waiting time variable for the bus model and for the rickshaw model for consistency across the model although they were not significant. The bold values highlight the significant variables (at a 10% significance level) in a particular mode choice.

5.2. Regression results

5.2.1. Effect of socio-demographics

The effect of income is significant in three mode choice models except for walking. The relationship is positive with the choice of rickshaw and CNG and negative with the choice of bus. This was expected considering that individuals with higher incomes are more likely to

Table 5
Estimates of the ICLV model.

	Bus		CNG		Rickshaw		Walk	
	Estimate	Robust t-ratio	Estimate	Robust t-ratio	Estimate	Robust t-ratio	Estimate	Robust t-ratio
Alternative Specific Constant	−2.3036	−2.9440	−15.1279	−6.6900	−0.3797	−1.2562	13.2589	3.8364
Income (in Taka)	−.00007	**−4.4982**	.00003	**1.8011**	.00003	**3.7784**	–	–
Commuting Distance	0.6635	**6.2633**	0.3013	**3.1328**	−0.3942	**−5.4236**	−7.3318	**−2.9815**
Age	−0.0450	**−1.9747**	0.0861	**3.2225**			−0.1868	−4.0787
Gender (Base = Female)	–	–	–	–	–	–	1.5339	**2.0506**
Mobility aids (Wheelchair = 1, Walking frame, Crutch = 2, Walking Stick = 3)	–	–	–	–	–	–	–	–
Waiting Time at Origin	−0.1135	−1.5047	0.4140	**5.6815**	−0.0075	−0.1797	–	–
Waiting Time at Destination	0.2612	**2.9330**	0.4623	**4.1037**	0.0923	**1.9158**	–	–
Latent Variables (LVs)								
Perceived deficiency in pedestrian infrastructures (LV1)	−0.3983	**−1.7767**	0.9208	**2.0861**	−0.0195	−0.0988	−0.8521	**−2.0011**
Perceived fare Related Problem (LV2)	−0.3301	−1.2387	0.4389	**2.0302**	−0.3011	−1.5650	−1.6137	**−2.7227**
Perceived lack of space to keep mobility aids (LV3)	−0.7758	**−2.2935**	−0.1171	−0.3101	0.1413	0.6706	1.6997	**2.2401**
Perceived unwillingness to provide service (LV4)	−0.1104	−0.3456	−0.3675	−1.1089	0.0060	0.0119	−0.6495	−1.3312
Perceived challenges related to excessive height of platform	−0.0833	−0.2129	0.2011	0.6587	−0.2096	−0.5907	0.6497	1.6064
Structural Equation Model Estimates based on Equation 2.1 to 2.5								
Age on LV1	−0.0124	**−1.7844**	−0.0150	**−3.0750**	−0.0130	−1.3249	−0.0131	−1.5570
Gender on LV1	−1.0207	**−5.2376**	−0.8464	**−3.8686**	−1.0372	**−5.2530**	−1.0266	**−5.0627**
Age on LV2	−0.0357	**−8.8906**	−0.0385	**−6.5073**	−0.0358	**−8.1174**	−0.0360	**−8.6203**
Gender on LV2	0.6383	**4.1478**	0.6913	**3.8468**	0.6427	**4.7578**	0.6343	**4.4491**
Mobility aid on LV1	0.4762	**3.0487**	0.4488	**3.8431**	0.4945	**2.1295**	0.4964	**2.4591**
Mobility aid on LV2	0.4780	**6.9026**	0.5253	**5.2554**	0.4796	**6.1869**	0.4864	**6.9774**
Mobility aid on LV3	−0.0350	**−3.4635**	0.1075	**4.9832**	−0.0349	**−3.2283**	−0.0350	**−3.3222**

choose private door-to-door mobility services such as rickshaws and CNG and are less likely to walk or take the bus, regardless of their ability to walk. Age is significantly and positively associated with the choice of rickshaw, and significantly and negatively associated with the choice of bus and walking. Age is not significant for the choice of rickshaw and CNG. As descriptive statistics suggest – large shares of MCPs use these modes – rickshaw and CNG seem to be a common mode choice among MCPs in Dhaka, irrespective of age. The relationship between gender and mode is significant and positive with walking only, indicating that mobility-challenged men are more likely to walk than women.

5.2.2. Effect of commuting distance

Commuting distance is significant in all models. It is negatively associated with rickshaws and walking, which could be expected considering that walking and pull rickshaws are generally most appropriate to cover short distances. However, the relationship is positive with motorized modes, that is, CNG or bus, meaning that these modes are used by MCPs for longer trips in Dhaka, which could be expected as well.

5.2.3. Effect of waiting time

While one could generally expect waiting time to be negatively associated with mode choice, in our model, we found a positive relationship with waiting time at the destination (prior to the return trip). This indicates that MCPs' transportation choices are defined by the other factors and they choose the mode regardless of its long waiting time. For instance, if an MCP chooses a rickshaw for commuting, which is influenced by several other factors used in the model, that person will wait for the rickshaw for a longer period of time. According to the literature, MCPs from Dhaka, Bangladesh depend highly on rickshaws and CNG because of the door-to-door service provided by these modes. However, it is common for rickshaw pullers and CNG drivers to show unwillingness to carry them because they do not want to carry the mobility aids leading to higher waiting times. So, MCPs have to wait for the rickshaw puller and CNG driver to carry them to receive door-to-door service (Bhuiya et al., 2022).

5.2.4. Effect of mobility aids

We did not find the influence of mobility aids on mode choice significant in any of the models. These results suggest that the type of mobility aid used by the respondents does not directly influence their choice of travel mode. However, the type of mobility aid they use significantly influences their perceptions of mode-related problems. This is validated by the fact that the coefficient of the mobility-aid variable is significant for the first three latent variables.

5.2.5. Effect of latent perception of five mode specific problems

Deficiencies in walking infrastructures are negatively correlated with the selection of buses and walking as a travel mode by MCPs. Multimodal access to public transportation accommodates the ways for a public transportation user to reach a bus stop to access a public transportation service. Multi-modal integration is particularly important for the choice of a bus for MCPs as they are heavily dependent on the first and last-mile access to the bus which does not provide door-to-door service (Grisé et al., 2018; Mohiuddin, 2021). In Dhaka, individuals mostly walk to access the bus services(Mohiuddin et al., 2022). In general, MCPs are likely to walk to the bus stop, and accommodating the specific needs of MCPs is imperative (Bhuiya, 2019). So, deficiencies in walking infrastructures make it challenging for MCPs to go to and from bus stops. For this reason, the greater the value of this LV, the more reluctant MCPs are to travel by bus.

Relatedly, the higher the deficiencies in walking infrastructures, the lower the likelihood to choose walking as a travel mode; and the higher the likelihood of choosing CNGs. As CNGs provide door-to-door services, they virtually eliminate the need to walk. Furthermore, these motorized means of transportation are generally more suitable than other modes for relatively long trips. Hence, poor sidewalk conditions are likely to encourage MCPs to use CNGs.

Problems related to fares are positively related to the choice of CNGs. As described in the factor analysis, the problems related to fares are linked to the misconduct of bus staff. In general, buses and CNGs are well-suited modes for relatively long-distance travel. When MCPs face a higher level of misconduct from bus staff, they are compelled to use CNG.

Lack of space on the bus to keep mobility aids has a positive and significant relationship with specific mobility aid devices. This implies that wheelchair users likely suffer the most from this perceived constraint since wheelchairs require more space than any other mobility aids. Unsurprisingly, this latent variable is positively associated with walking; when MCPs suspect there will not be enough space on board to keep their mobility aid (or simply sit) they may choose to walk instead.

MCPs' mode choice was not found to be significantly related to the other two LVs – perceived unwillingness to provide service and the perceived problem of the excessive height of the platform. The perceptions regarding these two problems do not significantly influence the choice of CNG and rickshaw as these two modes are more tailored to transportation-disadvantaged individuals. In the case of the public bus, individuals have to share space with others, which makes it difficult for MCPs to accommodate both themselves and their mobility aid. Even for a person without mobility challenges, an overcrowded bus is not the most attractive travel option. MCPs are likely to experience difficulties when traveling by bus. More generally, an insignificant latent variable may indicate that MCPs have largely accustomed or adapted to the related mode-specific challenges. The unwillingness to provide service is not significant for both CNG and rickshaws. This may be because MCPs generally try to overcome such unwillingness by offering higher fares for these two modes, especially in the case of a rickshaw, which is the most common motorized mode in Dhaka (Bhuiya et al., 2021). Additionally, the results show that the excessive height of the platform does not have a significant influence on mode choice. This problem is common to rickshaws, CNGs, and buses in Dhaka since there are no specific design guidelines about platform heights for different vehicles (Dhaka Transport Coordination Authority, 2004; Dhaka Transport Coordination, 2015). Despite experiencing hardships in boarding a vehicle with a high platform, MCPs might have found ways to circumvent this problem.

5.2.6. Interaction of sociodemographic factors with latent perception of mode-specific problems variables

Age is significantly and negatively associated with the perceived deficiency in walking infrastructure latent variable when MCPs decide to travel by bus or CNG. This is surprising as MCPs tend to get older, they should perceive more severely the issues with the pedestrian infrastructure. This outcome needs further investigation. Also, age is negatively associated with the perceived fare-related problem latent variable which is expected as when people get older, they tend to become more adapted to the issues of higher fare charges for being an MCP and reluctance of the mode operator to take them on their mode. Thus, they tend to rate those issues less severe compared to their younger counterparts.

Gender is found to be negatively associated with different mode-related problems perception latent variables. Male MCPs rate walking-related problems less severely. Mobility aid types used by the MCPs are positively related to walking-related problems implying that MCPs with a higher level of disability condition tend to rate walking-related problems more severely. Wheelchair users suffer the most from deficiencies in pedestrian infrastructure. This can be attributed to the width of footpaths that is too narrow to accommodate a wheelchair; the cracks in which wheelchairs get stuck; and the lack of cut curbs that make many footpaths inaccessible to wheelchair users.

Gender has a significant and positive relationship with the fare-related latent variable. It may be that female MCPs are likely to rate fare-related problems less severe than others, or drivers charge them less

in comparison to other MCPs. Mobility aid is positively related to this fare-related latent variable, thus suggesting that MCPs with a higher level of disability experience these problems more acutely. It is not unlikely for rickshaw pullers or CNG drivers to charge additional fares from MCPs as they have to perform additional services, such as assisting wheelchair users to carry bulky instruments.

Across types, mobility aids maintain a significant positive relation with the perceived lack of space for such devices in all mode choice models, except when the choice of bus is the outcome variable. This implies that when MCPs perceive a mode provides less space to keep their mobility aids, they are not likely to select that mode. A wheelchair requires more space than a walking frame or crutch and a cane requires less space than a walking frame or crutch. Thus, it is likely that with the increase in the level of disability and level of the bulkiness of the mobility aid, MCPs are likely to suffer more from lack of space for mobility aids.

Mobility aids have a significant negative association with the latent perception of lack of space to keep supporting instruments in the selection of the bus and rickshaw as modes. Mobility aid has a significant positive relation with a latent perception of lack of space to keep supporting instruments in the selection of CNG. The effect size of mobility aids in selecting the bus and rickshaw is relatively smaller for these modes than for CNG.

6. Discussions and policy implications

Our findings about MCPs' mode choices in Dhaka are generally consistent with previous literature. For example, the findings that younger, low-income MCPs are more likely to walk coincide with the results of Paydar and Fard (2021) and Lehman (2018) regarding the influence of socio-demographic factors on walking and transit ridership. Meanwhile, the high propensity of elderly MCPs to use rickshaws in Dhaka can be attributed to the convenience of door-to-door service that this mode provides (Cidel, 2021).

Most importantly, our study provides novel insights about MCP's perceptions of transportation systems' limitations in a South Asian megacity, and their significant role in mode choice. Although our sample is not representative and limited to 400 survey respondents in Dhaka, Bangladesh, our modeling results shed light on the significant influence of MCPs' perceptions of different modes on their mode choice. This is a contribution to prior knowledge, typically focused on the direct relationships between mobility impairment and mode choice – e.g., people in a wheelchair are less likely to take the bus (Frye, 2013). Interestingly, our findings suggest that the type of mobility aid, and related mobility challenge, is not directly associated with any specific mode choice in Dhaka. We found however that mobility aids have a significant relationship with the following latent variables: perceived deficiency in walking infrastructure, fare-related problems, and lack of space to keep mobility aids. This indicates that the effect of mobility aid does not always directly influence the mode choice rather it can sometimes indirectly influence the mode choice by shaping the latent perception of MCPs. Policymakers and practitioners should focus on addressing these issues to improve MCPs' perceptions of related systems and thus their likelihood of using them, as part of ongoing efforts to facilitate MCPs' mobility and accessibility. Although recent policies and plans mentioned in the introduction section aim to improve MCPs' access to opportunities in Bangladesh, these plans remain very general and lack specific guidelines.

In Dhaka, our results suggest that improving the walking environment is a critical priority to promote MCPs' pedestrian mobility, not only as a primary mode for shorter trips, but also as a complementary mode to the bus for longer trips. This recommendation stems from our finding that perceived deficiencies of the pedestrian infrastructure are negatively associated with the bus as a mode choice. As suggested by Deka and Gonzales (2014), removing barriers to walking will be especially helpful to ensure MCPs' first- and last-mile mobility(Deka and Gonjalez, 2016). Such improvements would be especially beneficial for MCPs who cannot afford private door-to-door services like rickshaws and CNGs in Dhaka.

Policymakers should also devise and implement policies that oblige public transit operators to provide (i) service to all patrons – refusing service to MCPs should be severely fined; (ii) space on buses for MCPs to keep mobility aids; and iii) access ramps to facilitate MCPs' on-boarding and off-boarding. We found that the lack of space on board for mobility aids negatively influences the choice of bus. Additionally, the excessive height of the platform is a major perceived barrier to taking the bus. Guidelines and designs for universal accessibility of the vehicles should be developed to promote the mobility of PWDs(Aarhaug and Beate, 2015).

Given the high share of MCPs using rickshaws, a short-term priority should be to make rickshaws universally accessible. Almost half of the respondents (46%) were using door-to-door rickshaw services, including pull-rickshaws and more expensive CNGs for regular trips, despite problems inherent to these modes. Folding ramps can be installed on rickshaws to address the excessive height of platforms (Hudson, 2017), perceived by MCPs as a significant obstacle to using these modes. App-based rickshaw and CNG services can be introduced to increase fare transparency and prevent rickshaw pullers and CNG drivers from charging extra for carrying MCPs, where fare-related issues are another perceived obstacle revealed by our study. Existing app-based ride-hailing services like Uber, which exist in Bangladesh, can be adapted to include universally accessible rickshaws (Kumar et al., 2018).

The use of the ICLV model also helped disentangle the complex relationships between mobility aid needed, sociodemographic characteristics, latent perceptions of obstacles to using different modes, and mode choice. The discrete choice component of the ICLV showed that individual choices are influenced by latent perceptions of mode-specific limitations of transportation systems. In addition, the structural equation component of the ICLV model showed that latent perceptions are significantly influenced by socio-demographics (e.g., gender) and the type of mobility devices used by individual MCPs. In most of our models, the direct relationship between gender and binary mode choice was not statistically significant. Similarly, the direct effect of mobility devices was not statistically significant. However, both gender and mobility devices were significantly associated with latent variables. In other words, these results suggest that MCPs' gender and mobility devices do not seem to have a direct effect on mode choice; however, their effect may be indirect, through latent variables. Thus, excluding latent variables from the mode choice modeling framework would overestimate the effects of gender and mobility devices on mode choice, which could be misleading for policy formulation; whereas including latent perception variables can help policymakers address the barriers to using different modes as perceived by various subgroups of MCPs, by gender and mobility impairment.

Finally, future research should expand on this study, the first of its kind to use ICLV to model MCPs' mode choice for regular trips. The data used in this study was collected in one city only and from one category of PWDs, that is, MCPs. Future studies could replicate similar analyses in other cities and identify mode-specific constraints faced by people with other disabilities. Furthermore, future research may want to consider a multinomial modeling strategy, common for modeling of mode choices. To do so, data on travel time, travel distance, and travel cost must be collected for all possible modes available. It is a limitation of our data that we collected this information only for the mode that respondents actually used for surveyed trips. We did not ask respondents to provide similar information for modes they did not use, as we assumed they would not know the answer with precision. Furthermore, such data could not be estimated from secondary data, not even using Google Maps; there is no feature to calculate travel times by pull rickshaws or CNG in Google Maps. Another limitation of the study is that the results only speak to the experience of MCPs who visit rehabilitation centers in Dhaka. Future research should attempt to recruit more broadly.

Nevertheless, our study has shed light on the overall potential of ICLV techniques to inform policy about the specific obstacles to mobility and accessibility, as experienced by PWDs.

7. Conclusion

Kakar et al. (2021) have argued that transportation inequities must be better understood to achieve social justice through policy. With this study, our primary goal was to advance knowledge on transportation inequities affecting PWDs. Secondly, we wanted to expand to PWDs and to a rapidly developing megacity the ICLV modeling technique that is typically used to uncover the role of unobservable perceptions or attitudes in mode choice. We estimated the influence of latent perceptions of the limitations of transportation systems, in addition to that of individual, and trip-related factors on mode choice, for mobility-challenged persons living in Dhaka, Bangladesh.

We found that apart from socio-demographic, disability, and travel-related attributes, individual perceptions of mode-related problems significantly influence MCPs' mode choice. In particular, perceptions of obstacles to walking, which mostly result from Dhaka's rather organic development and limited investments in pedestrian infrastructure, significantly influence MCPs' choice of traveling by bus; and anticipated high fares significantly influence the choice of CNG and rickshaw. Drawing on this assessment, we formulated specific policy recommendations to make Dhaka's transportation system more accessible to MCPs, and therefore more equitable overall.

Our results also shed light on the risks of overestimating the direct relationships between mobility impairment and mode choice, and sociodemographic characteristics such as gender and mode choice, when excluding latent variables from mode choice models. Although this research is focused on Dhaka, its methodology can be improved and expanded to other contexts. Particularly, the approach can most directly help investigate MCPs' mode choices in other developing cities that face similar transportation challenges (Aarthi, 2019; Malik, 2017; Dhumgana, 2020; Shafi, 2018). More broadly, in rapidly growing and mature economies alike, MCPs face severe transportation challenges (Bascom, 2017; Clery et al. 2016), and the proposed ICLV framework can help identify and address specific issues with transportation systems, as perceived by MCPs. MCPs and other PWDs are a significant part of society (Clery et al., 2017). Enhancing their mobility is a necessary pathway to create truly inclusive transport systems that promote universal access to opportunities.

Author contribution

Hossain Mohiuddin: Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Revising the manuscript, Visualization.

Md Musfiqur Rahman Bhuiya: Methodology, Data Collection, Formal Analysis, Writing - Original Draft, Revising the manuscript, Visualization.

Md Musleh Uddin Hasan: Methodology, Data Collection, Formal Analysis, Writing - Original Draft, Revising the manuscript, Funding Acquisition.

Hue-Tam Jamme- Methodology, Formal Analysis, Writing - Original Draft, Revising the manuscript.

Data availability

The authors do not have permission to share data.

References

Aarhaug, A., Beate, E., 2015. The impact of universally accessible public transport–a before and after study. Transp. Policy 44, 143–150.

Aarthi, N., 2019. Bus Stops, Commute Still a Nightmare for Disabled People. Times of India. Retrieved from. https://timesofindia.indiatimes.com/city/chennai/bus-stops-commute-still-a-nightmare-for-disabled-people/articleshow/73001351.cms.

Abir, A.K.M., Haque, M.S., 2011. A study on mobility problem of disabled people in Dhaka city. In: Paper Presented at the 4th Annual Paper Meet and 1st Civil Engineering Congress, Dhaka, Bangladesh.

Aghaabbasi, M., Moeinaddin, M., Asadi-Shekari, Z., Shah, M.Z., 2019. The equitable use concept in sidewalk design. Cities 88, 181–190. https://doi.org/10.1016/j.cities.2018.10.010.

Al-Ahmadi, H.M., 2016. The Effects of Mode Perceptions on Intercity Mode-Choice.

Ashok, K., Dillon, W.R., Yuan, S., 2002. Extending discrete choice models to incorporate attitudinal and other latent variables. J. Market. Res. 39 (1), 31–46. https://doi.org/10.1509/JMKR.39.1.31.18937.

Babaei, M., Hedayati, A., 2020. Investigating the factors affecting the mode choice behavior of disabled people - case study: hamadan city. Transport Eng. 12 (1) https://doi.org/10.22119/jte.2020.87701.

Bascom, G.W., 2017. Transportation Related Challenges for Persons with Disabilities. (Master of Landscape Architecture (MLA)). Utah State University. Retrieved from. https://digitalcommons.usu.edu/etd/5265/.

Ben-Akiva, M., Boccara, B., 1987. Integrated framework for travel behavior analysis. In: Paper Presented at the the International Association of Travel Behavior Research (IATBR) Conference, Aix-En-Provence, France.

Ben-Akiva, M., Walker, J., Bernardino, A.T., Gopinath, D.A., Morikawa, T., Polydoropoulou, A., 2002. Integration of choice and latent variable models. In: Perpetual Motion, pp. 431–470. https://doi.org/10.1016/B978-008044044-6/50022-X.

Bhuiya, M.M.R., 2019. A Study on Mobility Pattern of Movement Challenged Persons of Dhaka. (Masters of Urban and Regional Planning). Bangladesh University of Engineering and Technology, Bangladesh.

Bhuiya, M.M.R., Hasan, M.M.H., Jones, S., 2022. Accessibility of movement challenged persons and challenges faced by their escorting family members – a Case Study of Dhaka, Bangladesh. J. Transport Health 24 (10), 101323. https://doi.org/10.1016/j.jth.2021.101323.

Bombom, L.S., Abdullahi, I., 2015. Travel patterns and challenges of physically disabledpersons in Nigeria. GeoJournal. https://doi.org/10.1007/s10708-015-9629-3.

Bouscasse, H., 2018. Integrated choice and latent variable models: a literature review on mode choice. In: Grenoble Applied Economics Laboratory (GAEL). Retrieved from. https://gael.univ-grenoble-alpes.fr/sites/gael/files/doc-recherche/WP/A2018/gael2018-07.pdf.

Bradley, S.B.M., Hernandez, M.C.R., 2011. Geriatric assistive devices. Am. Fam. Physician 54 (4), 405–411.

BSSMU, 2023. Bangabandhu Sheikh Mujibur Medical University. Retrieved from. https://bsmmu.ac.bd/.

CDD, 2021a. About US-centre for disability in development. https://cdd.org.bd/about-us/.

CDD, 2021b. From Despair to Resilience: Annual Report 2020-2021. Retrieved from. https://cdd.org.bd/wp-content/uploads/2022/04/annual_report_cdd_2020-2021.pdf.

Chang, Y.J., 2010. Mobility and Accessibility: What are the main problems individuals with mobility issues encounter in the KGO neighbourhood in their daily commute within the neighbourhood? Retrieved from. http://www.thestorefront.org/wordpress/wp-content/uploads/2012/10/Mobility-and-Accessibility-What-are-the-Main-Problems-Individuals-with-Mobility-Issues-Encounter-in-the-KGO-Neighbourhood.pdf.

Chen, J., Li, S., 2017. Mode choice model for public transport with categorized latent variables. Math. Probl Eng. 2017, 1–11. https://doi.org/10.1155/2017/7861945.

Cheng, L., Chen, W., Yang, S., Wang, H., Wu, J., 2016. Modeling mode choice of low-income commuters with sociodemographics, activity attributes, and latent attitudinal variables -case study in Fushun, China. Transport. Res. Rec. 2538, 25–38. https://doi.org/10.3141/2581-04.

Cidel, J., 2021. An Introduction to Transport Geography: Transport, Mobility and Place. The Rowan and Littlefield Publishing Ltd: Maryl.

Clery, E., Kiss, Z., Taylor, E., Gill, V., 2017. Disabled People's Travel Behaviour and Attitudes to Travel. Department of Transport, UK. Retrieved from. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/647703/disabled-peoples-travel-behaviour-and-attitudes-to-travel.pdf.

CRP, 2017. About CRP. Retrieved from. https://www.crp-bangladesh.org/about-crp.

CRP, 2022. Annual Report 2021-2022. Retrieved from. https://www.crp-bangladesh.org/sites/default/files/Annual%20Report%202021-2022_compressed.pdf.

Cunha, J. H., 2020. Crutches. Retrieved from https://www.emedicinehealth.com/crutches/article_em.htm#what_is_the_history_of_crutches.

Daly, A., Hess, S., Patruni, B., Potoglou, D., Rohr, C., 2011. Using ordered attitudinal indicators in a latent variable choice model: a study of the impact of security on rail travel behaviour. Transportation 39 (2), 267–297. https://doi.org/10.1007/S11116-011-9351-Z.

Danso, A.K., Ashigbi, E.K.Y., Tudzi, E.P., 2011. Mobility challenges of persons with disabilities (PWDs) at the University of Ghana. J. Disabil. Stud. 3 (1), 12–18.

Das, H., Goswami, S., 2016. Where are the footpaths? A case for protecting pedestrian rights in India. The CityFix. Retrieved from. https://thecityfix.com/blog/where-are-footpaths-case-protecting-pedestrian-rights-india-himadri-das-sahana-goswami/.

Deka, D., Gonjalez, A.J., 2016. The generators of paratransit trips by persons with disabilities. Transport. Res. Pol. Pract. 70, 181–193. https://doi.org/10.1016/j.tra.2014.10.018.

Dempsey, N., Bramley, G., Power, S., Brown, C., 2011. The social dimension of sustainable development: defining urban social sustainability. Sustain. Dev. 19 (5), 289–300.

Dhaka Transport Coordination Authority, 2004. Strategic Transportation Plan.

Dhaka Transport Coordination Authority. 2015. Revised Strategic Transportation Plan.
Dhumgana, S., 2020. Using Public Transport an Ordeal for Disabled People. Retrieved from. https://myrepublica.nagariknetwork.com/news/using-public-transport-an-ordeal-for-disabled-people/.
Dingi, A.E., Esztergár-Kiss, 2021. The influence of education level on urban travel decision-making. Period. Polytech. Transp. Eng. https://doi.org/10.3311/PPtr.16871.
Eisenberg, Y., Heider, A., Gould, R., Jones, R., 2010. Are communities in the United States planning for pedestrians with disabilities? Findings from a systematic evaluation of local government barrier removal plan. Cities 102. https://doi.org/10.1016/j.cities.2020.102720.
Exel, N.J.A., Piet, R., 2010. Perceptions of public transport travel time and their effect onchoice-sets among car drivers. J. Trans. Land Use 2 (3/4), 75–86.
Frye, A., 2013. Thematic Study Prepared for Global Report on Human Settlements 2013: Disabled and Older Persons and Sustainable Urban Mobility. Retrieved from. https://unhabitat.org/wp-content/uploads/2013/06/GRHS.2013.Thematic.Disabled.and_.Older_.Persons.pdf.
Ganesh, S., 2019. Most city buses are not disabled-friendly. Retrieved from. https://www.thehindu.com/news/cities/Madurai/most-city-buses-are-not-disabled-friendly/article28336194.ece.
Grisé, E., Boisjoly, G., Maguire, M., El-Geneidy, A., 2018. Elevating access: comparing accessibility to jobs by public transport for individuals with and without a physical disability. Transportation Research part A: policy and Practice. Transport. Res. Pol. Pract. 125, 280–293.
Guo, Y., Yang, L., Huang, W., Guo, Y., 2022. Traffic safety perception, attitude, and feeder mode choice of metro commute: evidence from shenzhen. Int. J. Environ. Res. Publ. Health 17 (94). https://doi.org/10.3390/ijerph17249402.
Habib, K.N., Sasic, A., Zaman, H., 2012. Investigating telecommuting considerationsin the context of commuting mode choice. Int. J. Sustain. Transport. 6 (6), 362–383.
Hayati, A., Faqih, M., 2013. Disables' accessibility problems on the public facilities within the context of surabaya, Indonesia. Humanit. Soc. Sci. 1 (3) https://doi.org/10.11648/j.hss.20130103.11.
Hu, X., Wang, J., Wang, J., 2013. Understanding the travel behavior of elderly people in the developing country: a case study of Changchun, China. Procedia Soc. Behav. Sci. 96 https://doi.org/10.1016/j.sbspro.2013.08.099.
Hu, X., Shao, L., Wang, W., 2015. Impact of perceptions of bus service performance on mode choice preference. Adv. Mech. Eng. 1 (11) https://doi.org/10.1177/1687814015573826.
Huda, N., 2023. Best Orthopedic Specialist Doctor in Dhaka. Retrieved from. https://www.whereindoctor.com/2018/08/orthopedic-specialist-doctor-list-of.html.
Hudson, L., 2017. Different Ways to Get Mobility Scooters into Cars. Retrieved from. https://www.yorkshirecareequipment.com/advice-tips/different-ways-get-mobility-scooters-cars/.
Imrie, R., 2000. Disability and discourses of mobility and movement. Environ. Plann. 32, 1641–1656. https://doi.org/10.1068/a331.
Iseki, H., Taylor, B., 2010. Style versus service? An analysis of user perceptions of transit stops and stations. J. Public Transport. 13 (3), 39–64.
Islam, M.A., 2018. Fare of public transport services in case of Dhaka city and in comparison with neighboring countries. Eng. Technol. 3 (1), 498–505. https://doi.org/10.31142/etj/v3i11.01.
Johanson, M.V., Heldt, T., Johanson, P., 2006. The effects of attitudes and personality traits on mode choice. Transport. Res. Pol. Pract. 40, 507–525.
Kakar, I.S., Peden, M., Jagnoor, J., 2021. Intersectionality based policy analysis: equity in mobility in India. Transport Pol. 101, 14–22. https://doi.org/10.1016/J.TRANPOL.2020.11.010.
Kannan, R., 2016. For the Disabled, Footpaths Are a Nightmare. Retrieved from. https://www.thehindu.com/news/cities/chennai/for-the-disabled-footpaths-are-a-nightmare/article4895765.ece.
Kesik, O.A., Demirci, A., Karaburun, A., 2012. Analysis of Pavements for Disabled Pedestrians in Metropolitan Cities. Lambart Academic Publication, Germany.
Keyes, A.K.M., Crawford-Brown, D., 2018. The changing influences on commuting mode choice in urban England under Peak Car: a discrete choice modelling approach. Transport. Res. F Traffic Psychol. Behav. 58, 167–175. https://doi.org/10.1016/j.trf.2018.06.010.
Kumar, N., Jafarinaimi, N., Morshed, M.B., 2018. Uber in Bangladesh. https://doi.org/10.1145/3274367.
Lehman, K., 2018. Understanding the Effects of Demographic and Socio-Economic Factors on Public Transit Ridership Trends. University of South Florida. Retrieved from. https://core.ac.uk/download/pdf/216957145.pdf.
Leonard, J., 2021. What types of mobility aids are available? Retrieved from https://www.medicalnewstoday.com/articles/318463.
Li, Y., Sun, S., 2020. Prediction of travel mode choice behavior preference under the impacts of congestion pricing based on ICLV model. In: 20th COTA International Conference of Transportation Professionals. December 16—19, Xian, China.
Litman, T., 2019. Evaluating accessibility for transport planning: measuring people's ability to reach desired goods and activities. https://www.vtpi.org/access.pdf.
Liu, C., Susilo, Y.O., Karlstrom, A., 2015. The influence of weather characteristics variability on individual's travel mode choice in different seasons and regions in Sweden. Transport Pol. 41, 147–158. https://doi.org/10.1016/j.tranpol.2015.01.001.
Madhuwanthi, R.A.M., Marasinghe, A., Nomura, S., 2016. Factors influencing to travel behavior on transport mode choice:- A case of colombo metropolitan area in Sri Lanka. Int. J. Affect. Eng. https://doi.org/10.5057/IJAE.IJAE-D-15-00044.
Malik, T.A., 2017. Transport for Disabled. *The Dawn*. Retrieved from. https://www.dawn.com/news/1320120.
Mampearachchi, W.K., Suman, S., 2014. Usability of public transport for differently abled people in Sri Lanka. Engineer XLVII (2), 46–52.
McFadden, D., 1986. The choice theory approach to market research. Market. Sci. 5 (4), 275–297.
Mitra, S.K., Saphores, J.-P., 2018. How do they get by without cars? An analysis of travel characteristics of carless households in California. Transportation 47, 2837–2858. https://doi.org/10.1007/s11116-019-09994-6.
Mohiuddin, H., 2021. Planning for the first and last mile: a review of practices at selected transit agencies in the United States. Sustainability 13 (4), 2222.
Mohiuddin, H., Fitch-Polse, D.T., Handy, S.L., 2023. Does bike-share enhance transport equity? Evidence from the Sacramento, California region. J. Transp. Geogr. 109, 103588.
Mohiuddin, H., Fitch-Polse, D.T., Handy, S.L., 2024. Examining market segmentation to increase bike-share use and enhance equity: the case of the greater Sacramento region. Transp. Policy 145, 279–290.
Mohiuddin, H., Jamal, S., Bhuiya, M.M.R., 2022. To bike or not to bike: Exploring cycling for commuting and non-commuting in Bangladesh. Transp. Res. Interdiscip. Perspect. 14, 100614.
Mohiuddin, H., Rahman, M. H., Ashik, F. R., Bhuiya, M. M. R., 2022. Analysis of modality and trip chaining patterns in Dhaka. Findings.
Mohiuddin, H., Rahman Bhuiya, Jamal, S., Chen, Z., 2022. Exploring the choice of bicycling and walking in Rajshahi, Bangladesh: an application of integrated choice and Latent Variable (ICLV) models. Sustainability 14 (22), 14784.
Morrison, E., Prajwal, N., Bailey, A., 2020. It's High Time BMTC Got People with Disabilities on Board. Here Are Five Steps to Ensure This.
Neves, B.D., Unsworth, C., Browning, C., 2023. 'Being treated like an actual person': attitudinal accessibility on the bus. Mobilities 18 (3). https://doi.org/10.1080/17450101.2022.2126794.
NGDO, 2023. National Grassroots Disability Organization-NGDO. Retrieved from. https://ngodhaka.com.bd/ngosite/index/237.
Odame, P.K., Sam, E.F., Amaoak, Sakoyi, R.O., Arko, B., 2023. State of public transport services to Ghana's disability population: lessons from public transport operators in the Accra Metropolitan Assembly. Soc. Sci. Humanites Open 7 (1). https://doi.org/10.1016/j.ssaho.2023.100413.
O'Hagan, M., 2021. Reluctant Towns, Cities and States Are Being Dragged into Court to Fix Sidewalks for People with Disabilities. Retrieved from. https://time.com/6105909/sidewalk-accessibility-lawsuits/.
Paulssen, M., Temme, D., Vij, A., Walker, J.L., 2014. Values, attitudes and travel behavior: a hierarchical latent variable mixed logit model of travel mode. Transportation 14 (4), 873–888.
Paydar, M., Fard, A.K., 2021. The contribution of socio-demographic factors to walking behavior considering destination types; case study: temuco, Chile. Soc. Sci. 10 (12) https://doi.org/10.3390/socsci10120479.
PDF, 2017. PDF activities. https://www.pdfbd.org/index.html.
Penfold, C., Cleghorn, N., Creegan, C., Neil, H., Webster, S., 2008. Travel Behaviour, Experiences and Aspirations of Disabled People. Retrieved from.
Pocuc, M., Mirovic, V., Simic, J.M., Karamasa, C., 2021. Mobility analysis of persons with disability. Discrete Dynamics in Nature and Society. https://doi.org/10.1155/2021/7430340.
Rahman, M.M., Assadekjaman, 2013. Rickshaw Pullers and the Cycle of Unsustainability in Dhaka City. Retrieved from.
Rahman, F.I., Bari, M.M., Islam, M.A., Joyanto, T.M., 2020. Analysis of mode choice behavior and value of time in Dhaka City, Bangladesh. Int. J. Traffic Transport. Eng. 10 (2) https://doi.org/10.7708/ijtte.2020.10(2).02.
Rayna, S.E., Khalequzzaman, M., Khan, F.A., et al., 2021. An assessment of Bangabandhu Sheikh Mujib medical university for improving the research capacity. J. Glob. Health Rep. 5, e2021079 https://doi.org/10.29392/001c.26315.
Rosenberg, D.E., Huang, D.L., Simonovich, S.D., Belza, B., 2013. Outdoor built environment barriers and facilitators to activity among midlife and older adults with mobility disabilities. Gerontol. 53 (2), 268–279. https://doi.org/10.1093/geront/gns119.
Sakaki,S., Gomez, J.W., 2018. Too often, Dhaka remains inaccessible for people with disabilities. World Bank. Retrieved from https://blogs.worldbank.org/endpovertyinsouthasia/too-often-dhaka-remains-inaccessible-people-disabilities.
Sanit, P., Nakamura, F., Tanaka, S., Wang, R., 2010. Location and mode choice decision mechanism analysis of multi-worker household in Bangkok, Thailand. J. East. Asia Soc. Transport. Stud. 10, 1242–1257.
Schocker, J., Quddus, M.A., Noland, R.B., Bell, M.G.H., 2008. Mode choice of older and disabled people: a case study of shopping trips in London. J. Transport Geogr. 16, 257–267.
Shafi, A., 2018. In: Photos: Why Wheelchair Users in Delhi Find it Difficult to Use Buses, Even Low-Floor Ones. Retrieved from. https://scroll.in/roving/894005/in-photos-why-wheelchair-users-in-delhi-find-it-difficult-to-use-buses-even-low-floor-ones.
Sharma, S., 2019. Factors Influencing Travel Behavior and Mode Choice. Retrieved from. https://www.geospatialworld.net/blogs/factors-influencing-travel-behavior-and-mode-choice/.
Shashank, A., 2015. Walkability and Connectivity: Unpacking Measures of the Built Environment. (Masters of Science). Simon Fraser University, Canada.
Shrestha, B.P., Millonig, A., Hounsell, N.B., McDonald, N., 2016. Review of public transport needs of older people in European context. J. Popul. Aging 10, 343–361.
Smalley, C., Frost, K., Bertocci, G., 2013. Ramp slopes encountered by wheeled mobility device users in public transit buses. In: https://www.resna.org/sites/default/files/legacy/conference/proceedings/2013/Wheeled%20Mobility/Smalley.html.
Sumit, K., Brijis, K., Ross, V., Wets, G., Ruiter, R.A.C., 2022. A focus group study to explore risky ridership among young motorcyclists in manipal, India. Saf. Now. 8 (2), 40. https://doi.org/10.3390/safety8020040.

Sze, N.N., Christensen, K.N., 2017. Access to urban transportation system for individuals with disabilities. IATSS Res. 41, 66–73.
Tauhid, A.B.M., 2007. A Study on Accessibility of Physically Challenged People to Some Selected Urban Services and Facilities in Dhaka. (Masters in Urban and Regional Planning). Bangladesh University Of Engineering And Technology. Retrieved from. http://lib.buet.ac.bd:8080/xmlui/bitstream/handle/123456789/2929/Full%20Thesis%20.pdf?sequence=1&isAllowed=y.
The Business Standard, 2021. 7 Years on, HC Ban on Motorcycle Riding on Footpaths Ignored. https://www.tbsnews.net/bangladesh/7-years-hc-ban-motorcycle-riding-footpaths-ignored.
The Dawn, 2023. Public Transporters Increase Fares after Closure of CNG Stations. Retrieved from. https://www.dawn.com/news/1729502.
Thomas, B., 2021. Fare Play. Retrieved from. https://bangaloremirror.indiatimes.com/bangalore/crime/fare-play/articleshow/85444370.cms.
Tokuda, K., 2001. Road transport barriers encountered by people with travel difficulties in Japan. IATSS Res. 25 (1), 12–22. https://doi.org/10.1016/S0386-1112(14)60002-9.
UKAID, 2022. Inclusive Design and Accessibility of the Built Environment in Solo, Indonesia. Retrieved from. https://cdn.disabilityinnovation.com/uploads/images/AT2030-InclusiveInfrastructure-Solo-FullReport-May2020.pdf?v=1655806476.
Ullah, A., 2019. No laws for reckless motor bikers. https://www.daily-sun.com/arcprint/details/402278/No-laws-for-reckless-motor-bikers-/2019-06-26.
UN HABITAT, 2016. New urban agenda HABITAT III. http://habitat3.org/wp-content/uploads/NUA-English.pdf.
United Nations, 2006. United Nations Convention on the Rights of Persons with Disabilities. Retrieved from.
United Nations, 2016. Goal 11 Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable. Retrieved from. https://unstats.un.org/sdgs/report/2016/goal-11/.
Velho, R., 2019. Transport accessibility for wheelchair users: a qualitative analysis of inclusion and health. International Journal of Transportation Science and Technology 8, 103–115. https://doi.org/10.1016/j.ijtst.2018.04.005.
Verbich, D., Ahmed, E.G., 2016. The pursuit of satisfaction: variation in satisfaction with bus transit service among riders with encumbrances and riders with disabilities using a large-scale survey from London, UK. Transport Pol. 47, 64–71. https://doi.org/10.1016/J.TRANPOL.2015.12.009.
Vij, A., Walker, J.L., 2016. How, when and why integrated choice and latent variable models are latently useful. Transport. Res. Part B 90, 192–217.
World Health Organization, 2018. Disability and Health. Retrieved from. https://www.who.int/news-room/fact-sheets/detail/disability-and-health.
World Health Organization, 2022. Disability Inclusion. Retrieved from. https://www.worldbank.org/en/topic/disability#.