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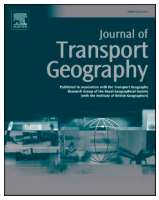

Inequalities within mobility inequalities: A case study of mode specific problems faced by movement challenged persons of Dhaka, Bangladesh

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ABSTRACT

This study explores mode-specific problems faced by movement-challenged persons (MCPs) in making trips by different travel modes in Dhaka, Bangladesh. 400 MCPs were asked to rank the extent of mobility challenges of four modes on a scale of one to five through a questionnaire survey. MCPs reported lack of ramp and undulated surface are the most severe problems related to bus and walking respectively while excessive fared charged by drivers is found as the most severe problem for both rickshaw and CNG. This study captures the uneven effects of mode-specific challenges endured by MCPs of different gender, ages, and mobility aid users. Opinions on the lack of standardized slope along footpaths, the presence of cracks on footpaths, the lack of ramps on the buses, and rude behavior of bus staff vary significantly with gender, age, and mobility aids; the unwillingness of bus staff to carry MCPs varies significantly with age and walking instrument; the narrow width of footpaths, the additional fare charged by rickshaw pullers, the lack of space to keep the mobility supporting aids on buses and rickshaws, and the lack of available space to maneuver on a bus varies significantly with the walking instrument.

1. Background of the study

The Sustainable Development Goals (SDGs) set out by the United Nations has pledged to ensure inclusive and equitable development across the globe (United Nations, 2016). Particularly, SDG 11 on sustainable cities and communities, SDG 10 aimed at reducing inequalities, and the focus of SDG 3 good health and well-being for all with a focus on minority and disadvantaged groups (United Nations, 2019). Persons with Disabilities (PWDs), individuals with physical impairment (such as ambulatory, vision, speech, hearing) or cognitive impairment, are one of the largest minority groups in the world with >1 billion people across the world experiencing some sort of disability. Therefore, it is necessary to ensure their right and privileges to achieve SDGs (World Health Organization, 2011).

However, PWDs experience numerous challenges to interact with other people in society and accessing the built environment. Consequently, it is very common for them to experience mobility challenges in their day-to-day movement due to their impairment (European Disability Forum, 2000; Ferrari et al., 2013; Grisé et al., 2018). A review of current literature reveals a very grim picture of accessibility to transportation for PWDs, with unfriendly built environments and transportation modes around the world making mobility inequality a global phenomenon (Field and Jette, 2007; Frye, 2013). Particularly, mobility-challenged persons (MCPs), a group of PWDs, who uses a wheelchair, crutch, walking frame, cane, or other supporting devices based on their level of disability, experience great hardship owing to numerous challenges and problems faced by them while making trips by different transportation modes (Frye, 2013; Bhuiya, 2019; Leonard, 2021). Resulting from mode-specific challenges and their constraints on the freedom of movement, MCPs may travel less often than non-PWDs, and participate less in social activities which may even lead to social isolation (Cochran, 2020; Tennakoon et al., 2020; Venkataram et al.,

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2023).

Although the above-mentioned mode-specific problems are visible in both developed and developing countries despite having universal accessibility-related regulations (Bhuiya et al., 2022; Hasan and Dávila, 2018; Tennakoon et al., 2020), albeit to different extents, mobility-related challenges are more acutely observed in developing countries, particularly in South Asian cities (Malik, 2017; Shafi, 2018; Nunez et al., 2022). Like many developing countries, in Bangladesh, it is a very common phenomenon for MCPs to experience various challenges while making a journey by any transport mode. In contrast to developed countries, MCPs or other PWDs do not have access to accessible public transportation system, adapted cars with universal accessibility or accessible paratransit as mobility options for them. So, in a city where riding by bus is a nightmare for common people, safety is a major concern for the pedestrian, rickshaw pullers (a three-wheeler pulled by humans) exploit passengers by charging additional fare (Hasan and Dávila, 2018), it is extremely difficult for MCPs to move from one place to another and face transport inequality (Bhuiya, 2019).

In line with international commitments and policies, Bangladesh has laws and plans to ensure mobility rights for disabled persons, including MCPs, (Asia-Pacific Development Center on Disability (APCD) and South Asian Disability Forum (SADF), 2013; Ministry of State Bangladesh, 2001; Dhaka Transportation Coordination Authority (DTCA), 2013) to ensure equitable transportation system for Dhaka and other cities of Bangladesh. Unfortunately, all those policies had little impact on mobility-related problems of MCPs, including mode-specific challenges experienced by them while traveling by different modes. The mobility-related problems faced by MCPs are especially difficult in the context of a developing country megacity like Dhaka, where haphazard development of built-environment is rampant, public transport is inaccessible, road infrastructure and active transport infrastructure (e.g., pedestrian footpath) are not disabled-friendly (Abir and Haque, 2011; Alam, 2009; Tauhid, 2007). Research containing empirical data and field observations has documented the poor conditions of existing transportation services and infrastructure for the MCPs and other PWDs of Dhaka and other cities in Bangladesh (Abir and Haque, 2011; Bhuiya, 2019).

The hostile urban landscape of Dhaka separates MCPs from their able-bodied counterparts and is a clear instance of the mobility inequality that MCPs face. MCPs undergo mobility inequality because of their disability but it can also be hypothesized that the extent of the disability originated mode-specific problems faced by them can also vary between MCPs belonging to different age, and gender groups which are faced by non-PWDs. There are many studies focused on mobility inequalities faced by women (Lecompte and Pablo, 2017; Malik et al., 2020; Zhang et al., 2022), wheelchair users, and MCPs using other mobility aids (Ipingbemi, 2016; Stjernborg, 2019; Bhuiya et al., 2022), low-income people (Benevenuto et al., 2019; Bulczak and Gugushvili, 2022). As MCPs can be stratified based on gender, income, and other socioeconomic characteristics and different mobility aids, it can be hypothesized that the mobility inequalities vary among different socioeconomic groups, and mobility aid users. Literature or policy discussions, even SDG, rarely expanded beyond the ability-disability dichotomy to address the concept of multi-layer mobility inequality for MCPs with mobility inequality at the first layer and then, disaggregation of mobility inequality based on socioeconomic characteristics, and mobility aids at the next layer(s). This study address the research question how the mobility inequality i.e. mode-specific challenges faced by MCPs varies among different groups of MCPs and explores the relationship between these problems concerning socioeconomic factors and mobility aids. The study provides a more nuanced understanding of the mobility inequality for MCPs which will help to prioritize the mode-specific problems to be dealt with and take into consideration socioeconomic aspects of MCPs while taking policies to be dealt with these problems (Bondemark et al., 2021; Bulczak and Gugushvili, 2022; Zhang et al., 2022).

The organization of the study is as follows: Section 1 describes the study context and research questions; Section 2 describes the study related mobility inequalities and mode specific problems conducted in different countries including Bangladesh; Section 3 describes methodology: study area selection, data collection, data analysis approach; Section 4 illustrates the study results derived from descriptive statistics and modeling outcome; section 6 discusses the findings and section 7 concludes the study with policy recommendations.

2. Literature review

The mobility challenges faced by MCPs vary across different transportation modes. This section focuses on mode-specific problems faced by MCPs and the (possible) relation of these problems with socioeconomic factors (age, gender, income, education) and disability.

2.1. Mobility inequality

Mobility inequality is defined as differences in the ability and capacity to move (Hidayati et al., 2021). Banister (2018) ascribed mobility inequality as a physical activity measured in terms of travel time, distance, and available modess (Banister, 2018). Meanwhile, Sheller (2018) described mobility inequality in relation to the freedom of travel and travel experiences attached to socioeconomic characteristics of individuals (Sheller, 2018).

Gender-based mobility inequality is studied in terms of travel patterns and restrained mobility of women at varying sociocultural context. In many male-dominated societies where women are more bound to homes such as in India, Pakistan, and South Africa, have less liberty to travel independently (Venter et al., 2007; Adeel et al., 2017). Higher safety concern due to poor built-environment among women results in their avoidance of using certain routes or sidewalks or mode (Jamal et al., 2020; Mohiuddin et al., 2022b,a). Stafford et al. (2020) argued that heightened fear among women regarding traveling is the gender-insensitive environment of the transit environment. Age as a factor pertaining to mobility inequality has been linked to physical and financial abilities to travel. Financial abilities to travel conveniently enhance between the age of 40s and 60s, when individuals are likely to have a steady monthly income (Hjorthol, 2008). Children and teenagers experience various levels of limited independent mobility as they do not have the license to drive a car or are required to be accompanied by family to make a trip (Stafford et al., 2020). As individuals age, their physical ability to travel decreases, and their mobility gets limited (Ding et al., 2020). Literature reveals low income or poor people experiences more mobility inequality than the higher-income group. Ureta (2008) found that the low-income group voluntarily limits their mobility within walking distance and mostly travels for accomplishing necessary tasks in Chile. Santos et al. (2014) found that low-income people have lower car ownership which wanes their movement and available mode of travel in the USA. Motta et al. (2013) found that low income individuals in Brazil have limited choices of travel modes and that the bus is mostly used by low-income people owing to its affordability. In conclusion, female; low income, elderly people, people with physical constrains are more prone to experience transport inequality.

2.2. Relation of mode-specific problems with socioeconomic factors and disability

The extent of problems faced by MCPs varies with the mobility aids used by them and their socioeconomic situation is documented in several studies on the challenges faced by MCPs and other PWDs in making trips on public transportation in Sweden, Nigeria, Scotland, India, Malawi, Mexico, Mozambique, and South Africa (Department for International Development (UK), 2002; Frye, 2013; Ipingbemi, 2016; Stjernborg, 2019). It can be assumed that wheelchair users suffer more acutely than those using crutches or canes in the absence of bus ramps as

without ramps it would be extremely difficult, even impossible, for MCPs to board on the bus. Elderly MCPs suffer more from a lack of ramps on buses as it becomes difficult for them to exert the required physical strength to board without the support of a ramp (Ipingbemi, 2016). These studies also found that it is very common for transport staff to behave rudely towards MCPs, specifically wheelchair users, which greatly discourages them to make trips by public transportation. Sometimes, bus staff may even refuse to allow MCPs to board on buses or tease or harass them; and for female MCPs, it might even worsen to sexual harassment (Frye, 2013; Stjernborg, 2019). Levels of education might play a role in perceiving transportation problems, with highly educated people possibly perceiving transportation problems differently than those with lower levels of education (Bhuiya and Shao, 2021). Monthly income can also influence the perception of MCPs towards mode-specific problems. For example, paying an excessive fare to rickshaw pullers or CNG drivers might not have the same level of acuteness for high-income MCPs as low-income MCPs (Tauhid, 2007). It can be hypothesized that the extent of mode-specific problems faced by MCPs is dependent on their age, gender, and mobility aids (Frye, 2013; Stjernborg, 2019). Besides, it is also evident from literature perception towards mode-specific problems might vary with education attainment as well as income level.

2.3. Mode specific problems and mobility inequality faced by MCPs in Dhaka

MCPs (and other PWDs) face complex situations to traveling by bus due to the unfriendly design of buses and possible rude behavior from bus staff in Dhaka based on field observations (Abir and Haque, 2011; Frye, 2013). Frye (2013) identified universal accessibility issues for wheelchair users and other MCPs on public transportation, such as the absence of specially designed reserved seating, the necessity of climbing stairs to board a bus in the absence of ramps, and the lack of space to keep mobility assistance instruments. Footpaths in Bangladesh are not well-designed for MCPs as many footpaths are so narrow that even a physically fit person cannot walk comfortably. The absence of curb ramps or the presence of curb ramps with a very high slope makes it difficult for people to shift from roadways to footpaths (Bhuiya et al., 2022; Tauhid, 2007). The presence of obstacles, like the unplanned placement of trash bins or large trees on the footpaths in the cities of Bangladesh, often compels MCPs to maneuver or change direction, exacerbating their mobility challenges (Abir and Haque, 2011). Conflicts with other vehicles running on the footpath significantly hinder the walking of persons with mobility challenges (Imrie, 2000). Rickshaw, a three-wheeler non-motorized vehicle pulled by humans, and auto-rickshaws powered by compressed natural gas (locally known as CNGs) are considered to be very suitable for MCPs as it provides door-to-door service. Unfortunately, MCPs also face unfriendly attitudes from rickshaw-pullers and CNG drivers as they must assist PWDs in getting on/off the rickshaw or carrying mobility supporting instruments as found by Bhuiya et al. (2022) through a qualitative study. It is not uncommon for rickshaw-pullers and CNG drivers to exploit MCPs for their disability and charge extra fares (Abir and Haque, 2011; Bhuiya et al., 2022).

Based on the literature review, it can be understood that these studies have not addressed the mode-specific problems dedicatedly to evaluate mobility inequalities for MCPs through lens of rigorous statistical analysis and did not dive into how these problems are experienced by people of different age, gender, ability as well as how these challenges are perceived differently by people from different income, gender, age groups of PWDs. This study aims to address this gap in literature.

3. Materials and methods

3.1. Selection of study area

The current study focuses on Dhaka, the capital of Bangladesh and the 11th largest megacity in the world (Division of Economic and Social Affiars UN, 2019). According to recent Worrld Report as reported by Sakaki and Gomes (2018), >1 million PWDs are living in Dhaka city (Sakaki and Gomes, 2018). As such, Dhaka presents an excellent case study area to explore transport mode-specific problems of MCPs (Bhuiya et al., 2022). The case study is based on a survey of MCPs from Dhaka city.

3.2. Questionnaire preparation and data collection

A total of 400 MCPs from Dhaka city were surveyed through a paper-based questionnaire and interview process. The surveys/interviews were conducted at rehabilitation centers throughout the city. Management at the Centre for Rehabilitation for the Paralyzed, Bangabandhu Sheikh Mujib Medical University, Physically Challenged Development Foundation, and the National Grass-root Disabled Organization provided the researchers permission to conduct the survey/interviews at their institutions. Study participants were selected using a convenience sampling approach without stratification for gender, age, income, education level, supporting instrument used, or private vehicle ownership. Table 1 summarizes the various participant characteristics and how they were coded ordinally for modeling.

The participant characteristics were converted to ordinal scales for modeling purposes as set out in Section 4. While most of the scales are self-explanatory, the mobility aid bears further discussion. Previous disability focused research (e.g., Bradley and Hernandez, 2011; Cunha, 2020) has indciated that mobility aids can be used as a proxy for the level of disability. For example, a wheelchair is typically used by a person with the least ability in their lower limbs, connoting an increased level of disability. Whereas walking sticks (i.e., canes) indicate a less sever disability affecting individual mobility. These relative individual abilities/mobilities are represented in the 1–3 ordinal scale in Table 1 where a walking stick is assigned a “1” (i.e., least disabled) and a wheelchair a “3” (most disabled) for the study participants.

Table 1
Summary of study participants.

Categories of Participant Characteristics	Percent of Participants	Coded value
Gender		
Male	43.4%	0
Female	56.6%	1
Age		
Young – 0-25 years	26.1%	1
Middle – 25-50 years	40.5%	2
Older – >50 years	33.4%	3
Education		
Up to Secondary School Certificate – up to 10 years	35.5%	1
Higher Secondary School Certificate – 12 years schooling	37.3%	2
Post-secondary – >12 years	27.2%	3
Monthly Income		
Lower – < 25,000 Taka** (<217 USD)	33.4%	1
Middle – 25,000-50,000 Taka (217–534 USD)	47.3%	2
Upper – > 50,000 Taka (>534 USD)	19.3%	3
Mobility aids		
Walking stick	33.2%	1
Walking frame/Crutch	34.7%	2
Wheelchair	32.1%	3

* Taka – Currency of Bangladesh.
* 1 USD = 115 Taka(Wise, 2023).

The survey instrument allowed respondents to indicate their experiences using different transport modes in Dhaka with respect to 18 different criteria. These criteria were selected based on a review of the literature and an understanding of the urban transport context in Dhaka. Urban transport there is dominated by four primary modes: pedestrian, human-power rickshaw, fixed-route bus, and what is referred to locally as CNG, which is typically a three-wheeled enclosed vehicle powered by compressed natural gas.

The 18 criteria represented a range of potential impediments to MCPs using a given mode such as: lack of a ramp to physically access a vehicle or lack of adequate personal space to ones more experiential in nature like whether staff/drivers were supportive or hostile to the needs of MCPs. Participants were given the opportunity to rate their personal experience with each of the four modes in terms according to how severely each of the mode-specific criteria impacted use of each mode. The rating was done on a five-point Likert scale where 1 indicated the least severe impacts and 5 signaled a criterion severely impacting the experience of an MCP using a particular mode.

3.3. Data analysis

Data analysis was conducted using R studio and Microsoft office Excel. Relation of each mode specific problems with socioeconomic factors (age, gender, education, income) was explored using ordinal logistic regression. To determine the relation of mode choice of MCPs with mode specific problems, multinomial logistic regression was used. Factor analysis has been conducted to convert the mode-specific problems into a smaller number of explanatory variables. Factors scores of factors were used as independent variables for the multinomial regression. Socioeconomic factors have also been used as predictors for mode choice model. Fig. 1 describes the modeling approaches.

Predicted probability curves have been generated to identify significant trends in mode choice which were not comprehendible from regression analysis. The probability curve reveals how the probability of selecting different modes changes for different categories of nominal variables and the value of continuous variables. In the probability curves, probability of mode choice is compared by keeping disadvantaged groups (low income, gender, wheelchair user) as one group and other groups have been combined as another group (middle or high income, female, non-wheelchair users). As the probability curves aims to identify transport inequality, respondents belonging to disadvantaged groups have been kept in one group and other respondents have been kept in another group to understand mobility inequality in respect of the non-disadvantaged group. The purpose of the probability curve is to understand the inherent heterogeneity in the mode choice behavior of MCPs based on their age, gender, income, and wheelchair use status. This will give us a better picture of by isolating the influence of the different socio-demographic aspect on the mode choice decision that may not be easily visible from the regression coefficient table. These plots also help us to understand at what point of a variable, the change in behavior may happen (e.g., at what travel time, MCPs may be more likely to prefer specific mode for travel).

4. Results

The surveys indicated that the majority (45%) of MCP respondents used rickshaws with 22% and 14% reporting the use of CNGs and buses, respectively. Some 16% indicated pedestrian movement (walking/wheelchair) as a primary mode with another 4% indicated relying primarily on a private vehicle for day-to-day transport in Dhaka. After eliminating the respondents who indicated the private vehicle as their primary mode, analysis was conducted on the remining 384 study participants.

4.1. Mode-specific problem severity scores

The average rank score among participants for each of the 18 criteria was determined using Eq. (1).

$$R = \sum_{1}^{n} f_i x_i \Big/ n \tag{1}$$

Where:
R = the average rank of a problem;

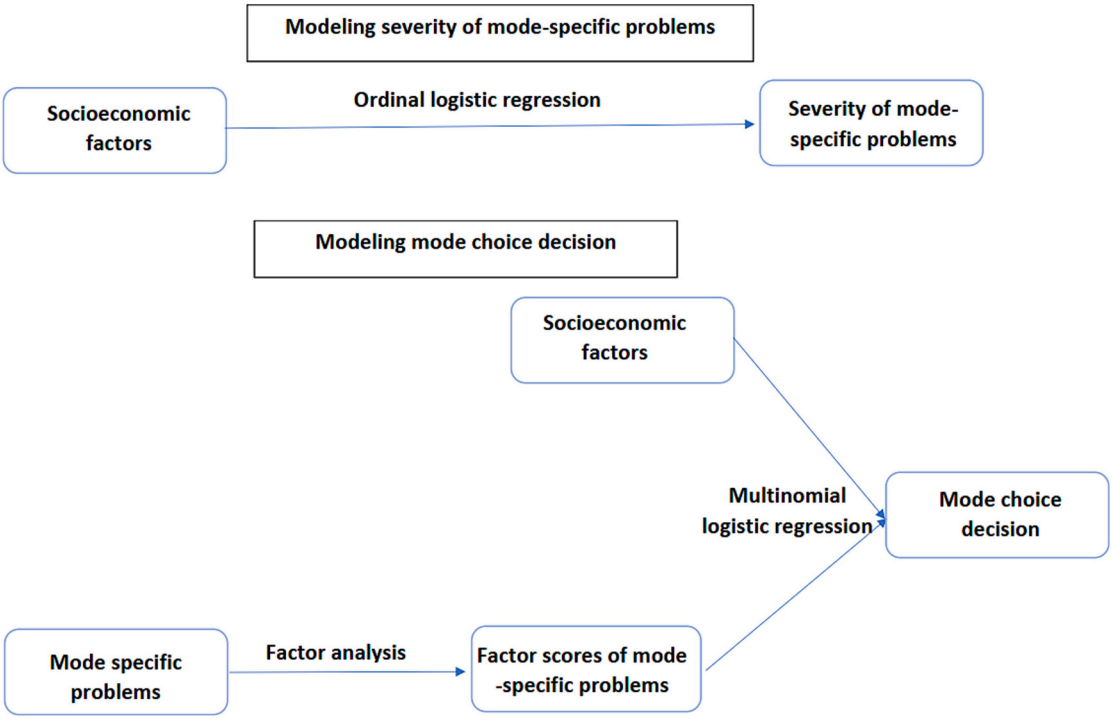

Fig. 1. Modeling approach for severity of mode-specific problems and mode choice decision.

f_i = the number of respondents providing a particular rank to a problem; and

x_i = that particular rank of the problem, and n = total number of samples.

This average rank score, or *Severity Score*, is then used to indicate the degree of impact each criterion was reported to have with respect to MCPs using each of the four modes. The results are summarized in Fig. 2. The severity of a mode-specific problem increases with the value of R.

As set out in Fig. 2, the most severe walking, bus, rickshaw and CNG-related mode-specific problem is presence of undulated surface, lack of ramp in bus, payment of additional fare to rickshaw puller and payment of additional fare to CNG drivers. Physical issues such the presence of undulated surfaces, lack of boarding ramps, platform height and lack of space were indicated as most severe mode-specific problems experienced by MCPs. Among the three most acute mode-specific problems, two pertained to walking. Equity-related issues such as charging additional fares were ranked as primary concerns for rickshaw and CNG users. Based on severity score, MCPs experience the problem of excessive fare charged from them more severely while traveling my CNG than rickshaw. 16 (>90%) out of 18 mode-specific problems had severity score greater than four i.e. implying all these problems are experienced acutely by MCPs.

Additionally, MCPs indicated experiencing long waits when hailing a rickshaw (average 13 min) or CNG (22 min) as some drivers are unwilling to carry them. Correlating the average waiting times with the severity scores of a driver unwilling to carry returned 0.56 for rickshaws and 0.52 for CNGs. The moderately strong correlations indicate that the unwillingness of some drivers to carry MCPs resulted in longer waiting times for MCPs. Islam (2018) found that the average fare/km in Dhaka for rickshaws and CNGs were 19.20 Taka and 29.57 Taka, respectively. MCPs reported their average fare/km as 24.20 Taka for rickshaws and 34.75 Taka for CNGs.

4.2. Results from statistical models

Table 2 presents the estimates of the statistical modeling performed using the mode-specific severity scores as the dependent variable and the ordinal values of MCP age, gender, mobility aid/level of disability, income, and education as the independent variables.

Mobility aids: Table 2 reveals that, except for the excessive height of platform on CNGs and conflict with motorcycles on footpaths, mobility aid has a significant positive relationship with 16 of the 18 problems. In other words, the severity of mode-specific problems faced by MCPs is exacerbated by their level of disability. Wheelchair users endure more hardships from model-specific problems and cane users the least, relative to the other mobility aids. It is noticeable that wheelchair users have the highest score for all 18 of the considered problems, and they encounter all the problems more acutely than other mobility aid users (Appendix Fig. A1). Walking frame/ crutch users have a higher score than cane users for the 18 problems.

Gender: According to Table 2, gender has a significant relation with 10 of the 18 problems Six problems have a significant positive relationship with gender, indicating these problems are experienced more severely by male MCPs. On the other hand, four problems have significant negative relationships with gender, indicating that female MCPs experience these problems more severely. Female MCPs also experience the problems of lack of space to maneuver on the bus, lack of space to keep mobility aid, excessive height of platform of CNG, conflict with motorcycles on the footpath, and presence of obstacles on footpaths more acutely. In summary, female MCPs have the highest severity score for 13 problems while male MCPs have the highest severity score for 5 of the studied problems (Appendix Fig. A2).

Age: According to Table 2, age has a significant relation with (13) of the 18 problems. Bus-related problems (lack of ramp and lack of space to maneuver), walking-related problems (lack of standard slope of the footpath, presence of obstacles, and cracked surface of the footpath), and rickshaw related problems (lack of space to keep mobility aid and the excessive height of platform) have a significant positive relationship with age. This relationship implies that older MCPs face these problems more severely and the severity score of these problems also reflects these findings. Younger MCPs are not without their own set of hardships as indicated by the strong negative relationship between age and the problems of the payment of excessive fares and receiving reluctance from both rickshaw pullers and CNG drivers to board them implying

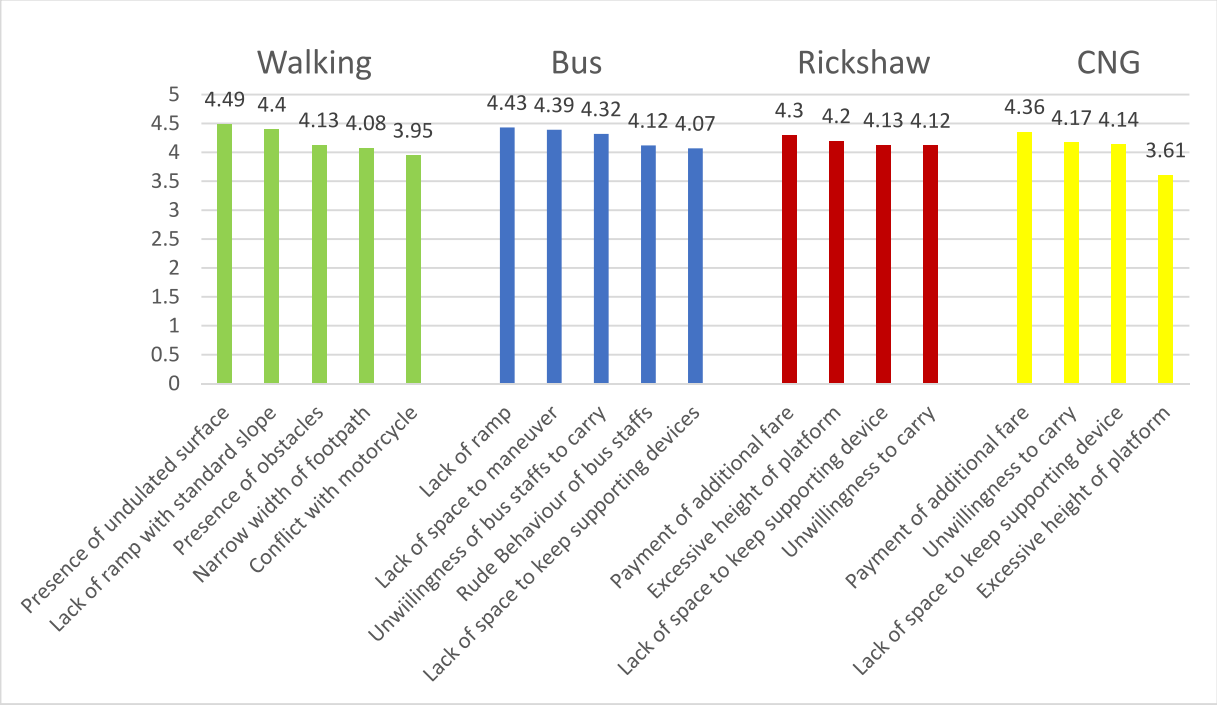

Fig. 2. Average severity score of mode-specific problems.

Table 2
Estimates from ordinal logistic regression of mode specific problems.

	Mode: Bus					Mode: Rickshaw			
Problems Variables	Lack of ramp	Lack of space to maneuver	The unwillingness of bus staff to carry	Rude Behavior of bus staff	Lack of space to keep mobility aid	Excessive height of the platform	Payment of additional fare	Unwillingness of rickshaw pullers to carry	Lack of space to keep mobility aid
Mobility aid	1.554***	1.098***	1.025***	1.211***	1.093***	1.550***	0.99***	0.992***	2.043***
Age	1.074***	−0.034	−0.741***	−0.773***	1.375	1.081***	−1.259***	−0.930***	0.090
Gender	−1.092***	−0.082	1.560***	1.419***	−0.209	−0.643**	1.166***	1.242***	−0.360
Education	0.011	−0.01	0.048	0.068	−0.098	0.123	0.024	0.062	−0.132
Income	0.070	0.050	−0.038	−0.003	0.150	0.019	0.051	0.057	0.001
McFadden R^2	0.25	0.07	0.16	0.16	0.087	0.14	0.169	0.18	0.21
	Mode: Walking					Mode: CNG			
Problems Variables	Lack of ramp with a standard slope	Narrow width of footpath	Presence of obstacles in the footpath	Presence of undulated surface	Conflict with motorcycle	Excessive height of the platform	Payment of additional fare	Unwillingness of CNG drivers to carry	Lack of space to keep mobility aid
Mobility aid	1.384***	1.0974***	1.572***	1.317***	0.973***	0.037	1.335***	0.876***	1.851***
Age	1.174***	0.041	0.785***	0.947***	−0.105	0.137	−0.743***	−0.861***	0.137
Gender	−1.292***	−0.028	−0.389	−0.612**	0.007	0.016	1.09***	0.550**	−0.203
Education	0.088	0.001	−0.167	−0.053	−0.104	0.039	0.022	−0.004	−0.055
Income	0.171	0.008	0.044	0.04	−0.055	−0.011	−0.022	0.054	−0.033
McFadden R^2	0.23	0.07	0.18	0.165	0.072	0.01	0.15	0.09	0.18

***$p > 0.001$, ** $p > 0.01$, *$p > 0.05$ Number of Samples: 384.

they face these problems more acutely and highest severity score for younger MCPs also connote to these findings. Among the considered 18 problems, the elderly group (>50 years) reported the highest severity scores for 11 problems, while young (0–25 years old) MCPs have the highest score for 7 problems (Appendix Fig. A3).

Education and income: Statistical modeling reveals there is no significant relationship between the mode-specific problems with education and income. Appendix Fig. A4 and A5 present the average scores of the problems for different income and age groups.

4.3. Mode specific problems and mode choice decision

Initially, multinomial logistic regression for mode choice decision were developed with each mode-specific problem, but no significant relationship between the problems with mode choice was found. Later, factor analysis had been conducted to load the problems into smaller number of factors. After conducting factor analysis of the mode-specific problems from the data, five factors have been identified. According to Table 3, factor analysis derived five factors: excessive fare, walking-related problems, lack of space to keep mobility aids, unwillingness to carry by drivers, and excessive height of the platform. Factor scores will be considered as the severity of each loaded factor as a problem.

The problem of excessive fare charged by rickshaw pullers and CNG drivers from MCPs as well as rude behavior made by bus staffs to MCPs and showing reluctance to carry MCPs have been loaded into factor "Excessive fare". The unwillingness of bus staff to help MCPs on-board and off-board where such a 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 and thus, these two problems can be linked to excessive fare charged. Factor "Walking related problem" covers all the walking related problems as well as unavailability of ramps in buses to transfer from walking on the footpath to

Table 3
Factor analysis of mode-specific problems.

Mode specific problems	Factor 1 Excessive fare	Factor 2 Walking related problem	Factor 3 Lack of space to keep mobility aids	Factor 4 Unwillingness to carry by drivers	Factor 5 Excessive height of platform
Unwillingness of bus conductors to carry movement challenged persons	0.844				
Rude behavior of bus conductors and drivers	0.751				
Excessive fare charged by a rickshaw puller	0.924				
Excessive fare charged by CNG driver	0.904				
Lack of ramp in bus		0.552			
Lack of space to maneuver in bus		0.614			
Presence of obstacles on the footpath		0.727			
Conflict with motorcycles on the footpath		0.402			
Lack of ramp to access footpath		0.733			
Narrow width of the footpath		0.644			
Lack of available space to keep mobility aid in the rickshaw			0.934		
Lack of available space to keep mobility aid in CNG			0.931		
Unwillingness of rickshaw pullers to carry MCPs				0.871	
Unwillingness of CNG drivers to carry MCPs				0.882	
Lack of space to keep mobility aid in bus				0.529	
Excessive height of platform of Rickshaw					0.693
Excessive height of platform of CNG					0.916

being on-board, and lack of space on buses to maneuver. Unwillingness to carry by rickshaw pullers or CNG-drivers have been loaded into factor "Unwillingness to carry" and unavailability of space to mobility aids have been loaded into factor "Lack of space to keep mobility aid". Factor "Excessive height of platform" encompasses problems of excessive height of platform of rickshaw and CNG. Derived factors are regressed in a multinomial logistic model to determine how a particular factor influences choice of a particular mode (Table 4). Walking is used as reference mode in the model.

According to Table 4, elderly MCPs have higher possibility of selecting CNG and rickshaw than walking. Model estimates reveal than MCPs prefer to travel by bus or CNG or rickshaw than walking as the travel time increases. Meanwhile, it is found MCPs with higher level of disability have lower possibility of selecting bus and rickshaw as travel mode in comparison to walking. So, wheelchairs are likely to be least interested in taking bus and rickshaw than walking to make a trip. As wheelchair users experience problems of lack of ramp in bus and lack of space to keep mobility aids in rickshaw than other mobility aid users, wheelchair users might be more reluctant to travel by bus or rickshaw. Gender, education, and income are not significantly related to any mode choice.

4.4. Predicted probability of selecting different modes

Predicted probability plots have been developed to comprehend the probability of selecting different modes with change in socio-economic characteristics and disability level of MCPs. As MCPs experience more walking related problems severely, they have higher possibility of choosing rickshaw than walking. On the contrary, with the increase in severity of unwillingness to carry by drivers and excessive height of platform, MCPs are less inclined to select bus, CNG or rickshaw in comparison to walking. The factors derived from mode specific problems are not found to maintain a significant relation with the choice of other modes.

Fig. 3 to Fig. 6 show the probability of selecting different modes by MCPs with change in gender, income, mobility aids, severity of problems. Fig. 3 reveals the probability of selecting different modes with a change in age. The relatively flat curve (range is 5%) of rickshaw implies the probability of selecting rickshaw of MCPs of different age groups does not vary much with age. The probability of selecting bus and walking decreases and probability of selecting CNG increase with age. The probability of elderly MCPs traveling by bus is lower than that of walking.

Fig. 4(a) and Fig. 4(b) reveal how the probability of selecting different modes changes with an increase in factor scores (severity) of problems of the excessive height of platform and unwillingness to carry by drivers respectively for male and female MCPs respectively. There was no discernable difference between male and female MCPs in the probability curve for the bus and rickshaw. The probability curve of the rickshaw is exhibited in Fig. 4(a). The curve is relatively flat in contrast to the sharply descending curve of the bus. The reason behind the flatter nature of the curve of the severity of the excessive height of the platform might be that MCPs are using rickshaws because of the door-to-door service provided by this mode irrespective of the challenges by them to avail it. The unwillingness to carry does not seem much effect as the curves are relatively flat except for the walking (Fig. 4(b)).

Fig. 5 (a), (b) and (c) depicts the probability of selecting modes with change in severity of problem of excessive height of platform, problem of unwillingness to carry and change in travel time for different income groups of MCPs respectively. From Fig. 5(a), low-income group of MCPs shave been found to have a higher tendency to use rickshaws than their counterparts. Middle and high income MCPs tend to use more of rickshaw and CNG which are relatively costlier than bus which is mostly used by the low income MCPs. With the increase of excessive height of the platform problem severity, both of these income groups become less likely to use bus; however, probability of choosing CNG and rickshaw remains relatively flat. According to Fig. 5(b), as MCPs experience the problem of unwillingness to carry more severely, the probability of selecting CNG as a travel mode plummets at a smaller rate for different income groups. With the increase in severity of the problem of this problem, the probability curve for rickshaws remains relatively unchanged for income groups imply that this problem does not influence the selection of rickshaws much. Meanwhile, Fig. 5(c) reveals that with the increase in travel time is 20 min or greater, the probability of walking is close to zero. The probability of selecting bus and CNG enhances with travel time for both groups. Interestingly, the probability of traveling by rickshaw for MCPs increases up to a travel time of 30 min. When travel time is >30 min, the probability of selecting rickshaw decreases. The probability of using bus increases with the increase of the travel time for both income groups (much higher rate for low income) which is expected as bus is more convenient economically if individual is traveling long distances.

Fig. 6(a) shows the probability of selecting modes with change in the (a) severity of the problem of the excessive height of platform for different mobility aid users. Non-wheelchair user MCPs have been found to have a higher tendency to use rickshaws than other MCPs. Fig. 6 (b) illustrates the probability of selecting modes with change in the severity of the problem of unwillingness to carry for different mobility aid users. With the increase in severity of the problem of this problem, the probability curve for rickshaws remains relatively steady for different mobility aid users denote that this problem does not influence the choice of rickshaws for traveling much. As MCPs experience the problem of unwillingness to carry more severely, the probability of selecting CNG as a travel mode increases for different mobility aid users. Fig. 6 (c) change in probability of different mode choice with variation in travel time for different mobility aid users. With the increase in travel time, the probability of walking is near to zero. However, wheelchair users have the probability of moving on with the wheelchair for longer time than that of non-wheelchair users. Meanwhile, wheelchair users have higher probability of traveling by CNG than non-wheelchair users.

All these predicted probability plots imply a basic thing: MCPs are not facing inequity in terms of being an MCPs, also there is significant inequity exists among these groups in terms of income and the level of their disabilities. This finding is important for policy purposes as the policymakers need to address these heterogenies within the MCPs while developing policies to address the need of MCPs. Also, these findings indicate that captivity of low-income groups towards bus as their probability of discarding rate of bus due to severity of height, unwillingness to carry problem are lower than the middle- and high-income groups. This may imply that middle- and higher-income groups can afford CNG and rickshaw more easily than the low income. This inequality within inequality is a major finding of this study that can

Table 4
Estimates from multinomial logistic regression of mode choice.

Variables	Modes		
	Bus	CNG	Rickshaw
Age	0.036	0.146***	0.076**
Gender	−0.844	−0.956	−0.760
Education	0.179	−0.155	−0.006
Income	−0.932	1.153	1.009
Instrument	−4.385***	−1.427	−3.207***
Travel time	0.511***	0.517***	0.440***
Excessive fare-related problem	−0.140	0.248	−0.017
Walking related problems	0.496	0.593	0.558*
Lack of space to keep mobility aids	−0.067	0.029	0.359
Unwillingness to carry by drivers	−0.756*	−0.762*	−0.676*
Excessive height of the platform	−1.083***	−0.855**	−0.760*
Constant	−9.503***	−14.679***	−7.657***
AIC	575.141	575.141	575.141

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.
Reference mode: Walking
No of observations: 384.

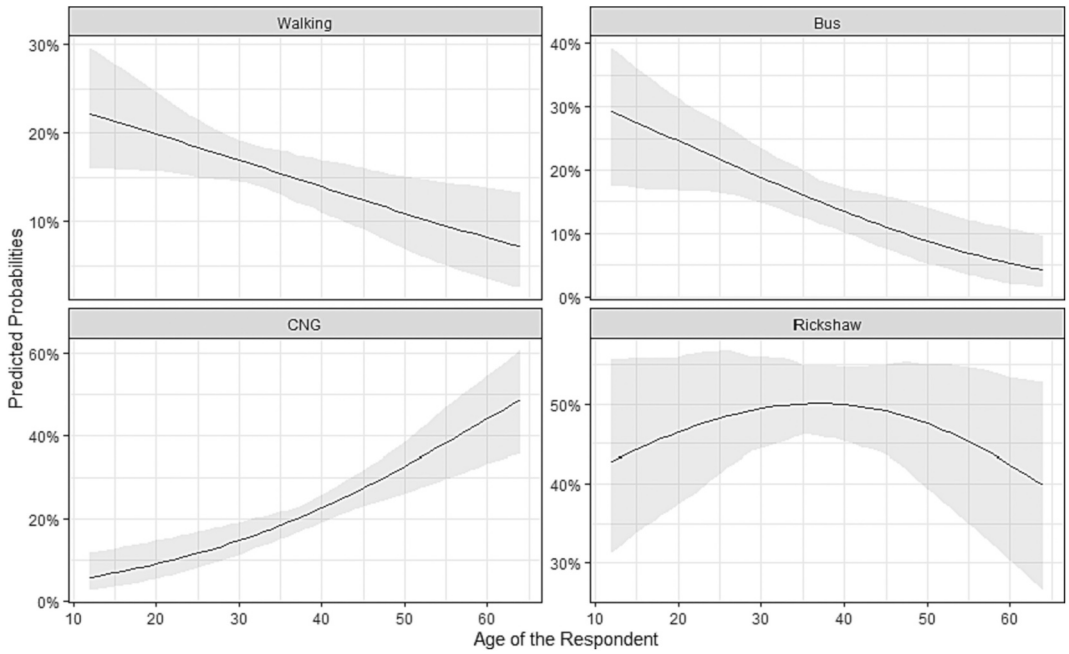

Fig. 3. Predicted Probability of selecting modes with change in age.

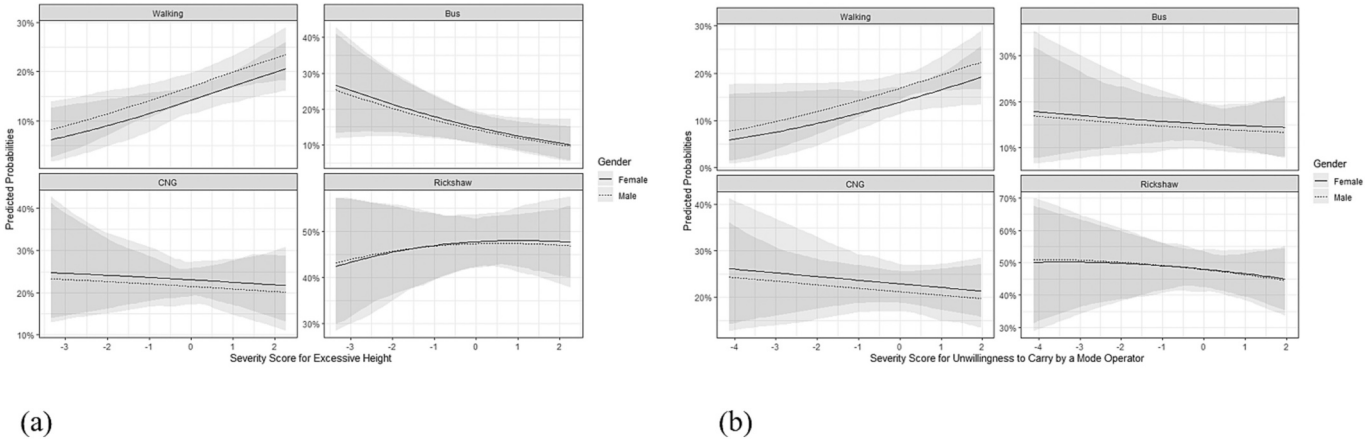

Fig. 4. (a): Probability of selecting modes with change in severity of problem of the excessive height of platform for male and female MCPs (b): Probability of selecting modes with change in the severity of the problem of unwillingness to carry for male and female MCPs.

explored in detail in later studies. Kakar et al. (2021) argued that a better understanding of the transport inequities is required to inform policies (Kakar et al., 2021). This detail analysis of the inequities experienced by the MCPs from the context of mega city Dhaka can guide developing more equitable transport policies.

5. Discussions

Statistical analyses found that, among 18 mode-specific problems 83.33% were influenced by mobility aid, 44.4% by age, and 27.27% by gender. The majority of mode-specific problems are experienced by females, and elderly MCPs, and wheelchair users. Interestingly, this study finds in some instances (problems) for MCPs, younger people and male with disability are more disadvantaged which contrast with the general notion that women and elderly people are transportation disadvantaged. The presence of undulated surface, lack of ramps on buses, and the lack of ramps with standard slope along the footpath are the first, second, and third most acute mode-specific problems experienced by MCPs, respectively.

To move over a footpath surface full of cracks, to access a ramp with high slope of footpath, to board a rickshaw with an elevated platform, and to board a bus with stairs in the absence of a ramp, require MCPs to exert great physical strength. As physical attributes differ among MCPs in terms of gender and age of people, the problems are more acutely experienced by female and elderly MCPs and are also reflected in their severity rankings of mode-specific problems (Miller, 2018; Mussleman & Brouner, 2005). Wheelchair users may experience an additional layer of difficulty as they may need to request assistance from rickshaw pullers or other passengers to board the elevated platform of a bus without a ramp, to get up a steep slope, or to push the wheelchair when it gets stuck in a depression on the footpath (Chang, 2010; Grossman and Magaña, 2016).

Based on the experience of the surveyed MCPs, the unwillingness of bus drivers and rickshaw pullers to carry MCPs and the additional fares charged by rickshaw pullers and CNG drivers were identified as severe problems (>4). It is exploitative for rickshaw pullers or CNG drivers to take advantage of others' disabilities to charge an additional fare which might because of the hassle of binding wheelchair with rickshaw

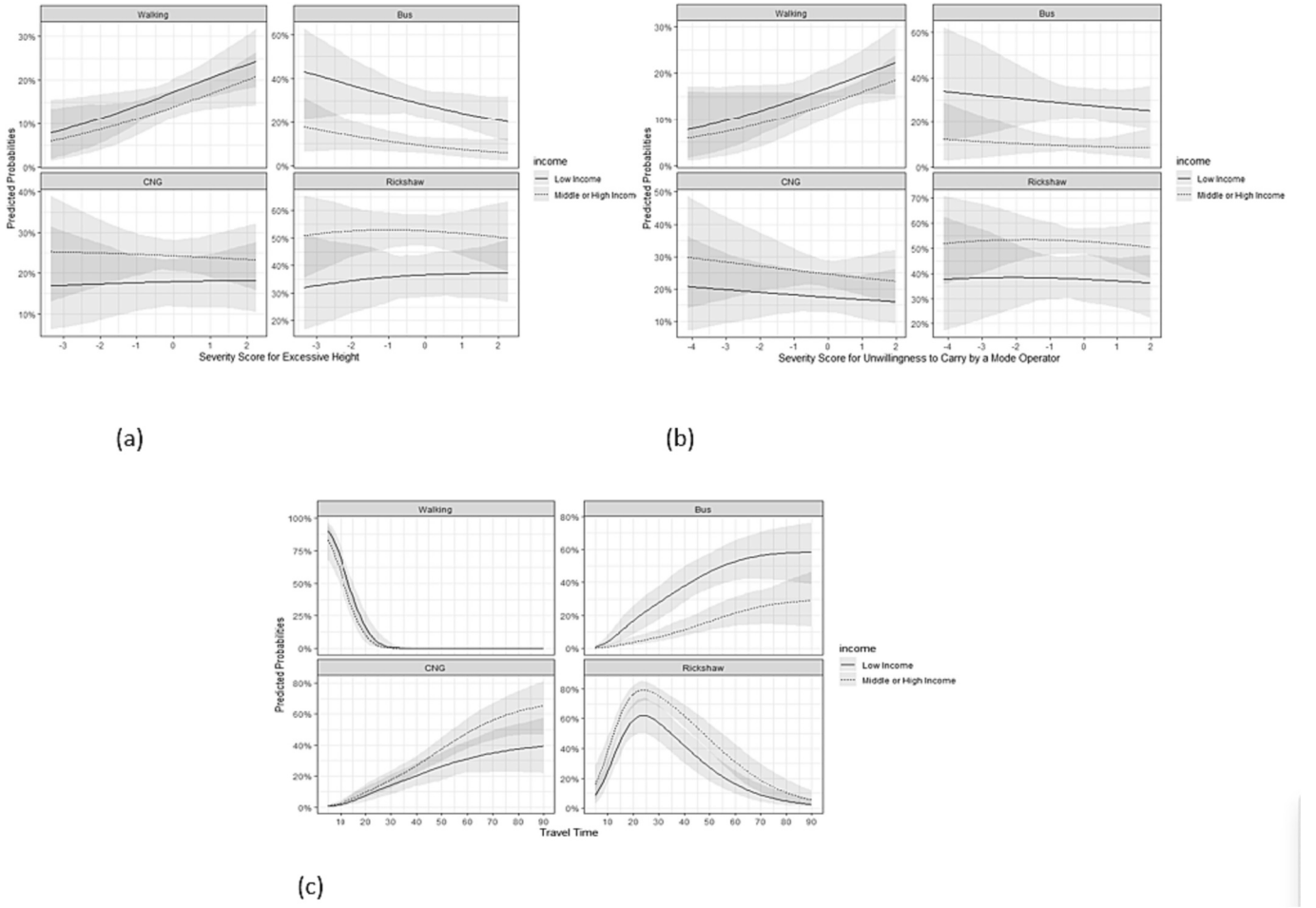

Fig. 5. Probability of selecting modes with change in (a) severity of problem of excessive height of platform (b)of the problem of unwillingness to carry (c)travel time for different income groups.

(Zaman, 2015; Robert, 2019). Elderly MCPs face unwillingness to carry less severely than other age groups for both rickshaw and bus modes, which can be attributed to the social norm in Bangladesh to be respectful of the elderly (Shrestha et al., 2017).

Another noticeable issue is that female MCPs are victims of misbehavior by bus staff. In the context of a developing country where women are often considered to be inferior to men, women with weakness, like a disability, will likely be considered more inferior, resulting in being teased or becoming the victim of rude and abusive behavior by the bus staff (Unnayan Onnesha, 2011).

The study also found the probability of selecting rickshaws remains relatively the same for MCPs of different ages. With the increase in severity of excessive height of platform and unwillingness to carry, the probability of selecting rickshaw remain unchanged for female and male MCPs, different mobility aid users and different age groups of MCPs. Meanwhile, the probability of selecting a rickshaw varies with changes in travel time. Probability of selecting bus increases with an increase in travel time which signifies the importance of bus for MCPs despite its mode-specific problems.

6. Conclusions and recommendations

Current discussions on mobility inequality have not adequately addressed the issues faced by those with disabilities, especially in the context of developing countries. Even fewer discussions have delved into the nuances of the inequalities unevenly experienced across mobility aids and socioeconomic characteristics. This study explored the severity of bus, rickshaw, CNG, and walking-related mode-specific problems reported by MCPs, and through statistical modeling derived the relations of those problems with age, gender, education, income, and mobility aid used by MCPs in the context of the megacity of Dhaka in the Global South country of Bangladesh.

Mode-specific problems are a great hindrance to ensuring sustainable, inclusive, and equitable transportation for MCPs (Venkataram et al., 2024). To achieve SDGs, particularly SDGs 11, 10, and 3, it is necessary to understand and tease apart mobility inequality so that appropriate policy measures can be targeted to resolve mode-specific problems faced by MCPs (United Nations, 2019). Studies like Ipingbemi (2016) and Rosli et al. (2017) have urged translating policies and laws into actions, design, and dissemination in a pragmatic way to deal with mode-specific problems through appropriate need assessment of stakeholders (Ipingbemi, 2016; Mohiuddin, 2021). Although existing transportation policies for Dhaka acknowledge the requirement of friendly infrastructure, transport service, and design for universal accessibility for MCPs and other PWDs, none of the policies have any specific guidelines for implementing universal accessibility, such as for standard ramp slopes or footpath widths. The study reveals wheelchair users and female and elderly MCPs experience a lack of ramps more severely. Currently, there are no buses with ramps running in Dhaka city which more inaccessible to wheelchair users than other MCPs. However, relevant transport authorities should take initiative to install ramps in buses, particularly for these groups of MCPs. If an institutional and wholesale design change is less feasible, simple and effective solutions can be initiated, like installing a folding ramp on rickshaws that can

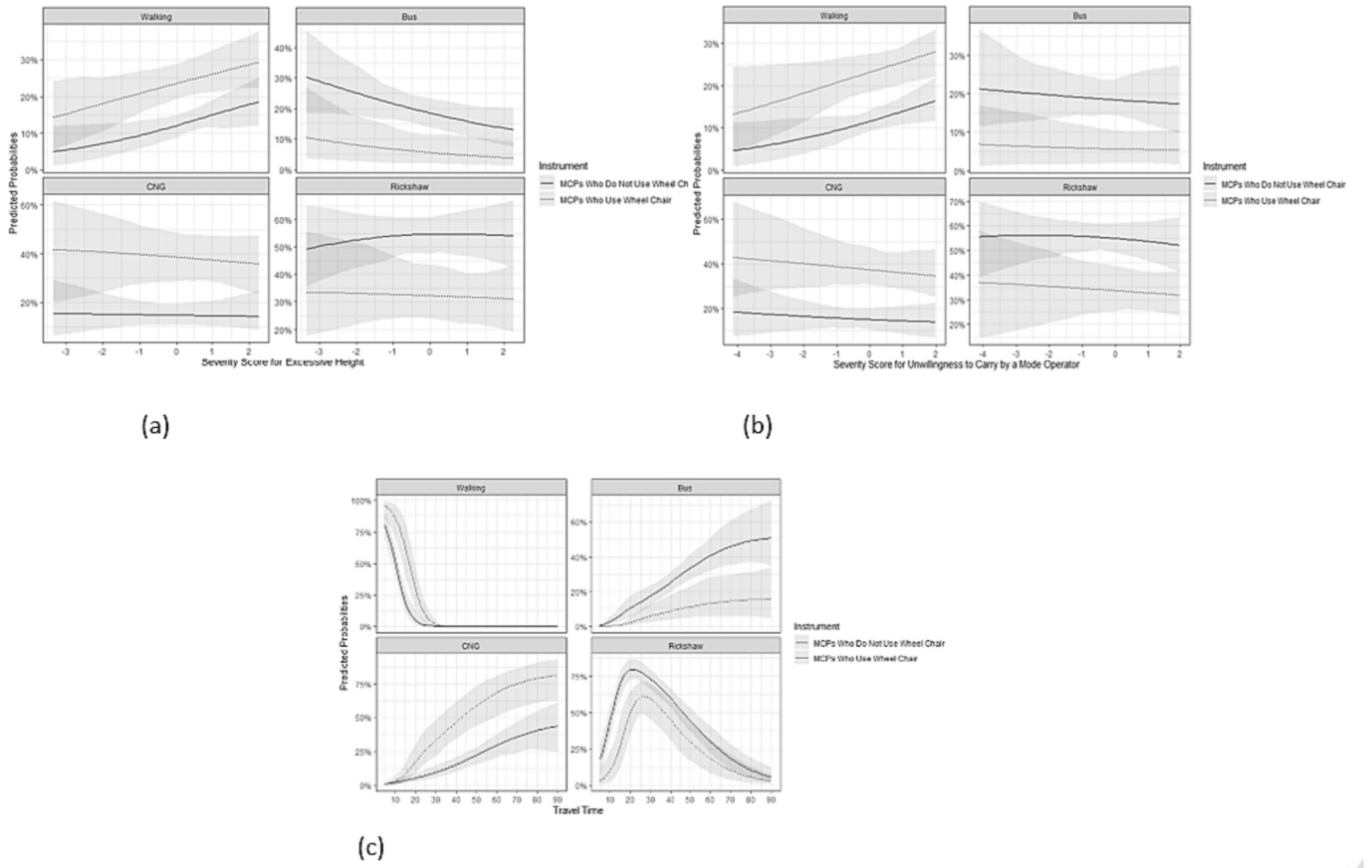

Fig. 6. Probability of selecting modes with change in the (a) severity of the problem of the excessive height of platform for different mobility aid users (b) severity of the problem of unwillingness to carry (c) travel time for different mobility aid users.

allow MCPs to board more conveniently (WheelchairTravel.com, 2022). Government can market rickshaws with modified designs with lower platforms and more space to keep supporting instruments to resolve the hardship MCPs, especially wheelchair users, and female and elderly MCPs. It is appreciable that DTCA has designed proposed Bus Rapid Transport (BRT) and Mass Rapid Transit (MRT) for Dhaka in RSTP to be universally accessible but first and last-mile connectivity between land uses and transit stops should be ensured by alleviating exiting footpath related problems to ensure complete accessibility for MCPs to bus stops. As female, wheelchair users, and elderly MCPs are likely to face physically challenged mode-specific problems more acutely, footpaths should be kept with the least undulation on the surface or without obstacles through regular maintenance, and buses and footpaths should be provided with a reasonable slope so that MCPs, specifically female, wheelchair users and elderly MCPs, overcome these challenges with minimum physical effort.

It should be acknowledged that there is a lack of awareness in Bangladesh and elsewhere regarding the mode-specific problems of MCPs (Ipingbemi, 2016), which can be attributed as a reason behind the unfriendliness of transport staff in Dhaka towards MCPs. Mass media can play a vital role in this regard. Transportation staff in Dhaka generally showing respect to elderly MCPs is appreciable, but they should be made aware and trained to respect and support MCPs of all gender and age instead of exploiting a particular group of MCPs (Rosli et al., 2017). Local government bodies (like ward commissioner office) of Dhaka must perform their mandatory duty, such as to keep the footpaths smooth, free of cracks and hap-hazards, and to duly pave with the right surface, for MCPs at the neighborhood level (Rahman, 2008; Jamal et al., 2020).

This study only considered a single group of MCPs, those with physical mobility challenges. The methodology in this study can be used as a framework to analyze the mode-specific problems of other PWDs who suffer from mobility challenges, such as visually impaired persons. The methodology followed in this study can be applied to explore mode-specific problems and other populations of other cities of the world. Although this study followed a quantitative approach, a more in-depth, qualitative analysis of mode-specific challenges can be conducted like key informant interviews or focus group discussions for future studies. This study has also only focused on intra-city modes and travel within Dhaka. In Bangladesh, trains are widely used for inter-city travel, and trains and other inter-city modes should be examined in future explorations.

Author statement

Author declares no conflict of interest for the paper. The contribution of the authors as follows:

Md Musfiqur Rahman Bhuiya: Study Conception, Study Design, Data collection, data analysis and visualization, manuscript preparation and revision, funding.

Md Musleh Uddin Hasan: Study design, data collection, funding, manuscript preparation and revision.

Hossain Mohiuddin: Data analysis and visualization, manuscript preparation and revision.

Afrin Hossain Anni: Data analysis and visualization, manuscript preparation.

Steven Jones: Manuscript preparation and revision.

Zhi Chen: Manuscript preparation and revision

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Data availability

The authors do not have permission to share data.

Declaration of Competing Interest

None.

Appendix

Fig. A1. Score of mode specific problems for different mobility aid users.

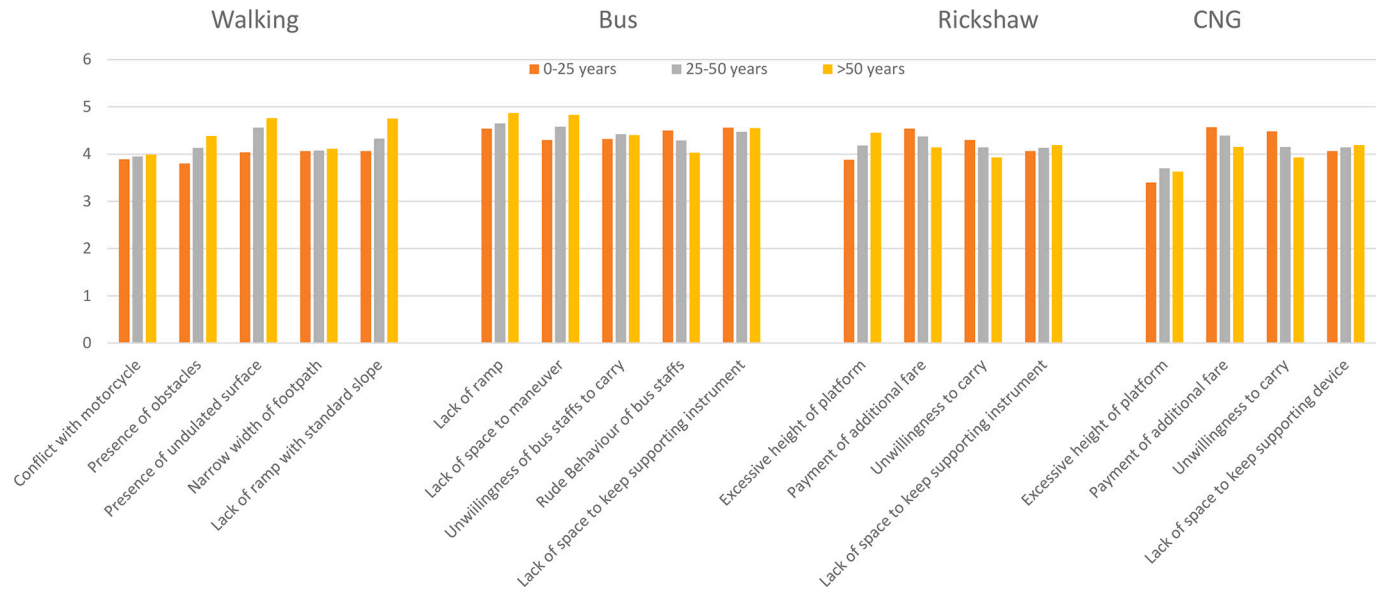

Fig. A2. Score of mode specific problems for different age group of MCPs.

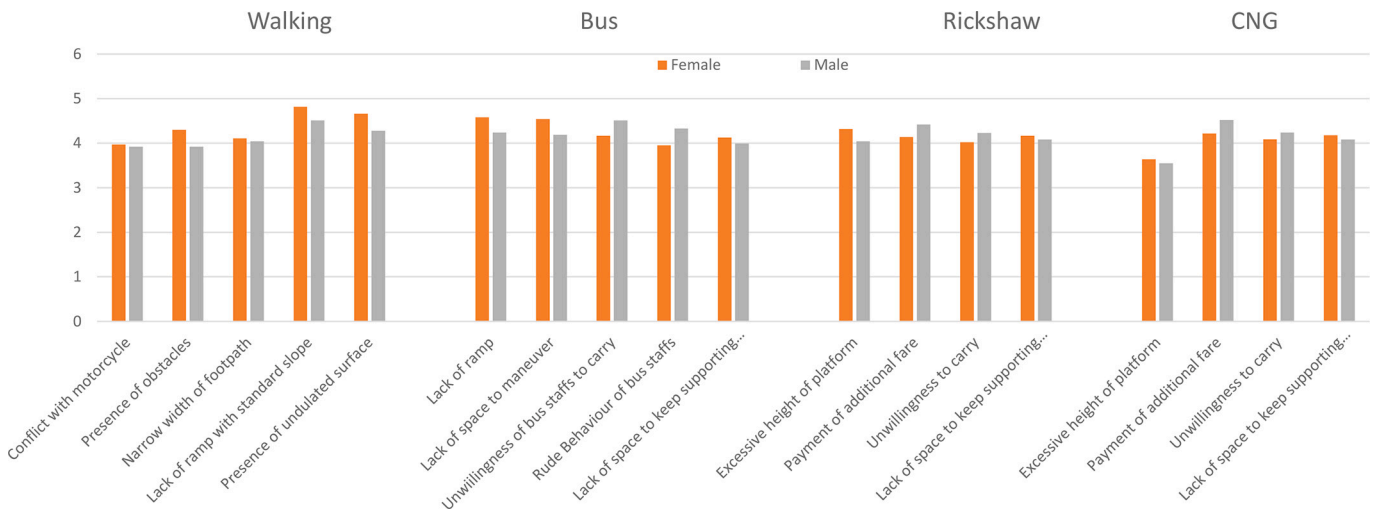

Fig. A3. Score of mode specific problems for female and male MCPs.

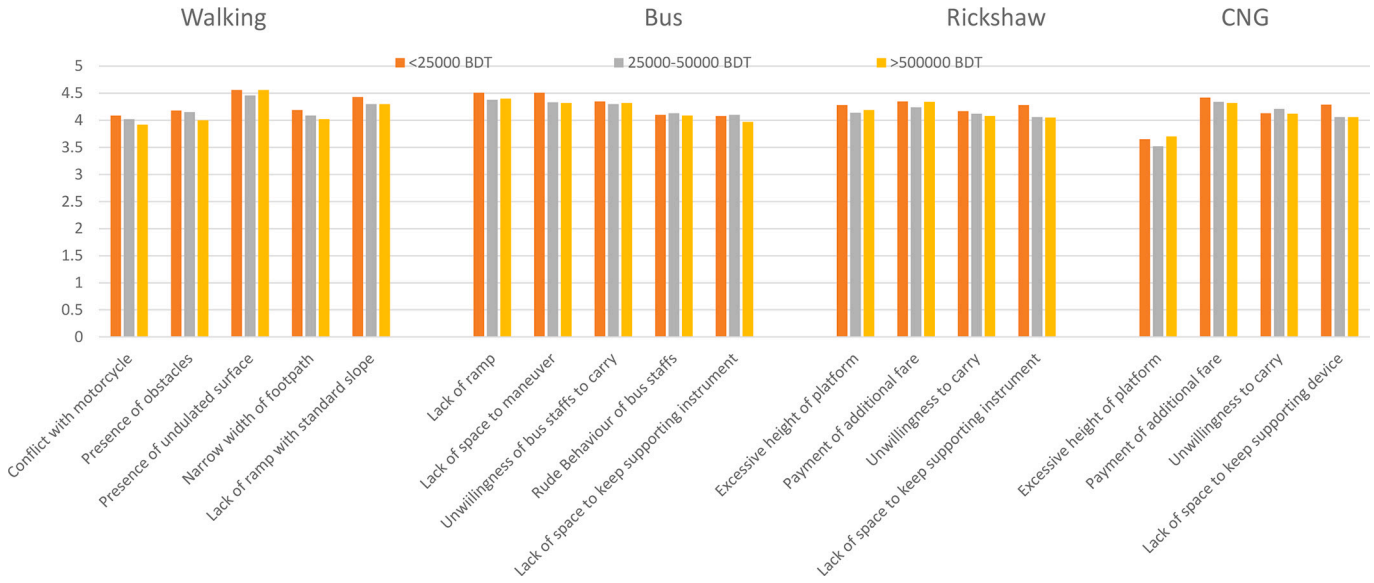

Fig. A4. Average rank of mode-specific problems for different income groups of MCPs.

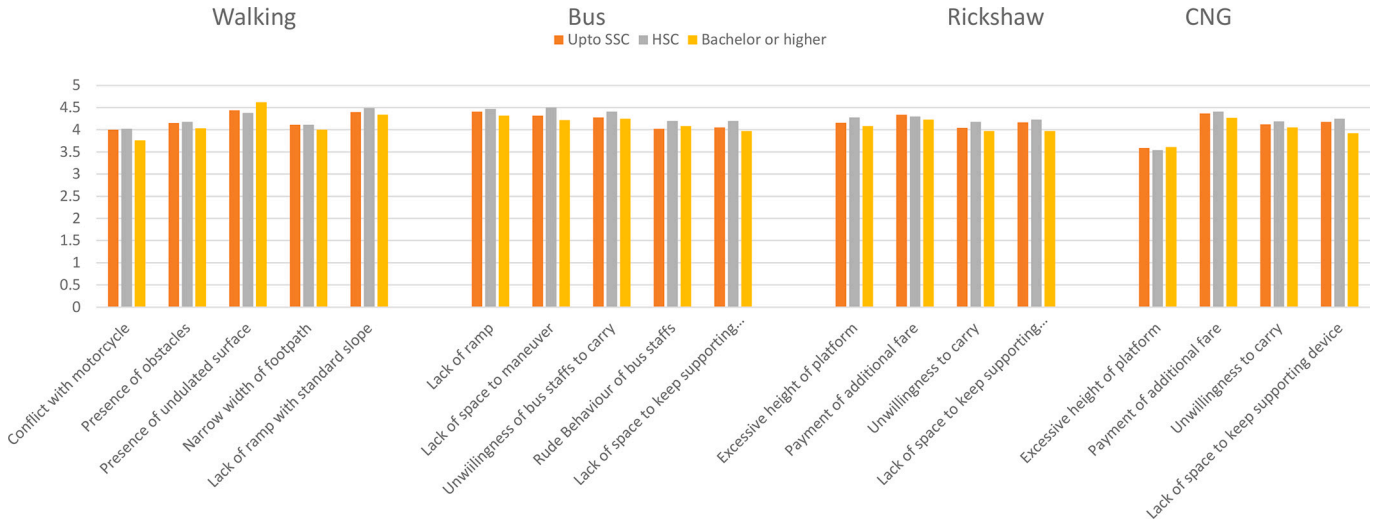

Fig. A5. Average rank of mode-specific problems for different education groups of MCPs.

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