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Exploring the perceptions about public transport and developing a mode choice model for educated disabled people in a developing country

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ABSTRACT

People with disabilities are an important part of every community. However, they often face problems while using public transport, which results in several negative consequences including social exclusion. This study aims at exploring the problems faced by persons with disabilities (PWDs) while using public transport along with their mode choice in Lahore, Pakistan. This study uses a questionnaire-based approach to collect the data. Exploratory factor analysis is conducted to extract the underlying factors describing the perceptions of the PWDs about the issues with public transportation. It also uses non-parametric tests such as Kruskal Wallis and Mann Whitney U tests to determine the effects of demographic variables on the underlying factors. In addition, it estimates a binary logit model to determine the mode choice of PWDs in Lahore, Pakistan. The non-parametric tests on underlying factors indicated that females declared higher level of agreement with spatial and financial inequity and infrastructural inaccessibility as compared to males. Furthermore, those traveling with wheel chairs showed significantly higher level of agreement with service inadequacy as compared to those without any mobility aids. The binary logit model indicated that female PWDs are less likely to use public transport relative to other modes when compared to the male respondents. The respondents belonging to the higher income categories are less likely to use public transport relative to other modes when compared to the lowest-income category. The respondents who do not own a vehicle are more likely to use public transport relative to other modes when compared to those who own a vehicle. In the logit model, gender, household income, use of mobility aids, primary purpose of traveling, vehicle ownership, and infrastructural inaccessibility were found to be significant predictors of mode choice. Although transport-related policies exist for PWDs, more specific policies and stricter implementation is required to improve the accessibility and public transport ridership of PWDs.

1. Introduction

People with disabilities are an important part of any community, who are often ignored in the design of infrastructure in various countries (Abidi and Sharma, 2014). There are several types of disabilities including deafness, blindness, mental and physical disabilities etc. Here only people with physical disabilities are referred to as the people with disabilities (PWDs). Despite several international and national laws and policies in place, problems facing disabled people still exist not only in the developing countries but also in the developed countries (Stancliffe, 2014). According to the World Health Organization (WHO), about 15 % of the world population has some kind of disability with 2–4 % of them facing severe disabilities limiting their mobility (Bickenbach, 2011). The report also highlights that the disability is more prevalent in the developing world. In addition, the reported number of disabled people has been increasing over the years, which further necessitates their inclusion into the fabric of society.

PWDs often have limited access to various social activities, which is linked to the way how transportation systems are planned and designed. As a result, disability has been found to be associated with poverty, limited access to health and educational facilities, and less social inclusion (Bickenbach, 2011; Soltani et al., 2019). Despite various national and international policies and guidelines, inaccessibility remains a problem for the PWDs (Anand and Sevak, 2017). Since PWDs often live in poverty, they are generally dependent on public transportation. Hence, well planned and designed public transportation systems satisfying the needs of PWDs can help develop more inclusive societies.

According to the census conducted back in 1998, about 4–6 % of the

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population had a disability in Pakistan, however, this figure underestimates the actual number of disabled people in Pakistan (Rathore et al., 2011). In addition, the terrorism wave during the past two decades also resulted in additional people with various kinds of disabilities (Waheed & Ahmad, 2012). PWDs are often ignored in the design of shopping malls, hotels, restaurants, and public healthcare in Pakistan (Ahmad, 2013). The mobility and access of people with disabilities is further reduced due to the unavailability of accessible ramps and other facilities at railway stations and bus stops (Ahmad, 2015). In addition, public transport vehicles seem to overlook the requirements of the disabled people.

Lahore is the second most populous city of Pakistan. Its public transport system is struggling to cope with the current travel demand (Javid et al., 2016). In particular, people with disabilities have developed negative perceptions about the public transport system due to its poor performance and lack of consideration for PWDs (Park & Chowdhury, 2022). This study aims at exploring the perceptions of PWDs about the current public transport system in Lahore. In addition, it aims at modeling the mode choice behavior of PWDs in Lahore. For this purpose, a questionnaire was designed to collect the required data.

The rest of the manuscript is organized as follows: the next section presents a comprehensive review of the literature about PWDs and transportation. Section 3 explains the methodology adopted to achieve the objectives of this study. Section 4 presents the results and discussion. Section 5 highlights the practical and policy related implications of the study. Finally, conclusions and recommendations are presented in Section 6.

2. Literature review

Transportation is an important factor for any community to improve its quality of life and decrease the level of social isolation. Individuals may easily engage in their community for education, employment, health and socializing if their access to transportation is increased. The concept of universal design of accessible transport environment first given by Ronal Mace who was an architect by profession defines this design as “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design”. The main focus of this design is to build such an environments where PWDs can function as the natural members of community (Aarhaug and Elvebakk, 2015).

However, transport-related problems are among the most commonly faced issues by PWDs (Kett et al., 2020). In the UK there are approximately 11.2 million out of 62 million people who are facing different disabilities and out of them, 57 % are facing mobility problems (Penfold et al., 2008). In England and Wales, 41 % people have difficulties regarding travelling and transportation. 25 % cannot easily travel to and from medical centers and 23 % people cannot visit their friend and family due to inaccessible transportation (DPTAC, 2002). Due to poor travelling facilities 23 % people have to leave their job opportunities (Campion et al., 2003). In London and France, disabled people are unable to enjoy their trips in leisure time, again the reason being the inaccessible and uncomfortable transport facilities (Dejoux and Marin-Lamellet, 2010). Inaccessible school transportation also affects the education of children have mobility impairment. In the U.S., 2.8 million of the 53.9 million school aged children have disability and in Canada, 174,810 children reported some disability (Ross, 2020). Due to this childhood disability, accessible transportation system should be considered as an important part of inclusive society.

Public transport has a great role in making the mobilization of people easy and comfortable, however, PWDs often remain excluded during the planning and design stage of public transport system in several countries across the world. The requirements, perceptions, and preferences of disabled people may be different from those without disabilities. For instance, people with reduced mobility or with a disability value public transport accessibility almost twice as much as those without reduced mobility (Cepeda et al., 2018). In Nigeria, up to 60 % people spent approximately 10 min or less and 29.7 % people spent 11–15 min to reach their nearest bus stops (Ipingbemi, 2015). A study conducted in Bangkok, Thailand also reported long distances between public transport stops and tourist spots to be causing inaccessibility for disabled people (Fernandes-Ferreira et al., 2020). This could reduce the public transport accessibility for PWDs. Persons with Disability (PWDs) who often lack private transportation options are more dependent on public transportation system. A study conducted in Malaysia reported that certain train stations were inaccessible to PWDs due to poor planning, design, and maintenance (Isa et al., 2016). It was also recommended that proper height of ticket counters and adequate ramp gradients be provided for better PWDs accessibility. A study conducted in Brazil reported that the main problems with public transport were related to its quality of service. Furthermore, there was a lack of trained employees to help PWDs with wheel chairs (Almada and Renner, 2015). High costs of transportation have also been limiting the access to healthcare facilities for disabled people (Soltani et al., 2019). People with physical disabilities were found to have lower access to jobs in two Canadian cities, Montreal and Toronto, as compared to general public (Grisé et al., 2019).

3. Methodology

3.1. Study area

This study was conducted in Lahore, which is the second most populous city of Pakistan. Lahore is a cultural and educational hub and thus, attracts people from all over Pakistan. The heavy influx of people has resulted in additional demand for public transport over the years. The current public transport system is struggling to cope with the ever-rising travel demand. Public transport in Lahore mainly consists of buses. Generally, public transport stops and vehicles lack necessary infrastructure for PWDs in Lahore.

3.2. Questionnaire design

As a first step, several meetings were held with the representatives of various NGOs and rehabilitation centers for PWDs in Lahore in order to explore the transport-related problems facing PWDs. The reported problems were then categorized into five different categories namely, service inadequacy, spatial and financial inequity, social barriers, vulnerability, and infrastructural inaccessibility. Finally, a questionnaire was prepared comprising demographic questions, current mode choice and 25 questions on 5-point Likert scale about the 5 aforementioned categories in order to explore the perceptions of PWDs about the problems associated with public transport in Lahore.

3.3. Questionnaire administration

Since the percentage of physically disabled people is small considering the overall population of Lahore, collecting data from PWDs was a challenging task. In addition, the COVID-19 pandemic made it further difficult to conduct random in-person interviews. Therefore, a convenience-based sampling approach was adopted. The PWDs were approached at various probable locations such as at their rehabilitation centers and during seminars/workshops focused on PWDs. It took about 3 months from January to March 2021 to collect 268 complete responses. Since the pandemic has also affected the mode choice over the past almost two years, the respondents were asked to report their mode choice before the pandemic which they are likely to return to once the pandemic is over.

3.4. Analyses methods

Initially, a descriptive analysis of the collected data was conducted,

which also included computation of relative importance index (RII) to figure out the ranking of the public transport-related issues faced by PWDs. Then exploratory factor analysis was carried out on the 5-point Likert type items to discover the underlying factors. After extracting the underlying factors, factor scores were computed using a refined method and the effects of socio-economic and demographic variables on these factors were determined using Kruskal Wallis and Mann Whitney U tests. Finally, the mode choice behavior of PWDs was modeled using a binary logistic model. All the analyses were performed using SPSS v. 20.

4. Results and discussion

4.1. Descriptive analysis

Table 1 shows the socio-demographic distribution of the sample. Out of 268 respondents, 69.8 % were male and 30.2 % were females. The census distribution indicated that the average distribution of upper and lower limb disabilities was 62.6 % and 37.4 % among males and females, respectively (Jahangeer, 2011). The distribution of male and female PWDs in the sample is not too far off from their census distribution indicating that the sample is nearly representative in terms of gender.

Table 1
Socio-demographic distribution of the sample.

Variable	Category	Percentage	Census Distribution
Gender	Male	69.8	62.6
	Female	30.2	37.4
Profession	Student	47.0	—
	Business/Employee	49.3	
	Housewife/retired	3.7	
Education	Under Matric	1.9	—
	Matric	65.7	
	Intermediate	16.0	
	Graduate	12.7	
	Postgraduate	3.7	
Household Income (PKR)	<25,000	55.2	—
	25,001–50,000	35.4	
	>50,000	9.3	
Age	<18	36.2	—
	18–30	36.2	
	31–40	17.2	
	41–50	8.2	
	>50	2.2	
Vehicle Ownership	Car/Motorbike/Other	23.1	—
	None	76.9	
Primary Purpose of Traveling	Studying	47.8	—
	Work	38.4	
	Shopping/Social/ Health/Other	13.8	
Travel distance (kilometers)	<5	16.8	—
	6–10	34.3	
	11–15	22.8	
	16–20	13.4	
	21–25	11.9	
	>25	0.7	
Trip Frequency	None	0	—
	Once a Week	7.8	
	2–3 Times a Week	9.3	
	4–5 Times a Week	57.5	
	Everyday	25.4	
Mobility Aids	None	19.4	—
	Wheel Chair	33.2	
	Crutches/Cane/ Walker/Other	47.4	
Travel Mode	Private Transport	14.9	—
	Public Transport	53.7	
	Ridesharing/DRT	7.5	
	Paratransit	13.4	
	Office Transport	8.2	
	Nonmotorized Transport	1.5	
	Other/Wheelchair	0.7	

The respondents younger than 18 years old generally represented the technical education students at rehabilitation centers with ages varying between 16 and 18 years. The share of the PWDs older than 50 years old was very small (i.e., only 2.2 %). According to the census distribution, the prevalence of disabilities is more common among older adults, however, this study focuses only on educated PWDs. Therefore, the distribution of disabilities with respect to age are likely to be different from those reported in the census. In addition, the more common disabilities among older adults are likely to be hearing and seeing, whereas this study only focuses on the physical disabilities. About 55 % of the respondents indicated they belong to the lowest income category i.e., <25,000 (PKR). Most of the respondents (47.4 %) declared they use some kind of assistance such as crutches, walker, cane etc. followed by those who use wheel chair (33.2 %) and those who do not use any mobility aids (19.4 %). The majority of the respondents (76.9 %) did not own a private vehicle. Most of the respondents (53.7 %) use public transport. Majority of the respondents travel for their primary purpose for >4 to 5 times a week. The distribution of the responses for all the 25 Likert type questions are shown in Table 2.

4.1.1. Relative importance index

The relative importance index, as its name suggests, ranks the Likert type items according to their importance. Items with higher ranks represent the most important issues according to the respondents and may need to be prioritized over other low-ranked items. RII was computed for all the Likert-type items in five sections of the questionnaire (Table 3). The RII was computed using the following formula (Aziz et al., 2016):

$$RII = n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5/5(n_1 + n_2 + n_3 + n_4 + n_5)$$

where, $n_1, n_2, n_3, n_4,$ *and* n_5 are the numbers representing strongly disagree, disagree, neutral, agree and strongly agree, respectively.

The RII values for Section 1 indicated that the most common service-related issue faced by the respondents was “too high floors of public transport vehicles” followed by crowded vehicles and untrained staff. Interestingly, long waiting times was the least important issue. For Section 2, the RII indicated that unavailability of sufficient space for mobility aids was the most serious issue followed by unavailability of space for PWDs and non-existence of discounted fares. Similarly, RII for Section 3 showed that the most important issue concerning social barriers was the unwillingness of family members to allow PWDs to use public transport followed by the feeling that other passengers are disturbed when PWDs ride public transport. For Section 4, the most serious problem was the fear of getting lost followed by pick-pocketing and other issues. The RII values for Section 5 indicated that unavailability of accessible ramps at bus stops is a more important infrastructural issue than unavailability of automatic entry and exit gates at bus stops.

4.2. Factor analysis

Exploratory factor analysis with maximum likelihood estimation and Varimax rotation was conducted on all the Likert type items (Table 4). The items with high correlations and cross-loadings were removed from the analysis. Finally, a five-factor solution was obtained using the eigenvalues criterion (i.e., eigenvalues > 1.0), which explained about 54.651 % of the variance in the data. The determinant of the correlation matrix was 0.001; KMO value was 0.844; and Bartlett’s test of sphericity was significant indicating satisfactory results.

The first factor explained about 18.946 % of the total variance. All the seven items loading on this factor represented issues related to the service attributes of the public transport system such as “public transport staff is not cooperative, ”public transport is too crowded“, and ”public transport is too slow“ etc. 3 items loaded on the second factor, which explained about 11.465 % of the total variance. The items loaded

Table 2
Percentage distribution of responses for the Likert type items in the questionnaire.

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Section 1					
Walking to bus/ train stop is difficult	11.6	7.1	12.3	26.5	42.5
Public transport is too crowded	7.8	5.2	10.4	45.9	30.6
Public transport is too slow	6.7	17.5	25.0	28.0	22.8
Public transport is uncomfortable	6.3	11.9	17.2	35.8	28.7
Public transport staff is not cooperative	11.9	13.4	20.9	31.0	22.8
Public transport stops are too far from my origin or destination	7.1	11.2	18.7	32.8	30.2
Waiting time is too long	10.4	15.3	22.4	30.2	21.6
Public transport is not suitable during bad weather	12.7	14.6	15.7	28.4	28.7
It is difficult to buy tickets/use fare machines	11.2	14.6	18.3	32.5	23.5
Bus/train floor is too high (difficult to get on the bus/ train)	6.7	6.7	11.2	28.0	47.4
No trained staff inside public transport for helping/guiding PWDs	10.8	7.5	11.6	31.0	39.2
No trained staff at bus/train stops for helping/guiding PWDs	6.0	9.7	13.4	35.1	35.8
Section 2					
No designated spaces in public transport for PWDs	6.0	7.8	18.3	34.7	33.2
No designated spaces at bus/ train stops for PWD	4.9	8.6	22.0	34.0	30.6
Not enough space for carrying mobility aids in the public transport buses/ trains	6.3	6.3	16.4	37.7	33.2
No discounted fares for PWDs	6.3	9.3	14.2	39.6	30.6
No special public transport service for PWDs	10.1	8.2	18.7	29.5	33.6
Section 3					
My family/friends do not want me to use public transport	14.2	9.7	19.8	29.5	26.9
I feel other passengers are disturbed when I ride public transport	12.3	9.0	19.8	25.7	33.2
Section 4					
	9.7	17.5	16.8	37.3	18.7
Public transport is not safe and secure for PWDs					
Passengers are not cooperative	23.9	18.3	20.5	24.6	12.7
Pick-pocketing in public transport	17.2	13.4	26.1	27.6	15.7
I may get lost while using public transport	21.3	14.9	21.6	27.2	14.9
Section 5					
Bus stops entry/exit are not equipped with auto gate facilities	24.3	35.1	17.9	12.3	10.4
There are no accessible ramps to enter/exit the bus at bus stops	23.1	22.8	16.4	17.5	20.1

Table 3
Ranking of the problems with public transport system using relative importance index.

Items	RII	Rank
Section 1		
Bus/train floor is too high (difficult to get on the bus/train)	0.805	1
Public transport is too crowded	0.772	2
No trained staff at bus/train stops for helping/guiding PWDs	0.770	3
Walking to bus/train stop is difficult	0.763	4
No trained staff inside public transport for helping/guiding PWDs	0.760	5
Public transport is uncomfortable	0.737	6
Public transport stops are too far from my origin or destination	0.736	7
Public transport is not suitable during bad weather	0.692	8
It is difficult to buy tickets/use fare machines	0.685	9
Public transport is too slow	0.685	9
Public transport staff is not cooperative	0.678	10
Waiting time is too long	0.675	11
Section 2		
Not enough space for carrying mobility aids in the public transport buses/trains	0.770	1
No designated spaces in public transport for PWDs	0.763	2
No discounted fares for PWDs	0.757	3
No designated spaces at bus/train stops for PWDs	0.754	4
No special public transport service for PWDs	0.737	5
Section 3		
My family/friends do not want me to use public transport	0.675	1
I feel other passengers are disturbed when I ride public transport	0.568	2
Section 4		
I may get lost while using public transport	0.717	1
Pick-pocketing in public transport	0.690	2
Public transport is not safe and secure for PWDs	0.622	3
Passengers are not cooperative	0.599	4
Section 5		
There are no accessible ramps to Enter/exit the bus at bus stops	0.578	1
Bus stops entry/exit are not equipped with auto gate facilities	0.499	2

on the second factors represented issues related to the unavailability of space for PWDs and lack for any special treatment. The third factor explained about 9.147 % of the total variance. Only two items loaded on this factor, which represented the social barriers to traveling by public transportation i.e., "My family/friends do not want me to use public transport" and "I feel other passengers are disturbed when I ride public transport". Three items related to safety and security loaded on the fourth factor explaining about 8.977 % of the total variance. About 6.116 % of the variance was explained by the fifth factor which was represented by the items concerning lack of infrastructure.

Based on the items loading on each underlying factor, they were labeled as service inadequacy, spatial and financial inequity, social barriers, vulnerability, and infrastructural inadequacy, respectively. All

Table 4
Results of exploratory factor analysis using maximum likelihood estimation (Varimax rotation).

	Factor				
	1	2	3	4	5
Section 1					
Public transport staff is not cooperative	0.708				
Public transport stops are too far from my origin or destination	0.702				
Public transport is not suitable during bad weather	0.650				
Public transport is too crowded	0.638				
Waiting time is too long	0.622				
It is difficult to buy tickets/use fare machines	0.596				
Public transport is too slow	0.550				
Section 2					
Not enough space for carrying mobility aids in the public transport buses/trains		0.766			
No designated spaces in public transport for PWDs		0.740			
No discounted fares for PWDs		0.640			
Section 3					
My family/friends do not want me to use public transport			0.798		
I feel other passengers are disturbed when I ride public transport			0.731		
Section 4					
Passengers are not cooperative				0.667	
Pick-pocketing in public transport				0.656	
I may get lost while using public transport				0.595	
Section 5					
There are no accessible ramps to Enter/exit the bus at bus stops					0.736
Bus stops entry/exit are not equipped with auto gate facilities					0.633
% variance explained	18.946	11.465	9.147	8.977	6.116
Cronbach's alpha	0.860	0.826	0.798	0.718	0.621

these factors were internally consistent as indicated by their Cronbach's alpha values (>0.7) except the fifth factor; namely; infrastructure accessibility (>0.6). Factor scores were computed using Bartlett's method to represent the relative standing of each respondent on all the five underlying factors.

4.2.1. Effects of socio-demographic variables on the underlying factors

The effects of socio-economic and demographic variables on the underlying factors were determined using Kruskal Wallis and Mann Whitney U tests. Mann Whitney U tests indicated that females scored higher on the perceptions regarding spatial and financial inequity (U = 6400.5, p = 0.044), and infrastructural inaccessibility (U = 6060.5, p = 0.009) as compared to men. In the conservative society of Lahore, females may be more concerned about availability of sufficient space in public transport in order to have some privacy. The effects of gender were not significant on the other three factors. Kruskal Wallis test indicated significant differences between different age groups on factor 2 ($\chi^2 = 7.852$, p = 0.020) and factor 3 ($\chi^2 = 9.409$, p = 0.009). Post hoc Mann Whitney U tests showed that the 18–30 years old age group scored significantly higher on factor 2 (U = 3541.0, p = 0.003) and 3 (U = 3546.0, p = 0.003) as compared to the youngest age group.

Vehicle owners scored significantly lower on factor 2 (U = 5223.0, p = 0.030) and factor 3 (U = 5299.0, p = 0.042), and significantly higher on factor 4 (U = 4938.0, p = 0.007) as compared to non-vehicle owners. Vehicle owners are more likely to have a higher income and therefore, financial inequity may not matter much to them. Similarly, they may not be aware of the social barriers since they use their vehicles more than public transport as indicated by the descriptive analysis. Kruskal Wallis test indicated significant differences between the respondents carrying different types of mobility aids on factor 1 ($\chi^2 = 7.147$, df = 2, p = 0.028). The post hoc Mann Whitney *U* test further showed that those with wheel chairs showed significantly higher level of agreement with service inadequacy as compared to those without any mobility aids.

Significant differences were found between the perceptions of those traveling for various purposes on factor 3 ($\chi^2 = 6.713$, df = 2, p = 0.035). Post hoc tests indicated that those traveling for work showed higher level of agreement with social barriers than those traveling for studying (U = 5497.0, p = 0.030). Similarly, those traveling for shopping/social/health purposes showed higher level of agreement with social barriers than those traveling for studying (U = 1857.0, p = 0.046). Household income was found to have no significant influence on any of the underlying factors.

4.3. Binary logit model

A binary logit model was developed to model the mode choice behavior of PWDs. All the modes other than public transport were combined into a single category called "other modes". Hence, the binary outcome variable (mode choice) comprised two categories; namely, public transport and other modes. A forward stepwise logit regression approach known as Wald approach was used to model the mode choice behavior. All the socio-economic and demographic variables along with the five underlying factors were entered as explanatory variables with first category being the reference category for the categorical variables. The model with the significant variables is shown in Table 5. The likelihood ratio test was significant indicating that the developed model is a significant improvement over the intercept-only model. Hosemer and Lemeshow test was non-significant ($\chi^2 = 11.067$, df = 8, p = 0.198). The Cox & Snell R Square and Nagelkerke R Square values were 0.331 and 0.442, respectively. The model correctly classified 75.0 % of the cases. Gender, household income, types of mobility aids, traveling purpose, vehicle ownership, and Factor 5 were found to be statistically significant.

Female respondents are less likely to use public transport relative to other modes when compared to the male respondents. In general, several studies have reported that females use public transport more often than their counter parts (Harbering and Schlüter, 2020). However, considering the conservative society of Pakistan, female PWDs are likely to avoid public transport in order to avoid getting help from strangers while getting on and getting off public transport.

The respondents belonging to the higher income categories are less likely to use public transport relative to other modes when compared to the lowest-income category. This result is quite intuitive in that it indicates that the respondents with higher income are more likely to own a vehicle and able to afford other transport modes such as taxis and ridesharing services. In addition, females working population is small in Pakistan indicating that the females may be traveling for purposes such as shopping, social and health trips, which do not have a fixed schedule and thus, other modes such as taxis and ridesharing services may provide better and more flexible service for such activities.

The respondents who do not carry any mobility aids are less likely to use public transport relative to other modes when compared to those who use wheel chairs. This result seems counter intuitive in that those using wheel chairs are more likely to face troubles while using public transport. More exploratory research is needed to determine the effects of types of mobility aids on mode choice.

The respondents traveling for work and other (shopping/social/health) purposes are less likely to use public transport relative to other modes when compared to those traveling for studying purposes. As explained earlier, trips made for shopping, social and health purposes may not have a fixed schedule and therefore, more flexible modes with door-to-door service such as rickshaws, taxis and ridesharing may be more appropriate. The respondents who do not own a vehicle are more

Table 5
Parameters estimates for the binary logit model.

Variable	Regression coefficient	Sig.	Odds ratio	95 % C.I. for odds ratio	
				Lower	Upper
Gender	−1.040	0.002***	0.353	0.180	0.693
Income		0.001***			
Income_1	−0.736	0.024**	0.479	0.253	0.907
Income_2	−3.048	0.000***	0.047	0.009	0.257
Mobility_aids		0.014**			
Mobility_aids_1	−0.542	0.146	0.582	0.280	1.208
Mobility_aids_2	−1.340	0.004**	0.262	0.106	0.646
Purpose		0.000***			
Purpose_1	−1.560	0.000***	0.210	0.104	0.426
Purpose_2	−1.207	0.010**	0.299	0.119	0.754
Vehicle_ownership	1.472	0.000***	4.360	1.913	9.937
Infrastructure_inaccessibility (factor 5)	−0.350	0.009**	0.705	0.542	0.916
Constant	1.181	0.023*	3.256		

* significant at the 0.05 level, ** significant at the 0.01 level, *** significant at the 0.001 level
Gender = 1 if the respondent is female and 0 otherwise
Income _1 = 1 if the respondent's household income is between 25,001 to 50,000 and 0 otherwise
Income_2 = 1 if the respondent's income is >50,000 and 0 otherwise
Mobility_aids_1 = 1 if the respondent carries crutches/cane/walker/other and 0 otherwise
Mobility_aids_2 = 1 if the respondent carries no mobility aids and 0 otherwise
Purpose_1 = 1 if the respondents is traveling for work and 0 otherwise
Purpose_2 = 1 if the respondents is traveling for shopping/social/other purposes and 0 otherwise
Vehicle_ownership = 1 if the respondent does not own a vehicle and 0 otherwise

likely to use public transport relative to other modes when compared to those who own a vehicle. This is in line with existing studies (Schmöcker et al., 2008).

The respondents who showed higher level of agreement with infrastructural inaccessibility are less likely to use public transport relative to other modes when compared with those who showed lower level of agreement with infrastructural inaccessibility. It indicates that PWDs face problems while using public transport due to the unavailability of necessary infrastructure. Hence, providing the necessary infrastructure may improve public transport ridership by PWDs.

5. Policy implications

The member countries of the United Nations signed an international treaty called "Convention on the Rights of Persons with Disabilities", which aims at protecting the rights of disabled people. The Convention stresses that the member nations should take suitable measures to provide access to transportation. Aside from this convention, countries have developed their own policies regarding the rights of disabled people. The Special Citizens Act (2008) introduced by the Pakistani government aimed at improving access for PWDs (Special Citizens Act, 2008). One of the policies was to allocate special seats to PWDs in public transport vehicles. The Special Citizens Act 2009 (Right to Concession in Movement) made the relevant authorities bound to ensure discounted public transport fare for PWDs (Special Citizens, 2009). After a constitutional amendment, the policies regarding PWDs were handed over to the provincial governments. Nonetheless, public transport still remains to be more or less inaccessible to PWDs (Gul, 2020).

The results of this study emphasize the need for more specific transport-related policies for PWDs. For instance, only ensuring discounted fares and special seats in public transport vehicles may not improve access to and ridership of public transport by PWDs. The respondents declared several issues with public transportation which need to be resolved such as high floor buses, ill-trained public transport staff, insufficient space for carrying mobility aids, safety and security issues, and unavailability of ramps at public transport stops etc. It must be highlighted that these improvements, particularly infrastructure developments require huge funding mostly in terms of subsidy for public transport, which is likely to be a burden to the already crippling economy of Pakistan. Alternative options such as contracts between local transport authorities, community support groups and charitable organizations may help improve public transport accessibility for PWDs (Mulley et al., 2012).

The transport-related problems facing PWDs cannot be viewed independently of the general problems with the public transportation system in Lahore. For example, PWDs reported crowdedness to be one of the major problems with public transport vehicles. This is a general problem being faced by almost all the travelers in Lahore. Therefore, resolving several public transport problems for general public will also help in satisfying the needs of PWDs except few issues specific to PWDs which could be resolved through special citizen acts. Recent developments in Pakistani major cities have more or less ignored the public transport system resulting in the deterioration of existing public transport system and an increase in usage of private vehicles (Imran, 2009). Transport policies in the near future must aim at enhancing the quality of service provided by the public transport system, which can partially resolve the problems faced by the PWDs.

Another aspect, as also indicated by the results, is that PWDs also face social barriers such as unprofessional behavior from public transport staff and the feeling that other passengers are disturbed when PWDs ride public transport vehicles. It could be a result of the fact that PWDs are often disrespected in Pakistan and several people have negative attitude towards them (Rathore et al., 2011). PWDs oriented policies must also ensure sufficient budget and provisions for awareness campaigns regarding the rights and dignity of disabled people.

6. Conclusions

A questionnaire survey was conducted to evaluate the perceptions of physically disabled persons about public transport as well as to model their mode choice behavior in Lahore, Pakistan. The relative importance index was computed for all the Likert-type items, which indicated that the most critical service-related issues for PWDs were "too high floors of public transport vehicles", crowded vehicles and untrained staff. Similarly, the unavailability of sufficient space for carrying mobility aids inside public transport vehicles was declared the most serious issue concerning spatial and financial inequity. The most serious problem among social barriers was the fear of getting lost. In addition, the unavailability of accessible ramps at bus stops was declared the most important issue by the majority of the respondents concerning infrastructural inaccessibility.

Exploratory factor analysis was conducted on the Likert type items

which resulted in a five-factor solution. Factor scores were then computed and non-parametric statistical tests were performed to determine the influence of demographic variables on the underlying factors. Significant differences were found between females and males regarding the perceptions about spatial and financial inequity, and infrastructural inaccessibility. Vehicle owners declared significantly lower level of agreement with service inadequacy, and spatial and financial inequity, whereas significantly higher level of agreement with vulnerability as compared to non-vehicle owners. Significant differences were found about service inadequacy between those using wheel chairs as compared to those without any mobility aids.

A binary logit model was developed to model the mode choice for PWDs. Gender, household income, use of mobility aids, primary purpose of traveling, vehicle ownership, and infrastructural inaccessibility were found to be significant predictors of mode choice. Female respondents were less likely to use public transport relative to other modes when compared to the male respondents. Also, the respondents belonging to the higher income categories are less likely to use public transport relative to other modes when compared to the lowest-income category. The respondents traveling for work and other (shopping/social/health) purposes are less likely to use public transport relative to other modes when compared to those traveling for studying purposes. The respondents who do not own a vehicle are more likely to use public transport relative to other modes when compared to those who own a vehicle. The respondents who showed higher level of agreement with infrastructural inaccessibility are less likely to use public transport relative to other modes when compared with those who showed lower level of agreement with infrastructural inaccessibility.

This study had some limitations. The survey was conducted during a pandemic, and a convenience-based sampling approach was adopted which may introduce some bias in the results. The representation of older PWDs was small in the sample. Further, the problems faced by people with different types of disabilities could be different. For instance, visually impaired people may be more concerned about the audio announcements. Hence, further studies focusing on each type of disability are required to determine the needs of disabled people regarding public transport.

CRediT authorship contribution statement

Hassan Ali: Methodology, Software, Writing – original draft, Writing – review & editing. **Muhammad Abdullah:** Conceptualization, Methodology, Formal analysis, Software, Writing – original draft, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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