

A STUDY ON RESIDENT'S TRAVEL BEHAVIOR IN BUS RAPID TRANSIT STATION AREAS: EVIDENCE FROM LAHORE, PAKISTAN

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Transit-oriented development is a strategy to encourage sustainable travel behavior. Most studies on travel behavior concerning mass transit have been conducted in developed nations. Yet, this research is still in its infancy in developing economies like Pakistan, where travel behavior differs significantly from developed countries. Our study aims to fill this research gap by exploring the resident's travel behavior in TOD areas using bus rapid transit (BRT) stations as a case study in Lahore. For this, 426 individual responses were collected through a simple random sampling technique. This collected data were analyzed through descriptive statistics and Chi-Square test using MS excel and SPSS software. This study concluded that most respondents are walkers to access BRT stations. In addition, most respondents are more likely to use a motorcycle and prefer walking to their workplace and shopping markets rather than BRT and other modes of transport. Further, it is concluded that most residents are more likely to take a motorcycle and walk every weekday for non-commuting trips. It is found that time, distance, and fare of the respondents are significantly associated with mode choice in the study area. Careful consideration should be paid to high-density mixed-use development and a walkable environment around BRT station areas to encourage TOD that can enhance sustainable travel behavior.

Key Words: *Bus Rapid Transit, Travel behavior, Transit-oriented Development, Lahore*

1. INTRODUCTION

Big cities have been suffering from unplanned growth, traffic congestion, and environmental problems in the world, particularly in developing economies ¹. To overcome the above-mentioned issues, the utmost efficient way is to take the benefits of mass transit to lessen the automobiles and promote cycling and walking ^{2,3}. One of the most effective ways to encourage mass transit is to harmonize the relationship between the built environment and travel behavior ⁴. Furthermore, past studies advocate that more mixed-use, transit-rich, and compact urban

patterns can encourage non-motorized means and transit, resulting in less automobile use ^{5,6}. Furthermore, the above-mentioned issues could be lessened through land use and transport integration, particularly in developing countries ⁷. Recently, Transit-oriented Development (TOD) has gained popularity worldwide ⁸.

The concept of TOD was first evolved in 1993 by Peter Calthorpe since the publication of "The Next American Metropolis". Calthorpe defined TOD as a "mixed-use community within average 2000-foot (600m) walking distance of a transit stop and core commercial area. TODs mix residential, retail, office,

open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot, or car" ⁹⁾. Later, TOD can be described in detail as "land-use and transport planning that makes sustainable transport modes convenient and desirable, and that maximizes the efficiency of transport services by concentrating urban development around transit stations" ¹⁰⁾.

Globally, TOD gained a reputation as a strategy to mitigate several urban issues such as traffic congestion, long commuting distances and time, and air pollution ^{11,12)}. Land use and transportation integration policies aim to achieve positive travel behavior, including reducing automobile usage, traffic congestion, mass transit ridership, walking, and cycling ¹³⁾. TOD is expected to be effective at altering people's travel behavior, mainly encouraging mass transit and non-motorized modes while reducing the use of cars ¹⁴⁾. TOD is adopted as a strategy to enhance the neighborhood's sustainable travel behavior ¹⁵⁾. Similarly, ¹⁶⁻¹⁸⁾ determined that residents living in TOD areas were more likely to use active transport and mass transit than those living in non-TOD areas.

Little efforts have been carried out on the underlying influences of TOD areas on travel behavior around BRT stations in developing countries. To fill this research gap, our study contributes to the current literature on bus rapid transit (BRT) and resident's travel behavior in TOD areas. This study investigates the resident's travel behavior residing around BRT station areas in Lahore. This research seeks to answer the questions: What are the resident's travel characteristics who live in the proximity of BRT stations? What is the travel mode choice behavior of the residents living in TOD areas near BRT stations for work and non-work trips? What is the association between mode choice and travel characteristics? Yet no such studies are available in the Pakistan context. The remainder of this paper is organized as follows; Section 2 offers a brief overview of major findings of previous studies regarding travel behavior around transit station areas. Section 3 describes materials and methods, including study area description and research methodology. The results are discussed, and discussion of the major findings of the analysis are presented in section 4. Finally, section 5 presents conclusions and recommendations.

2. LITERATURE REVIEW

The residents encourage rail transit due to its comfort, reliability, capacity, and good image ¹⁹⁾. However, BRT has gained a global reputation as the

most prevalent mass transit system for its flexibility, low operating and capital cost compared to rail transit ²⁰⁻²⁴⁾. BRT operates in more than 182 cities with a total length of 5,539km. Around 90% share of the BRT system is operating in high and upper-middle-income nations, while 9.8% and 0.6% share is operating in lower middle income (i.e., Lahore) and low-income economies, respectively ²⁵⁾. Evidence shows that BRT is mainly established in Latin American cities, shadowed by Asia, Europe, and North America. More interestingly, BRT has obtained more reputation in higher-income countries due to extensive resources and strong political will to encourage sustainable development. Several mega cities have been invested in BRT as an alternative to rail transit in Global South ²⁶⁾. Moreover, BRT has remarkable potential to stimulate the TOD due to its less expensiveness and faster construction than rail transit ²⁷⁾ which is expected to change resident's travel behavior around station areas.

TOD has several possible benefits, including encouraging mass transit and non-motorized means, decreasing car use and congestion, and growing job accessibility ^{20,28)}. In literature, several studies measured the TOD's benefits and its influence on travel behavior such as mode choice ^{29,30)} and vehicle kilometers traveled (VKT) ^{5,16,17,31,32)}. In short, TOD shaped travel behavior and changed the new transport infrastructure ²⁷⁾. Previous studies determined that residents of TOD neighborhoods are more likely to use transit and non-motorized means and tend to reduce car use than those living in non-TOD neighborhoods ^{8,16,33)}.

Most of the previous studies have been conducted on rail transit in developed countries to explore travel behavior ^{4,14,38-41,19,20,31,32,34-37)}. However, little research has investigated the travel behavior around BRT station areas. A study compare the travel behavior of individuals to examine the changes in spatial mobility before (2016) and after (2018) BRT investment in Dar es Salaam, Tanzania ⁴²⁾. They determined that BRT use was spatially limited among the traveler compared to informal means of transportation, i.e., tricycles, motorcycles, and minibuses. They also found in the perspective of spatial mobility patterns; individuals are now considering the BRT to trip changing that supports them to access various amenities, travel more distance, and create further trips. Another study was conducted in Hanoi, Vietnam, regarding the influence of BRT on commuter travel behavior. They concluded that BRT has remarkably positive effects on enlightening travel time effectiveness, promising commuters to take mass transit more in their daily commuting, and enhancing walking distance to the nearby station ⁴³⁾.

A study on land use features influences the com-

muter's travel behavior for BRT stations within a 500m radius in Bangkok, Thailand, based on interviews with BRT passengers²⁷⁾. They determined that walking, bus, and motorcycle taxi are the utmost usual means of access to BRT stations. Further, they concluded that land use features such as commercial, residential, financial, and retail land use concentration around BRT stops influenced the commuter's propensity to walk to the BRT stops. A study investigated the passenger's travel behavior and perceptions of BRT Lahore⁴⁴⁾. They determined that BRT was a significant mode of public transit, mainly among students, low-income people, and laborers. Moreover, they concluded that males and females of various ages used the BRT, mostly younger to middle-aged groups. Our study differs from this one because they examined the passenger's travel behaviors at BRT stations without considering the residents living around BRT station areas. The impacts of urban structure on travel behavior for metro rail in Delhi, India, was examined and concluded that transit had displayed consistent associations between VKT and urban structure, so imitate TOD as a model⁴⁵⁾.

In summary, many previous studies have focused on developed countries, mainly the US, where travel behavior varies from developing nations. Most existing research has emphasized the rail transit areas rather than proximity to the BRT stations. Moreover, much of the previous studies have focused on work trips and little interest in non-work trips, particularly grocery trips which can account for daily trips, and the share of such trips is large. In addition, previous studies have considered only transit passengers for investigating travel behavior. However, little is known regarding resident's travel behavior in TOD areas, particularly in developing countries. Our study fills these research gaps and investigates the travel behavior of the residents living in residential and mixed-use TOD areas of BRT stations in Lahore.

3. MATERIALS AND METHODS

(1) Study area

This study focuses on Lahore, the provincial capital and second biggest city in Pakistan. Lahore's population is growing rapidly. The total population of Lahore was 6.32 million in 1998. By the end of 2017, Lahore had a population of 11.12 million, comprising a total area of 1772 km² (Punjab Bureau of Statistics, 2017). Lahore city incorporates nine administrative zones and one cantonment (see Figure 1). Due to the rapid urbanization process, the city is sprawling in an unplanned manner and crossed a

radius of 38 kilometers in 2017. As a result, the built-up area of Lahore city reached 925.8 km² in 2017, which was 686.8 km² in 1998⁴⁷⁾. In Lahore, an efficient and comprehensive BRT system was introduced in 2013 to offer affordable, comfortable, and efficient mobility options to its residents and reduce congestion problems, serving 27 stations with a total length of 27 km (see Figure 1), integrated with Speedo Bus Service⁴⁸⁾. The BRT currently carries approximately 135,000 commuters daily. According to the Punjab Mass transit Authority, it has attained the highest daily ridership of almost 179,000 people. TOD is being accepted globally in several cities, reducing private vehicles and urban sprawl by developing transit stations and enhancing the neighborhood's sustainable travel behavior. However, according to the official's interview, no policy, regulations, rules, and incentives regarding BRT-based TOD have yet been prepared by the government to promote sustainable travel behavior. So, it is necessary to study the resident's travel behavior around BRT station areas in a timely manner.

For this study, it is challenging to study all BRT station areas due to the unavailability of the data, so we need to select the potential stations for investigating the resident's travel behavior. First, a discussion was conducted with five professionals of the Lahore Development Authority (LDA), local government, and the transport department officials in Lahore in August 2021 to select BRT stations for this study. From the discussion, we expected to learn about the location, population density, station ridership, development type (controlled/less controlled), development age, and area characteristics' effects on the density, diversity, and design in the station area. These criteria were applied to all BRT stations as selection criteria, and we chose the eight stations ensuring heterogeneity in criteria weightage. The selected stations were Shahdara, Bhatti Chowk, Ichra, Model Town, Naseerabad, Kamahan, Nishtar Colony, and Dullu Khurd (see Figure 1). The present study has considered a buffer boundary of 800m for evaluating the residents' travel behavior due to the absence of a universal boundary for TOD in the Lahore context.

(2) Research methodology

The present study created an 800m buffer around the selected BRT stations to illustrate the TOD zones using ArcGIS (see Figure 1). Schlossberg (2006) took a 10-minutes walking distance of 800m, which is appropriate for TOD planning. In this study, it wasn't easy to study the travel behavior of all residents in the study area, so we used Slovin's formula to select the population. The formula is given below;

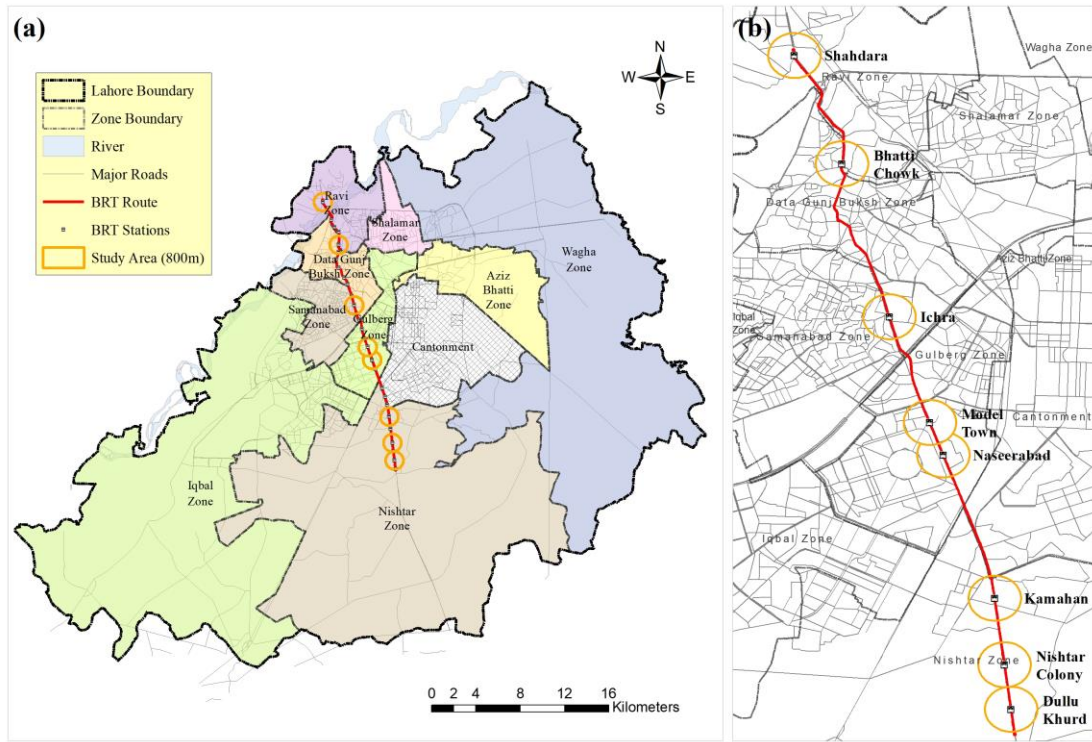


Figure 1: (a) Lahore city with administrative zones and study area (b) A study area within a catchment of 800m from BRT stations

$$n = \frac{N}{1 + Ne^2} \quad (1a)$$

Where n represents the sample size, N shows the population size, and e is the margin of error. In our study, the population size in the buffer zone was 42,349 households, including the residential and mixed-use development. The computed sample size was 396 at a confidence level of 95%. The simple random sampling technique was used to collect the data from the selected samples. The random samples were determined using MS Excel and linked with ArcGIS to show the spatial location of the samples. After that, the survey team provided with longitude and latitude of the random samples. The rule was formulated if the sample house is locked or women are present in the house who feel reluctant to answer the questionnaire, so the next house must take into consideration from left or right of the selected sample during the survey.

The survey team carried out a household survey through a questionnaire to study residents' travel behavior in the transit zone in July – August, 2022. A survey team consists of four urban planning undergraduate students of the University of Engineering and Technology, Lahore. Firstly, three hours training session was held for the surveyors to understand the contents of the questionnaire. After that, the author conducted ten pilot surveys in station areas for a deep understanding of the survey team and whether

residents could understand the contents of the questionnaire. We found that the survey team and residents clearly understand the contents of the questionnaire. The questionnaire was developed in the English language; however, the survey team asked the questions in the native language (Urdu) from residents.

This study carried a sample of 426 individual responses from household surveys and mainly focused on commuting and grocery trips. The study variables are divided into four main categories; socio-economic characteristics, travel characteristics to access the BRT stations, travel behavior to work, and travel behavior to grocery trips. The socio-economic characteristics of the respondents are gender, age, marital status, education, profession, monthly income, monthly household income, house ownership, number of person in a house, number of children under 12 years in a house, number of workers in a house, number of cars, number of motorcycles, number of cycles, and driving license. Travel characteristics mainly include the nearest BRT station distance, most frequent access mode to reach BRT station with time and cost. Further, respondents were asked to respond to a list of 15 statements associated with the reason for choosing access mode using a 5-Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree), frequency of non-commuting trips (times/month), frequency of travel modes (BRT, public bus, Hiace that is a mini

bus having 18-22 seats, car, taxi, motorcycle, auto-rickshaw, Qingqi that is three wheelers having a seating capacity of 6 persons, cycle, and walk) for non-commuting trips. The travel characteristics for commuting and grocery trips include the average work trips (trips/week), mode of transport, total time (minutes), total distance (meters), total fare (Pakistani rupee), and 15 statements related with the reason of choosing travel mode were asked using a 5-Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree).

The collected data were analyzed using MS Excel and SPSS software. Descriptive statistics were calculated for the respondent's socio-economic and travel characteristics. A Chi-Square test was performed to identify the association between the mode of transport and the respondent's average time, distance, and fare.

4. RESULTS AND ANALYSIS

(1) Socio-economic characteristics of respondents

The socio-economic characteristics of the respondents are summarized in Table 1. This study mainly includes male respondents because females are reluctant to respond to the questionnaire due to fear of harassment and avoid talking to an unknown person. Moreover, females prefer to go outside with males. The percentage of young people (31 – 40 years) is higher than teenagers and aged people. It may be because they are eager to travel more. The respondents are mainly married in the study area; 86.2% of the total respondents share. Most of the respondents completed high school education. The respondents are primarily private employees or business owners, accounting for more than 73% of total respondents. In this study, the average monthly income of the respondents is 52,542 PKR (1 PKR = 0.0043 US Dollar), most respondents are associated with private jobs or business owners, and the average monthly household income is 68,643 PKR. Almost 79% of respondents have their own house. As for the number of people in a house, most families have either 5 or 6 people. For all respondents, the average household size is estimated at 5.8 persons per house. Almost 41% of respondents have no child under 12 years; however, the average number of children in a household is two. Most houses have one worker, and the average number of workers is 2.43 because some house has two or more workers who have their own business.

Table 1 also shows automobile ownership in the study area. Most residents residing without a car account for more than 87% of respondents, and al-

most 73% have one motorcycle. Residents are more likely to use a motorcycle than a car for daily activities. More than 97% of respondents have no bicycle. It may be because of hot and cold weather conditions or the lack of cycling lanes. Most of the respondents do not have a car and motorcycle driving license.

(2) Access to BRT stations

Table 2 shows the access mode, average distance, time, and fare to BRT stations. The two access modes with the highest share include walking (81%) and motorcycle (17%). Few respondents are less likely to use Qingqi, auto rickshaw, and car to go to BRT stations. As for distance from house to BRT station, the average distance for car users is almost 667m. The average time is 1 minute with an average fare of 10 PKR (0.043 US Dollar). For all respondents, the average distance for motorcycle users is nearly 617m to the BRT station, with an average time of 2 minutes and an average cost of almost 13 PKR. In total, the average distance of auto rickshaw users is 750 m. The average time of an auto rickshaw rider is 10 minutes, which is higher among all modes because auto rickshaw drivers wait till they are fully occupied. As well as, the fare is high, accounting for 30 PKR. Auto rickshaw is a three-wheeler vehicle that carries three passengers in total, so the fare is high compared to similar modes of transport, i.e., Qingqi. The average distance of Qingqi users is almost 1017m. The distance is high compared to other modes because the driver of the Qingqi took the long route to pick up more passengers or another reason residents of some streets are installing the gate for security purposes. The average time is almost 8 minutes to reach BRT station with a fare of 20 PKR. The average distance of walkers is about 511m. Therefore, they can quickly get to BRT stations within an average of around 6 minutes.

Figure 2 shows the reasons for travel mode from home to BRT stations. A combined average of 85% of respondents agree and strongly agree with the statements associated with the travel mode. The fact is that 81% of respondent's mode share is walking, and 17% of respondents used their motorcycle to reach the nearest BRT stations. For all respondents, a combined average of 14% respondents strongly disagree and disagree with the mode choice statements because of less safety from accidents, less environment friendly mainly motorcycle, I can have a seat (30% respondents disagree), I don't need to travel with people whom I don't know (43% respondents disagree), I can carry heavy luggage (40% respondents disagree mainly walkers). At the same time, the rest of the respondents are neutral with the statements.

Table 1: Socio-economic characteristics of respondents

Characteristics	Attribute	Percentage	Characteristics	Attribute	Percentage
Gender	Male	99.8	Number of children under 12 years	9 persons	2.8
	Female	0.2		10 persons	1.9
Age (years)	≤ 18	0.9		More than 10 persons	5.7
	19 – 30	22.1		No child	41.3
	31 – 40	40.8		1 child	27.7
	41 – 50	27.5		2 children	23.3
	51 – 60	8.0		3 children	3.5
Marital status	> 60	0.7		4 children	2.1
	Single	13.8		5 children	1.4
Education	Married	86.2		More than 5 children	0.7
	Below high school	20.7	1 worker	66.5	
	High school	37.5	2 workers	24.4	
	Higher secondary school	24.4	3 workers	6.6	
	Bachelor	12.2	4 workers	1.4	
Profession	Master	4.0	5 workers	0.7	
	Ph.D.	1.2	More than 5 workers	0.4	
	Government employee	8.0	No car	87.1	
	Private employee	41.3	1 car	8.2	
	Business owner	32.2	2 cars	3.3	
Average monthly income (Pakistani rupee)	Labor	14.3	3 cars	0.7	
	Other	4.2	> 3 cars	0.7	
	Average monthly income (Pakistani rupee)	52542 (average)	No motorcycle	11.7	
	Average monthly household income (Pakistani rupee)	68643 (average)	Number of motorcycles	1 motorcycle	72.8
House ownership	Owned	78.9	2 motorcycles	12.0	
	Rented	20.9	3 motorcycle	3.3	
	Leased	0.2	> 3 motorcycles	0.2	
Number of persons	1 person	3.7	Number of bicycles	No bicycle	97.4
	2 persons	2.1	1 bicycle	2.1	
	3 persons	7.0	2 bicycles	0.5	
	4 persons	18.1	Driving license of the car	Yes	15.0
	5 persons	19.5	No	85.0	
	6 persons	22.1	Driving license of motorcycle	Yes	39.2
	7 persons	10.3	No	60.8	
	8 persons	6.8			

Table 2: Access to BRT stations

Access travel mode to BRT station	Percentage	Time (minutes)	Distance (m)	Fare (PKR)
Car	0.7	1	666.67	10
Motorcycle	16.7	2.1	616.55	12.96
Auto Rickshaw	0.2	10	750	30
Qingqi	1.4	7.67	1016.67	20
Walk	81.0	5.63	510.85	0

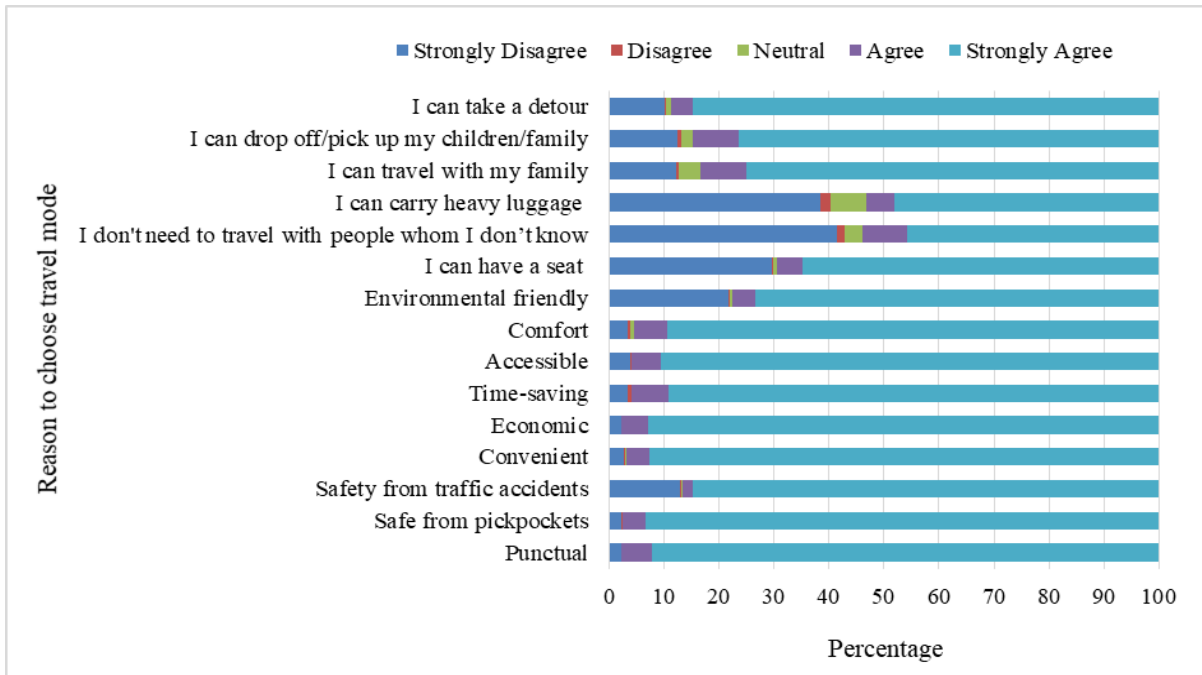


Figure 2: Reasons for choosing mode to BRT stations

(3) Frequency of non-commuting trips

It is computed that the average frequency of non-commuting trips is 4.35 per month. Figure 3 shows the frequency of using each travel mode for the non-commuting trip. The frequency is considered a key variable that each respondent either walks, drives, or uses BRT. These are evaluated in the questionnaire based on whether residents used the travel mode based on responses such as never, a few times a year, once a month, once a week, a few times a week, and every weekday. Almost 34% of respondents never used the

BRT, while around 29% of respondents took BRT a few times a year for non-commuting trips. Almost 18%, 6%, and 4% of respondents traveled on BRT once a month, once a week, and a few times a week respectively. Interestingly, only 8.7% of respondents took BRT every weekday for non-commuting trips because of the unavailability of personal vehicles or higher fares of other transport modes, i.e., auto rickshaw, taxi, etc.

Most respondents never took the public bus, Hiace, car, taxi, and auto rickshaw, for non-commuting trips; it may be because of less distance and higher traveling cost and time. More than 92% of respondents have not

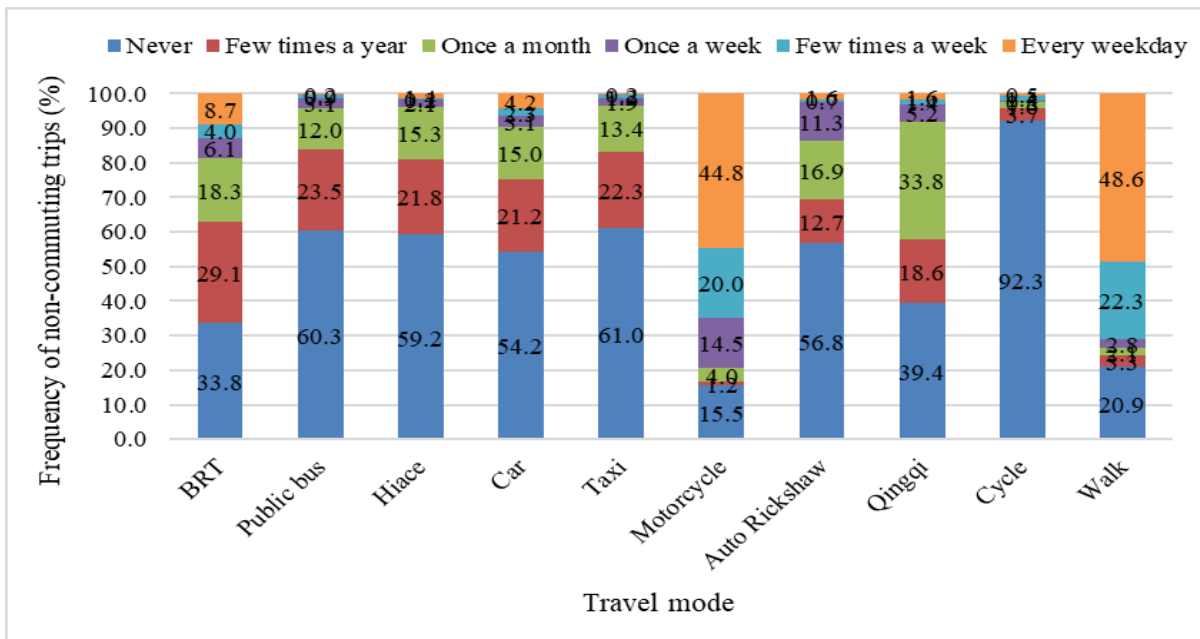


Figure 3: Frequency of non-commuting trips

used cycles for trips due to a lack of ownership and cycling tracks. For all respondents, almost 11% of respondents used an auto rickshaw once a week. Moreover, 20% and 22% used motorcycles and walking respectively for few times a week for trips. Almost 45% of respondents are more likely to take a motorcycle every weekday for non-commuting because of fewer distances and low travel costs. Similarly, almost 49% of respondents are more likely to walk every weekday for trips because they reside near non-commuting places.

(4) Travel behavior to work trips

Figure 4 shows the respondent’s average work trips (trips/week). More than 78% of respondents have six weekly trips to their workplaces. On the other hand, a few respondents have taken 7 and 5 trips per week to go to their workplace. Almost 3.5% of respondents have taken less than four trips to the workplace due to online work in the wake of COVID-19. Moreover, 0.5% and 0.2% of respondents have taken 8 and 10 trips, respectively, because the workplace is very near their houses.

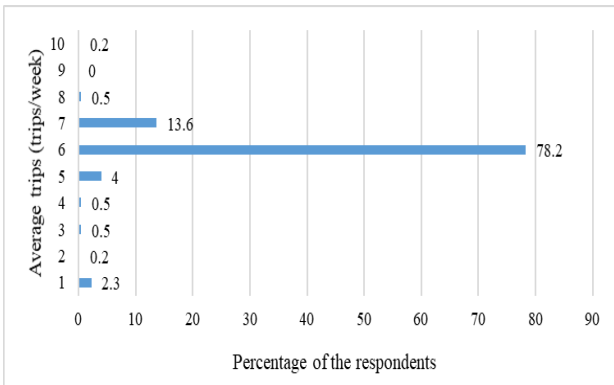


Figure 4: Average work trips (trips/week)

Figure 5 shows the main travel mode to the workplace. The three modes with the largest share such as motorcycle (53%), walking (25%), and BRT (12%). The largest share of motorcycle users said that BRT and other modes of transport take much time compared to a motorcycle. If we take BRT, we need to change two or three modes to reach the workplace,

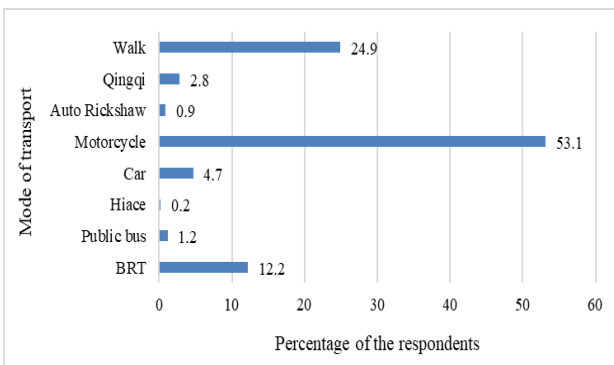


Figure 5: Main mode of transport to work trips

increasing the travel cost and time. One-fourth of respondents go to their workplace via walk because the workplace is near their houses. While walking was not so attractive because of unsafe roads and lack of footpaths. Only 12% of respondents prefer to use BRT because the workplace near BRT stations, or it may be some respondents have no personal vehicle. The combined share of all other modes is less than 10% because respondents are just taken for long distances who have workplaces away from their houses or those who have no personal vehicle.

Figure 6 shows the reason for choosing travel mode to work. For all respondents, a combined average of 81% respondents agree and strongly agree with the given statements. It may be because of the higher share of motorcycles and walking as a travel mode. In contrast, combined average of 17% of respondents are strongly disagree and disagree with the statements because of personal mode that was less safe from accidents, less economic, less environmentally friendly, most people don't like to travel with other unknown people (46% respondents disagree), and cannot carry heavy luggage on the motorcycle and with a walk (37% respondents disagree). The rest of the respondents accounting average of 2%, are neutral with the statements.

Table 3 shows respondent’s average time, distance, and fare for each main travel mode to reach their workplace. The average BRT time is 35 minutes from the house to the workplace for a distance of around 13km, with an average fare of almost 35 PKR. For BRT, the flat fare is 30 PKR for the whole route set by the government. In this study, the average fare is higher than the flat fare because some respondents change to other modes from the station to reach their workplace. Fewer respondents prefer to use public buses and Hiace than BRT, who want to travel long distances to the workplace. The average distance for public buses and Hiace is around 27km and 40km, respectively. The average car trip time is 31minutes, who have workplaces far away from their houses, accounting for an average distance of almost 28km and an average fare of 417 PKR. In contrast, the average motorcycle trip time is 15 minutes, and the distance is about 9km, with an average fare of 84 PKR for all respondents. Their workplace is relatively close to their houses. The average time of an auto rickshaw trip is 25 minutes; for those who want to take a distance of around 13km, however, the average fare is almost 200 PKR, which is higher than a motorcycle and Qingqi. The average time of Qingqi is about 14 minutes, with an average distance of 6km. The average fare of Qingqi is 37 PKR, and primarily low-income people prefer to ride Qingqi and have a workplace at a short distance from their houses. For all residents, the walker's average time is 7 minutes,

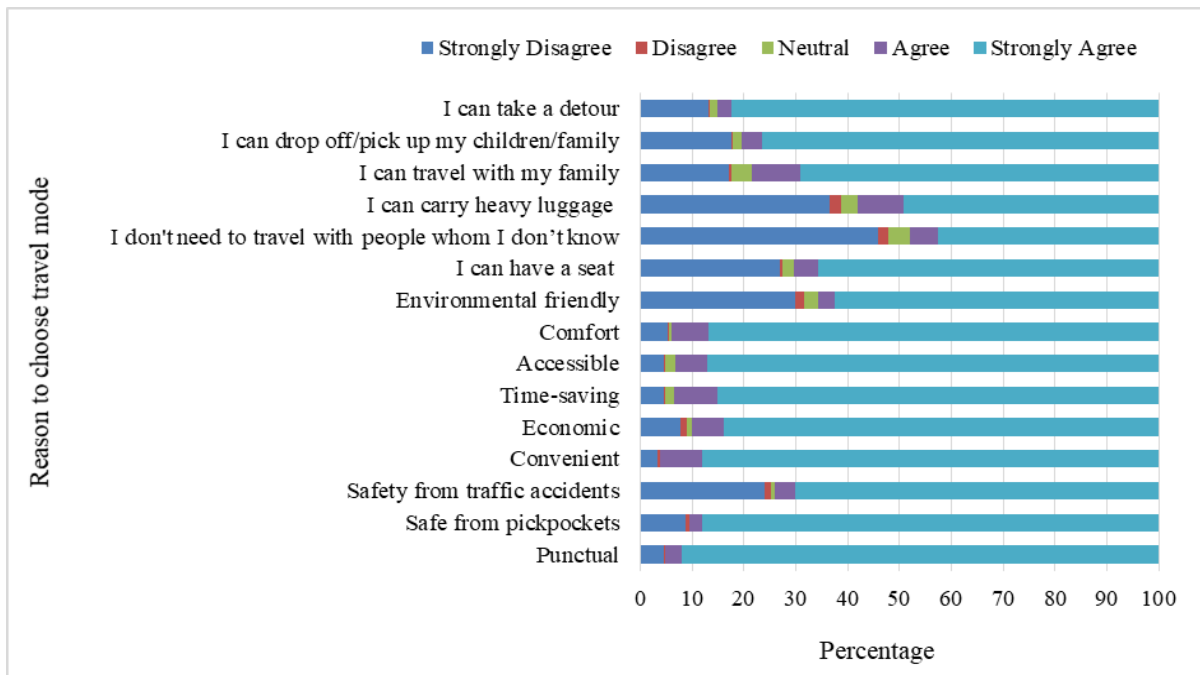


Figure 6: Reasons for choosing travel mode to work

who reside near their workplaces and have an average distance of 722m.

Table 3 also shows the association between mode of transport and time, distance, and fare. There is a significant association at 5% significance level between mode choice and time ($\chi^2 = 863.65$, $df = 364$, $p < 0.05$), distance ($\chi^2 = 1542.66$, $df = 945$, $p < 0.05$), and fare ($\chi^2 = 1259.81$, $df = 217$, $p < 0.05$) of the respondents.

Table 3: Association between mode choice and travel behavior characteristics to work trips

Variable	Mode of Transport								Pearson Chi-Square	df	p-value
	BRT	Public bus	Hiace	Car	Motor cycle	Auto Rickshaw	Qingqi	Walk			
Time (minutes)	34.54	49	55	31.50	15.29	24.75	14.33	6.53	863.65	364	0.000
Distance (m)	13023	27310	40000	28486	8788	13600	6142	722	1542.66	945	0.000
Fare (PKR)	35.19	44	600	417	84.42	197.50	37.50	0.00	1259.81	217	0.000

(5) Travel behavior to grocery trips

Figure 7 shows the average trips to the grocery for all respondents. Almost 75% of respondents visit the shopping place once a week for grocery items. Some respondents, accounting for 13% of the total, go to the shopping place twice a week and visit the nearby shopping place/market for groceries. However, 2.3% and 3.8% of respondent's average trips are 3 and 4, respectively, who have a short distance of shopping

places from their houses. Some respondent's average trips are 5 or 6, accounting for 2.6% of the total respondents. The rest of the respondents who took seven or more than seven trips had shopping places near their houses or in the same street.

Figure 8 shows the main travel mode for grocery trips for all respondents. The two modes of transport with the highest share are motorcycle (59%) and walking (22%). The walkers have shopping places near their houses. The share of auto rickshaws and Qingqi is 4.3% and 2.1%, respectively, for grocery trips. For all residents, the share of cars is 6.1% of the

respondents who want to go away from the house for shopping purposes with their families frequently. More than 6% of respondents use BRT mode to go shopping places who want to go to shopping markets located near BRT stations or have no option to use other modes of transport.

Figure 9 shows the reason for choosing the main travel mode for grocery purposes. For all respondents, a combined average of 85% respondents agree and

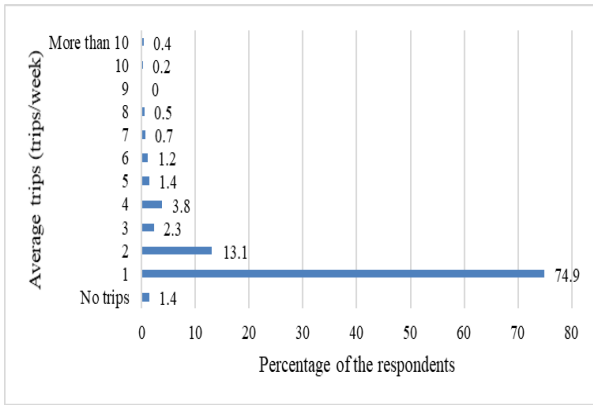


Figure 7: Average grocery trips (trips/week)

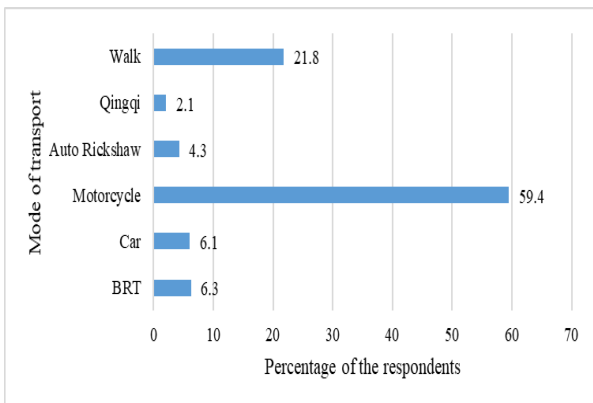


Figure 8: Main mode of transport to grocery trips

strongly agree with the statements related to the travel mode to the grocery trips. It may be because most respondents have their vehicles, mainly motorcycles or walkers. In contrast, a combined average of 13% of respondents strongly disagree and disagree with the travel mode's statements. It may be because

of less safety from an accident on a motorcycle, less environmentally friendly, and I don't need to travel with people I don't know (almost 43% of respondents disagree). At the same time, nearly 2% of respondents remain neutral with the statements.

Table 4 shows the respondent's average time, distance, and fare for each main travel mode for the grocery trips. The average BRT trip time is about 28 minutes, with an average distance of 9km and an average fare of 33 PKR. The average car trip time is 19 minutes for those who want to get away from their houses for shopping purposes, with an average distance of almost 11 km and an average fare of 212 PKR. In contrast, the average motorcycle trip is short, only taking 13 minutes, an average time of almost 7km, and the average fare is 74 PKR. The average trip time of an auto rickshaw is 9 minutes; residents who want to take a short trip of almost 4 km with their family members. The average fare of the auto rickshaw trip is 62 PKR. The average trip time of Qingqi is 12 minutes, and respondents used it for short distances of almost 4km. The average fare of the Qingqi trip is 22 PKR. As for walkers, the average trip time is 5 minutes to the grocery. The average distance is 503 m because they have grocery markets near their houses.

Table 4 also shows the association between mode of transport and time, distance, and fare of grocery trips. There is a significant association at 5% significance level between mode choice and time ($\chi^2 = 527.56$, $df = 180$, $p < 0.05$), distance ($\chi^2 = 993.67$, $df = 470$, $p < 0.05$), and fare ($\chi^2 = 802.84$, $df = 150$, $p < 0.05$) of the respondents.

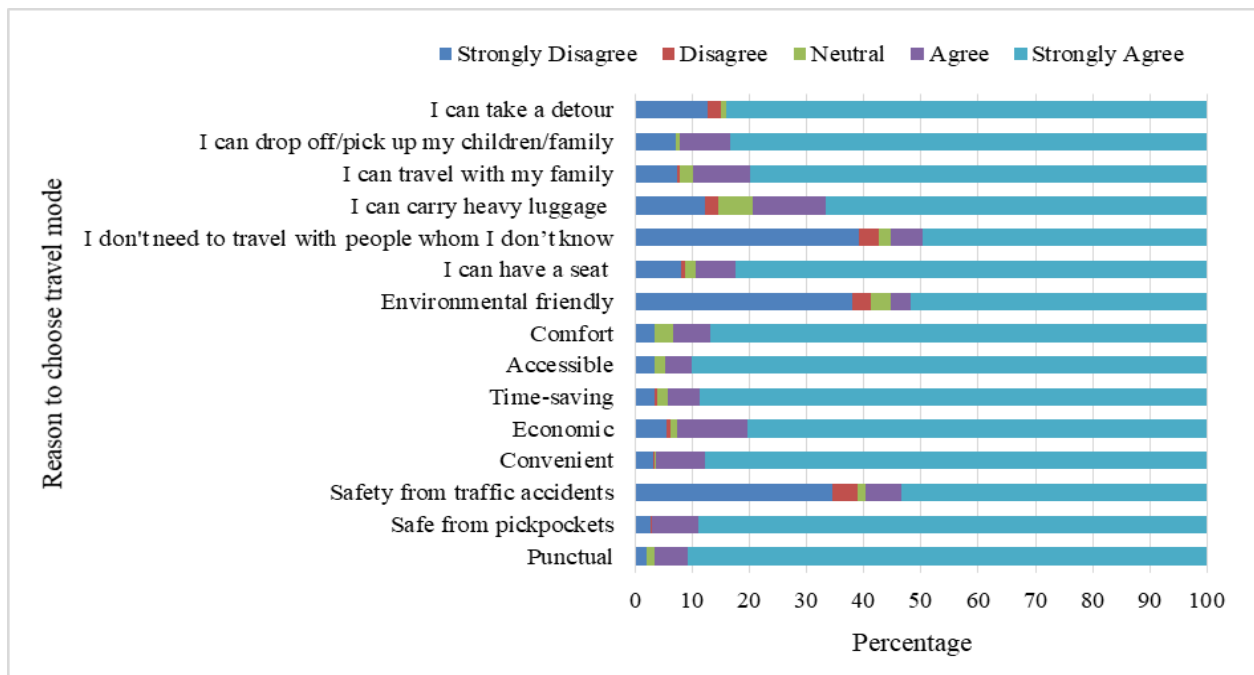


Figure 9: Reasons for choosing travel mode to grocery

Table 4: Association between mode choice and travel behavior characteristics to grocery trips

Variable	Mode of Transport						Pearson Chi-Square	df	p-value
	BRT	Car	Motorcycle	Auto Rickshaw	Qingqi	Walk			
Time (min)	27.81	19.00	12.58	9.33	12.00	5.08	527.56	180	0.000
Distance (m)	9179	10910	6749	4261	3622	503	993.67	470	0.000
Fare (PKR)	33.33	212.31	74.19	62.22	22.22	0.00	802.84	150	0.000

5. DISCUSSION AND CONCLUSIONS

Most of the previous studies on travel behavior concerning transit-oriented development areas have been conducted in developed countries, mainly in the United States, where travel behavior varies in developing nations. Moreover, most research has emphasized the rail transit areas rather than the proximity to the BRT stations. Therefore, this study investigates the resident's travel behavior residing around BRT station areas in Lahore.

This study concluded that most respondents access the BRT stations by walking and motorcycle. It found that most respondents are more likely to use motorcycles and prefer walking to their workplace rather than BRT and other modes of transport. The fact is that BRT and other modes have taken more time and cost as compared to motorcycles due to the change of modes from BRT stations to the workplace. Some respondents are walkers because their workplaces are closer to their houses. As for grocery trips, most respondents preferred motorcycles and walking to visit the shopping places. The reason is that few shopping places are close to BRT stations. Still, residents prefer motorcycles more because they can go with their families without any inconvenience like hassle, fear to change mode, harassment, etc. Some markets are close to their house or in the street so the residents can go easily via walk. Further, it also determined that most residents are more likely to take a motorcycle and walk every weekday for non-commuting trips. Very few residents preferred BRT due to the absence of their own vehicle. This study determined that there is a significant association between mode choice and travel characteristics like time, distance, and fare of the respondents.

Our study is consistent with those of Chalermpong and Ratanawaraha²⁷⁾, and some findings are the same. According to their study, the largest share of access

modes to BRT stations are walking and motorcycles, and the same conclusion is drawn in our study. But the car share to access the BRT station is different according to Chalermpong and Ratanawaraha. Regarding average access distances, that is not similar to our study. Our study is also similar to those of Joseph et al.⁴²⁾. Their study concluded that BRT use was limited among travelers compared to informal means of transportation, i.e., motorcycles and minibuses. In our study, almost 12% and 6% of residents are likely to use BRT for work and grocery trips, respectively, but that share is not so large.

This study drew some recommendations to encourage sustainable travel behavior close to the BRT stations. Different BRT stations require different policy measures to promote TOD towards sustainable travel behavior. The evidence on mode share can be utilized to design suitable facilities close to BRT stations. As for the evidence on the access distance, motorcycles and walking play a noticeable role in offering access for BRT's users. The recommendation is that the TOD plans should be formulated in connection with the informal modes of transport, including motorcycles and walking. In the case of Lahore, transportation infrastructure cannot be changed due to hurdles in land acquisition as a result of public opposition, and huge finance is required. So, the existing road network should be modified with footpaths to encourage a walking environment. Moreover, our findings support that high-density mixed-use development strategies, particularly for employment centers and supermarkets for grocery and shopping, should be encouraged around BRT stations to reduce travel distance and duration and promote walking and BRT use.

This study has some limitations; this study selected the representative stations with a small sample size for travel behavior, so the future study should be conducted by taking all BRT stations and other con-

trol areas with a large sample size to show the difference in travel behavior for TOD and non-TOD areas. This study did not consider the TOD characteristics; therefore, future research can take TOD characteristics in connection with the resident's travel behavior.

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