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Exploring determinants of travel-mode choice during the covid-19 pandemic outbreak: A case study of Islamabad, Pakistan

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Abstract

The COVID-19 outbreak is changing the patterns in travel activity for key destinations. Travel behavior during the pandemic has not been investigated adequately, specifically in developing countries. A sound understanding of travel-mode choice determinants is needed to design interventions to slow down and prevent the spread of the COVID-19 disease. This study explores travel-mode choice determinants for three key destinations, the workplace, market, and hospital, in Islamabad, Pakistan, during the COVID-19 disease outbreak. This study used a primary dataset of 163 observations and applied the multinomial logit (MNL) regression to analyze it. The survey results highlighted that the proportion of public transport mode was marginal for the three key destinations because public transport was closed during the lockdown, except for the metro bus. The streamlined model estimation results implied that the family-size factor had no relationship with the travel-mode choice. Males were most likely to travel to the workplace and market by 2&3 wheelers and least likely to travel by car. Females, unemployed persons, and students are likely to stay at home. Married people were more likely than single people to travel to the workplace and hospital by car. Self-employed people and state officials/public servants were most likely to go to the market by car. People living in towns/rural areas and cities were likely to travel by motorcycle/rickshaw and car, respectively. People living farther than 5 km from the workplace were most likely to travel by car, followed by motorcycle. This study is important for designing strategies to curb the pandemic with sustainable mobility during the lockdown.

Keywords: Travel behavior, Discrete choice, Coronavirus, Transport policy, Islamabad

1. Introduction

COVID-19 is a novel disease caused by the family of coronaviruses, and the outbreak began in Wuhan, China in December 2019 [1]. It has already shown its potential to spread within China and across the border due to human mobility. It spreads from person to person when a person with COVID-19 expels small droplets through coughs, sneezes, or speaks, and another person breathes in these droplets [2]. Furthermore, these droplets can land on objects and surfaces (e.g., tables, doorknobs, and handrails), and people can be infected by touching their eyes, nose, or mouth after touching these objects or surfaces [2]. As of 27 April 2020, this COVID-19 outbreak has rapidly spread across 213 countries and territories with a report of 2,883,603 confirmed positive cases and 198,842 confirmed deaths [3]. All countries in Asia have reported confirmed COVID-19 cases [4]. Asia is the Earth's largest continent and consists of different cultures and religious backgrounds. Pakistan, a country in Asia, borders China. A map of Pakistan is shown in Figure 1. As of 27 April 2020, Pakistan has reported a total of 14,079 confirmed COVID-19 cases with 301 deaths [5]. The COVID-19 pandemic has caused household and national economic losses because many venues with high risks of spreading the COVID-19 disease are temporarily closed, such as crowded areas, markets, public transport, educational institutions, and religious facilities.

The government of Pakistan has adopted various strategies to slow down the spread of coronavirus. These strategies include self-quarantine and isolation, social distancing, avoiding public transport, closing borders with other countries, and smart lockdown (closing the areas reported with the COVID-19 outbreak) [6]. Furthermore, educational institutions, religious facilities, markets and shopping malls, and social and business-related facilities were closed due to a 15-day lockdown from 23 March 2020 [7]. Public transport is a high-risk venue for spreading the coronavirus because commuters normally are less than 2 meters from each other during their travel. On 24 March 2020, the Islamabad Capital Territory (ICT) administration issued an order to ban the intra-city, inter-city, and inter-province movement of commuters by public transport to limit social interactions. However, the metro bus (or namely BRT) still operated from 8:30 am to 10:30 am and then from 3:30 pm to 5:30 pm. One seat between two passengers was kept empty for social distancing during travel [8]. Taxis were allowed to operate under a separate standard operating procedure [8].

Social distancing, to prevent the spread of the coronavirus, has become the new norm and changes the travel behavior of commuters [9]. Travel by public transport is decreasing. The active modes (i.e., walking and cycling) are essential for maintaining satisfactory well-being levels due to reduced out-of-home activities [9]. There are some similar studies relevant to the impact of social distancing

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on travel activities in developed countries because of disaggregated data availability. Haas et al. [10] investigated the impact of intelligent lockdown on travel behavior in the Netherlands during the COVID-19 outbreak using longitudinal mobility data. Their findings showed that approximately 80% of travel activities were reduced. The total travel distance decreased by 68%, and 20% of people were expected to choose active modes of travel. Stavrinos et al. [11] characterized travel behavior among adolescents, with the COVID-19 pandemic restrictions in the US, using the linear mixed-effect model. Weekly driving and vehicle-miles driven (VMD) were reduced by 37% and 35%, respectively. A decrease in driving was found to a lesser extent among ethnic minorities, older adolescents, and employed adolescents. Another recent study of changing patterns in travel activity, subject to restrictions caused by the COVID-19 outbreak, was conducted in Australia [12]. The results showed that the reduction in car use was 60% larger than for pre-COVID-19. However, the studies mentioned above have not explored the determinants of the travel-mode choice.

The differences between the developed and third world countries could be attributed to peculiarities in the built environment, public transport services, road infrastructure, and household vehicle ownership patterns. There is a need to study the travel behavior during the pandemic in developing countries to support consistent strategic interventions, to prevent the spread of the coronavirus. Many travel-mode choice studies exist in Pakistan, but those studies were before the COVID-19 outbreak or under normal conditions, not during a pandemic. Gender has a relationship with the travel-mode choice. Men are more likely to travel more often than females and prefer public transport, while women prefer private vehicles [13]. Large cities in Pakistan have many travel-mode choices, and travelers preferred more comfortable modes at a higher cost, i.e., Light Rail Transit (LRT) [14]. Senior citizens, however, were likely to choose the bus rapid transit (BRT) [14]. Commuters preferred walking for job-related trips in small cities [15]. A high immobility rate was observed among women in Pakistan (55%) as compared to men (4%), and this percentage shows a further decrease if women are married and have children [16]. Travel behaviors and trip activities of commuters during and before the pandemic might be different due to social distancing performance. The COVID-19 pandemic outbreak has changed the patterns of travel-mode choice, and this remains unexplored in Pakistan. A sound understanding of travel-mode choice determinants for key destinations during the pandemic in a third world country of Asia is informative. This can help to design strategies to curb the pandemic and keep equity in passenger mobility in some developing countries of Asia.

This study explores the determinants of travel-mode choice for three key destinations (i.e., workplace, market, and hospital) in Islamabad, Pakistan during the COVID-19 disease outbreak. The study area is located in Islamabad, the capital city, and its hinterland. The study used the primary dataset of 163 observations collected from 2 through 10 April 2020 using a web-based approach. Multinomial logit (MNL) regression was applied to model the data sample. Based on the existing literature discussed above, this is a novel case study of travel-mode choice in Islamabad, Pakistan, during the pandemic. The empirical findings of this study are informative for designing strategic interventions for travel to prevent and slow down the spread of the COVID-19 disease. The limitations of this study, however, are fourfold: 1) the study used a small-sized dataset of 163 observations, 2) most of the respondents are young adults (the 18-40 age group), 3) only literate people who had internet access participated in answering the questionnaire, and 4) the study covered only Islamabad and its hinterland. These restraints limit generalization and replicability for other parts of Pakistan. According to the Cochran formula, this sample size (163 observations) provides a margin of error of up to 7.68% if the sample estimate of proportion in the population is assumed to be 0.5 (the value that provides the highest standard error) [17].

Figure 1 Map of Pakistan (adopted from google maps [18])

2. Data source and methodology

2.1 Data source and description

The survey was conducted in Islamabad, the capital of Pakistan, and other rural areas around Islamabad, see Figure 1. The survey was conducted from 2 through 10 April 2020 using the Google Form link as the web-based approach. The link was posted on Facebook social media. Only adults aged 18 years and older were allowed to fill out the survey form. The COVID-19 confirmed cases increased from 2,421 on 2 April to 4,489 on 9 April 2020 [4]. Only 165 respondents volunteered to fill out the survey form online. After data cleaning, there were only 163 observations for data modeling. The sample size of 163 observations provides the desired confidence level of 95% and a margin of error of up to 7.68% if we assume the sample estimate of proportion in the population to be 0.5 [17]. The sample size can be approximated via the equation below [17]:

$$\text{Margin of error} = \text{Z score of confidence level} \times \sqrt{\frac{p(1-p)}{n}} \quad (1)$$

where p is the sample estimate of proportion in the population, and n is the sample size. We assumed that the population size is unlimited. The proportion, p, of 0.5 provides the greatest margin of error. A smaller margin of error is preferable. The margin of error becomes smaller if the proportion, p, becomes either greater or smaller than 0.5 [17]. A sample with more than 30 observations is regarded as a large-size sample [19]. A sample of 30-60 observations may be enough to develop a hypothesis, and the sample size for conjoint studies typically ranges from 150 to 1,200 observations [17].

The descriptive statistics of the data sample are shown in Table 1. There are three output variables of the travel-mode choice, from home to the key destinations during the COVID-19 disease outbreak, i.e., workplace, market, and hospital. The travel modes were classified into five categories: the public-transport modes (i.e., bus and van), car (i.e., car, taxi, and Uber (including Careem)), 2&3 wheelers (i.e., motorcycle and rickshaw), active modes (i.e., walking and cycling), and no travel. We grouped car, taxi, and Uber into one group, called "car", in our study because passengers of these modes typically do not share their ride with other passengers (or strangers) during their travel in Islamabad, except with their relatives and friends. Furthermore, a private car offers a similar environment as that of a taxi or Uber (though an Uber/taxi driver is present).

Table 1 Descriptive statistics of the data sample

Variable	Category	Frequency	Percentage
Output variable			
Workplace	Public transport (bus and van)	11	6.7%
	Car (car, taxi, Uber)	50	30.7%
	2&3 wheelers	24	14.7%
	Active modes	16	9.8%
	I do not go to work	62	38.0%
Market	Public transport (bus and van)	1	0.6%
	Car (car, taxi, Uber)	56	34.4%
	2&3 wheelers	35	21.5%
	Active modes	40	24.5%
	I do not go to market	31	19.0%
Hospital	Public transport (bus and van)	4	2.5%
	Car (car, taxi, Uber)	60	36.8%
	2&3 wheelers	20	12.3%
	Active modes	6	3.7%
	I do not go to hospital	73	44.8%
Input variable			
Gender	Female	45	27.6%
	Male	118	72.4%
Marital status	Married	55	33.7%
	Single [a]	108	66.3%
Education level	Bachelor's and lower	86	52.8%
	Master's /Ph.D.	77	47.2%
Occupational type	Academic/researcher	24	14.7%
	Company/industry employee	32	19.6%
	Unemployed person/student	56	34.4%
	Self-employed person	19	11.7%
	State official/public servant	32	19.6%
Age	18 – 40 years, 41 years and older	153, 10	93.87%, 6.13%
Status in family	Son/daughter	111	68.1%
	Parent	52	31.9%
Family size	4 people and less	31	19.0%
	5 people	36	22.1%
	6 people and more	96	58.9%
Monthly household income	Less than 250 US$	43	26.4%
	250 to 500 US$	63	38.7%
	More than 500 US$	57	35.0%
Home location	City	113	69.3%
	Town/rural area	50	30.7%
Distance from home to workplace	Less than 5 km	66	40.5%
	Longer than 5 km	97	59.5%
Distance from home to market	Less than 5 km	126	77.3%
	Longer than 5 km	37	22.7%
Distance from home to hospital	Less than 5 km	72	44.2%
	Longer than 5 km	91	55.8%
Total		163	100.0%

[a] The widowed/engaged/divorced respondents are grouped into the same category with 'single' because their proportions are marginal in the data sample and did not significantly affect the estimation results of the streamlined models. Therefore, all the marginal cases are grouped with the most similar category.

That is why they are grouped into the same category. It does not matter whether a passenger of a taxi or Uber owns a car or not. However, this type of passenger does not share his/her ride with other strangers during traveling. Bus and van are grouped into the public transport category. For the three key destinations, the public transport modes account for the smallest proportions: 6.7% for the workplace, 0.6% for the market, and 2.5% for the hospital. This may be because, during the travel survey, many public transport modes were not allowed to operate for the intra-city, inter-city, and inter-province movement of commuters. The metro bus (or BRT) was allowed during the rush hour, i.e., from 8:30 am to 10:30 am and from 3:30 pm to 5:30 pm [8]. Similar findings in developed countries reported that the travel by public transport decreased during the COVID-19 outbreak [9], and the trips by public transport reduced by 90% in the Netherland during the outbreak [10]. The majority of respondents would rather stay at home than go to workplaces, markets, and hospitals.

The input variable section is composed of two main components, i.e., socioeconomic characteristics and home location-related variables. All the input variables are arranged as categorical variables. For the socioeconomic characteristics, we consider gender, marital status, education level, occupational type, status in family, family size, and monthly household income. The descriptive analysis showed that the majority of respondents in the data sample were males (72.4%), single (66.3%), holders of bachelor's or lower degrees (52.8%), the 18-40-year group (93.87%), and sons/daughters (68.1%). Of the sample data, 14.7%, 19.6%, 34.4%, 11.7%, and 19.6% were academics/researchers, company/industry employees, unemployed persons/students, self-employed persons, and state officials/public servants, respectively. About three-fifths (58.9%) and two-fifths (38.7%) of the respondents belong to families with at least 6 members and a combined income of 250-500 US$/month, respectively. For the home location-related variables, the respondents who lived in cities and towns/countryside were 69.3% and 30.7%, respectively. The percentages of all the respondents living less than 5 km and farther than 5 km (from home to the workplace) were 40.5% and 59.5%, respectively. People living less than 5 km and farther than 5 km (from home to market) were 77.3% and 22.7%, respectively. Of all the respondents, 44.2% and 55.8% of the respondents resided less than 5 km and longer than 5 km from home to the hospital, respectively.

2.2 Methodology

The travel-mode choice is a nominal variable, and a discrete choice model is applied to model the data sample. According to the discrete choice model, choice makers can choose only one alternative from a choice set. All possible alternatives are included in the choice set, and the number of alternatives is finite [20]. Multinomial logistic (MNL) regression is used to model the disaggregated data because of its simplicity in the mathematical framework and flexibility for any data types and sample sizes. This model does not require a large sample size, unlike the mixed logit model, nested logit model, and the multinomial probit model. For the MNL model, the unobserved term of one alternative is assumed to be unrelated to the unobserved term of another alternative [20]. The probability of an alternative to be chosen by a choice maker is calculated using Equation (2) [20]:

$$P_{n,i} = \frac{e^{\beta' x_{n,i}}}{\sum_j e^{\beta' x_{n,j}}} \tag{2}$$

where indices n and i (i∈j and j = 1, 2 … J) are the choice maker and alternative, respectively. J is the finite number of a choice set. x is a column vector of the input variables (including a constant, socioeconomic characteristics, and home location-related information). β is a column vector of the corresponding parameter estimates.
The maximum likelihood function is typically used to estimate the parameters [20]:

$$LL(\beta) = \sum_{n=1}^{N} \sum_i y_{n,i} \ln(P_{n,i}) \tag{3}$$

where y_(n,i) [y_(n,i)=1] is a dummy variable of alternative i, chosen by individual n.

The attribute levels of all the input variables were arranged as dummy coding because dummy coding can capture the non-linear effects in the levels of categorical input variables. The details of dummy coding are presented by Hensher et al., pp. 119-121 [21]. In our study, the first attribute level of each input variable was used as the reference category.

Package "mlogit" of the R program was used to estimate the parameters, using a Core i3 laptop with 4 GB of RAM.

3. Results and discussion

In the development of travel-mode choice models for the key destinations (i.e., workplace, market, and hospital), we deliberately excluded the public transport modes for all three key destinations and the active modes for the hospital destination. The frequencies of these choices for the mentioned destinations were too few (see Table 1) and cannot be included in the choice set to model the data sample due to model violation. Social distancing (physical distancing) is an intervention for preventing the spread of COVID-19 disease in Pakistan and across the world. The percentage of traveling to hospitals by active modes is only 3.7% (see Table 1, row 16). It is probably difficult to access hospitals by active modes.

The travel-mode choice models were developed by adding one variable after another to evaluate the potential variables, called the forward selection method. We have four alternatives for the workplace and market destinations and three alternatives for the hospital destination. The degree of freedom, k (i.e., the number of alternatives minus one), of each input variable is equal to 3 for the workplace and market destinations and 2 for the hospital destination. Each variable that was added to the travel-mode choice models of the workplace and market destinations increased k by 3, and the travel-mode choice model for the hospital destination increased k by 2. The critical chi-square, χ^2, at the 0.05 significance level, is 7.815 for k = 3 and 5.991 for k = 2. The log-likelihood value and likelihood ratio index are presented in Table 2. The estimation results of the streamlined models showed that the input variables of gender, marital status, unemployed person/student, self-employed person, state official/public servant, monthly household income of more than 500 US$, home location, and distance from home to the workplace were associated with the travel-mode choice for the workplace destination at the 0.05 significance level. The streamlined model of travel-mode choice for the market destination found that the input variables of gender, self-employed person, state official/public servant, and home location were associated with the travel-mode choice at the 0.05 significance level. The distance from home to the market had no relationship with the travel-mode choice at the 0.05 significance level. This, however, does not necessarily imply that the distance did not affect the travel-mode choice. It is possible if the travel distance interval is arranged in a shorter interval (e.g., less than 1 km, 1 to 3 km, and more than 3 km), or a continuous variable is used in place of the categorical variable. For the hospital destination, the travel-mode choice was significantly influenced by the input variables of marital status, monthly household income of more than 500 US$, and the home location at the 0.05 significance level. The factors of age, household size, and status in family were not statistically associated with the travel-mode choice for all three key destinations at the 0.05 significance level. The age factor might have a relationship with the travel-mode choice for the three key destinations if age is categorized into a smaller interval.

Pearson's product-moment correlation approach was applied to calculate the correlation coefficients among the output variables and significant input variables, as shown in Table 3. All the correlation coefficients among the input variables were marginal, i.e., < 0.5. We assumed the multicollinearity problem of our research to be ignorable. The collinearity is assumed to be relatively low for the discrete choice model because it is difficult to differentiate the impact of each input variable on each categorical output variable [22].

Table 2 Likelihood ratio index results of adding one input variable after another variable

Variable	Workplace			Market			Hospital		
	k	**Log-likelihood**	**Likelihood Ratio Index**	***k***	**Log-likelihood**	**Likelihood Ratio Index**	***k***	**Log-likelihood**	**Likelihood Ratio Index**
Intercept	3	-191.51		3	-220.32	-	2	-150.88	
Gender	6	-187.47	8.08	6	-208.3	24.04	-	-	-
Marital status	9	-182.35	10.24	-	-	-	4	-146.39	8.98
Unemployed person/student	12	-175.23	14.24	-	-	-	-	-	-
Self-employed person	-	-	-	9	-202.52	11.56	-	-	-
State official/public servant	-	-	-	12	-194.3	16.44	-	-	-
Income: more than 500 US$	-	-	-	-	-	-	6	-142.09	8.6
Home location	15	-158.36	33.74	15	-175.58	37.44	8	-130.33	23.52
Distance to workplace	18	-144.39	27.94	-	-	-	-	-	-

Table 3 Correlation coefficients among the output and significant input variables

	Work place	**market**	**Hospital**	**Gender**	**Marital status**	**Unemployed person/student**	**Self-employed person**	**State official/public servant**	**More than 500 US$**	**Home location**	**Distance to workplace**
Workplace	1.000										
market	0.536	1.000									
Hospital	0.400	0.394	1.000								
Gender	-0.099	-0.106	-0.066	1.000							
Marital status	-0.228	-0.146	-0.222	0.063	1.000						
Unemployed person/student	0.296	0.112	0.074	-0.189	-0.352	1.000					
Self-employed person	-0.080	-0.203	-0.051	0.096	-0.097	-0.263	1.000				
State official/public servant	-0.210	-0.185	0.006	0.063	0.431	-0.358	-0.180	1.000			
More than 500 US$	-0.125	-0.083	-0.121	0.050	0.184	-0.124	-0.026	0.253	1.000		
Home location	-0.004	0.015	-0.051	0.153	0.145	-0.169	0.032	0.083	-0.033	1.000	
Distance to workplace	-0.312	-0.232	-0.079	-0.006	0.060	-0.245	0.066	0.093	0.107	0.067	1.000

The estimation results of the streamlined models for the three key destinations (i.e., workplace, market, and hospital) are presented in Table 4. The first and second columns are the variables and travel-mode choices, respectively. Columns 3 through 5 are the corresponding parameter estimates. The McFadden R2 values are 0.1876 for the workplace destination, 0.1373 for the market destination, and 0.068 for the hospital destination. The travel-mode choice model for the workplace destination had the best model fit, followed by the models for the market and hospital destinations. The intercept coefficients are included to capture the average unobserved effects, and they have no interpretable meanings [20]. The impacts of the input variables on the travel-mode choice for the key destinations are interpreted as follows.

As compared to females, males were most likely to travel to workplaces and markets by 2&3 wheelers, followed by active modes, and least likely to travel by car. Unlike the finding for pre-COVID-19 under normal daily activities, men were more likely to walk and use public transport [13]. In Metro Manila, the Philippines, males had a higher baseline preference than females to travel to work by motorcycle before the COVID-19 outbreak [23]. Females were more likely than males to stay at home rather than go to workplaces and markets. A similar finding was reported for a random day pre-COVID-19 that females were more likely to stay at home than travel probably due to societal norms and cultural values [24]. Also, women tended to participate less frequently in out-of-home activities [13]. The immobility rate of women was 55% in Pakistan, which was a high rate as compared to men (4%) [16]. Gender had no significant relationship with the travel-mode choice for the hospital destination, unlike the workplace and market destinations.

Married people were most likely to travel to workplaces and hospitals by car than single people because married people might have a combined income that is higher than single people. There was no relationship between the marital status factor and the travel-mode choice for the market destination.

Unemployed persons and students were more likely than people with jobs to stay at home. This is because all educational institutions remained closed during the pandemic [7]. Therefore, students were likely to study online at home during school closure [25]. Self-employed people and state officials/public servants were most likely to go to the market by car.

Respondents who belong to families with a household income of more than 500 US$/month were more likely than respondents with a lower household income to travel to hospitals by car. People with high household incomes had a higher baseline of car ownership [23, 24].

People living in towns and the countryside were most likely to travel to the workplace, market, and hospital by motorcycle and rickshaw, while those residing in cities were most likely to travel by car to the three key destinations. Another reason that few people living in towns/rural areas used public transport is the limited public transport availability. Furthermore, the ban on the intra-city and inter-city movement of passengers by public transport (except the metro bus) is another major reason that commuters were less likely to travel by public transport. On 24 March 2020, the ICT administration issued an order for not allowing passenger mobility by public transport, except the metro bus [8].

People living farther than 5 km from the workplace were most likely to travel by car, followed by motorcycle. Those living less than 5 km (from home to the workplace) were more likely to travel by the active modes than the public transport modes. There was a similar finding in the case of short trips. Commuters might walk and cycle recreationally to the workplace due to reduced out-of-home activities during the COVID-19 outbreak [9].

Table 4 Model estimation results-coefficients (standard error)

Variable	**Travel mode**	**Workplace**	**Market**	**Hospital**
Intercept	Car	-0.659 (0.611)	-0.01 (0.399)	-0.681 (0.292)*
	2&3 wheelers	-2.547 (0.93)**	-2.708 (1.05)**	-1.257 (0.377)***
	Active modes	-1.676 (0.978).	-0.59 (0.484)	-
Gender				
Female (ref.)				
Male	Car	0.058 (0.496)	0.459 (0.512)	-
	2&3 wheelers	1.562 (0.813).	3.541 (1.095)**	-
	Active modes	1.404 (0.847).	1.708 (0.586)**	-
Marital status				
Single				
Married	Car	0.932 (0.496).	-	0.929 (0.399)*
	2&3 wheelers	0.576 (0.592)	-	-0.137 (0.638)
	Active modes	0.463 (0.781)	-	-
Occupational type				
Academic/researcher (ref.)				
Unemployed person/student	Car	-1.555 (0.554)**	-	-
	2&3 wheelers	-1.028 (0.673)	-	-
	Active modes	-0.325 (0.691)	-	-
Self-employed person	Car	-	1.583 (0.844).	-
	2&3 wheelers	-	-0.729 (1.082)	-
	Active modes	-	-1.599 (1.278)	-
State official/public servant	Car	-	1.036 (0.607).	-
	2&3 wheelers	-	-0.546 (0.726)	-
	Active modes	-	-1.364 (0.812).	-
Monthly household income				
Less than 250 US$ (ref.)				
More than 500 US$	Car	-	-	0.494 (0.385)
	2&3 wheelers	-	-	-1.464 (0.797).
	Active modes	-	-	-
Home location				
City (ref.)				
Town/rural area	Car	-1.313 (0.551)*	-0.347 (0.576)	-0.08 (0.422)
	2&3 wheelers	0.116 (0.567)	0.625 (0.61)	0.934 (0.569)
	Active modes	-0.276 (0.701)	0.197 (0.598)	-
Distance from home to the workplace				
Less than 5 km (ref.)				
Farther than 5 km	Car	1.46 (0.506)**	-	-
	2&3 wheelers	0.886 (0.584)	-	-
	Active modes	-2.586 (1.089)*	-	-
Summary of model fit				
Log-Likelihood		-144.39	-175.58	-130.33
McFadden R^2		0.1876	0.1373	0.068
Likelihood ratio test		chisq = 66.689	chisq = 55.903	chisq = 19.123

Ref.: Reference; chisq = chi square

Significance codes: 0.001 ‘***’; 0.01 ‘**’; 0.05 ‘*’; 0.1 ‘.’

The no-travel choice is used as the reference category for the three models.

4. Conclusions and recommendations

This study explores the determinants of the travel-mode choice for three key destinations (i.e., workplace, market, and hospital) in Islamabad, Pakistan, during the COVID-19 disease outbreak. This study used the primary dataset of 163 observations collected from 2 through 9 April 2020 using a web-based approach and applied MNL regression to model the data sample. The survey results showed that the percentages of the public transport modes were marginal for the three key destinations during the COVID-19 disease outbreak, but most respondents stayed at home. The streamlined models showed that the status in family and family size was found to have no relationship with the travel-mode choice for the three key destinations at the 0.05 significance level. Males were most likely to travel to the workplace and market by 2&3 wheelers, followed by the active modes, and least likely to travel by car. Females were more likely than males to stay at home. The impact of gender on the travel-mode choice for the hospital destination was not statistically significant. Married people were more likely than single people to travel to the workplace and hospital by car. There was no relationship between the marital status factor and travel-mode choice for the market destination. Unemployed persons and students were more likely than people with jobs to stay at home. Self-employed people and state officials/public servants were most likely to go to the market by car. People with household incomes of more than 500 US$/month were more likely than people with lower household incomes to travel to the hospital by car. However, the household income had no impact on the travel-mode choice for the workplace and market destinations. People living in towns and the countryside were most likely to travel to the workplace, market, and hospital by motorcycle/rickshaw. In contrast, people residing in cities were most likely to travel by car to the three key destinations. Those living farther than 5 km from the workplace were most likely to travel by car, followed by motorcycle. Travel distance had no impact on the travel-mode choice for the market and hospital destinations in Islamabad during the Covid-19 outbreak.

Overall, commuters were most likely to travel by car to the three key destinations because some public transport modes were not operated, except the metro bus. Women, students, and unemployed persons were likely to stay at home, which helps to prevent the spread of the COVID-19 disease. It is found that people are less likely to travel by the active modes than the private modes for the workplace and hospital destinations. However, people residing less than 5 km from home to the workplace are more likely to travel by the active modes than the public-transport modes. Some travel becomes inaccessible for commuters without cars and motorcycles. Correspondingly, the government should have provided incentives or subsidies to commuters with low incomes to purchase bicycles for travel. This would help social development in terms of mobility during the pandemic while some public transport modes were not operated. Also, this solution can increase physical activities for out-of-home activities, e.g., sports, fitness, and shopping. Another option is that the government should have promoted ride-sharing and carpooling programs to fulfill travel demand because public transport by bus and van was reduced during the lockdown. The public transport managers and operators should also have increased the frequency and decreased the occupancy rate of public transport modes to improve social distancing.

Future studies should explore the driving factors that encourage people to stay at home during the COVID-19 outbreak and how the outbreak degrades their physical and mental health and well-being. Furthermore, other studies should understand how low-income people travel to key destinations during the COVID-19 outbreak while public transport is temporarily closed and how those commuters are satisfied with the policy of public transport management. Understanding the primary concerns of residents during outbreaks are indispensable to provide social, mental, and emotional support to improve life satisfaction and well-being more efficiently and effectively, especially among low-income people.

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