The Impact of COVID-19 Pandemic on Mobility and Travel Behavior

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Abstract- **People have various travel needs in their day-to-day life which were influenced due to measures recommended and imposed by the government in the pandemic. Various strategies were used by the government to reduce the spread of COVID – 19 including lockdown, closure of schools, work from home order, quarantine, restriction of travel, and mass gathering resulted in low road traffic movements and consequently low road traffic collision. This study aims to examine the changes that occurred in the travel behavior of people due to the COVID – 19 pandemics. Data required for travel origin-destination study were collected through an online questionnaire survey that included questions on frequency and purpose of trips before and during a pandemic, mode choices, use of shared mobility, and distance traveled.**

Keywords- Travel movement, Impact of a pandemic on traffic behavior, Traffic survey, Mode of traffic, Traffic patterns

1. INTRODUCTION

The COVID -19 pandemic has changed our way of life within a very short period of time, affecting not only the health sector but different Industries and commercial sectors also. Transportation, like other fields, was also severely impacted by the spread of the virus, including how and when people travel. Daily travel patterns of commuters and mobility behavior have been significantly affected by the pandemic. All transportation modes like driving, walking, and cycling have been impacted by a number of mobility restrictions and regulations that have been enacted in most countries by local governments at different levels to slow down the transmission of COVID -19 (i.e., social distance norms, closure of offices and schools, partial or complete lockdown). The virus has had an impact on the overall travel behavior of people, their mode choices, mobility, logistics, supply chain as well as on the environment. As the risk for infectious disease spreading within a common confined environment was higher, the Stay at Home and Work from the Home message was promoted across the globe, hence trip making has been significantly reduced during the lockdown period. Public transport and shared transport, in particular, have seen an all-time low in ridership. Analyzing and understanding travel behaviors and patterns is very important in transportation planning, to understand the current requirements and to predict future needs. This research aims to understand and document the impact of a global pandemic on current and future travel behavior, patterns, activity engagement, overall trip making, mobility disruptions, and shifts in modal choices that have occurred as a consequence of the pandemic and restrictive measures enacted to control the spread of the virus in the country.

2. NEED OF THE STUDY

Travelling has various benefits including education, business, recreation, health and wealth, while transport service providers on the other hand public or private generate revenue to boost the economy, hence travelling is very essential in an economic conscious society. Travel behavior is a result of commuter's social demographic characteristics, surrounding built environment and land use policies.such characteristics include commuters age, gender, level of income, car ownership etc. In pandemic period government had to deploy severe measures to contain the virus spreading like restrictions on mobility and promote social distancing. Mobility restrictions were applied at various levels like local, regional, national and international level. The implications of social distancing might be drastic in transportation sector. Even after the lockdown was partially loosened, severe measures slightly eased and period of new normality started, major changes in people's habits and travel behavior was seen. It can be expected that people will travel less and try to avoid public and shared transport like metros, public buses, car sharing, bike sharing, given the fear of exposure to the virus. Hence there is an urgent need to investigate the impact of this virus on our transportation system to formulate strategies that can be used to achieve positive and healthful outcomes at a system level.

3.METHODOLOGY

This paper explores individual's willingness to use and pay for different modes of transport, especially public transport and shared mobility in and after pandemic period. The methodology adopted in this study is a combination of both qualitative and quantitative research. For the present study, a questionnaire was designed in three parts. In first part respondents' sociodemographic details were included, like gender, age, education background, occupation, Income levels and existing travel restrictions in their area. In second part, closed ended questions were designed to understand the trip frequency by different modes during and after pandemic period. The travel modes considered for study includes public transport, private vehicles (4 wheelers and 2 wheelers), paratransit transport, walking and shared transport facilities. Travel purpose were considered like visiting medical facilities, religious places, education, leisure, to buy necessities etc. In third part, questions were

designed to understand the commuter's preference towards particular mode of transport and his travel pattern.

4.DATA COLLECTION

Questionnaire survey was conducted to collect required data for research. Considering COVID -19 regulations and procedures, it was difficult to conduct survey with hard copies hence, a questionnaire was prepared on Google forms and distributed using social media platforms to collect responses for this study. Snowball sampling technique was used to collect responses. Total sample size was decided considering respondents' location, age, gender education background, income levels etc. Data cleaning was performed to delete invalid responses, including incomplete questionnaires and the ones which have similar responses for all the questions. The primary purpose of travel pattern was defined as the purpose of that particular trip which people usually undertake. Respondent's may be able to reduce overall other less important trips but they may be compelled to travel for certain primary trip purpose. Hence it is important to focus on primary trips in the questionnaire as it determines the regular or main trips performed, distance travel and mode chosen. A Section of the questionnaire was dedicated for the questions on the primary purpose of travelling, mode choice, frequency and distance covered. In addition to these questions, other elements who has major impact on travel behavior like safety and security, comfort, infection concern, travel time saving, social status, cleanliness, door to door service was included in the questionnaire. The presents study's scope is to capture the changes in individuals' self-reported mobility and travel behavior during and after COVID -19 outbreak. There are some limitations with this study, firstly this study is based on the data collected through an online questionnaire survey, so the people who had access to the internet and who could understand and communicate in English responded to this questionnaire. Thus, generalizing outcomes for an average population in a society might not be practical. An increase in the sample size and diversity of sample is recommended for future studies. Nevertheless, the findings of this study could have implications for transportation planning in new normal era.

5.SURVEY AND ANALYSIS

In survey, percentage of female participants (58%) were higher than male participants (42 %). Majority respondents (72 %) had a high education level with monthly household income of 65,000 Rs – 1,15,000 Rs. Most of the respondents were from urban area, where strict travel restriction implemented during COVID – 19 spreads. Students' participation in survey was 24%, whereas office workers were 64% and remaining 12% were non-working respondents. Descriptive analysis and quantitative comparative analyses were conducted on the collected data. Exploratory factor analysis was used to understand the underlying factors affecting the mode preference.

5.1 Descriptive analysis

5.1.1 Changes in trip frequencies

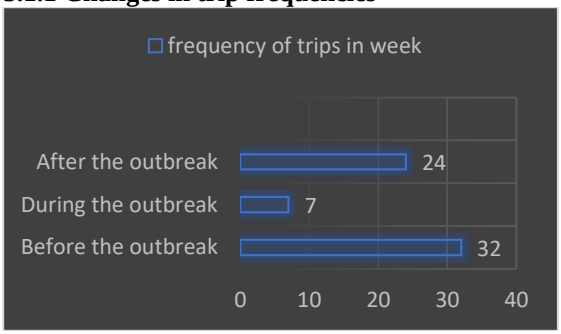

Fig. 1. Total number of trips per week
(Source: Questionnaire survey - Primary source)

The results shown in Fig. 1 are the variations in trip frequencies in week including before, during and after the most serious period. This data extracted from questionnaire survey shows that respondents had 32.8 total average trips in a week before the outbreak of COVID -19. During the most serious period of the COVID – 19, respondents had reduced their trips to 7 total average trips per week and after the outbreak it has been recovered to 24.2 average trips per week.

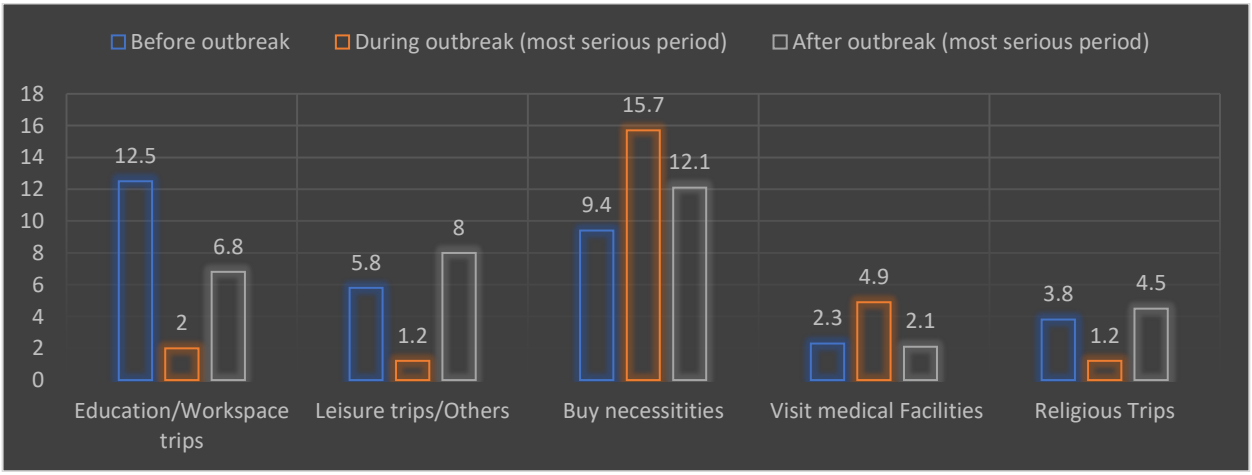

Fig. 2. Primary purpose of travelling per week before, during and after most serious period of COVID -19 pandemic
(Source: Questionnaire survey - Primary source)

The primary purpose of trips is the main reason for which people travel during their daily life. Trips are generally made out of necessity; people may avoid making trips for reasons like leisure in pandemic but they may not be able to avoid making trips for the reasons they consider primary. The primary purpose of travelling, distance travelled and mode of travel may change considering the circumstances during pandemic. Major changes have been observed in the commuter's self – reported trips by purpose with respect to COVID – 19 pandemic spread, as shown in Fig 3. The data of total number of trips by purpose during the most serious period, before and after the most serious period was collected by questionnaire. The primary purpose of travelling for most of the respondents before COVID was work or education. However, it reduced drastically in pandemic period. Expect for the trips to buy necessities, all other trips substantially reduced during the most serious period of COVID – 19 pandemic and slowly recovering to normal level again. Trips to buy necessities increased during pandemic, as people were facing fully and partially locked down. Shopping became the primary purpose of travelling for majority respondents as the locked – down situation forced people to stay at home and panic caused by locked down encouraged people to increase these trips during the most serious period. As Leisure, Recreational, sports were a primary purpose for a small percentage of respondents, they were combined into a single category titled 'other' for survey and analysis purposes. As data shows, the primary purpose of traveling drastically changed from work/education and others to shopping during the most serious period.

5.1.3 Distance traveled for primary outdoor trips

Fig no. 3 describes, the travel behavior of respondents during COVOD – 19, about 68% of the respondents traveled a distance between 0 to 10 km during the most serious period, whereas only 17 % traveled this distance before COVOD - 19. The average distance traveled by respondents, who traveled mainly for education purposes before and during COVID -19, was 16 km and 1.5 km respectively. The average distance traveled for work before and during COVID -19, were 18 km and 6 km respectively. For people who owned a private mode of transport, a car traveled significantly longer distances for primary trip purposes before COVID – 19 but car ownership did not have a significant impact on the distance traveled for the primary trip purpose during COVID -19. Those who owned a motorbike covered approximately similar distances for primary trip purposes before and during COVOD -19. Essential workers traveled significantly more distance compared to before COVID – 19 period, as they have to perform their duties and sometimes additional duties during pandemics. According to the study all the socio-demographic factors like gender, household income, education background didn't have any major impact on distance traveled for primary purposes during a pandemic period except age. As COVID -19 has been found to be dangerous particularly for older people, the distance traveled by them during the most serious period was drastically less compared to before period.

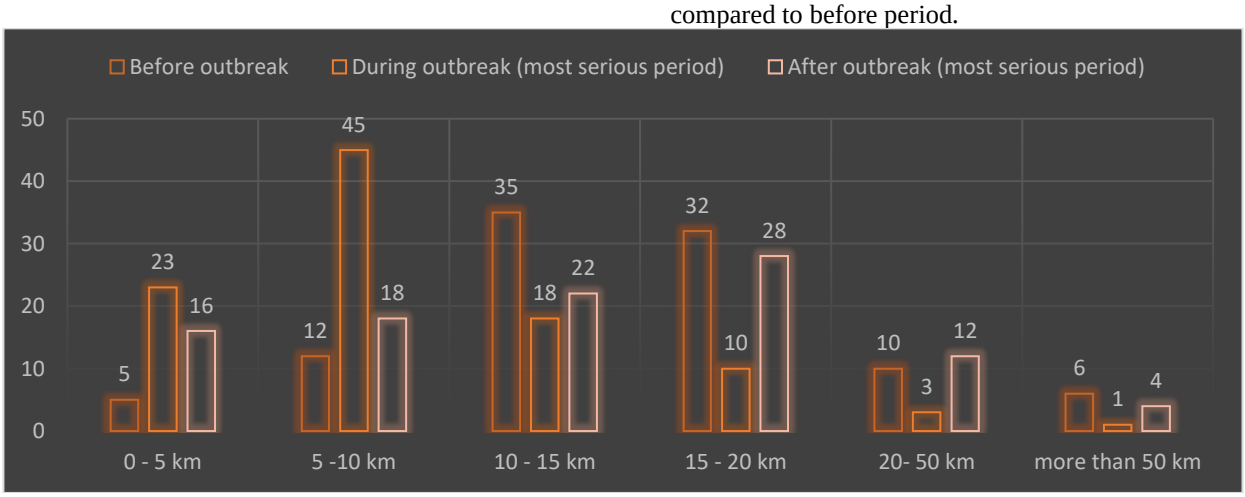

Fig. 3. Distance travelled for primary outdoor trip per day before, during and after most serious period of COVID -19
(Source: Questionnaire survey - Primary source)

5.1.4 Number of primary outdoor trips

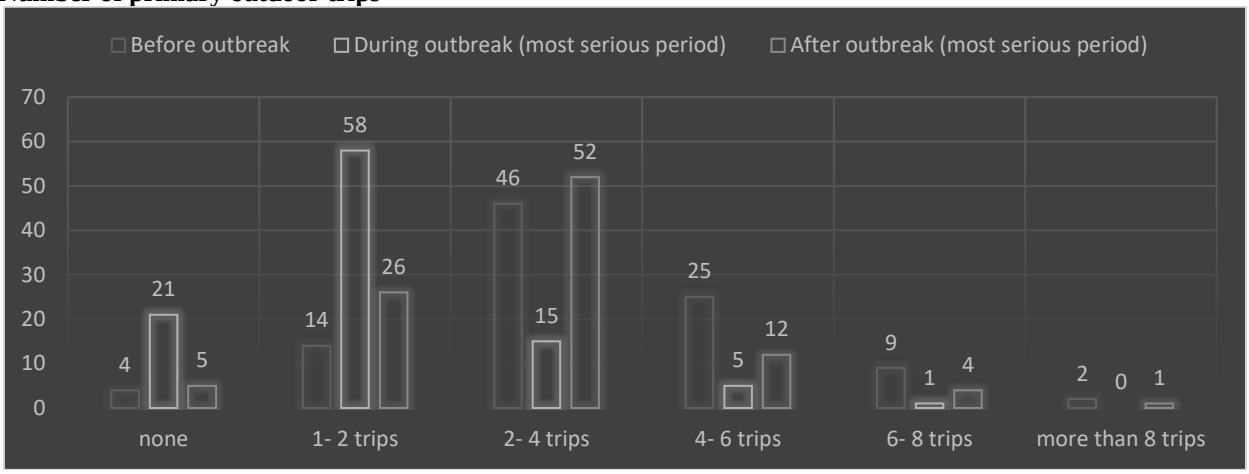

Fig. 4. Number of primary outdoor trips per day before, during and after most serious period of COVID -19 pandemic
(Source: Questionnaire survey - Primary source)

In this study, a trip was considered as a one – way trip from origin to destination, for example a trip from home to market was considered as a one trip and again from market to home was considered as another trip. The above chart compared the total number of trips generated on daily basis before, during and after COVID -19 pandemic period. The total number of trips remarkably reduced during the pandemic period as expected. From fig no 4. we can understand that most of the respondents (79 %) undertook 0-2 trips per day for primary purpose of travelling during COVID -19. Respondents who undertook 2 -4 trips before pandemic was 46%, which reduced to 15 % during pandemic and also recovered to 52% after most serious period. Only 6% respondents undertook 4 -6 rips per day for primary purpose compared to 34 % before pandemic period. No of trips generated by essential workers during pandemic period was almost similar compared to before period. Again, socio demographic factors like gender, household income, education background didn't have any major impact on trip generation and the ratio of trip generated by senior citizen was drastically less compared to other age groups.

5.1.5 Changes in mode choices

The variations of individuals' trips by different modes in during, before and after pandemic are presented in Fig. 5. Different modes of transport were considered while conducting a survey like public transport, shared transport, Car, two wheelers, para-transit and walking etc. According to survey, the use of public transportation, shared transportation and para- transportation were substantially decreased during COVID – 19 outbreak
period, compared to other modes of transport, as respondents places a high priority on infection related factors compared to factors that generally affects mode choices like travel time saving, cost and comfort. The willingness to use Two-wheelers for transportation was relatively high considering the low risk of contagion and use of Two wheelers in rapidly growing delivery industry.

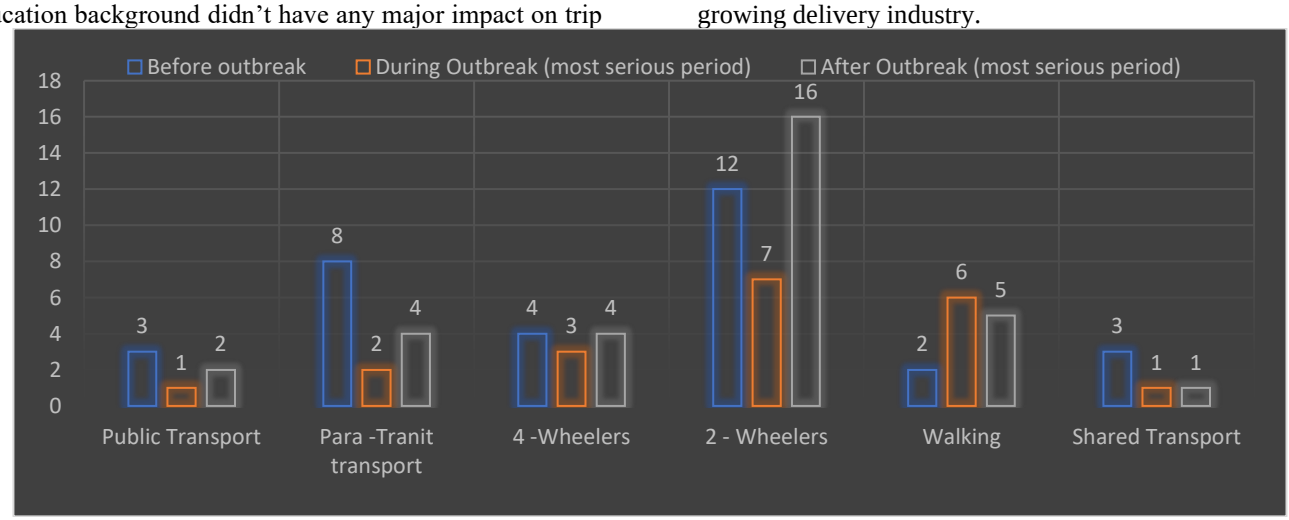

Fig. 5. Mode of primary outdoor trips before, during and after most serious period of COVID -19 pandemic
(Source: Questionnaire survey - Primary source)

5.1.6 Distribution of responses for factors affecting mode choice before, during and after most serious period of COVID – 19 pandemic.

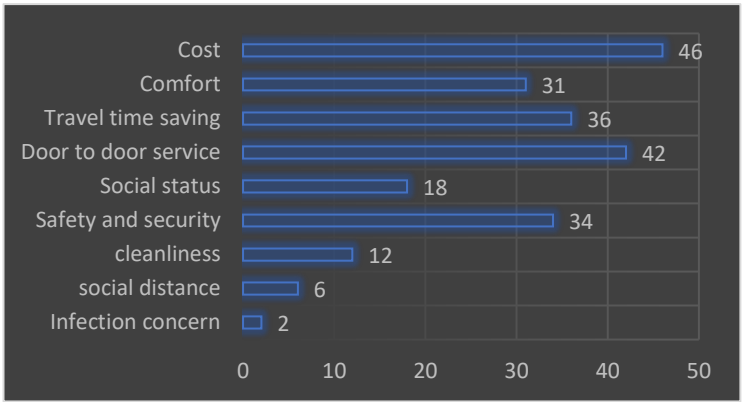

Fig. 6.1. Distribution of responses for factors affecting mode choices before COVID -19 pandemic (Source: Questionnaire survey - Primary source)

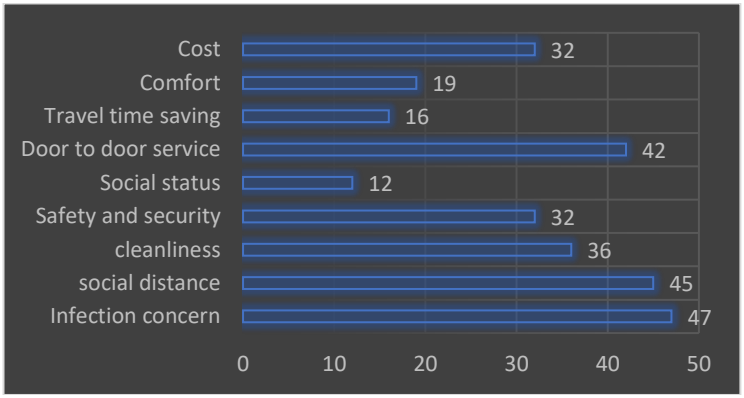

Fig. 6.2. Distribution of responses for factors affecting mode choices during COVID -19 pandemic

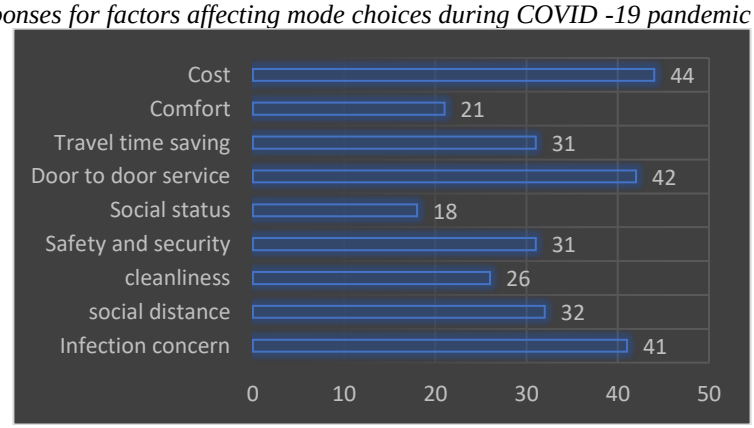

Fig. 6.3 Distribution of responses for factors affecting mode choices after the most serious period of COVID -19 pandemic (Source: Questionnaire survey - Primary source)

Legend: 0-10: No Priority 10-20: Low priority 20-30: Neutral 30-40: Moderate priority 40-50: High priority

The primary purpose of travel and model choices were substantially different during the pandemic period compared to normal situations. Hence the study of all the factors affecting mode choice during COVID -19 was necessary to understand the mode choice behavior on the ground level and to plan future policies of transportation. Fig.6 Charts represent the data of **the** distribution of responses for factors affecting mode choice before, during, and after the most serious period of COVID – 19 pandemics. It can be explained from table 6, respondents placed a high priority on pandemic-related factors and low priority on travel time saving and overall comfort while choosing the mode of transport during the outbreak compared to before and after the period. After the most serious period, the priority of pandemic factors like cleanliness, social distancing, and infection concern was reduced slightly and priority of their day-to-day factors like Travel time saving, the cost was increased.

6. DISCUSSION AND ANALYSIS

Travel behaviors and mode choices were drastically changed during pandemic situations compared to the pre-pandemic period mainly due to fear of infection by individuals and the

restrictions imposed by authorities. This study presented the outcomes of an online questionnaire survey that was proposed to identify the changes in travel behaviors due to the ongoing COVID -19 pandemic. It focuses especially on primary travel, travel purposes, and mode choices during the pandemic because trips for primary purposes are made out of necessities and cannot be avoided. While conducting a survey, Respondent's personal details were considered as the independent variables, including age, gender, respondent's educational background, ownership of the vehicle, employment status, type of employment, and household income levels as it deeply affects the overall trip generations and respondents' willingness to use any mode of transport.

According to this data, respondents with higher ages were found to decrease their trips drastically when the time was changed from before – to -serious, as compared to people with other age groups. Similarly, elders were found to recover their total reduced trips faster than other age groups after the most serious period. The gender was not found significantly relevant to increase or decrease in total average trip generation, during and after the most serious period. Respondents with higher education backgrounds have significantly reduced their trips during most serious periods as compared to individuals with a comparatively lower education background. Business owner/Self employees were Respondents with higher age, education background, owning the private vehicle and perceiving high severity of COVID – 19 have reduced their leisure and visiting trips compared to the respective others. During the time change of most serious to after serious period, respondents who own car, living in an urban area and faced travel restrictions were recovering their leisure trips faster than other respective ones. However, respondents from the lower-income backgrounds were less likely to recover their leisure trips after the most serious period.

Respondents with higher age have reduced almost all types of trips for every purpose and by every mode when the time has changed before most serious period to during the most serious period. However Male respondents were less likely to reduce their purchasing and hospital trips during the most serious period. The data indicate that individuals with low-income background respondents were not likely to reduce their trips during the most serious period but those who feel threatened by the COVID -19 have reduced their religious trips during the before-to-serious periods.

It was observed that shopping for necessities become the primary purpose of traveling during COVID – 19 pandemics. The shift from work, study, leisure trips to shopping trips indicates that additional attention is required on the subject during the pandemic period. Trip generation for work, education, and other purposes was reduced due to lockdown but regardless of the level of restrictions i.e., complete, partial, or small lockdown and growth of delivering industry, shopping trips increased drastically. Shopping trips were made for buying groceries and other household items and were shorter in distance and time as compared to other trips. Online activities like online shopping could be a viable alternative to further reduce outdoor trip generation. The surge in online activities has been observed all around the world during pandemics. There are still many barriers to this online-based activity like weak physical connectivity and insecure payment methods but reducing this barrier can help in reducing outdoor trips for shopping.

found to reduced their trips from before- to-serious period and recovered faster in after most serious period compared to other occupations. The use of public and shared transport reduced drastically during the most serious period and recovered very slowly compared to another mode of transport. In the case of public transport, respondents with lower-income backgrounds didn't reduce their trips, as compared to others with higher-income backgrounds. According to the survey, male respondents were found to be less likely to increase their paratransit/shard trips compared to female respondents after the most serious period. Unemployed or retired individuals were more likely recovering their shared/paratransit trips than respective others.

Respondents with higher education backgrounds, workers, self-employed and business people have reduced their trips drastically during the most serious period of COVID -19. However, respondents with lower-income backgrounds were less likely to reduce their overall average trips by public transportation. It is understandable as the lower income background respondents may work on daily wages and have less likely to shift remotely due to their nature of work. After the most serious period, a rapid recovery in trip generation by bike, motorbike, and walking was found for the respondents who faced travel restrictions in their areas.

Increased use of private cars and active transport like walking and bicycles and decreased use of public transport and paratransit were observed during pandemic. Respondents placed a high emphasis on infection-related factors like social distance and cleanliness while choosing a travel mode compared to the factors which generally affect the mode choice like cost, travel time saving, and comfort. Public transport ridership declines during the outbreak period mainly because of government restrictions and infection concerns by people. However, public transport will remain to be a primary need of society, even it is not safe from the pandemic viewpoint. Hence strategies like providing sanitization facilities for users in public transportation and reducing person-to-person contact in the overall procedure should be adopted to make public transport safer during the pandemic period.

In general, findings indicate that the change in respondents' mobility and travel behavior is related to the mode of travel and the COVID – 19 severities. These findings are helpful to understand the COVID – 19 impacts on travel patterns and relationships of the individual's characteristics with the change in travel frequencies by purpose.

7. CONCLUSION

The COVID – 19 pandemic has changed the overall travel habits and behaviors of the world's population. This study has explored people's mobility behavior, including trips by mode and purpose before the outbreak, during the most serious period, and after the most serious period of the

pandemic. This study confirms that the individual's mobility behavior is sensitive to the COVID – 19 severities and provides important insights for transportation planners and policymakers to better prepare for traffic management plans in the future that are resilient to a pandemic spread. Individual characteristics (age, gender, education background, etc.) and perceived details (safety perception, Travel restrictions) play an important role in the behavioral change in COVID – 19 severity period. Hence such information should be considered in transportation planning and policy preparation. Sufficient efforts will be required to increase public transportation usage in the post-pandemic era and more research is required to understand and minimize pandemic impacts on mobility and travel behavior as well as to find more avenues to promote safer modes of transportation.

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