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Assessment of COVID-19 induced travel pattern changes in Dhaka City
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A B S T R A C T
In response to Coronavirus 2019 (COVID-19) pandemic, Bangladesh enforced social distancing measures to mitigate the virus transmission rate through lockdowns. However, it is challenging for people to follow through and stay home in developing nations where socio-economic conditions are divergent from developed countries. This research aims to investigate COVID-19 induced travel pattern changes of residents and significant demographic factors affecting the trip generation in Dhaka City, the most densely populated Bangladeshi city. A questionnaire survey was used to extract information on demographic characteristics of respondents in Dhaka City and their travel patterns in the pre-pandemic era and during the pandemic. Analyses reveal striking differences in work trips except for workers and craftsmen. The use of telemedicine facilities is noticeable. Preference for public transport has decreased yet a decent percentage (9%) of people use buses during the pandemic. However, non-motorized modes are also very popular (19.93%) in the pandemic. The findings offer major implications for transportation planners and policymakers on how to dynamically plan for such crisis by combining a range of strategies so that safe and sustainable urban mobility and reduction of unnecessary travel demand can be ensured.

1. Introduction
The Coronavirus 2019 (COVID-19) pandemic has killed more than 2 million while infecting an additional 90 million till January 2021. Bangladesh, a developing country, has been particularly affected by COVID-19 (Sakamoto et al., 2020) and is currently placed 32nd in the world (Worldometer, 2021). Dhaka, the ninth-largest and the sixth-most densely populated city in the world (World Urbanization Prospects, 2019), is a COVID-19 hotspot. (WHO, 2020). The main way to control virus transmission is by safeguarding people from COVID-19 exposure (Islam et al., 2020). Advanced nations like South Korea, Taiwan, and New Zealand have noticeably reduced virus transmission cases by following guidelines and strategically restricting travel (Shammi et al., 2021). Although Bangladeshi cities have encouraged social distancing measures, a city like Dhaka accommodating 32% population below the lower poverty line faces challenges in carrying out essential activities while staying at home (Shahadat, 2008). A population of over 18 million residents in Dhaka requires a robust transportation system to facilitate daily activities despite the pandemic situation. Incessant traffic congestion and delays increase physical contact and virus transmission chances in the city, especially among public transport captive riders (Ahmed et al., 2021; Hasnat et al., 2018; Quddus et al., 2019). Moreover, Information and Communication Technologies (ICTs) penetration is very low and skewed towards a few professions among the rich (Ahmed, 2009; Ray and Subramanin, 2013). Thus, people are not accustomed to online banking, education and shopping. Rather, they are habituated with performing activities physically, which is a huge safety concern against COVID-19 transmission.

2. Literature review
Numerous studies on COVID-19 outbreak related to the safety of healthcare, social, food and domestic safety have already appeared in many scientific literatures. The Socio-economic and psychological effect of COVID-19 is also explored (Haghani et al., 2020). Several studies proposed Guidelines to ensure the safe transport of suspected and confirmed COVID-19 patients (Liew et al., 2020). Transmission of COVID-19 has also been examined using travel data (Candido et al., 2020; Zhong et al., 2020; Lytras et al., 2020; Mouchtouri et al., 2020). Travel has been identified as a prime factor in the global spread of infectious diseases (Gezairy, 2003; Lai et al., 2020; Zheng et al., 2020). Hence several researchers have paid attention to travel pattern change caused by COVID-19 and similar other outbreaks. Travel behavior can be defined as inert or habitual, which does not change very often (de

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distance measures have reduced trip numbers in some cases, mainly in Sweden (Jenelius and Cebecauer, 2020). However, this can also increase traffic congestion and air pollution in the future (Shakibaei et al., 2020). Non-therapeutic measures such as lockdowns, quarantines and social distancing measures have reduced trip numbers in some cases, mainly arising from increased adoption of ICT in Spain (Aloi et al., 2020), the Netherlands (de Haas et al., 2020) and Australia (Beck and Hensher, 2020). On the other hand, essential trips such as food and shopping that cannot be substituted by ICT have remained unchanged in Australia (Beck and Hensher, 2020) and Japan (Parady et al., 2020).

Although most of these studies reported decreased physical travel, they were carried out in developed countries where socio-economic conditions are divergent from developing countries like Bangladesh. According to several COVID-19 travel impact investigations in Bangladesh, people continue to travel for work, and use bus because of its cheapness (Anwari et al., 2021; Zafri et al., 2021). Increased reliance on urban areas, the concentration of commercial and industrial activities in a few areas, inefficient supply-chain structure, lack of self-sufficient regions, poverty and inequality were some of the main reasons for increased COVID-19 incidence rates in Bangladesh (Rahman et al., 2021). In contrast to previous studies focusing on Bangladesh generally, this study investigates Dhaka City, where the COVID-19 incidence is severe.

3. Methodology

3.1. Data collection

A questionnaire survey was conducted to capture the details on demographic characteristics of the trip-makers and the information complemented to trip generation for “Before” and “During” COVID-19 crisis. Both web-based survey and face to face interview was performed from November 2020 to January 2021. A web-based survey can reach a large number of people within a short period of time and would be comfortable for the respondents to participate during the pandemic in the survey. On the other hand, face to face interview was conducted maintaining proper safety guidelines to extract data from people living in slums in Dhaka City as most of them neither have proper internet connection nor do use smartphones.

The questionnaire survey included 2 sections. The first section extracted details on demographic characteristics of the trip-makers – gender, age, net monthly income (NMI) and occupation. The second section of the questionnaire was designed to ask about the information related to purposes of trip generation and travel characteristics of the respondents for the “Before COVID-19” and “During COVID-19” situations. In this study, a two-way trip is accounted as a single trip for analysis and modelling. The trip purposes are classified as (i) Work/Academic (W/A) Trips, (ii) Shopping Trips, (iii) Grocery Trips, (iv) Recreational Trips, and (v) Medical Trips. To investigate the changes in travel pattern. However, it affects society as a whole (de Haas et al., 2020).

4. Results and analysis

4.1. Demographic characteristics of respondents

Demographic attributes of survey respondents are summarized in Fig. 1 where most respondents are male (57.6%) and are aged 19–24 years (26.6%). Most respondents (41%) were low-income people (0–8000 BDT). In this study, the occupation worker is considered as day laborer, mosaicry worker, building painter. Craftsman is considered as mechanics, plumbers, electricians, artisan, smith, manufacturer etc. Unemployed is the person who has no job or searching for a job and “Others” includes persons with undefined occupations. In terms of occupation, students (30%) and private service holders (22%) are the most active participants. The response observation for the age group and occupation is due to the digital nature of the survey as young people (typically students) are more advanced in ICT facilities than adults are.

4.2. Travel pattern change reflected by travel characteristics

The specific modes presented as options in the questionnaire survey are based on consultation with transportation experts. A wide variety of

\[
\begin{align*}
\text{logit}(P(Y \leq j)) &= \log \left( \frac{P(Y \leq j)}{1 - P(Y \leq j)} \right) = \alpha_j + \beta_j X_j + \epsilon, \quad j = 1, \ldots, J
\end{align*}
\]

where, P is the probability of dependent variable Y.

\[
\alpha = \text{Regression Intercept} \\
\beta = \text{Co-efficient of Independent Variable} \\
X = \text{Independent Variable} \\
n = 1, 2, 3, \ldots
\]
Fig. 1. Distribution of Gender, Age, Income and Occupation of respondents.

Fig. 2. The preference of overall travel mode travel Before and During COVID-19.
modes run in the streets of Dhaka City, including rickshaw and leguna. Rickshaw is a three-wheeled, non-motorized vehicle that is a very popular and easily available non-motorized vehicle (NMV) in Bangladesh (Ismat Esrar, 1992) that plays a crucial role in Dhaka's transport system (Hossain, 2011). On the other hand, Leguna is a short-distance vehicle, also known as a local passenger van. They are recognized as a special transportation service in Dhaka City with high flexibility and availability in selected routes only (Rahman, 2016). The public transportation of Dhaka City consists of primarily buses and leguna.

Analysis of travel mode choice as shown in Fig. 2 reveals a drastic fall in bus and leguna use during the pandemic. Usually, in public transport, a large number of people travel together within a limited space. COVID-19 pandemic induced social distancing measures reduced the preference for bus and leguna, while sharply increasing online activity. A large percentage of the respondents are students/young adults whose academic institutions and offices have shifted activity from physical tasks to online. The use of nearly all the modes of travel has decreased except for cycle and walking, where the preference of cycle increased slightly and that of walking escalated dramatically during COVID-19 period.

Inertia analyses of overall mode preferences using Sankey diagrams as shown in Fig. 3 assessed whether or not the respondents continue to rely on the same mode used before COVID-19. The overall mode preference before and during COVID-19 are displayed on the left and right sides of Fig. 3 respectively. Fig. 3 depicts that almost 50% bus users shifted to the more available and cheaper rickshaw. The remaining people still using bus are at great risk of getting infected. However, a small percentage of ride sharing car users shifted to online while a smaller percentage shifted to private cars or ride sharing cars. The remaining people still using bus are at great risk of being affected by COVID-19. However, a small percentage of ride sharing car users shifted to the more available and cheaper rickshaw.

Fig. 4 reveals the variation in average journey duration at pre-COVID and COVID times. Although the journey time has decreased from a majority of 31–45 min before COVID-19 to 16–30 min during COVID-19 (because of lower vehicle density on roads), the reduction is small. This is because a considerable number of people continue to make trips because of the normal physical nature of their jobs. Consequently, the proportion of people travelling during morning rush hour has not changed much during COVID-19, as shown in Fig. 5. Thus virus transmission may be high.

4.3. Analyses of trip purposes and overall trip generation

Fig. 6 represents the percentage of respondents making trips of various frequencies for work and academic purposes per week. Fig. 6 reveals a large drop in (5–8 times per week) W/A trips, which have been replaced by online activities. Most of these trips would be the trips to educational institutes. However, 37.7% respondents still travel 5–8 times per week while 10.4% travel 1–4 times per week during COVID-19, indicating these people still go to work physically. So, compared to students, the job-holders and earners of the family are at greater risk of getting infection. In this study, shopping trips are considered as trips to shopping centers and malls to purchase cosmetics, electronic products and other luxurious products. In the figure FUTMST stands for “Feels Unnecessary To Make Shopping Trips”. As shown in Fig. 7, both shopping and grocery trips have decreased. People are either buying the bare necessities or buying more things in the same trip. Interestingly, shopping trips have decreased more than grocery trips have, possibly because of greater online prevalence for shopping trips.

The proportion of respondents disinterested in recreational trips more than doubled to 78.7% during COVID-19. This is because people feel recreation trips are considered as non-essential trips and thus avoid these trips to protect themselves from virus contagion. On the other hand, medical trips have decreased less than other types of trips. Although, the trips for other purposes declined, people still have to make trips to hospitals, medical test centers and to pharmacies. The situation has been exacerbated because of transportation of COVID-19 patients. Hence, a scope still remains for the spreading of virus through trip generation. There has been a slight increase in the telemedicine activity, which matches with the report from National Telehealth Centre (DGHS, 2021a). This should be promoted more in the future.

Overall, respondents have shifted from high frequency trips to lower frequencies as presented in Fig. 7. Still, a considerable amount of trips is generated during the pandemic as offices, markets and emergency services are still open except for academic institutes.

4.4. Examining the difference in trip frequency for each purposes

Five separate t-tests have been analyzed for five trip purposes. Like many statistical procedures, the null hypothesis asserts that there is no significant difference in the true mean between the paired samples. On the other hand, the alternate hypothesis assumes that there is a significant difference between the means. Table 1 reveals a significant change in trip frequency in all trip purposes since the significant value (Sig. value) is less than 0.05 at 95% confidence level for all cases. Based on the t-value, shopping trips hold the greatest difference while medical trips hold the least differences due to the COVID-19 pandemic.

4.5. Association between trip purposes and demographic characteristics

Fig. 8 temporally compares trip frequency for various trip purposes related to the characteristics using stacked graphs. It can be seen that, W/A trips reduced during COVID-19 as expected, particularly the reduction by females was more than of males. This indicates that males are more vulnerable to COVID-19 infection. A large percentage of people from age groups 25–30, 31–40 and 41–60 still work physically per week from office to ensure smooth operation. This age group refers adults, from age groups 25, indicating these people still go to work physically. So, compared

Fig. 8 reveals that females generated less shopping trips during the pandemic compared to males, highlighting the greater adaptation of females to the usage of online shopping facilities (Dashe, 2019). Children and the elderly reduced shopping trips significantly during COVID-19.
whereas the younger and middle-aged people still make noticeable shopping trips. Worker, craftsman and people from “Others” occupation stopped making shopping trips and feel unnecessary to make shopping trips during the crisis.

The reason for less reduction of grocery trips could be the regular obligatory demand of grocery items. In fact, people aged between (31–40) category and (41–60) are going to markets physically to buy groceries, exposing themselves to virus infection. Lack of online activity in Fig. 8 for purchasing groceries in “Craftsman” category describes that not all people have access or knowledge to use internet.

All categories of people drastically reduced their recreational trips. All high frequency trip generations declined, while most people became disinterested in making recreational trips as mentioned earlier in Section 4.4.

There has been a noticeable increase in the usage of Telemedicine service. People have become more interested during the pandemic to satisfy their medical purposes using fewer trips.

4.6. Correlation matrix

It can be seen from Fig. 9 that none of the value of $r$ is above 0.7; meaning that factors are distinct and independent of each other referring there is no multicollinearity between the factors. Hence, it would be possible to examine the individual explanation of all the independent variables on the dependent variable by statistical modelling which is explained in the following section.

4.7. Home-based trip generation model

This section presents the estimated parameters and Odd Ratio (OR) of OLR models to assess the effect of trip-makers demographic characteristics attributes on the overall trip generation. OR indicates the multiplicative change in the odds of being in a higher category on the Overall Number of Trips (ONT) generated before COVID-19 for every one-unit increase on the demographic factors, holding the remaining factors constant. Two models have been analyzed, one focusing on trip numbers before COVID-19 pandemic, and another one during the pandemic. The independent variables are chosen after ensuring there was no multicollinearity among the independent variables, as shown in Fig. 9.

Model 1

Model 1 (M1) investigates the effect of demographic factors on the overall number of trips (ONT) generated before COVID-19, where the considered factors are Gender (Y1), Age (Y2), Net monthly income.
(NMI) (Y3) and Occupation (Y4). From Table 2, it can be seen that Gender, Age and NMI have significant impact on ONT. The significance value (Sig.) is less than 0.05, which indicates that the variables are statistically significant. Estimates ($\beta$) for Y2 is negative, meaning older people made fewer trips before COVID-19. The estimate parameter for Y3 is positive, referring before COVID-19 high income group generate more trips than the remaining people. Since, the significance level of Y4 greater than 0.05, generation of (ONT) before COVID-19 is independent of occupation. OR for Age (0.780) is below 1, indicates moving from one category to another (downward), the odd of increasing ONT generated before COVID-19 is 0.780 by one ordinal scale.

Based on Table 2 the equation can be expressed as

\[
\log \left[ \frac{P(Y \leq j)}{1 - P(Y \leq j)} \right] = \alpha_j + 0.952Y1 - 0.248Y2 + 0.378Y3 + 0.041Y4 \text{ where, } j = 1, \ldots, J - 1
\]
Model 2

Model 2 (M2) investigates the significance of demographic factors on the overall number of trips (ONT) generated during COVID-19 pandemic, where the considered factors are Gender (Y1), Age (Y2), Net monthly income (NMI) (Y3) and Occupation (Y4). During COVID-19, the travel behavior has changed. From Table 3, it can be seen that Gender, NMI and Occupation have significant impact on ONT during COVID-19 period. Since, Y2 has significance level greater than 0.05, generation of (ONT) during COVID-19 is independent of Age. The estimate (β) for NMI is still positive. This indicates, even in the pandemic people with high income generate more trips.

Based on Table 3 the equation can be expressed as

\[
\log \left[ \frac{P(Y \leq j)}{1 - P(Y \leq j)} \right] = \alpha_j + 1.083Y1 - 0.092Y2 + 0.564Y3 + 0.304Y4 \text{ where, } j = 1, \ldots, J - 1
\]

### 4.7.1. Model fitting information

The significance value (Sig.) of the chi-square test for both ordered regression models are less than 0.05. Therefore, we reject the null hypothesis where null hypothesis states there is no significant difference between Baseline Model to Final Model. As a result, there is a significant difference between Baseline Model to Final Model, hence the Final Model is well established. For both the models, the (Sig.) of the Pearson statistics and deviation statistics are less than 0.05 for the fitting degree test, which indicates that the fitting degree of both the models are good (Zhang et al., 2019). Suitabilities are assessed and confirmed for M1 and M2 respectively using the following goodness of fit indicators: log Likelihood (1080.840, 1002.441), Pearson goodness of fit statistic (1104.490, 1391.792), Deviance statistic (897.611, 878.733) (Cramer, 2010).
Fig. 8. (a): Temporal comparison of trip frequency for Work trip purpose, (b): Temporal comparison of trip frequency for Shopping trip purpose, (c): Temporal comparison of trip frequency for Grocery trip purpose, (d): Temporal comparison of trip frequency for Recreation trip purpose, (e): Temporal comparison of trip frequency for medical trip purpose.
(c): Temporal comparison of trip frequency for Grocery trip purpose

(d): Temporal comparison of trip frequency for Recreation trip purpose

Fig. 8. (continued)
5. Discussion and policy implications

These findings display an unconventional change in the urban mobility landscape. As the world is still fighting the pandemic, this change can transcend into a new regular way of living. Hence, priority must be given to appropriate transport planning and policy measures reflecting on sustainable urban mobility objectives and accomplishing the greater community goals under such crucial circumstances.

Since public transport has been associated with an increased risk of viral transmission, (Anwari et al., 2021) the use of bus and leguna has drastically declined during COVID-19. On the other hand, private car usage has not decreased much during the pandemic period, as people feel safer travelling in private cars. Consequently, traffic congestion and air quality in Dhaka City continue to get worse (Rahman et al., 2019; Sakib, 2021). Interestingly, the rich prefer to use private cars, while the poor and middle class rely on public transport during pandemic. 8.91% of respondents continue to use the bus during pandemic (Fig. 2) as the travel cost is far less than that of private transport, especially on long journeys. Thus, transport planners and operators need to focus on improvements of public transport by upgrading both safety and level of

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**Fig. 8.** Temporal comparison of trip frequency for medical trip purpose

**Fig. 9.** Correlation matrix for demographic attributes of trip-makers.
service of buses and leguna to ensure a sustainable transportation system for Dhaka City. The internal design of buses can be modified and rearranged while using dividers to facilitate physical distancing among passengers as they board and descend from them (Bhaduri et al., 2020; Politis et al., 2021). To prevent virus transmission through banknote payments in buses and leguna, contactless payment like mobile financial services (MFS) can be implemented.

Another mode which the Bangladesh government should focus on is the rickshaw. Fig. 2 reveals a negligible change in rickshaw usage during the pandemic. Rickshaw occupies a special role in being both affordable to the poor and offering greater social seclusion compared to public transport. However, the rickshaw is usually suitable for short-distance travel. The current governmental limitation imposed on bus usage (to 50% seats) has forced some users to switch to rickshaws, which may explain the relatively unchanged travel preference for rickshaws during the pandemic (Anwari et al., 2021). However, the problem with rickshaws is that rickshaw pullers are either capricious regarding sanitizing facilities or unable to afford financially the disinfectants and safety masks. Thus, the viral transmission increases through high-volume movements of rickshaws. Recommending minimal use of rickshaws can be an easy way to reduce the rate of transmission, but this decision can cut the income source of the rickshaw pullers who hail from low-income households. In addition, low and middle-income groups are more likely to be socially excluded if both the bus and rickshaw are not available anymore. Hence, transport policymakers need to emphasize the use of bicycles and rickshaws with proper sanitizing facilities so that all these people hailing from the low-income groups can do safe travels and at the same time maintain their income.

Active transport (bicycle and walking) can be promoted during the pandemic to ensure social distancing while retaining mental and physical fitness (De Vos, 2020). Despite the potential of bicycles to reduce air pollution and help maintain a healthy lifestyle, its usage has not increased much during the pandemic (Fig. 2) because of insufficient facilities for bicycle riders in the roadway (Chiran, 2021). Transport infrastructure operators should thus give emphasis on building and maintaining safe and bicycle lanes to promote cycling amongst the youth and to attract the private vehicle riders to shift to bicycles.

Completely opposite to the trend observed in other modes, pedestrian activity has jumped in the COVID-19 pandemic (Fig. 2). Studies in other countries also revealed similar results on walking (Aloi et al., 2020; de Haas et al., 2020; Mogaji, 2020). However, previous studies have revealed the lack of safe walking conditions in Dhaka City (Debnath et al., 2021). Thus, the Government needs to improve walkway facilities in Dhaka City.

According to Fig. 8, male trip-makers travel more compared to females even during the pandemic. Hence, they are more susceptible to COVID-19 infection. As a result, maximum COVID-19 patients are males in Bangladesh (DGHS, 2021a). Numerous studies have revealed similar behavior on the risk of male travelers (Abdullah et al., 2020; Bhaduri et al., 2020; Anwari et al., 2021; Politis et al., 2021). This is because in

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**Table 2**

| Overall number of trips generated before COVID-19 model estimation (M1) | Estimate (β) | Std. Error | Wald | df | Sig. | Odd Ratio (OR) | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|
| Threshold | [ONT before COVID-19 − 0] | −1.437 | 0.187 | 59.301 | 1 | 0.000 | 0.248 | 0.944 |
| | [ONT before COVID-19 − 1] | 0.596 | 0.178 | 11.259 | 1 | 0.001 | 2.667 | 3.069 |
| | [ONT before COVID-19 − 2] | 2.668 | 0.205 | 169.877 | 1 | 0.000 | 6.374 | 8.032 |
| | [ONT before COVID-19 − 3] | 3.923 | 0.254 | 237.647 | 1 | 0.000 | 3.424 | 4.421 |

**Table 3**

| Overall number of trips generated during COVID-19 model estimation (M2) | Estimate (β) | Std. Error | Wald | df | Sig. | Odd Ratio (OR) | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|
| Threshold | [ONT during COVID-19 − 0] | 1.948 | 0.216 | 81.494 | 1 | 0.000 | 1.525 | 2.371 |
| | [ONT during COVID-19 − 1] | 3.772 | 0.247 | 232.855 | 1 | 0.000 | 3.127 | 4.256 |
| | [ONT during COVID-19 − 2] | 6.367 | 0.339 | 352.969 | 1 | 0.000 | 5.703 | 7.031 |
| | [ONT during COVID-19 − 3] | 7.203 | 0.423 | 290.868 | 1 | 0.000 | 6.374 | 8.032 |

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developing countries like Bangladesh, mostly males have to work outside to earn for the family, whereas females look after the home (Ahmed et al., 2021). Hence, local authorities need to create awareness among the men and take necessary action so that males take extra safety practices during their pandemic trips. On the other hand, adults aged between 31 and 60 years have generated a considerable amount of trips during the pandemic for working and buying groceries physically, as shown in Fig. 8. Thus, national authorities and policymakers should focus on these specific age groups of people to minimize exposure to the virus.

Although the average travel time decreases during COVID-19, the traffic congestion and travel delay still occurred during the peak period of the day, mostly during 5:00 AM-9:00 AM (Fig. 5). This may still create crowding situations and stimulate virus transmission. Policy makers should dynamically plan by combining a range of strategies involving regulation of flexible operating hours of various managerial departments and essential businesses implementation of the role of ICT in behavioral changes. Developing countries like Bangladesh where a large proportion of people do not have access or have limited usage knowledge about ICT tools should focus on ensuring how people can still participate in activities that have largely shifted to ICT solutions to reduce unnecessary travel demand (Anwari et al., 2021). Helplines and psychological assistance services can be widened for all age groups and occupations to use the internet to meet a variety of social needs. All meetings, conferences and desk jobs should be encouraged to be performed online.

6. Conclusion

The main concern of this study was to investigate the change in travel behavior and trip characteristics of residents of Dhaka City due to the outbreak of COVID-19. A questionnaire survey was conducted online along with a face-to-face interview to assess the travel behavior of 806 Dhaka City residents. Through various descriptive analyses, appropriate statistical tests, and home-based trip-generation models, this study has compared the fundamental mobility patterns at during-COVID-19 and pre-COVID-19 levels. Bus and leguna usage have declined during COVID-19, yet 9% of respondents still use these modes during the pandemic and hence are at increased risk of disease contraction. On the other hand, there is a negligible decrease in the usage of cars and rickshaws. Moreover, cycle usage has increased slightly while walking has increased dramatically, indicating people’s increased preference for active transport. Fig. 4 shows that the trip duration of most trips has decreased from 30 to 45 min (before pandemic) to 16–30 min during the pandemic. However, respondents’ preference for making trips during the morning peak periods remain considerably high during the pandemic (Fig. 5). Paired sample t-tests revealed significant differences in trips, particularly in shopping trips. Stacked graphs display that during COVID-19, females use more online facilities to do academic classes, perform their works and shopping compare to males. Online education/work tendency decrease in behavioral changes. Stacked graphs display that during COVID-19, females use more online facilities to do academic classes, perform their works and shopping compared to males. Online education/work tendency decreases in people aged over 24 years. Blue-collar workers still have to commute physically. Although people reduced their shopping trip frequencies, adults aged 31–60 still visit grocery markets physically 1–2 times per week. OLR modelling reveals that gender, age and NMI had significant impact on overall travel before COVID-19, while gender, NMI and occupation had a significant impact on overall travel during COVID-19.

This study suggests numerous future research insights. First, there is a need for continued estimations considering more exclusive factors that will enable researchers to measure how travel experiences and behavior change in a broader way over time till the COVID-19 pandemic continues. Second, future research can estimate changes in activities and travel behavior post-pandemic.

CRediT authorship contribution statement

Tommy Paul: Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Review and editing, Visualization. Abu Bakar Siddik Ornob: Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Visualization. Rohit Chakraborty: Methodology, Software, Validation, Writing – original draft, Visualization. Nafis Anwari: Conceptualization, Supervision, Writing – review & editing.

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