

Risk perceptions of COVID-19 transmission in different travel modes

Niaz Mahmud Zafri ^{a,*}, Asif Khan ^a, Shaila Jamal ^b, Bhuiyan Monwar Alam ^c

^a Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh

^b School of Earth, Environment & Society, McMaster University, 1280 Main St. West, Hamilton, ON L8S 4K1, Canada

^c Department of Geography & Planning, University of Toledo, OH 43606, USA

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ABSTRACT

COVID-19 pandemic has caused adverse impacts on different aspects of life around the globe, including travelers' mode choice behavior. To make their travel safe, transportation planners and policymakers need to understand people's perceptions of the risk of COVID-19 transmission in different travel modes. This study aimed to estimate mode-wise perceived risk of viral transmission and identify the factors that influenced the perceived risk in Bangladesh. The study used a five-point Likert scale to measure the perceived risk of COVID-19 transmission in each travel mode. Using ordinal logistic regression models, the study explored the factors that influenced the perceived risk of COVID-19 transmission in different travel modes. The study found that people perceived a very high risk of viral transmission in public transport (bus), moderate risk in shared modes (rickshaw, auto-rickshaw, ridesharing), and very low risk in private modes (private car, motorcycle/scooter, walking, cycling). Such high-risk perception of viral transmission in public transport and shared modes might lead to a modal shift to private modes, which would worsen urban transport problems and undermine sustainable transportation goals. The study also found that socio-economic factors (gender, age, income) significantly influenced perceived risks in all travel modes. Contrarily, psychological factors (worry, care, and trust) were significant only for public and shared modes, but not for private modes. Lastly, travel behavior-related factors influenced perceived risk in shared and private modes.

Background

Contagious diseases have been impacting the world for many centuries (Zafri et al., 2021). The Spanish Flu, a particular type of influenza, emerged in 1918, resulting in around 500 million people being infected and ten percent of the infected people died (CDC, 2009). Severe Acute Respiratory Syndrome (SARS) is an ongoing worldwide pandemic that emerged in Hong Kong in 2003, resulting in about 8,500 infections; more than one-tenth of whom died so far (WHO, 2003). The H1N1, also known as Influenza A, was a short-lived pandemic between 2009 and 2010, mainly affecting the U.S. and Mexico (Al-Muharrmi, 2010). Middle East Respiratory Syndrome (MERS), caused by the novel Coronavirus MERS-CoV, affected more than 27 countries after starting from Saudi Arabia in 2012 (Killerby et al., 2020). Besides these, some other contagious diseases, such as Seasonal Dengue and Chikungunya, Diphtheria, Plague, Foot and Mouth Disease, Bird Flu, Swine Flu, Ebola, Zika Virus, Cholera, and Yellow Fever have impacted locally and regionally (WHO, 2020). The latest and devastating one, named COVID-19, continues to profoundly impact the world in all aspects of people's lives. As

of 18 June 2021, approximately 178 million people worldwide have been infected by COVID-19, resulting in 3.86 million deaths (Worldometer, 2020).

Climate change and other human-induced factors, including encroachment into the forests, have increased the frequencies of the epidemic and pandemic events and their intensities (Boukerche and Mohammad-Roberts, 2020; Stanford, 2020). It seems that even if we manage to curb COVID-19 at some point, new pandemics will emerge. People's response to different incidences of pandemic outbreaks has been quite similar (Muley et al., 2020). Therefore, we should be prepared to minimize the effects of pandemics by taking lessons from past and present experiences. Research on the COVID-19 pandemic covering various aspects will be helpful to fight this and future emerging pandemic situation.

Previous studies suggest that a confined space has a higher probability of COVID-19 transmission (Tirachini and Cats, 2020). The implication for transportation is that the modes in which passengers ride with others in a confined space are likely to be unsafe compared to the modes in which people travel alone or share with a small number of people

* Corresponding author.

E-mail addresses: zafri@urp.buet.ac.bd (N.M. Zafri), asif@urp.buet.ac.bd (A. Khan), jamals16@mcmaster.ca (S. Jamal), bhuiyan.alam@utoledo.edu (B.M. Alam).

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known to them (De Vos, 2020). The virus can also spread by touching the surface contaminated by Coronavirus germs from infected people and touching the nose or mouth afterward (ECDC, 2020). There is high chance of this occurrence in public and shared transport modes. Therefore, a large number of people reduced their travel by public and shared transport modes and shifted towards active and private transport modes since the detection of COVID-19 (Bhaduri, 2020; Shakibaei et al., 2021; Zhang, 2021; Zafri et al., 2021). Researchers assumed that people's perception of risk in different travel modes could influence their decision regarding mode choice (Tirachini and Cats, 2020; De Vos, 2020; Budd and Ison, 2020). Therefore, it is necessary to understand people's perceived risk of COVID-19 transmission in different modes. This understanding would also be helpful to predict mode choice behavior during the COVID-19 pandemic as well as for the future emerging pandemic.

Muley, Shahin (Muley et al., 2020) systematically reviewed the scientific literature on the relationship between transportation and pandemics to understand transportation's role in controlling infectious diseases and the impacts of these events on different transportation aspects. Through their comprehensive review, they were in a well-placed position to identify future research areas on these topics. According to them, there is limited research on the change in travel behavior due to pandemics and recommended examining travelers' perception of the risk of infection and their attitude towards different transportation modes. To the best of our knowledge, no existing empirical study has examined people's perceptions about the risk of COVID-19 transmission in different travel modes. To address this gap, we conducted a questionnaire survey in Bangladesh to explore individuals' perceived risk of COVID-19 transmission in different modes and identify factors that influenced their perceived risks.

Bangladesh experienced health emergencies at different scales in the last two decades, but none was more devastating than the COVID-19 (Zafri et al., 2021). The first confirmed COVID-19 case in Bangladesh was recorded on 8 March 2020 (GoB, 2021). The number of registered infected people stood at 844,970, including 13.5 thousand casualties, till 18 June 2021 (GoB, 2021). The actual number of infections is likely to be higher due to underreporting of COVID-19 cases in Bangladesh (Biswas et al., 2020). In the initial period, government responses included border control, closure of offices, businesses, educational institutions, lockdown of places, and restrictions on inter-city and intra-city movements from 26 March 2020 (Zafri et al., 2021). This state continued for about two months, after which all the activities were gradually resumed, except the educational institutions (Zafri et al., 2021).

The educational institutions are still closed as Bangladesh experienced the second wave from early-March 2021, despite starting the vaccination drive from 7 February 2021 (The Daily Star, 2021). The highest number of COVID-19 infection cases per day was recorded on 7 April 2021, when the number reached 7,626 (The Daily Star, 2021). A new record was created when 112 people died of Coronavirus in Bangladesh on 19 April 2021 (The Daily Star, 2021).

Regarding the country's overall transportation system, different sizes of buses make up the public transport system in Bangladesh (DTCA, 2015). The public transport service was allowed to resume from 1 June 2020 after the first wave, on the condition of following some strict hygiene-related and safety guidelines (Zafri et al., 2021; The Daily Star, 2020). The services were temporarily suspended again from 5 April 2021 for a month as the country gradually went under strict lockdown following the second wave (Zafri et al., 2021). Since 6 May 2021, public transport services have been running again at 50% capacity and charging 60% extra fare under new directives. However, due to the lack of enforcement of the rules, the directives are hardly being followed (Shafiq, 2021).

Literature review

People's perception and travel behavior

The relationships among people's perception, attitude, and behavior have received attention from different disciplines (Reibstein et al., 1980). From the social psychology perspective, the "Theory of Planned Behaviour" by Ajzen (Ajzen et al., 1985) has been widely used to explain mode choice behavior. According to the theory, an individual's behavior and action are guided by the perceptions and attitudes they possess. Beliefs about a factor or phenomena can control the decision regarding furthering or hindering a particular behavior (Ajzen et al., 1985).

Therefore, if perception and attitude dictate behavior, then behavior towards an entity can be changed by altering people's perception of that entity (Reibstein et al., 1980). This can be done by altering its traits or persuading people to change their perceptions. Another study concluded that "choice of travel mode is largely a reasoned decision", and if circumstances remain unchanged, the travel mode choice also will remain relatively stable or unchanged [Bamberg et al., 2003, p. 175]. There might be a possibility that this pandemic might change travel behavior circumstances by changing people's perception of the risk of viral transmission in different travel modes (Muley et al., 2020).

Before the pandemic, in general, it was found that there were differences in the perception of public transport users and non-users regarding characteristics of travel by public transport and car (Reibstein et al., 1980). It indicates that users of different transportation modes perceive a set of attributes differently. Therefore, it is likely that perceptions of particular attributes associated with modes can lead people to prefer one mode over the others.

A study that examined the influence of a few factors contributing to choosing a travel destination found that perception of risks and safety played an important role in avoiding certain destinations (Sönmez and Graefe, 1998). The study also found that the level of safety perceptions varied from person to person. These findings imply that the perception of risk and safety is likely to be an important determinant of travel behavior. These findings are also consistent with the findings of Spears, Houston (Spears et al., 2013). They found that personal safety concern is a strong predictor of travel by public transport even after controlling other factors such as road network permeability and public transport service quality.

COVID-19 and travel behavior

The perceived risk of COVID-19 was a significant factor that dictated human mobility and risk-taking behaviors. Human mobility significantly declined even before lockdowns were declared and other restrictive measures were imposed to confine viral transmission in the regions where people had more risk-averse attitudes (Chan et al., 2020). Lockdowns and restrictive measures declared by governments and the severity of local outbreaks considerably influenced human mobility behavior during the COVID-19 (Zafri et al., 2021; Pan et al., 2020). Day-to-day travel reduced significantly due to these governmental measures (Tirachini and Cats, 2020; Zafri et al., 2021; Bucsky, 2020). For example, only one-tenth of the people in Karachi, Pakistan, made outdoor trips (Balkhi, 2020). Businesses, offices, and educational institutions were closed down while the places providing essential services kept running (Mahase, 2020). Non-essential activities were performed virtually on a limited scale (Astroza et al., 2020). Enormous economic damage resulted in the world. The GDP growth rate reduced from 3% to 2.4% in 2020 (Duffin, 2020). One of the main reasons behind this was the immobility of individuals and goods due to the pandemic.

Due to the negative pressure on the economic sector, restrictive measures were gradually lifted, and the volume of trips started to increase, although it has not reached the pre-COVID-19 levels (Zafri et al., 2021). Some companies are functioning virtually, and quite a high proportion of educational institutions remain closed or are operating

online (Holmes, 2020). Those who needed to travel were encouraged and compelled in some countries to adopt personal safety measures outdoors and in public places (Al Jazeera, 2020). Within a few months of the pandemic's arrival, there was an indication of travel behavior change. Apart from reduced travel, people have changed their trip purpose, travel mode, destination, and travel distance (Abdullah, 2020; Bhaduri, 2020; Muley et al., 2020; Shakibaei et al., 2021; Tokey,; Zafri et al., 2021). For instance, the modal share of public transport in Budapest, Hungary dropped from 43% to 18% (Bucsky, 2020). The main beneficiaries of the COVID-19 were private cars and cycles. Their share rose from 43% to 65% and from 2% to 4%, respectively (Bucsky, 2020). While this scenario was observed in Budapest during mobility restrictions, similar situations were experienced in other countries in the post-lockdown period during the pandemic. For example, a study conducted by Abdullah, Dias (Abdullah, 2020), based on a questionnaire survey of 1,203 people across more than fifteen countries, found that the modal share of private vehicles increased from 32% to 39%. At the same time, for public transport, it decreased from 36% to 13% for primary trip purposes during COVID-19. Considerable reductions in travel by public transport are likely to be related to perceptions of transmission risks on board (Tirachini and Cats, 2020). Studies conducted during the preliminary days of COVID-19 had hypothesized that people were likely to avoid public transport owing to the difficulty in ensuring a safe physical distance inside the vehicle (De Vos, 2020; Zafri et al., 2021).

COVID-19 and risk perception

Risk perception refers to the instinctive evaluation of the people regarding a hazard they might be exposed to (Cori et al., 2020). Analyzing risk perception and identifying factors influencing risk perception are important for understanding people's risk-taking behavior. People who perceive lower risk tend to take more risky behavior and less preventive measures to protect them from the hazard (Adefuye et al., 2009). Only a few studies have analyzed public risk perceptions of the COVID-19 pandemic (Bruine de Bruin, 2020; Dryhurst, 2020; He et al., 2021; Ding et al., 2020). In summary, risk perceptions of COVID-19 are influenced by several individual factors, which can be categorized into two broad categories—socio-economic factors and psychological factors.

Among the socio-economic factors, gender and age of the people are the most important determinants of risk perceptions of the COVID-19 pandemic. Females and older people perceive higher risk than males and younger people, respectively (Bruine de Bruin, 2020; Ding et al., 2020). People from higher-income groups perceive higher risk than lower-income groups (He et al., 2021). People with more knowledge who regularly keep themselves updated on pandemic information have a higher risk perception than others (Ding et al., 2020; Abir et al., 2020; Chen et al., 2020). People living with children or having household members with chronic diseases perceive a higher risk of COVID-19 (He et al., 2021).

Among the psychological factors, trust and concerns (worries) significantly influence the risk perception of COVID-19 (Dryhurst, 2020; Khosravi, 2020). People with higher trust in preventive strategies and government and medical professionals have lower risk perceptions of COVID-19. People who worry much about the impact of COVID-19 perceive a higher level of risk. The rest of the significant psychological predictors of risk perception are personal experience with the virus, individualistic and prosocial values, and individual and collective efficacy (Cori et al., 2020; Dryhurst, 2020).

Methodology

Data collection

We administrated a web-based survey between July and August 2020. The method started with constructing a draft questionnaire

following the literature review. It was revised after pilot testing. Once the questionnaire was finalized, we hired five surveyors to disseminate the questionnaire through electronic means. The survey was promoted in social media pages and groups through Facebook advertisements, using personal and professional networks, as well as by contacting the administrators of social media pages and groups to share the survey questionnaire. Facebook advertisements and all other steps helped collect data from a diverse sample by reaching a broader audience of Bangladesh. To inform the respondents about the survey, we mentioned the purpose of the study, the information to be collected, and the confidentiality of the collected information in the questionnaire. The questions and instructions were written in English and Bengali—the local language—so that, people were clear about what to do and felt comfortable while responding. Participation in the survey was voluntary. We used non-random sampling techniques to select samples for the survey as this technique was the most feasible sampling technique during the early pandemic (Shakibaei et al., 2021; Zafri et al., 2021). We received 804 responses from all over Bangladesh, and all of them were complete and valid. The spatial distribution of the collected samples is presented in Fig. 1.

Conducting a face-to-face survey was impractical and unsafe during the COVID-19 pandemic and would violate the physical/social distancing restrictions. Therefore, we conducted an online survey, for which our study has some limitations like other COVID-19 related studies conducted in the same way [e.g., Abdullah, 2020; Bhaduri, 2020; Shakibaei et al., 2021; Zafri et al., 2021]. Our online survey might not have covered people from all socio-economic groups, especially people who did not have internet access. A large portion of the respondents were young adults and belonged to the higher socio-economic groups of Bangladesh (Table 1), similar to other online survey-based studies (Bhaduri, 2020). We acknowledge this limitation of our survey.

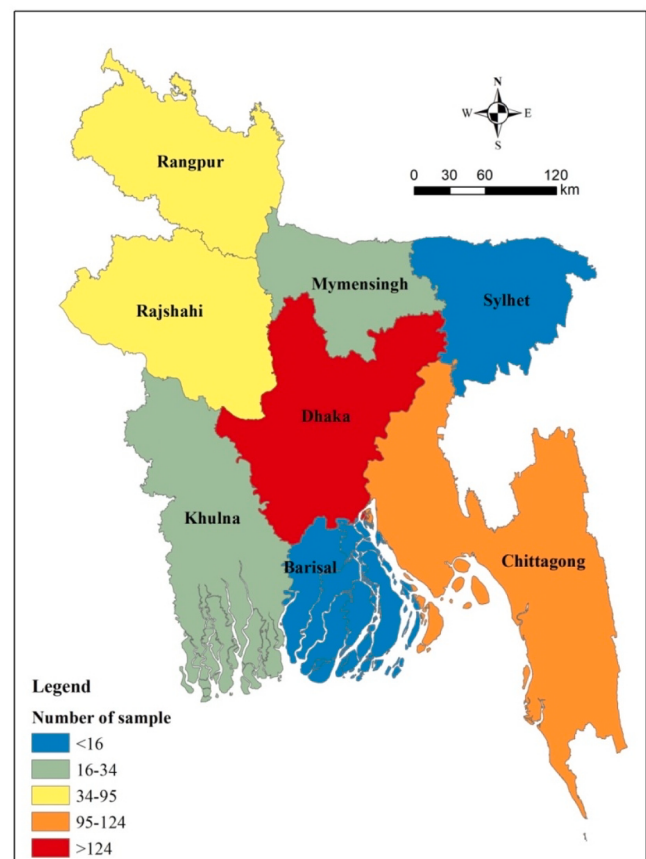


Fig. 1. Distribution of the collected sample across eight administrative divisions of Bangladesh.

Table 1
Summary statistics of the independent variables.

Variable	Note	%	Mean
Socio-economic variables			
Gender	Dummy variable: 1 if the respondent is male; 0 otherwise	67.0	
Age group 1	Dummy variable: 1 if the respondent is young (aged < 30 years); 0 otherwise	83.6	
Age group 2	Dummy variable: 1 if the respondent is middle-aged (aged 30–60 years); 0 otherwise	16.0	
Age group 3	Dummy variable: 1 if the respondent is old (aged greater than 60 years); 0 otherwise	0.4	
Income group 1	Dummy variable: 1 if the respondent is from the low-income group (<20000 BDT); 0 otherwise	19.7	
Income group 2	Dummy variable: 1 if the respondent is from the middle-income group (20000–60000 BDT); 0 otherwise	55.8	
Income group 3	Dummy variable: 1 if the respondent is from the high-income group (>60000 BDT); 0 otherwise	24.3	
Household size	Number of people in the household		4.55
Place of living	Dummy variable: 1 if the respondent is from a divisional district; 0 otherwise	64.7	
Psychological variables			
Confidence in one's immune system	Agreement with the statement (Five-point Likert scale: 1 = Strongly disagree, 5 = Strongly agree): "I feel that my immune system is very strong, and I am less likely to be affected by the COVID-19."		2.35
Trust in preventive strategies	Agreement with the statement (Five-point Likert scale: 1 = Strongly disagree, 5 = Strongly agree): "The more we take precautions and follow the health guidelines, the less is the risk of being affected by the COVID-19."		4.13
Worry about the health impact	Agreement with the statement (Five-point Likert scale: 1 = Strongly disagree, 5 = Strongly agree): "I am worried about the health impacts of COVID-19 in Bangladesh."		4.04
Care about risk	Dummy variable: 1 if the respondent does not care; 0 otherwise	14.8	
Keeping updated about pandemic 1	Dummy variable: 1 if the respondent keeps update regularly (at least once a day); 0 otherwise	75.2	
Keeping updated about pandemic 2	Dummy variable: 1 if the respondent keeps update occasionally (at least once a week); 0 otherwise	11.6	
Keeping updated about pandemic 3	Dummy variable: 1 if the respondent keeps update rarely; 0 otherwise	13.2	
Travel behavior-related variables			
Car ownership	Dummy variable: 1 if the respondent's household owned any private car; 0 otherwise	29.7	
Motorcycle ownership	Dummy variable: 1 if the respondent's household owned any motorcycle; 0 otherwise	30.5	
Bicycle ownership	Dummy variable: 1 if the respondent's household owned any bicycle; 0 otherwise	67.4	
Regular use travel mode 1	Dummy variable: 1 if public transport; 0 otherwise	30.8	
Regular use travel mode 2	Dummy variable: 1 if walking; 0 otherwise	19.5	
Regular use travel mode 3	Dummy variable: 1 if shared mode (e.g., CNG (auto-rickshaw), rickshaw, ridesharing); 0 otherwise	26.9	
Regular use travel mode 4	Dummy variable: 1 if private mode (e.g., cycling, motorcycle, car); 0 otherwise	22.8	

However, from Table 1, the sample characteristics of the respondents show that we were able to collect the sample from a diverse group of people of Bangladesh despite facing some challenges. Also, a large sample from young and middle-aged groups for a study like this should not be a significant concern in the case of Bangladesh, as people mostly

retire before they are 60 years (for example, the retirement age for government employees is 59 years). In addition, young and middle-aged people are students and working-age people, and they have the most travel demand. On the other hand, older people have limited travel demand, and due to the pandemic, their travel demand has decreased more. In conclusion, it could be said that although 804 samples collected through non-random sampling might not describe the risk perception of the people with the highest level of precision, it was sufficient to get an overall idea by achieving a decent precision and discuss the consequences and formulate policy recommendations.

We collected the data on 'perceived risk of COVID-19 transmission in different modes' on a five-point Likert scale ranging from 'extremely low = 1' to 'extremely high = 5' covering the usual modes used in Bangladesh—bus, private car, motorcycle/scooter, cycling, rickshaw (three-wheeler non-motorized human paddled mode carrying 1–2 passengers), auto-rickshaw (three-wheeler motorized mode carrying 1–4 passengers, locally known as CNG), ridesharing, and walking. Travel behavior-related data such as regular transport mode and vehicle ownership (e.g., car, motorcycle, bicycle) and respondents' socio-demographic characteristics (e.g., age, gender, income, and living arrangements) were collected as well. We also asked a set of perception-based questions to understand how the respondents perceived the COVID-19 transmission risks while using different transport modes.

Data analysis

First, we conducted a descriptive analysis (e.g., preparing graphs and tables) to estimate the perceived risk scores of COVID-19 transmission in different travel modes and identify possible reasons behind those results. We also conducted a one-way ANOVA test and Games-Howell post-hoc test to reveal any significant difference among mean risk perception scores of different travel modes. Finally, we ran separate ordinal logistic regression models to identify the contributory factors of the perceived risk of COVID-19 transmission in each travel mode. Ordinal logistic regression attempts to model the relationship between an ordinal dependent variable and one or more independent variables (Harrell and Harrell, 2015). In this study, the perceived risk of COVID-19 transmission of each travel mode was the dependent variable, which was measured on a five-point Likert scale. So, the dependent variable is an ordinal variable in nature. Therefore, ordinal logistic regression models were the appropriate method for this study. The socio-economic characteristics of the respondents, their psychological perceptions about COVID-19, as well as their travel behavior-related variables were used as independent variables to develop the model (Table 1). Description and summary statistics of the independent variables are presented in Table 1.

The ordinal regression model estimates coefficient (β), odds ratio (OR), and p -value for each independent variable. P -value shows which independent variables have a statistically significant impact on the perceived risk of COVID-19 transmission. In addition, a positive coefficient (β) of an independent variable indicates that the perceived risk of COVID-19 transmission increases with an increase in that variable, and a negative coefficient (β) indicates the opposite. OR is the exponential of the coefficient (β). For positive coefficient (β), OR value is found to be greater than one; whereas, OR value becomes less than one when the coefficient is negative. For a categorical independent variable, if the OR value is found X for one outcome of that variable, then the perceived risk of COVID-19 transmission is X times lower or higher for that outcome compared to the second outcome of that independent variable. For continuous/ordinal (Likert scale type) independent variables, if the OR value is found X , a single unit increase in that variable will increase/decrease the perceived risk of COVID-19 transmission X times.

Results and discussion

Mode-wise perceived risk of COVID-19 transmission

Fig. 2 shows the distribution as well as the mean and standard deviation scores of the perceived risk of COVID-19 transmission for eight

travel modes. Mean scores varied between 1.56 and 4.24 on a 5-point scale, indicating a mode-wise enormous difference in perceived risks of viral transmission. The perceived risk was found to be the highest for the bus (4.24), followed by ridesharing (3.51), auto-rickshaw (CNG) (3.34), rickshaw (3.07), motorcycle/scooter (1.92), cycling (1.81), walking (1.80), and private car (1.56). One-way ANOVA confirmed a

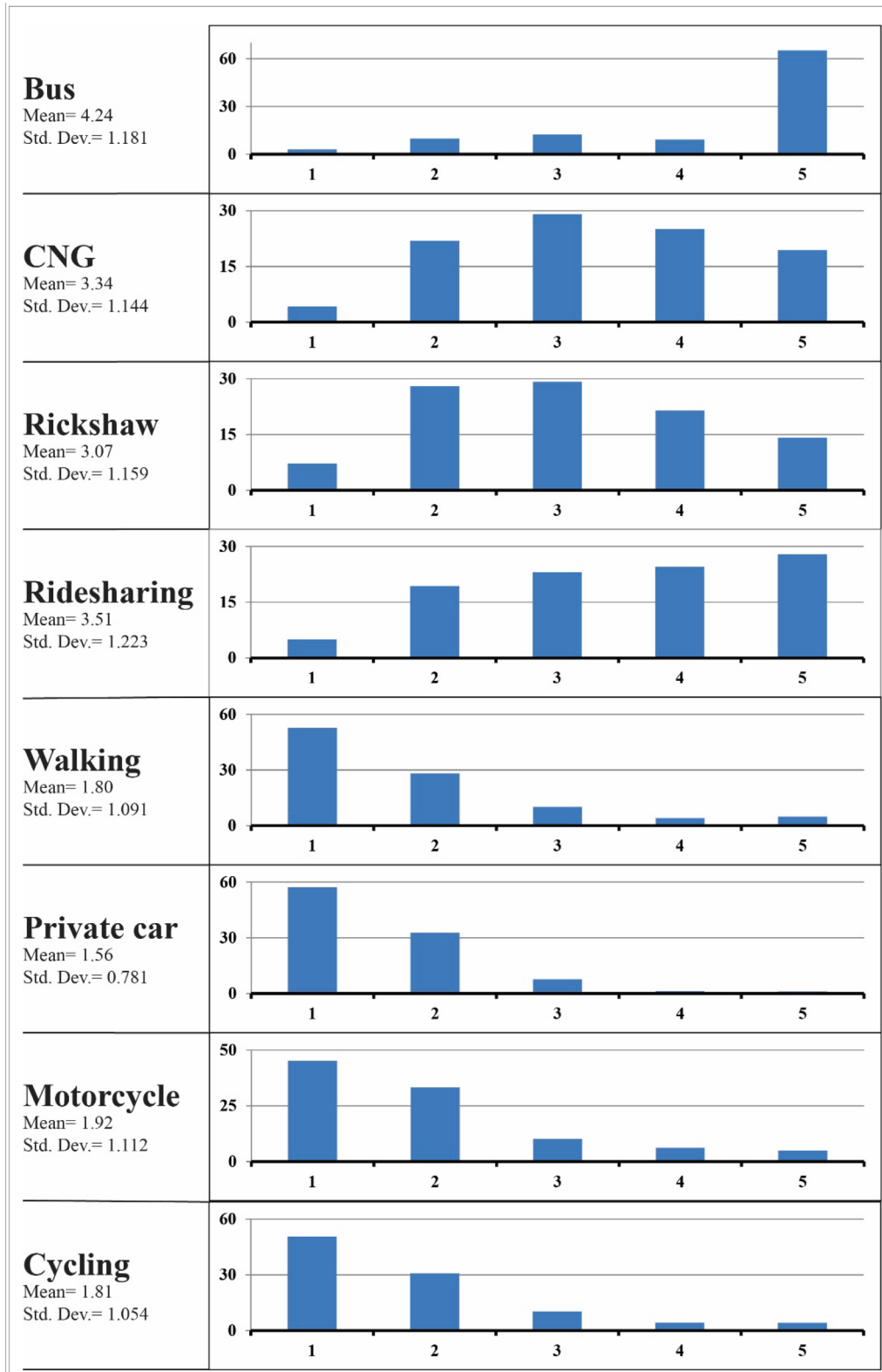


Fig. 2. Mode-wise perceived risk of COVID-19 transmission (5-point Likert scale: 1 = extremely low, 5 = extremely high).

significant difference in the perceived risk levels ($F(7, 6424) = 669.45$, $p = 0.000$) (Table 2). A Games-Howell post-hoc test revealed significant differences among the modes ($p < 0.01$), except walking, motorcycle/scooter, and cycling (Table 2). The eight travel modes could be categorized under three broad categories, based on the mean scores and mean difference of perceived risk as well as mode characteristics. These three broad categories are public transport (bus), shared mode/para-transit (CNG, rickshaw, and ridesharing), and private modes (private car, motorcycle/scooter, cycling, and walking). The perceived risk was the lowest for private modes and the highest for public transport modes. The risk level was found as 'moderate' for the shared modes.

A set of supplementary questions was asked to identify the reasons behind the mode-wise perceived risk of COVID-19 transmission of the respondents on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. The percentages of the responses to those statements are presented in Table 3. Results show that more than 70% of the respondents disagreed with the statement that it is possible to maintain social/physical distancing in public transport modes, while about the same portion of respondents agreed that it is possible to maintain it in private modes. In addition, around 76% of the respondents agreed that the bus was a suitable transport mode for spreading infectious diseases like COVID-19. About 66% agreed that the probability of maintaining hygiene (or disinfecting) in shared modes was less as multiple passengers use them. Furthermore, 75% of the respondents agreed that it was easier to maintain hygiene (e.g., sanitizing, and wearing gloves and masks) in personal vehicles than public transport and shared modes. Lastly, around 60% of respondents agreed that using a helmet in a motorcycle/scooter would help to prevent the spread of COVID-19.

Public transport can be considered a transmission ground for a virus. It could bring infected and non-infected passengers close to each other, where it might be difficult to avoid contact with the infected passenger (Troko et al., 2011). In Bangladesh, ensuring personal hygiene and maintaining social distancing in public transport is very difficult because of extreme overcrowding inside the bus, human-to-human interactions, fare payment by cash, vehicles' limitations (e.g., entering and exiting using a single door, insufficient space between two rows of seats), and lack of effort for disinfecting the bus regularly (Islam, 2020). Therefore, it is reasonable that the perceived risk of viral transmission was the highest for public transport modes. If an infected passenger uses a shared mode, its exposed surfaces become transfer points of the virus to other passengers who will touch the same surfaces. On the other hand, people could use private modes in the way they wanted and could take any preventive measures anytime to protect them from being infected by the virus (De Vos, 2020; Bucsky, 2020). Therefore, people perceived private modes safer than shared and public transport modes.

Modal shift from public transport and shared modes to private modes might be a probable outcome of the COVID-19 pandemic since people perceived that the risk of viral transmission in public transport and shared modes is more than private modes. In Bangladesh, studies showed that the use of public buses and shared modes was likely to decrease, and the use of private modes (motorcycle, car) and active modes was likely to increase due to the pandemic (Abdullah, 2020; Anwari, 2021; Zafri et al., 2021; Zafri et al., 2021). Lessons from China, where there was a

Table 3

Descriptive statistics of supplementary questions.

Question	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)
Social/physical distancing is possible in public transport.	37.7	35.6	10.4	12.1	4.2
Social/physical distancing is possible in private modes.	7.6	8.5	14.9	44.8	24.3
The bus is a suitable mode for spreading infectious diseases like COVID-19.	10.2	6.1	7.6	31.2	44.9
Since multiple passengers use share modes, there will be less possibility of disinfecting them.	8.5	12.3	13.1	43.5	22.6
Maintaining hygiene in private modes is easier compared to public and shared modes of transportation.	7.5	7.8	9	36.6	39.2
Wearing a helmet in a motorcycle/scooter will provide additional protection from the spread of COVID-19.	9.5	11.7	19	41.8	18

modal shift from bus/metro to private cars due to the pandemic, are consistent with this speculation (Ipsos, 2020). Also, in India, 35% of people were likely to change their travel mode for work trips during the post-COVID-19 period, and they would mostly shift from public transport to private modes (Thakur et al., 2020). This modal shift might bring an unprecedented negative impact on the urban transportation system in Bangladesh in a short period. One of the major problems that urban areas in Bangladesh have already started facing is the high number of private cars operating on the road (RAJUK, 2015). An increase in the number of private cars might worsen the traffic congestion problem in urban Bangladesh. Besides, an increase in the number of motorcycles might deteriorate traffic safety and complicate traffic management (DTCA, 2015; Zafri et al., 2021). Furthermore, the Government of Bangladesh has been planning to improve the country's public transportation system, including developing a mass transit system in Dhaka (e.g., MRT, BRT), which is under construction (DTCA, 2015; RAJUK,

Table 2One-Way ANOVA test and Games-Howell (post-hoc) test results: Mean difference (p -value).

	Private car	Bus	Rickshaw	CNG	Walk	Motorcycle/scooter	Bicycle	Ridesharing
Private car	–							
Bus	2.6 (0.00)	–						
Rickshaw	1.5 (0.00)	1.1 (0.00)	–					
CNG	1.7 (0.00)	0.9 (0.00)	0.2 (0.00)	–				
Walking	0.2 (0.00)	2.4 (0.00)	1.2 (0.00)	1.5 (0.00)	–			
Motorcycle/scooter	0.3 (0.00)	2.3 (0.00)	1.1 (0.00)	1.4 (0.00)	0.1 (0.36)	–		
Cycling	0.2 (0.00)	2.4 (0.00)	1.2 (0.00)	1.5 (0.00)	0.0 (1.00)	0.1 (0.40)	–	
Ridesharing	1.9 (0.00)	0.7 (0.00)	0.4 (0.00)	0.1 (0.06)	1.7 (0.00)	1.5 (0.00)	1.7 (0.00)	–
One-way ANOVA test results: $F(7, 6424) = 669.45$, p -value = 0.000								

2015). However, the declining share of public transport could affect the process of improvement as well as the introduction of a mass transit system. Therefore, it could be reiterated that the expected modal shift due to the COVID-19 pandemic might deteriorate the urban transportation system by increasing congestion, complicating traffic management, deteriorating traffic safety, and worsening air pollution. Increasing walk and bicycle trips could be the only positive side of the modal shift. However, it is unlikely to happen as most of the urban roads of Bangladesh are not pedestrian-friendly, and there is no mentionable infrastructure and facility available to encourage bicycle use (Gallagher, 2017).

Factors influencing the perceived risk of COVID-19 transmission

To determine the factors that influence the perceived risk of COVID-19 transmission, separate ordinal logistic regression models for each travel mode were developed. Table 4 presents the estimated coefficients (β), odds ratios (OR), and p -values of the significant independent variables as well as summary statistics of the developed models. Model statistics show that all the models were statistically significant ($p < 0.01$). However, the pseudo R^2 values for all the models are found to be low (highest for bus: 14%, lowest for walking: 2%). Low R^2 values were also found in previous studies related to COVID-19 risk perception (Dryhurst, 2020; Ding et al., 2020). The very low pseudo R^2 values for private modes indicate that the significant independent variables in the model were able to explain limited variation in the perceived risk of COVID-19 transmission. Interpretation of the results and discussion on the results are presented in the following sections.

Socio-economic variable

Among the socio-economic variables, gender was found significant and negative for public transport (bus), shared modes (CNG, rickshaw,

ridesharing), and cycling, indicating that male respondents perceived less risk of viral transmission in these modes than their female counterparts (Table 4). The middle-aged (30–60 years old) respondents perceived more risk of viral transmission in auto-rickshaw (CNG), rickshaw, motorcycle/scooter, and cycling than young respondents (Table 4). These results are consistent with the existing studies (Dryhurst, 2020; He et al., 2021; Ding et al., 2020), which show that females' and older people's perceived risk of COVID-19 is higher. According to these studies, females and older people are more risk-sensitive. Therefore, they engage in less risk-taking behaviors. They perceive themselves as more vulnerable, and their thoughts are more delicate than male and young people.

Income was found to be a significant influencing factor for the perceived risk of bus, walking, motorcycle/scooter, and cycling. The low-income group perceived less risk of viral transmission in public transportation, walking, motorcycle, and cycling than the higher income group (Table 4). He, Chen (He et al., 2021) show that perceived risk regarding COVID-19 was higher among the higher income group. The reason might be that the low-income group might be less aware of the COVID-19 transmission risk in modes and more likely to be concerned about their livelihood than the higher income group. In addition, the higher income groups usually travel in private modes, and they rated the transmission risk of the bus by comparing it with the mode they use regularly. Therefore, they perceived more risk on riding public transportation modes. The higher income group who are not using private modes is more likely to make a modal shift as they can afford a private mode.

Psychological variable

The model results show that psychological variables significantly explain the variation in public transport and shared modes (Table 4). Worries about the health impact of COVID-19 had a significant positive

Table 4
Results of ordinal logistic regression models.

Variables	Public transport (bus)		Shared mode/ Para-transit						Private modes							
	β	OR	CNG		Rickshaw		Ridesharing		Walking		Private car		Motorcycle		Cycling	
	β	OR	β	OR	β	OR	β	OR	β	OR	β	OR	β	OR	β	OR
Intercepts (Thresholds)																
Perceived risk = 1	-2.4*	0.1	-2.1*	0.1	-1.5*	0.2	-2.0*	0.1	0.1	1.1	0.1	1.1	-0.3*	0.8	-0.5*	0.6
Perceived risk = 2	-0.7*	0.5	0.1	1.1	0.5**	1.7	-0.1	0.9	1.5*	4.3	2.0*	7.3	1.2*	3.5	1.0*	2.7
Perceived risk = 3	0.2	1.2	1.5*	4.3	1.8*	6.1	1.1*	2.9	2.3*	10.2	3.5*	34.0	2.0*	7.6	1.9*	7.0
Perceived risk = 4	0.7**	2.0	2.7*	15.5	3.1*	21.6	2.2*	8.9	3.0*	19.8	4.3*	72.7	2.9*	18.7	2.7*	15.0
Socio-economic variable																
Gender: Male	-0.3***	0.7	-0.5*	0.6	-0.3**	0.7	-0.3**	0.7							-0.5*	0.6
Age group 2: Middle-aged			0.4**	1.5	0.4**	1.5							0.4**	1.5	0.5*	1.6
Income group 1: Low-income group	-0.5*	0.6											-0.5*	0.6	-0.5*	0.6
Income group 3: High-income group									0.3**	1.4						
Psychological variable																
Worry about the health impact	0.2**	1.2														
Trust in preventive strategies	0.2*	1.3	0.4*	1.4	0.3*	1.3	0.3*	1.4								
Care about risk: don't care	-1.0*	0.4	-0.7*	0.5	-0.4*	0.7	-0.6*	0.5								
Travel behavior related variable																
Car ownership											-0.6*	0.6				
Regular use travel mode 2: Walking									-0.5*	0.6			-0.3***	0.7	-0.7*	0.5
Regular use travel mode 3: Shared mode															-0.3**	0.7
Regular use travel mode 4: Private mode			0.5*	1.7	0.7*	2.0	0.4**	1.4			-0.4***	0.7				
Model Statistics																
Model fit (p -value)	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Nagelkerke R square (pseudo)	0.14		0.12		0.09		0.09		0.02		0.03		0.03		0.60	

N.B.: *significant at a 99% confidence level; **significant at a 95% confidence level; ***significant at a 90% confidence level.

impact on the perceived risk of viral transmission in public transportation. Trust in the preventive strategies variable had a significant positive impact on the perceived risk of viral transmission in all public transport and shared modes. This impact was found negative for the care about risk variable. When we interpreted these results, we understood that the perceived risk of COVID-19 transmission in public transport and shared modes increased if the respondents were worried about the health impact, had a higher level of trust in the preventive strategies, and cared about risk. These results are consistent with previous studies, which suggested that the perception of risk was higher if the people were worried about COVID-19 (Abir et al., 2020). Khosravi (Khosravi, 2020) argued that early concerns and trust of the public could assume a fundamental function in improving the apparent danger of a pandemic and expanding public interest in taking preventive measures. On the other hand, the opposite result was found in the studies by Dryhurst, Schneider (Dryhurst, 2020) and Cori, Bianchi (Cori et al., 2020), where they showed that a higher level of trust led to a lower level of risk perception. One explanation could be that people who have a higher level of trust in preventive strategies might understand the difficulties of maintaining these strategies in public transport and shared modes. Therefore, they perceive higher risk in these modes. One of the interesting findings is that none of the psychological variables showed a significant impact on the perceived risk of viral transmission in private modes. Therefore, authorities of public transport and shared modes need to take steps to gain the passengers' trust and reduce their concerns to prevent the potential undesirable modal shift.

Travel behavior-related variable

Travel behavior-related variables were significant for shared modes and private modes (Table 4). Respondents who used private modes for regular travel perceived a significantly higher risk of COVID-19 transmission in shared modes and lower risk in private modes. In addition, respondents who own a car perceive significantly lower risk in a private car. Besides, respondents who regularly travel on foot perceived low risk of viral transmission in walking, motorcycle, and cycling. Furthermore, respondents using shared modes for regular travel perceived lower risk in cycling. Based on this result, it could be expected that no modal shift from private modes is likely to happen as the private mode users perceived their existing travel modes as safer than others. However, an expected modal shift from shared modes to private modes, especially to cycling, is possible if a favorable environment is provided.

Conclusion

To anticipate the impact of COVID-19 pandemic on people's travel behavior, it is essential to understand people's perception of the risk of COVID-19 transmission in different travel modes. Therefore, this study aimed to estimate the mode-wise perceived risk of viral transmission and identify the factors that influenced the perceived risk. The findings of the study show that people perceived high risk of viral transmission in public transport (bus). On the other hand, they perceived moderate risk in shared modes (rickshaw, CNG, and ridesharing) and very low risk in private modes (private car, motorcycle/scooter, walking, and cycling). Due to high-risk perceptions in public transport and shared modes, a modal shift to private modes is possible. Unfortunately, such an increase in private modes' trip share at the expense of public transport would worsen urban transportation problems and undermine sustainable transportation goals.

Findings also suggest that socio-economic factors such as gender, age, and income significantly influence the perceived risk of all the considered modes. According to the findings, females may reduce their travel through public transport and shared modes of transport due to their perceived high risk of viral transmission. For the similar reason, individuals between 30 and 60 years may reduce travel through shared modes. Although we did not find any significant association between 30 and 60 year old people and the perceived risk of public transport, it is

highly unlikely that those who perceived shared modes as highly risky would switch to public transport as they will require to share the vehicle with more strangers. Therefore, individuals of this group may switch to private modes as well. As most of the working population belongs to this age group, a crucial consequence will occur for Bangladesh in terms of transportation demand management and a hindrance to ensure sustainability in the transportation sector if these individuals switch to private modes. In addition, we found that the low-income group is less likely to perceive high risk of viral transmission in terms of using public transport. One of the possible reasons could be unaffordability or lack of alternative modes for them to travel as highlighted by Jamal et al. (2022). Therefore, they kept traveling by public transport during the pandemic. As a result, confidence against possible viral transmission was developed among them, and consequently, they perceived low risk while traveling by public transport.

Interestingly, psychological factors such as worry, care, and trust were not significant for private modes, but they were significant for public transport and shared modes. As the findings suggest, those concerned about the health impact of COVID-19 and trust personal hygiene preventive measures were more likely to perceive higher risk in terms of using public transport. Lastly, private mode users were highly likely to perceive shared modes as a risk mode regarding viral transmission. We can link these findings to the "Theory of Planned Behaviour" by Ajzen (Ajzen et al., 1985), and can conclude that individuals who are female, between 30 and 60 years, do not fall within the low-income group, and are more concerned about health and hygiene likely to change their travel mode as there has been a change in their perceptions regarding viral transmission. Also, according to the theory, even though individuals' beliefs, perceptions, and attitudes can be biased, these produce their corresponding behavioral intentions and ultimately, individuals conduct the activity and show the behavior that is consistent with the beliefs, perceptions, and attitudes they possess (Ajzen et al., 1985; Bamberg et al., 2003). We cannot assert that similar implications will be experienced in all developing countries as there is differences in transportation infrastructures, available transportation modes, their affordability and public attitudes, beliefs and perceptions. However, countries with comparable socio-economic and cultural backgrounds with similar levels of transportation infrastructure may experience similar perceived risks in terms of using different transportation modes.

The findings of this study also showed that people perceived very low risk in active travel modes. Therefore, it can be concluded that the COVID-19 provides an opportunity to improve of the active transportation system. The government should provide adequate infrastructures and facilities to make the urban areas pedestrian-friendly so that pedestrians feel encouraged to travel more by walking, especially in high-density areas and commercial hubs. Cycling mode needs to be given preference over the motorized modes. A comprehensive study should be undertaken to examine the needs of the cyclists to understand the problems they face and address those through appropriate measures.

This study did not measure the actual risk of COVID-19 transmission in different travel modes. Future studies might be conducted to measure actual and perceived risk to compare if respondents tend to overestimate or underestimate the actual risk. Besides, this study is based on the survey conducted during the 1st wave of COVID-19. Further studies could be conducted to examine how the perceived risk has changed over time. Lastly, we conducted this study before the development of the vaccine. Presently, vaccination campaigns are being carried out throughout the world, including Bangladesh. It is likely that the perceived risk of COVID-19 transmission in different travel modes has changed after mass vaccination. Therefore, researchers should conduct further studies to analyze perceived risk after mass vaccination and compare their results with the pre-vaccination period.

CRediT authorship contribution statement

Niaz Mahmud Zafri: Conceptualization, Methodology, Formal

analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Asif Khan:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **Shaila Jamal:** Conceptualization, Methodology, Data curation, Writing – review & editing. **Bhuiyan Monwar Alam:** Conceptualization, Writing – review & editing, Supervision.

Declaration of Competing Interest

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

References

- Abdullah, M., et al., 2020. Exploring the impacts of COVID-19 on travel behavior and mode preferences. *Transportation Research Interdisciplinary Perspectives* 8, 100255.
- Abir, T., Kalimullah, N.A., Osuagwu, U.L., Yazdani, D.-A., Mamun, A.A., Husain, T., Basak, P., Permarupan, P.Y., Agho, K.E., 2020. Factors Associated with the Perception of Risk and Knowledge of Contracting the SARS-Cov-2 among Adults in Bangladesh: Analysis of Online Surveys. *Int. J. Environ. Res. Public Health* 17 (14), 5252. <https://doi.org/10.3390/ijerph17145252>.
- Adefuye, A.S., Abiona, T.C., Balogun, J.A., Lukobo-Durrell, M., 2009. HIV sexual risk behaviors and perception of risk among college students: implications for planning interventions. *BMC Public Health* 9 (1). <https://doi.org/10.1186/1471-2458-9-281>.
- Ajzen, I., 1985. From intentions to actions: a theory of planned behavior. In: Kuhl, J., Beckmann, J. (Eds.), *Action Control: From Cognition to Behavior*. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 11–39.
- Al-Muharri, Z., 2010. Understanding the influenza A H1N1 2009 pandemic. *Sultan Qaboos Univ. Med. J.* 10 (2), 187–195.
- Anwari, N., et al., 2021. Exploring the travel behavior changes caused by the COVID-19 crisis: A case study for a developing country. *Transport. Res. Interdiscipl. Perspect.* 9, 100334.
- Astroza, S., et al., *Mobility Changes, Teleworking, and Remote Communication during the COVID-19 Pandemic in Chile*. Trasport Findings, 2020. July.
- Balkhi, F., et al., *Psychological and Behavioral Response to the Coronavirus (COVID-19) Pandemic*. *Cureus*, 2020. 12(5): p. e7923-e7923.
- Bamberg, S., Ajzen, I., Schmidt, P., 2003. Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic Appl. Soc. Psychol.* 25 (3), 175–187.
- Bhaduri, E., et al., 2020. Modelling the effects of COVID-19 on travel mode choice behaviour in India. *Transport. Res. Interdiscipl. Perspect.* 8, 100273.
- Biswas, R.K., Afiaz, A., Huq, S., 2020. Underreporting COVID-19: the curious case of the Indian subcontinent. *Epidemiol. Infect.* 148, e207.
- Boukerche, S. and R. Mohammad-Roberts. *Fighting infectious diseases: The connection to climate change*. 2020 23 August, 2020; Available from: <https://blogs.worldbank.org/climatechange/fighting-infectious-diseases-connection-climate-change>.
- Bruine de Bruin, W., *Age Differences in COVID-19 Risk Perceptions and Mental Health: Evidence From a National U.S. Survey Conducted in March 2020*. The Journals of Gerontology: Series B, 2020.
- Bucksky, Péter, 2020. *Modal share changes due to COVID-19: The case of Budapest*. Transportation Research Interdisciplinary. Perspectives 8, 100141. <https://doi.org/10.1016/j.trip.2020.100141>.
- Budd, L., Ison, S., 2020. Responsible Transport: A post-COVID agenda for transport policy and practice. *Transport. Res. Interdiscipl. Perspect.* 6, 100151.
- CDC. 2009 H1N1 Pandemic (H1N1pdm09 virus). 2019; Available from: <https://www.cdc.gov/flu/pandemic-resources/2009-h1n1-pandemic.html>.
- Chan, H.F., Skali, A., Savage, D.A., Stadelmann, D., Torgler, B., 2020. Risk attitudes and human mobility during the COVID-19 pandemic. *Sci. Rep.* 10 (1) <https://doi.org/10.1038/s41598-020-76763-2>.
- Chen, Z.-L., et al., *Distribution of the COVID-19 epidemic and correlation with population emigration from Wuhan, China*. Chinese medical journal, 2020.
- Cori, L., Bianchi, F., Cadum, E., Anthonj, C., 2020. Risk Perception and COVID-19. *Int. J. Environ. Res. Public Health* 17 (9), 3114. <https://doi.org/10.3390/ijerph17093114>.
- De Vos, J., 2020. The effect of COVID-19 and subsequent social distancing on travel behavior. *Transport. Res. Interdiscipl. Perspect.* 5, 100121.
- Ding, Y., Du, X., Li, Q., Zhang, M., Zhang, Q., Tan, X., Liu, Q., Yi, S., 2020. Risk perception of coronavirus disease 2019 (COVID-19) and its related factors among college students in China during quarantine. *PLoS ONE* 15 (8), e0237626.
- Dryhurst, S., et al., 2020. Risk perceptions of COVID-19 around the world. *J. Risk Res.* 1–13.
- DTCA, The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, D.T.C.A. (DTCA), Editor. 2015.
- Duffin, E. *Impact of the coronavirus pandemic on the global economy*. 2020; Available from: <https://www.statista.com/topics/6139/covid-19-impact-on-the-global-economy/>.
- ECDC. *Transmission of COVID-19*. 2020; Available from: <https://www.ecdc.europa.eu/en/covid-19/latest-evidence/transmission>.
- Gallagher, R., 2017. Prioritising Dhaka's urban transport system. *J. Business Technol. (Dhaka)* 11 (1), 141–144.
- GoB. *Latest Status in Bangladesh*. 2021; Available from: <https://corona.gov.bd/>.
- Harrell, F.E., 2015. Ordinal Logistic Regression. In: Harrell, J.F.E. (Ed.), *Regression Modeling Strategies: With Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis*. Springer International Publishing, Cham, pp. 311–325.
- He, S., Chen, S., Kong, L., Liu, W., 2021. Analysis of Risk Perceptions and Related Factors Concerning COVID-19 Epidemic in Chongqing. *China. Journal of Community Health* 46 (2), 278–285.
- Ipsos. *Impact of Coronavirus to new car purchase in China*. 2020; Available from: <https://www.ipsos.com/en/impact-coronavirus-new-car-purchase-china>.
- Holmes, A., 2020. Facebook, Twitter, Google, and Microsoft will let employees work from home through 2020 or longer. Here's how tech companies are reconsidering remote work in the wake of COVID-19. in *Business Insider*.
- Islam, M.T., 2020. Social distancing in public transport yet another cruel joke. *The Business Standard*.
- Jazeera, A., *Which countries have made wearing face masks compulsory?*, in *AL Jazeera*. 2020.
- Jamal, S., Chowdhury, S., Newbold, K.B., 2022. Transport preferences and dilemmas in the post-lockdown (COVID-19) period: Findings from a qualitative study of young commuters in Dhaka, Bangladesh. *Case Studies on Transport Policy*. <https://doi.org/10.1016/j.cstp.2022.01.001>. In press.
- Khosravi, M., 2020. *Perceived Risk of COVID-19 Pandemic: The Role of Public Worry and Trust*. *Electronic Journal of General Medicine* 17 (4), em203. <https://doi.org/10.29333/ejgm/7856>.
- Killerby, M.E., Biggs, H.M., Midgley, C.M., Gerber, S.I., Watson, J.T., 2020. Middle east respiratory syndrome coronavirus transmission. *Emerg. Infect. Dis. J.* 26 (2), 191–198.
- Mahase, E., 2020. Covid-19: How does local lockdown work, and is it effective? *BMJ* 370, m2679.
- Muley, D., Shahin, M.d., Dias, C., Abdullah, M., 2020. Role of transport during outbreak of infectious diseases: evidence from the past. *Sustainability* 12 (18), 7367. <https://doi.org/10.3390/su12187367>.
- Pan, Y., Darzi, A., Kabiri, A., Zhao, G., Luo, W., Xiong, C., Zhang, L., 2020. Quantifying human mobility behaviour changes during the COVID-19 outbreak in the United States. *Sci. Rep.* 10 (1) <https://doi.org/10.1038/s41598-020-77751-2>.
- Zafri, N.M., et al., *Impact of COVID-19 Pandemic on Motorcycle Purchase in Dhaka, Bangladesh*. *Frontiers in Future Transportation*, 2021.
- RAJUK, *Dhaka Structure Plan 2016-2035*. 2015.
- Reibstein, D.J., Lovelock, C.H., Dobson, R.D.P., 1980. The Direction of Causality Between Perceptions, Affect, and Behavior: An Application to Travel Behavior. *Journal of Consumer Research* 6 (4), 370–376.
- Shafiq, S., 2021. Covid-19 health rules largely ignored on public transports. *Dhaka Tribune*.
- Shakibaei, S., de Jong, G.C., Alpkökin, P., Rashidi, T.H., 2021. Impact of the COVID-19 pandemic on travel behavior in Istanbul: A panel data analysis. *Sustainable Cities and Society* 65, 102619. <https://doi.org/10.1016/j.scs.2020.102619>.
- Sönmez, S.F., Graefe, A.R., 1998. Determining Future Travel Behavior from Past Travel Experience and Perceptions of Risk and Safety. *Journal of Travel Research* 37 (2), 171–177.
- Spears, S., Houston, D., Boarnet, M.G., 2013. Illuminating the unseen in transit use: A framework for examining the effect of attitudes and perceptions on travel behavior. *Transport. Res. Part A: Policy Practice* 58, 40–53.
- Stanford. *Forest loss makes diseases like COVID-19 more likely*. 2020; Available from: <https://www.futurity.org/forest-loss-zoonotic-diseases-pandemics-2331342/>.
- The Daily Star. *Public Transport: Pre-Covid fare, health rules not followed*. The Daily Star (2 September 2020) 2020 [cited 2020 27 September 2020]; Available from: <https://www.thedailystar.net/frontpage/news/public-transport-pre-covid-fare-health-rules-not-followed-1954377>.
- The Daily Star. *'Lockdown': Public transport services to resume tomorrow in 11 major cities*. *Coronavirus* (6 April 2021) 2021 [cited 2021 15 April]; Available from: <https://www.thedailystar.net/coronavirus-deadly-new-threat/news/govt-decides-resume-public-transport-services-divisional-cities-amid-restrictions-2073121>.
- The Daily Star. *New, grim record every day: 112 Covid-19 deaths in 24 hours*. *Coronavirus: A deadly threat* (1 May, 2021) 2021 [cited 2021 1 May]; Available from: <https://www.thedailystar.net/coronavirus-deadly-new-threat/news/new-grim-record-every-day-112-covid-19-deaths-24-hours-2080109>.
- Thakur, P., et al., *Impact of COVID-19 on Urban Mobility in India: Evidence from a Perception Study*. 2020: New Delh.
- Tirachini, A., Cats, O., 2020. COVID-19 and public transportation: current assessment, prospects, and research needs. *J. Public Transport*. 22 (1) <https://doi.org/10.5038/2375-090110.5038/2375-0901.22.110.5038/2375-0901.22.1.1>.
- Tokey, A.I., *Change of Bike-Share Usage in Five Cities of United States during COVID-19*. Findings, 2020. November.
- Troko, J., Myles, P., Gibson, J., Hashim, A., Enstone, J., Kingdon, S., Packham, C., Amin, S., Hayward, A., Van-Tam, J.N., 2011. Is public transport a risk factor for acute respiratory infection? *BMC Infect. Dis.* 11 (1) <https://doi.org/10.1186/1471-2334-11-16>.
- WHO. *Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update*. 2003; Available from: https://www.who.int/csr/don/2003_03_16/en/.
- WHO. *Emergencies preparedness, response*. 2020.
- Worldometer. *Countries where COVID-19 has spread*. *Coronavirus* (12 December 2020) 2021 [cited 2020 12 December]; Available from: <https://www.worldometers.info/coronavirus/countries-where-coronavirus-has-spread/>.
- Zafri, N.M., Afroj, S., Ali, M.A., Hasan, M.M.U., Rahman, M.H., Yuan, Q., 2021. Effectiveness of containment strategies and local cognition to control vehicular traffic volume in Dhaka, Bangladesh during COVID-19 pandemic: Use of Google Map based real-time traffic data. *PLoS ONE* 16 (5), e0252228.

- Zafri, N.M., Afroj, S., Nafi, I.M., Hasan, M.M.U., 2021. A content analysis of newspaper coverage of COVID-19 pandemic for developing a pandemic management framework. *Heliyon* 7 (3), e06544. <https://doi.org/10.1016/j.heliyon.2021.e06544>.
- Zafri, N.M., Khan, A., Jamal, S., Alam, B.M., 2021. Impacts of the COVID-19 pandemic on active travel mode choice in Bangladesh: A study from the perspective of sustainability and new normal situation. *Sustainability* 13 (12), 6975. <https://doi.org/10.3390/su13126975>.
- Zhang, N., et al., 2021. Changes in local travel behaviour before and during the COVID-19 pandemic in Hong Kong. *Cities* 112, 103139.