Transportation Research Part A 167 (2023) 103561

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Willingness to pay for COVID-19 mitigation measures in public transport and paratransit in low-income countries

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A R T I C L E I N F O

Keywords:
COVID-19
Public transport
Paratransit
Willingness to pay
Social distancing
Risk mitigation

A B S T R A C T

In order to combat the spread of COVID-19, various measures were taken in most countries to make public transit and paratransit safer. These additional measures, which include restrictions on number of passengers, provision of hand sanitisers and face coverings, and more frequent cleaning, add to the costs of operations or reduce profitability. The resulting financial pressure on the transport operators raises an important question on who pays for these additional measures. In most countries, this has been covered by one-time government bailouts to operators or strategies to increase fare, the latter of which directly affects the users. However, even without these interventions, there could be a demand and as such willingness to pay (WTP) for some of these intervention measures from the consumers concerned about safety. Knowing such WTP will not only help operators set their fare, but also help the governments decide the appropriate bailout needed. This paper addresses the issue by estimating the user's willingness to pay for selected COVID-19 mitigation measures in public transport and paratransit (motorcycle taxis) using survey data collected from two cities in low-income countries as case studies – Kampala, Uganda and Dhaka, Bangladesh. For public transport, these measures are - (1) social distancing (passenger loading at half capacity), and (2) mandatory hand sanitisation and increased cleaning of surfaces, while for paratransit, they are - (1) provision of a transparent shield between the rider and the passenger, and (2) provision of cleaned helmets at the start of each trip. The study analyses stated preference data using the utility maximisation framework and finds that the implementation or provision of COVID-19 mitigation measures improves the attractiveness of the associated public transport or paratransit alternatives, and transport users make trade-offs between safety and cost when making travel decisions. We find positive willingness to pay for all four mitigation measures, suggesting potential existence of a market for these measures. We also find that the typical mode choice factors such as costs, travel time and convenience became less important during the pandemic and the safety measures became more important considerations.

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https://doi.org/10.1016/j.tra.2022.103561
Received 28 February 2022; Received in revised form 27 November 2022; Accepted 3 December 2022
Available online 12 December 2022
0965-8564/

1. Introduction

The outbreak of COVID-19 has substantially affected travel behaviour, transport operations and associated policies in many countries across the world. As of now, the pandemic has taken over 6.56 Million lives, and infected over 626 Million people globally (Worldometer, 2022). The disease is known to spread through physical proximity via respiratory droplets of infected persons (WHO, 2020). As such, various countries responded by implementing unprecedented measures to minimise social proximity including isolation of arriving international passengers, introduction of local travel restrictions, and closure of schools, workplaces, shopping centres, and other public places, effectively imposing lockdowns at regional and/or national levels (De Vos, 2020). The lockdown measures were supplemented with additional preventive measures including social distancing, facemask wearing, hand sanitisation, and temperature screening.

However, such lockdowns could not be sustained for long in most countries due to the associated economic challenges and had to be lifted or eased, despite the potential risk of resurgence of new COVID-19 infections (Hargreaves, 2020). This has come with a raft of new measures affecting various sectors, including transport. The interventions in the transport sector have mainly affected public transport and paratransit, with some investments in walking and cycling provisions. Social distancing (passenger loading at reduced capacity), regular cleaning of vehicle interior surfaces, passenger hand sanitisation, compulsory wearing of face masks, and temperature screening have become requirements for public transport operation in various countries (MOH, 2020; De Vos, 2020; Tirachini & Cats, 2020; Dzisi & Dei, 2020; Wadud, et al., 2022). Similarly, for paratransit (motorcycle taxis), where it is impossible to achieve distancing between the driver and passenger(s) due to the small size of the vehicles, the measures introduced include regular sanitisation of motorcycle surfaces, compulsory wearing of helmets by riders,[1] and face masks by passengers (Otto, 2020). These new standards coupled with increased operating costs and reduced passenger demand have resulted in a financial crisis for public transport and paratransit operators, with many of them turning to their governments for bailouts (Tirachini & Cats, 2020; De Vos, 2020). While bailouts have been offered in many developed countries, this has not been done in most low-income countries where governments have limited or no capacity to subsidise transport services, which are often unorganized and loosely regulated. Consequently, most of the additional operating costs associated with COVID-19 mitigation have been transferred to transport users with little regard to their sensitivities. This could potentially lead to pressure from lobby groups and low compliance from users and operators, thereby jeopardising the progress made in making public transport and paratransit safe. This is a cause of concern especially in low-income countries where the rates of COVID-19 vaccination are still very low - currently standing at 9.5 % for the first dose (Our World in Data, 2022), and mitigiating the spread through transport related measures remains important.

The pandemic has also inspired innovation in both technological (Peters, et al., 2021) and non-technological areas (Athumani, 2020). In particular, installing transparent shields between riders and passengers on motorcycle taxis was either discussed or implemented as a means to reducing transmission in a few low-income countries, such as Uganda, Philippines or Indonesia. Yet some policymakers have argued that helmets may have more benefits compared to shields (Athumani, 2020). Regardless of the risk mitigation approaches, it is likely that the cost of adding the shields or cleaning the helmets will be transferred to the users, especially in the largely unorganized profit-driven motorcycle taxi sector in these countries.

The recent emergence of the Omicron variant suggests that it is still important for the policymakers and regulators to remain vigilant and open to new interventions to reduce transmission. For example, Bangladesh had recently proposed half-capacity public transport again (New Age, 2022), although this was later overturned due to pressure from transport lobby (Adhikary, 2022). Under the current circumstances, where most of the COVID-19 mitigation costs are being transferred to transport users, it is important to understand the users' willingness to pay (WTP) for COVID-19 mitigation to help guide policymakers on possible interventions to sustain compliance to the set guidelines for transport.

Given this context, this study uses Stated Preference (SP) data and discrete choice methods to estimate users' WTP for selected COVID-19 mitigation measures in public transport (buses and minibuses) and paratransit (motorcycle taxis) using two cities in low-income countries, Kampala (Uganda) and Dhaka (Bangladesh), as case studies. The study estimates the WTP for social distancing (half capacity) and sanitisation (of both hands and surfaces) in public transport, as well as, for provision of a shield (between the rider and passenger) and of a cleaned/disinfected helmet at the start of each trip in paratransit. Despite some literature on WTP for various COVID-19 mitigation measures in transport (Arunwuttipong, et al., 2021; Thombre & Agarwal, 2021; Awad-Núñez, et al., 2021), they did not investigate the relative importance attached to the different mitigation measures in monetary terms, a gap addressed in this study. There is also a lack of any studies on users' attitudes and willingness to pay for safety interventions in motorcycle taxis. In particular, we estimate the WTP for safety barriers on motorcycle taxis to test the feasibility of this innovation.

The rest of the paper is organised as follows, Section 2 presents a brief review of the literature, while Section 3 presents the survey design and data used in the study. Section 4 presents the econometric modelling framework, while Section 5 presents descriptive insights from the data, modelling results, and willingness to pay estimates. Section 6 draws conclusions.

[1] The term rider is often used to refer to a motorcycle taxi driver in Bangladesh and Uganda.

2. Literature review

2.1. The impacts of COVID-19 on public transport

Studies conducted in various countries have reported that the COVID-19 pandemic has substantially affected travel behaviour as most policies to mitigate the spread of the virus have restricted non-essential activities outside home (Arellana, et al., 2020; Beck & Hensher, 2020; Beck, et al., 2020; Ssali, 2020; Kitara & Ikoona, 2020). This has led to significant reductions in the number of trips, with public transport experiencing the greatest decline in ridership, mainly due to the high risk of transmission associated with mass travel (Teixeira & Lopes, 2020; Bucsky, 2020; de Haas, et al., 2020; Aloi, et al., 2020; Reza, et al., 2020). Many countries have seen increased reliance on private car travel (Campisi, et al., 2020; Abdullah, et al., 2020; Fatmi, 2020; Das, et al., 2021) and active travel (Zafri, et al., 2021; Zhang, et al., 2021; Budd & Ison, 2020; De Vos, 2020) as means to avoid proximity to others while making essential trips.

Despite the rise in active travel, public transport and paratransit system remains crucial to the functioning of large cities in the developing and emerging countries – and the lockdown measures could only be temporary. There were clear preferences among respondents in India to continue using their preferred pre-COVID modes during the pandemic (Bhaduri, et al., 2020), and for low-income countries, these are mainly public transport and paratransit modes. However, the need to maintain safe public transport operations during the pandemic has neccessiated the introduction of risk mitigation measures in public transport sector, as described earlier. These mitigation measures have come with cost implications for the operators which were either supported by government subsidies (Tirachini & Cats, 2020; De Vos, 2020) or increased fare for passengers. The latter case is more common in most low-income countries (Mogaji, 2020; Porter, et al., 2021), and requires further understanding of the passengers' willingness to pay for these increased costs.

2.2. The impacts of COVID-19 on paratransit (motorcycle taxis)

Motorcycle taxis are a popular mode of transport in many low-income countries (Ehebrecht, et al., 2018; Starkey, 2016; Wadud, 2020). This is largely attributed to the absence of reliable alternative public transport modes and the ability of motorcycle taxis to manoeuvre around traffic jams and provide fast door-to-door services, enabling quick access to essential social services and economic opportunities (Olvera, et al., 2012). The outbreak of COVID-19 has had significant negative impacts on motorcycle taxi transport in many countries, especially during lockdown periods, where passenger transport services were generally restricted and goods delivery services were promoted instead (Peters, et al., 2021). This led to an overall reduction in the number of trips, negatively affecting the revenues and livelihoods of operators, too (Batool, et al., 2022). To reverse the situation, different countries have introduced measures to ensure that motorcycle taxis get back to normal and safe operations. For example, in Uganda, the measures include regular sanitisation of motorcycle surfaces, carrying of strictly-one passenger, compulsory wearing of helmets by riders, and face masks by passengers (Otto, 2020). However, some of these measures have led to fare increases. Despite this increase, it is expected that motorcycle taxis will continue to dominate the urban transport market in most sub-Saharan and south-east Asian countries. Indeed, results from a worldwide expert survey show substantial mode shifts from public transport to motorcycles in various countries during the pandemic, with the shifts being much higher in India and other Asian countries (Zhang, et al., 2021).

The pandemic has also increased smartphone and mobile internet penetration among motorcycle taxi operators, who are increasingly relying on text messages, ride-hailing apps and e-payments to arrange trips (Peters, et al., 2021). Indigeneous innovations were also observed, of which safety barriers between motorcycle rider and passenger is a key one. These barriers have been mandated by the government in Philippines (DILG, 2020), and piloted in Indonesia by ridesourcing operator Grab (Ardiansyah & Purnomo, 2020). On the other hand, they were discouraged by authorities in Uganda (Athumani, 2020), citing lack of evidence about their effectiveness in mitigating the risks. Computational Fluid Dynamics (CFD) modelling shows that these shields can indeed reduce the risk of COVID-19 airborne transmission, thus allowing for safe travel (Hetherington, et al., 2021). However, it is not known whether the users are willing to pay extra (through increased fares) for such an innovation. This could dictate whether the market can have a role in providing such mitigation measures, or government mandates are required to encourage their use.

2.3. Previous studies on willingness to pay for COVID-19 mitigation measures

Following the outbreak of COVID-19, some studies have investigated the WTP for improved safety (reduced transmission risk) during travel. Awad-Núñez, et al. (2021) use Heckman's choice modelling framework to estimate the probabilities of accepting specific post-COVID-19 WTP levels (in terms of percentages above the current fare) linked to selected sanitisation measures and increased service frequency (to avoid crowding) in public transport and shared mobility services in Spain, however, they do not report the disaggregated WTP estimates for each mitigation measure in monetary terms. Thombre & Agarwal (2021) use descriptive statistics to establish the post-COVID-19 WTP for safer, faster, cleaner, comfortable and resilient public transport services in India in terms of percentages above the base fare. Similarly Arunwuttipong, et al. (2021) use descriptive statistics to estimate the mean and median WTP estimates for enhanced disinfection in public transport in Thailand. Away from transport, Oreffice & Quintana-Domeque (2021) estimate the general WTP for COVID-19 protective gear and how this is influenced by information on the rates of infection and death. However, to the best of our knowledge, no previous study has attempted to understand the underlying preferences and relative importance attached to the different mitigation measures in monetary terms.

3. Study design and data

3.1. Brief context of the case study cities

3.1.1. Kampala

Kampala is the capital and largest city of Uganda. The city has a multi-modal transport system comprising private cars, 14-seater small buses (matatus), buses, motorcycle taxis (boda bodas), cycling and walking. Like in many African cities, there is no formal public transport system in Kampala. Commuters rely on informal systems dominated by matatus (46 %) and boda bodas (32 %) followed by cars (19 %), then buses (2 %) (KCCA, 2018). Following the first confirmed case of COVID-19 in Uganda on 21 March 2020, transport was one of the most hit sectors, with public transport and motorcycle taxis being suspended and restrictions being placed on private vehicle travel on 25 March 2020. The resumption of transport operations came nearly-two and a half months later with new restrictions and regulations including carrying passengers at half capacity for public transport, limiting the number of private vehicle occupants to three (including the driver), compulsory sanitisation of hands and surfaces, temperature monitoring, and compulsory wearing of facemasks. It is worth noting that despite the resumption of transport operations in June 2020, services would occasionally be suspended following new waves of the pandemic in the country. The COVID-19 transport regulations remained in force and were only relaxed in April 2022 with increased vaccination drive (MOH, 2022).

3.1.2. Dhaka

Dhaka is the capital and largest city of Bangladesh. It is also among the megacities of the world, with a population of 16.8 Million (Cox, 2021), and the most densely populated city in the world. Despite its size, there are no rail based mass rapid transit in Dhaka, although one is currently under construction and is expected to open soon. The city's transportation needs are currently fulfilled by road transport vehicles like cars, buses, paratransit (laguna, autorickshaws, pedal rickshaws, motorcycle taxis), motorcycles, bicycles and walking. According to RSTP (2015), more than 60 % of the travellers use public transport for their journey to work. There were two lockdowns in Dhaka in response to COVID-19 that affected the public transport sector. All public transport activities (including trains, flights) were closed between March 28 and June 1 in 2020, when buses were allowed to operate at half capacity (with accompanying fare increases). Motorcycle taxis were banned for nearly 5 months. The second ban on public transport started on 5 April 2021, but the decision was quickly overturned to allow buses and trains to run at half capacities in 11 large cities. Nationwide, buses resumed operations much later on 11 August 2021, but only half of the buses were allowed. A third wave of restrictions in January 2022 on public transport was overturned almost as soon as it started due to the pressure from the strong transport lobby.

3.2. Survey design

The survey questionnaire was divided into three parts. The first part of the survey collected information on the respondent's travel behaviour before and during the pandemic, as well as their attitudes towards the COVID-19 mitigation measures in public transport and paratransit. The second part of the survey was a stated choice experiment only for respondents who frequently used either public transport or paratransit before the pandemic, and the experiments differed depending on the dominant mode category. The third part of the survey collected information on the demographics of the respondents, including their gender, age, level of education, employment status, income and parenthood status.

Respondents were presented with hypothetical choices requiring trading between the transport fare and selected COVID-19 mitigation attributes. The travel time attribute was not considered as the study focussed on choice between same mode alternatives, only with differences in the levels of implementation of the COVID-19 mitigation measures, and in all cases, these have the same travel time. This potentially limits our ability to capture the possibility that those in longer journeys could have a higher WTP to mitigate risks, since the exposure risks could be higher in those trips.

The mitigation measures considered are those where the cost is initially incurred by the operator and recovered through user fares. For public transport (buses and minibuses), the measures considered were (1) social distancing (passenger loading at half capacity), and (2) mandatory hand sanitisation plus increased cleaning/disinfection frequency of surfaces, while for paratransit (motorcycle taxis), the measures considered were (1) provision of a transparent shield between the rider and the passenger, and (2) provision of cleaned/disinfected helmets at the start of each trip.[2] Each choice task was composed of two unlabelled (same mode) alternatives, each with three attributes, and distinguished by the attribute levels. The attribute levels used in the stated choice experiments were reviewed and discussed with stakeholders to ensure that they are realistic in each city. The fare attribute levels were respondent-specific and were generated based on the respondent's reported pre-COVID fare for a typical commuting or education trip. The excerpts of the choice questions for public transport and paratransit are presented in Tables 1 and 2, respectively. Given that the shields for motorcycle taxis were not a familiar concept, images were shown to the repondents to familiarize them with the shields, before the actual choice questions were asked.

The "idefix" R package was used to generate efficient designs of the choice experiments (Traets & Gil, 2020). The choice tasks were designed to encourage trading between attributes, for example, alternatives, where COVID-19 mitigation measures were being implemented, were designed to be more expensive and paired with cheaper alternatives where COVID-19 mitigation measures were

[2] Increased ventilation or filtration rate in buses is not considered as the buses are almost always naturally ventilated and have windows open due to hot and humid conditions.

Table 1
Sample choice question for public transport.

Service attributes	Option 1	Option 2
Social distancing (half capacity)	*Not implemented*	*Implemented*
Mandatory hand sanitising and increased cleaning/disinfection frequency	*Implemented*	*Not implemented*
Fare, UGX	*4500*	*3750*
Please select your best option	☐	☐

Table 2
Sample choice question for paratransit.

Service attributes	Option 1	Option 2
Transparent shield between the rider and the passenger	*Not installed*	*Installed*
Helmets are provided and cleaned/disinfected at the start of each trip	*Not provided*	*Provided*
Fare, UGX	*3000*	*3750*
Please select your best option	☐	☐

not being implemented. It may be noted that the generation of efficient stated choice experiments requires knowledge on the priors of the parameter estimates (Bliemer & Collins, 2016). This study being the first of its kind, we could not rely on literature sources to determine the priors. We, therefore, organised pilot experiments in both Kampala and Dhaka and used the results of the pilot to generate the final efficient designs. The final designs were composed of 60 choice tasks, divided into 20 blocks, each with 3 choice tasks. Each respondent was presented with three choice tasks from one of the 20 blocks. A respondent could either participate in the public transport or the paratransit stated choice experiment depending on their respective mode usage frequencies.

3.3. Data collection

The surveys were conducted in Kampala (for Uganda) and Dhaka (for Bangladesh) between August and September 2021, immediately after the second wave of the pandemic.[3] Although the same survey questionnaire was used in both Kampala and Dhaka, there were slight differences in the tool itself and the data collection approaches. In Kampala, respondents were interviewed at their homes or places of work, while in Dhaka, they were intercepted and interviewed at bus stops or informal motorcycle taxi stands. Respondents were asked to provide consent before being interviewed, and the typical survey length was 15 – 20 min. Ethical approval of the design was obtained from the University of Leeds prior to the start of actual data collection. All health and safety precautions were maintained to keep both the surveyor and the respondents safe during the data collection process.

Table 3 presents the summary statistics of the survey data. Modal share and characteristics of users for different modes are not available in either cities. As such we included some socio-demographics from the national population. From Table 3, it appears that the Kampala sample is reasonably representative. The large gender imbalance in the Dhaka sample is due to the very low proportion of female users in public transport, and an even lower proportion in motorcycle taxis; anecdotal evidence suggests they are likely representative of the respective modes, too. Similarly, motorcycle taxis are more popular among the younger population in Dhaka, hence the larger share of that group in the sample. It is possible that young people were over-represented and older group under-represented in the public transport user sample in Dhaka.

4. Modelling framework

4.1. Utility model

The modelling in this study is based on the random utility theory (Marschak, 1960). Let U_{nik} be the utility of individual n derived from choosing alternative i in choice situation k. This can be expressed as:

$$U_{nik} = V_{nik} + \varepsilon_{nik} \text{ where } k = 1, 2, \cdots, K, i = 1, 2\cdots, J, \text{ and } n = 1, 2, \cdots, N \tag{1}$$

Where V_{nik} is the observed utility of alternative i for individual n in choice situation k and ε_{nik} is the random (unobserved) component of utility. V_{nik} has been expressed as a function of the travel cost (fare) and the COVID-19 mitigation attributes as follows:

For public transport (buses and minibuses)

[3] The survey design relied on retrospective questions to compare the pre-pandemic behaviour, which could be associated with recall issues. However given we had asked about the most frequent trip (and not infrequent ones), and the reasonable time span between the pre-pandemic period and the data collection, recall accuracy should not be a critical issue (Hipp, et al., 2020).

Table 3
Summary statistics of the survey data in comparison with national data (PopulationPyramid.net, 2020).

Demographic attribute	Kampala, Uganda			Dhaka, Bangladesh		
	Public Transport	Paratransit	National Population	Public Transport	Paratransit	National Population
Total sample size (No. of respondents)	695	674		576	637	
Average fare (Standard deviation) in Current USD*	0.54 (0.34)	0.87 (0.51)		0.27 (0.20)	1.63 (0.60)	
Proportion of respondents by gender (%)						
Male	35.3	48.7	49.3	89.4	94.7	50.6
Female	64.7	51.3	50.7	10.6	5.3	49.4
Proportion of respondents by parenthood (%)						
With children	78.4	65.6		35.9	27.5	
Without children	21.6	34.4		64.1	72.5	
Proportion of respondents by age (%)						
18–29 years	39.4	50.3	40.5	64.6	71.9	28.3
30–39 years	39.4	33.2	26.2	21.4	19.5	25.2
40–49 years	14.0	11.9	16.1	11.6	7.7	19.7
50 + years	7.2	4.6	17.1	2.4	0.9	26.8

* The calculation is based in central bank exchange rates of 03 December 2021 for Uganda (Bank of Uganda, 2021) and 02 December 2021 for Bangladesh (Bangladesh Bank, 2021).

$$V_{nik} = \beta_{FARE}FARE_{nik} + \beta_{SD}SD_{nik} + \beta_{SNT}SNT_{nik} \tag{2}$$

For paratransit (motorcycle taxis)

$$V_{nik} = \beta_{FARE}FARE_{nik} + \beta_{SHIELD}SH_{nik} + \beta_{HLM}HLM_{nik} \tag{3}$$

Where $FARE_{nik}$ is the fare of alternative i for individual n in choice situation k, SD_{nik}, SNT_{nik}, SH_{nik}, and HLM_{nik} are dummy variables indicating the implementation status/provision of social distancing (passenger loading at half capacity), better sanitisation measures, the transparent rider/passenger shield, and a cleaned/disinfected helmet, respectively, in alternative i for individual n in choice situation k. A dummy variable is assigned a value of 1 if the associated mitigation measure is being implemented; otherwise, it is assigned a value of 0. The β s are the model parameters to be estimated. These were interacted with the socio-demographics of the respondents as discussed later in Section 5 to identify any potential heterogeneity in preferences.

Assuming that the error terms (ε_{nik}) are distributed independently and identically across alternatives and individuals using a type I extreme value distribution and considering that the choices follow the unordered response mechanism, the choice probabilities can be calculated using the multinomial logit (MNL) model (McFadden, 1974).

$$P_{nik} = \frac{\exp(V_{nik})}{\sum_{j\in C_{nk}}\exp(V_{njk})} \tag{4}$$

Where P_{nik} is the probability of individual n choosing alternative i in choice situation k, and C_{nk} is the choice set of individual n in choice situation k.

Given the choice probabilities, the model parameters can be determined by maximising the log-likelihood function. However, in this case, we have several choice tasks (choice situations) per respondent, therefore, we need to capture the panel effect (that there are several observations per respondent) in the log-likelihood function as shown below.

$$LL(\beta) = \sum_n\sum_k\sum_i Z_{nik}\ln(P_{nik}) \tag{5}$$

Where dummy variable $z_{nik} = 1$ if individual n makes chooses alternative i in choice situation k, otherwise $z_{nik} = 0$.

4.2. Willingness to pay (WTP) estimation

WTP is the maximum price a consumer is willing to pay for a product or a service (Stobierski, 2020). The metric represents an upper threshold beyond which consumers will not pay a higher price and is widely used for transport policymaking. In the context of this study, WTP values help in quantifying the maximum price users would be willing to pay for the different COVID-19 mitigation measures in monetary terms (i.e. the monetary benefits attached to the mitigation measures). The WTP values for particular mitigation measures can be estimated as ratios of the partial derivatives of the applicable systematic utility functions with respect to the mitigation measure and the fare as shown in Equations (6) to (9):

For social distancing (half capacity) in public transport

$$WTP_{SD} = \frac{\partial V_{nik} / \partial SD_{nik}}{\partial V_{nik} / \partial FARE_{nik}} = \frac{\beta_{SD}}{\beta_{FARE}} \tag{6}$$

For better sanitisation measures in public transport

$$WTP_{SNT} = \frac{\partial V_{nik} / \partial SNT_{nik}}{\partial V_{nik} / \partial FARE_{nik}} = \frac{\beta_{SNT}}{\beta_{FARE}} \tag{7}$$

For the rider/passenger shield on motorcycle taxis

$$WTP_{SHIELD} = \frac{\partial V_{nik} / \partial SH_{nik}}{\partial V_{nik} / \partial FARE_{nik}} = \frac{\beta_{SHIELD}}{\beta_{FARE}} \tag{8}$$

For provision of cleaned/disinfected helmets on motorcycle taxis

$$WTP_{HLM} = \frac{\partial V_{nik} / \partial HLM_{nik}}{\partial V_{nik} / \partial FARE_{nik}} = \frac{\beta_{HLM}}{\beta_{FARE}} \tag{9}$$

5. Results and discussion

5.1. Preliminary insights from the data

5.1.1. Factors in travel choice decisions

During the surveys, respondents were asked to mention the most important factor affecting their travel choice decisions before and during the COVID-19 pandemic. Fig. 1 summarises the responses to this question in Kampala and Dhaka. In both cities, travel time and cost were the most important factors before the pandemic, followed by convenience and general cleanliness. However, since the pandemic started, the importance of travel time and cost has diminished in both cities, more so in Dhaka. Social distancing and the wearing of face masks by all travellers have emerged as very important determinants for mode choice during the pandemic.

5.1.2. Attitudes towards the motorcycle taxi shield

The surveys also captured the attitudes of the respondents towards the novel concept of using shields between motorcycle driver and passengers to mitigate COVID-19 risk exposure for the passengers. Fig. 2 summarises the attitudes towards the shields in Kampala and Dhaka. In both cities, majority of the respondents agree that motorcycle travel in the current circumstances presents a high risk of COVID-19 transmission and that the installation of a shield between the rider and passenger is likely to minimise the risk of transmission. However, there seems to be consensus in both cities that the shield has the potential to harbour micro-organisms and can be a source of new infections. It should be noted that although the shield offers susbtantial reduction in airborne COVID-19 exposure for motorcycle taxi passengers (Hetherington, et al., 2021), it does not offer absolute protection (e.g. via the fomite route), and there would be a need to sensitize the public about this. This also means that the shields would have to be sanitised regularly if installed on motorcycle taxis, which would have an impact on the operating costs.

Finally, there is a general concern in both cities, more so in Dhaka, that the shield could compromise the overall safety of motorcycle taxis as it might cause potential aerodynamic issues and uncomfortable seating positions. In general, residents from Kampala expressed stronger preferences compared to those from Dhaka, possibly due to cultural differences.

5.2. Model specification

The key variables included in the utility models for public transport and paratransit have been presented in Equations (2) and (3), respectively. Several interactions of each of these variables with the socio-demographics of the respondents have been tested to understand how sensitivities vary across demographic groups. The demographic attributes collected during the survey include the gender, age, level of education, employment status, income and parenthood status of the respondents.

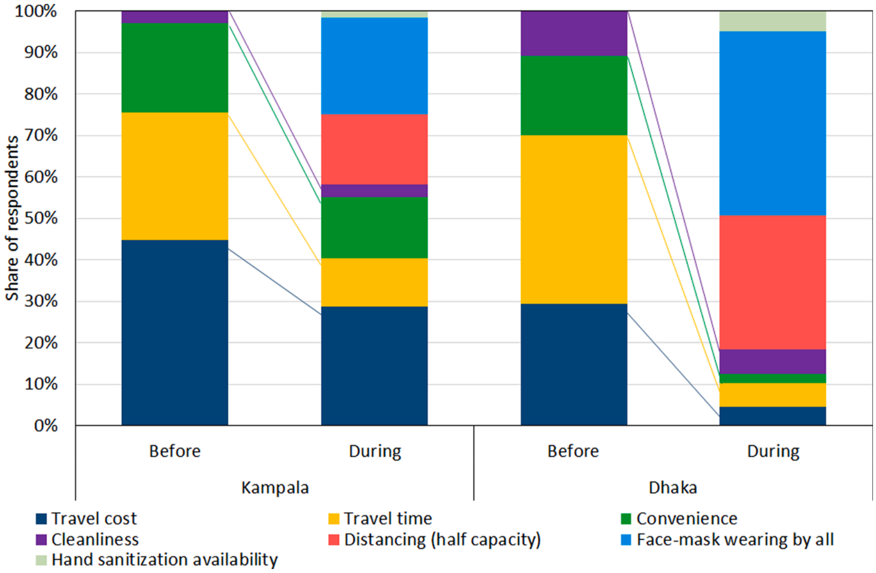

Fig. 1. Distribution of the most important factors affecting travel choice decisions before and during the COVID-19 pandemic.

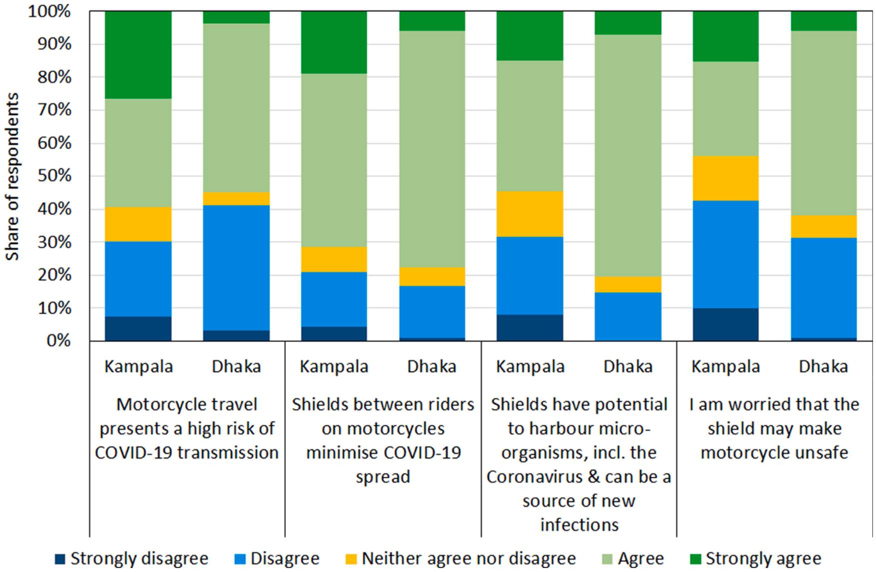

Fig. 2. Attitudes towards motorcycle taxi shield.

All the variables in the utility models for public transport and paratransit have been successfully interacted with each of the collected demographic attributes, except income, in both cities. This is likely because majority of the respondents were not comfortable with disclosing their income. At this level of demographic interaction, all the model results are satisfactory, with the expected parameter signs and acceptable levels of statistical significance. An attempt was made to interact the utility model parameters with combinations of demographic attributes (e.g. age - gender combinations); however, there were no significant gains in model fit.

5.3. Model results

This section presents the results of the best comparable models between the two cities. For public transport, these are the models with parenthood interactions (i.e. individuals with or without children); while for paratransit, the models include age-group interactions.[4]

5.3.1. Public transport (Buses and Minibuses)

Table 4 presents the estimation results of the public transport models for both cities showing that all the parameter estimates, and the overall models are statistically significant at the 95 % level of confidence. A statistically significant positive parameter sign indicates that the presence of or an increase in the value of the variable increases the probability of choosing an alternative, while a negative parameter sign indicates the opposite effect.

From Table 4, it is observed that the social distancing and the sanitisation parameters have positive signs, while the fare parameters have negative signs in both cities. This implies that keeping all other factors constant, the implementation of social distancing and sanitisation measures improves the attractiveness of a public transport alternative when compared to alternatives where such mitigation measures are not being implemented. An increase in fare reduces the attractiveness of a public transport mode alternative, as is expected. This shows that public transport users make a trade-off between safety and cost. The results also suggest that unsustainable fare increments for COVID-19 mitigation can reduce the net benefit from safety improvements, thereby prompting users to settle for cheaper and unsafe alternatives, which would compromise the gains made in fighting the pandemic.

Table 4 also shows that the social distancing parameters generally have a higher magnitude compared to the sanitisation parameters. This indicates that public transport users in both cities are more concerned about changes in the social distancing measures than they are to changes in the sanitisation measures. Individuals with children are generally more sensitive to COVID-19 mitigation measures and less sensitive to changes in the fare when compared to individuals without children. This could be explained by the higher degrees of responsibility that individuals with children have, which makes them avoid risk and value their safety more (Eibach & Mock, 2011).

5.3.2. Paratransit (Motorcycle taxis)

Table 5 presents the estimation results of the paratransit models for both cities showing that most of the parameter estimates and the overall models are statistically significant at the 95 % level of confidence.

The shield and helmet cleaning parameters both have positive signs, while the fare parameters have negative signs in both cities. This implies that keeping all other factors constant, the provision of a transparent shield between the rider and the passenger and a cleaned/disinfected helmet at the start of each trip would improve the attractiveness of motorcycle taxis compared to those that do not offer such provisions. As before, an increase in the fare reduces the attractiveness of the alternative.

The parameters associated with the shield generally have a higher magnitude compared to those associated with cleaned helmets for individuals within the same age group. This shows that motorcycle taxi users in both cities would be more sensitive to changes in the provision of the shields than they would be to changes in the provision of cleaned/disinfected helmets. We conjecture that suspicions about whether cleaning operations would take place in reality may have caused the observed lower preference for the helmet cleaning option.

Although there are no clear patterns of how preferences vary across age groups, it can be seen that individuals who are 50 years and above would generally be more sensitive to changes in the provision of transparent rider/passenger shields and cleaned/disinfected helmets compared to younger individuals. In the case of Uganda, the same group are also the most sensitive to changes in fare.

5.4. Willingness to pay

As mentioned earlier, WTP values help in quantifying the monetary benefits attached to the different COVID-19 mitigation measures. These values have been estimated using formulae described earlier in Section 4.2 and derived from the model results presented in Section 5.3 above. We report the estimates in the local currencies of each city, as well as their equivalent values in current United States Dollars (USD) to facilitate comparison between the cities.

5.4.1. Public transport (Buses and Minibuses)

Table 6 presents the WTP estimates for COVID-19 mitigation in public transport in Uganda and Bangladesh. From the table, it is observed that the WTP for social distancing measures is higher than that for sanitisation measures in both cities. In addition, it is observed that individuals with children generally have a higher WTP compared to individuals without children. As explained earlier, this could be attributed to the relatively higher degree of risk aversion behaviour among parents (Eibach & Mock, 2011).

We also observe that the WTP (in current USD) for COVID-19 mitigation in public transport is generally higher in Uganda compared to Bangladesh, despite the former's lower GDP per capita compared to the latter (The World Bank, 2020). This could be attributed to the Government of Uganda's widely publicised campaigns and activism against COVID-19. Also, public transport in Kampala is dominated by small buses (matatus), while in Dhaka, it is dominated by large buses, where seats are more spaced out compared to the matatus. Therefore, it is likely that public transport users in Kampala are more conscious and concerned about the spread of COVID-19 infection than those in Dhaka.

The average WTP for social distancing is more than 100 % of the current average public transport fares in both cities, while the

[4] The results for the other models specified with gender, age, level of education and employment status interactions are available in supplementary information.

Table 4
Estimation results of the public transport model.

Variable	Kampala, Uganda		Dhaka, Bangladesh	
	Parameter	*t*-stat	Parameter	*t*-stat
Social distancing (half capacity)				
Individuals with children	1.1532	13.07	1.1260	7.47
Individuals without children	0.8542	4.90	1.6070	13.71
Mandatory hand sanitisation plus increased cleaning/disinfection frequency of surfaces				
Individuals with children	0.2941	4.31	0.3306	3.10
Individuals without children	0.3815	3.12	0.3386	4.30
*Fare**				
Individuals with children	−0.1932	−3.52	−0.0261	−3.41
Individuals without children	−0.4057	−3.03	−0.0477	−6.21
Measures of fit in estimation				
Number of observations	2080		1720	
Number of decision makers	695		576	
LL(0)	−1441.75		−1192.21	
LL(F)	−1250.22		−960.11	
Number of parameters	6		6	
ρ^2_{adj} w.r.t LL(0)	0.1287		0.1896	
LR w.r.t LL(0)	383.06		464.20	
p-value of LR	<0.0001		<0.0001	

* For Uganda, the fare is in UGX – Uganda Shillings (x1000), while for Bangladesh, it is in BDT – Bangladeshi Taka.

Table 5
Estimation results of the paratransit model.

Variable	Kampala, Uganda		Dhaka, Bangladesh	
	Parameter	*t*-stat	Parameter	*t*-stat
Provision of a transparent shield between the rider and the passenger				
18–29 years	0.7267	7.62	1.0276	10.96
30–39 years	0.6360	5.66	1.4013	8.33
40–49 years	0.6406	3.95	0.8372	3.23
50 + years	1.3408	4.04	1.8314	3.05
Provision of a cleaned/disinfected helmet at the start of each trip				
18–29 years	0.1841	2.28	0.7015	9.67
30–39 years	0.1226	1.31	0.9377	6.04
40–49 years	0.5529	3.62	0.7025	3.48
50 + years	1.1513	3.79	1.3937	3.21
*Fare**				
18–29 years	−0.3490	−6.83	−0.0208	−13.10
30–39 years	−0.2349	−3.61	−0.0250	−7.94
40–49 years	−0.2462	−3.28	−0.0082	−3.03
50 + years	−0.9047	−4.70	−0.0208	−1.87
Measures of fit in estimation				
Number of observations	2013		1905	
Number of decision makers	674		637	
LL(0)	−1395.31		−1320.45	
LL(F)	−1285.42		−996.48	
Number of parameters	12		12	
ρ^2_{adj} w.r.t LL(0)	0.0702		0.2363	
LR w.r.t LL(0)	219.78		647.94	
p-value of LR	<0.0001		<0.0001	

* For Uganda, the fare is in UGX (x1000), while for Bangladesh, it is in BDT.

average WTP for sanitisation measures is approximately 70 % and 36 % of the current average public transport fares in Kampala and Dhaka, respectively. This again indicates potentially higher concerns about safety in Kampala. It is worth noting that in order to accommodate the loss of revenue from the capacity restrictions in public transport, fares were increased by 100 % in Kampala and 60 % in Dhaka. Therefore, the increases in fare attributed to the COVID-19 social distancing requirements imposed by the governments of both countries were within the maximum threshold users were willing to pay for safe travel in the context of the pandemic.

Table 6
Willingness to pay estimates for COVID-19 mitigation in public transport.

Mitigation measure	Kampala, Uganda		Dhaka, Bangladesh	
	UGX	Current USD*	BDT	Current USD*
Social distancing (half capacity)				
Individuals with children	5,950	1.67	43.17	0.50
Individuals without children	2,100	0.59	33.72	0.39
All (average)	4,700	1.32	36.80	0.43
Mandatory hand sanitisation plus increased cleaning/disinfection frequency of surfaces				
Individuals with children	1,500	0.42	12.68	0.15
Individuals without children	950	0.27	7.10	0.08
All (average)	1,350	0.38	8.61	0.10

* The calculation is based in central bank exchange rates of 03 December 2021 for Uganda (Bank of Uganda, 2021) and 02 December 2021 for Bangladesh (Bangladesh Bank, 2021).

5.4.2. *Paratransit (Motorcycle taxis)*

Table 7 presents the WTP estimates for COVID-19 mitigation in paratransit in Kampala and Dhaka. It is observed that the WTP for shields between riders and passengers is higher than that for cleaned/disinfected helmets in both cities. As can be expected from the parameters estimates earlier, the WTP in both cities generally increases with age up to a certain age group (40–49 years), after which it starts to fall.

Although the WTP trends between the two cities differ across age groups, the average WTP for the rider/passenger shield is almost the same in the two cities. Respondents were – on average – willing to pay around UGX 2,200 (approx. USD 0.62) per trip in Uganda and BDT 54 (approx. USD 0.63) per trip in Bangladesh for the shields. Although the WTP values (in current USD) are similar in the two cities, the average WTP for the safety shields is approximately 71 % and 38 % of the current average motorcycle taxi fares in Kampala and Dhaka, respectively. This indicates a relatively higher value attached to safety provisions in Uganda.

On the other hand, the average absolute WTP for a cleaned/disinfected helmet is much lower in Kampala compared to Dhaka. However, the average WTP for cleaned/disinfected helmets is approximately 26 % of the current average motorcycle taxi fares in both cities. This indicates a similar level of valuation attached to the safety provided by clean helmets.

6. Conclusions

In this paper, we investigated if there is a potential market for safety measures in the public transport and paratransit sectors and estimated the passengers' willingness to pay for such mitigation measures. Distancing (or capacity) measures and provision of sanitization were considered for public transport and frequent cleaning of helmets was considered for motorcycle taxis. In addition, the WTP for a novel COVID19 mitigation measure in motorcycle taxis – a barrier between the rider and the passenger – was estimated.

Our questionnaire survey results show that there have been substantial changes in the relative importance of the factors for mode choice in both Kampala and Dhaka. For example, typical mode choice factors such as costs, travel time and convenience became less important during the pandemic and COVID-19 mitigation and safety measures became important considerations. Choice experimentation shows that the implementation or provision of COVID-19 mitigation measures clearly improves the attractiveness of the associated public transport or paratransit alternatives. These changes in preferences will likely hold not only for Bangladesh and Uganda, but also other countries during times of other similar virus-borne pandemics. How much of these shifts are permanent is an important area for future exploration.

Public transport and paratransit users in both cities are willing to pay extra for all the four COVID-19 mitigation measures considered in this study. In particular, the average willingness to pay for social distancing was more than 100 % of the current average public transport fares in both cities. Given that this particular measure was implemented along with 100 % and 60 % increases in actual fares in Kampala and Dhaka, respectively, our results indicate that the fare increases were well within the users' valuation of the provision. The relatively muted public discontent for fare increases in both cities possibly reflect this.

Increases in public transport fare is not popular whether in a developed or a developing country. The impact of the additional fare on the disadvantaged sections of the society cannot be captured by the WTP metrics, and there is a need to understand the welfare and transport poverty impacts of such increases during the times of emergencies, when income potential for low-income group is already substantially diminished. It may well be possible that the relatively high WTP is a result of the non-discretionary nature of travel during the pandemic.

On the other hand, without the fare increase, transport operators – which act purely on the basis of profit maximization – could refuse to provide the necessary precautionary measures on-board increasing the risks further. Indeed bus operators in Bangladesh forced the Bangladesh government to backtrack on its decision to run buses at reduced capacity without additional fare increases during the third wave of the pandemic (Adhikary, 2022). Such WTP estimates will likely be useful in such negotiations between the government and the operators, especially to understand the balance between government support and fare increases to recover the lost revenue for public transport operators, especially in Western countries, which provided large subsidies to private operators during COVID-19. WTP estimates also provide a maximum acceptable level of transport fares during a pandemic – any increase beyond these could result in covert practices of using unsafe modes by passengers, especially in the context of low income countries where

Table 7
Willingness to pay estimates for COVID-19 mitigation in paratransit.

Mitigation measure	Kampala, Uganda		Dhaka, Bangladesh	
	UGX	Current USD	BDT	Current USD
Provision of a transparent shield between the rider and the passenger				
18–29 years	2,100	0.59	49.29	0.57
30–39 years	2,700	0.76	56.12	0.65
40–49 years	2,600	0.73	101.83	1.19
50 + years	1,500	0.42	88.22	1.03
All (average)	2,200	0.62	53.67	0.63
Provision of a cleaned/disinfected helmet at the start of each trip				
18–29 years	550	0.15	33.65	0.39
30–39 years	500	0.14	37.55	0.44
40–49 years	2,250	0.63	85.45	1.00
50 + years	1,250	0.35	67.14	0.78
All (average)	800	0.22	36.40	0.42

* The calculation is based in central bank exchange rates of 03 December 2021 for Uganda (Bank of Uganda, 2021) and 02 December 2021 for Bangladesh (Bangladesh Bank, 2021).

monitoring and enforcement practices can be poor.

Adding shields or barriers between the rider and the passenger on motorcycle taxis was viewed positively by more than two-thirds of the respondents in both cities, although there were some concerns about aerodynamic safety and potential for infections via the fomite route. Choice modelling shows that respondents were – on average – willing to pay around UGX 2,200 (approx. USD 0.62) per trip in Kampala and BDT 54 (approx. USD 0.63) per trip in Dhaka for the shields. However, considering the lower average motorcycle taxi fare in Kampala, this shows relatively higher valuation for the shields in Kampala.

Our results show that there is a potential demand for safety as an attribute in the public transport and paratransit sectors, and transport operators could potentially pass on the costs of COVID-19 mitigation provisions to the passengers and defray some or all of the costs. At a time when governments in low-income countries are averse to impose further lockdowns, transport operators may be able to compete on the basis of safety features and partially mitigate the policy gaps.

Contributions

AB designed the choice experiments, estimated the models and led the writing. ZW conceived the project, obtained funding, and checked the model results. PM, FR, MI, CU collected the data. All contributed to the wider survey design and writing.

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.

Acknowledgements

We acknowledge the support from UK Research and Innovation as part of the Global Challenges Research Fund (GCRF) and Newton Fund Agile Response Call to address COVID-19 (No. EP/V043226/1). We are also grateful to the two anonymous reviewers for suggestions to improve the work.

Supplementary information.

Supplementary information to this article can be found online at https://doi.org/10.1016/j.tra.2022.103561.

References

Abdullah, M., Dias, C., Muley, D., Shahin, M., 2020. Exploring the impacts of COVID-19 on travel behavior and mode preferences. Transportation research interdisciplinary perspectives 8, 100255.

Adhikary, T. S., 2022. *Buses at half capacity: Transport lobby prevails again.* [Online] Available at: https://www.thedailystar.net/news/bangladesh/transport/news/buses-half-capacity-transport-lobby-prevails-again-2941236 Accessed February 2022].

New Age, 2022. *Buses to run at half capacity across Bangladesh from Saturday.* [Online] Available at: https://www.newagebd.net/article/159786/buses-to-run-at-half-capacity-across-bangladesh-from-saturday [Accessed 15 February 2022].

Aloi, A., et al., 2020. Effects of the COVID-19 lockdown on urban mobility: Empirical evidence from the city of Santander (Spain). Sustainability 12 (9), 3870.

Ardiansyah, T. & Purnomo, J., 2020. *Jakarta's motorcycle taxis get backpack shield for virus battle.* [Online] Available at: [Accessed 17 January 2022].

Arellana, J., Marquez, L. & Cantillo, V., 2020. COVID-19 Outbreak in Colombia: An Analysis of Its Impacts on Transport Systems. *Journal of Advanced Transportation,* Volume 2020.
Arunwuttipong, A., et al., 2021. Intention to use and willingness to pay premium for enhanced disnfection of public transportation. Journal of Management Information and Decision Sciences 1–8.
Athumani, H., 2020. *Ugandan Creates COVID Shield for Motorcycles.* [Online] Available at: https://www.voanews.com/a/africa_ugandan-creates-covid-shield-motorcycles/6191949.html [Accessed 26 November 2021].
Awad-Núñez, S., et al., 2021. Post-COVID-19 travel behaviour patterns: impact on the willingness to pay of users of public transport and shared mobility services in Spain. Eur. Transp. Res. Rev. 13 (1), 1–18.
Bank of Uganda, 2021. *Exchange Rates.* [Online] Available at: https://www.bou.or.ug/bou/bouwebsite/ExchangeRates/index.html [Accessed 04 December 2021].
Bangladesh Bank, 2021. *Exchange Rate of Taka.* [Online] Available at: https://www.bb.org.bd/econdata/exchangerate.php [Accessed 04 December 2021].
Batool, Z., et al., 2022. The Effects of COVID19 on Public and Para-Transit Drivers in Developing Countries – A Case Study of Dhaka and Owerri. Working Paper.
Beck, M.J., Hensher, D.A., 2020. Insights into the impact of COVID-19 on household travel and activities in Australia – The early days of easing restrictions. Transp. Policy 99, 95–119.
Beck, M.J., Hensher, D.A., Wei, E., 2020. Slowly coming out of COVID-19 restrictions in Australia: Implications for working from home and commuting trips by car and public transport. J. Transp. Geogr. 88 (2020), 102846.
Bhaduri, E., et al., 2020. Modelling the effects of COVID-19 on travel mode choice behaviour in India. Transportation research interdisciplinary perspectives 8, 100273.
Bliemer, M.C., Collins, A.T., 2016. On determining priors for the generation of efficient stated choice experimental designs. Journal of Choice Modelling 21, 10–14.
Bucsky, P., 2020. Modal share changes due to COVID-19: The case of Budapest. Transportation Research Interdisciplinary Perspectives 8, 100141.
Budd, L., Ison, S., 2020. Responsible Transport: A post-COVID agenda for transport policy and practice. Transportation Research Interdisciplinary Perspectives 6 (2020), 100151.
Campisi, T., et al., 2020. The impact of COVID-19 pandemic on the resilience of sustainable mobility in Sicily. Sustainability 12 (21), 8829.
Cox, W., 2021. *Demographic World Urban Areas*, 17th Annual Edition: 202106. Demographia, St. Louis.
Das, S., et al., 2021. A radical modal shift from public to private transport mode. Transp. Policy 109, 1–11.
de Haas, M., Faber, R., Hamersma, M., 2020. How COVID-19 and the Dutch 'intelligent lockdown'change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands. Transportation Research Interdisciplinary Perspectives 6, 100150.
De Vos, J., 2020. The effect of COVID-19 and subsequent social distancing on travel behavior. Transportation Research Interdisciplinary Perspectives 5 (2020), 100121.
DILG, 2020. *DILG: Another motorcycle barrier design for back-riding couples approved by NTF.* [Online] Available at: https://www.dilg.gov.ph/news/DILG-Another-motorcycle-barrier-design-for-back-riding-couples-approved-by-NTF/NC-2020-1241 [Accessed 17 January 2022].
Dzisi, E.K.J., Dei, O., 2020. Adherence to social distancing and wearing of masks within public transportation during the COVID 19 pandemic. Transportation Research Interdisciplinary Perspectives 7 (2020), 100191.
Ehebrecht, D., Heinrichs, D., Lenz, B., 2018. Motorcycle-taxis in sub-Saharan Africa: Current knowledge, implications for the debate on "informal" transport and research needs. J. Transp. Geogr. 69, 242–256.
Eibach, R.P., Mock, S.E., 2011. The vigilant parent: Parental role salience affects parents' risk perceptions, risk-aversion, and trust in strangers. J. Exp. Soc. Psychol. 47 (3), 694–697.
Fatmi, M.R., 2020. COVID-19 impact on urban mobility. Journal of Urban Management 9 (3), 270–275.
Hargreaves, J.R., 2020. Lifting lockdown policies: A critical moment for COVID-19 stigma. Glob. Public Health 15 (12), 1917–1923.
Hetherington, R., et al., 2021. Exposure risk analysis of COVID-19 for a ride-sharing motorbike taxi. Phys. Fluids 33 (11), 113319.
Hipp, L., Bünning, M., Munnes, S., Sauermann, A., 2020. Problems and pitfalls of retrospective survey questions in COVID-19 studies. Survey Research Methods 14 (2), 109–114.
KCCA, 2018. *Public Transport a Challenge: Does KCCA Care?.* [Online] Available at: https://www.kcca.go.ug/news/308/#.Yz6UzXZBxPY [Accessed 06 October 2022].
Kitara, D.L., Ikoona, E.N., 2020. COVID-19 pandemic, Uganda's story. Pan Afr. Med. J. 35 (Suppl 2).
Marschak, J., 1960. Binary Choice Contsraints on Random Utility Indicators. In: K. Arrow, ed. *Stanford Symposium on Mathematical Methods in the Social Science.* California: Stanford University Press.
McFadden, D., 1974. Conditional logit analysis of qualitative choice behaviour. In: P. Zarembka, ed. *Frontiers in Econometrics.* New York: Academic Press, pp. 105-142.
Mogaji, E., 2020. Impact of COVID-19 on transportation in Lagos, Nigeria. *Transportation Research Interdisciplinary*. Perspectives 6, 100154.
MOH, 2020. *Guidelines for use of public transportation during the COVID-19 pandemic.* [Online] Available at: https://covid19.gou.go.ug/uploads/document_repository/authors/ministry_of_health/document/GUIDELINES_FOR_USE_OF_PUBLIC_TRANSPORTATION_DURING_THE_COVID-19_PANDEMIC.pdf [Accessed 26 November 2021].
MOH, 2022. *The COVID-19 Situation Update and Adjustments on Travel Restrictions in Uganda,* Kampala: Ministry of Health.
Olvera, L. D., Plat, D., Pochet, P. & Maïdadi, S., 2012. Motorbike taxis in the" transport crisis" of West and Central African cities. *EchoGéo,* Volume 20.
Oreffice, S., Quintana-Domeque, C., 2021. COVID-19 Information, Demand and Willingness to Pay for Protective Gear in the UK. Studies in Microeconomics 9 (2), 180–195.
Otto, A., 2020. *Gov't Issues SOPs for Boda Bodas.* [Online] Available at: https://ugandaradionetwork.com/story/govt-issues-sops-for-boda-bodas-operation [Accessed 26 November 2021].
Our World in Data, 2022. *Coronavirus (COVID-19) Vaccinations.* [Online] Available at: https://ourworldindata.org/covid-vaccinations [Accessed 17 January 2022].
Peters, K. et al., 2021. *Final Report: Accelerating COVID-19 related 'best practice' in the urban motorcycle taxi sector in SubSaharan Africa,* London: High Volume Transport Applied Research Programme, IMC Worldwide Ltd.
PopulationPyramid.net, 2020. *Population Pyramids of the World from 1950 to 2100, Uganda.* [Online] Available at: https://www.populationpyramid.net/uganda/2020/ [Accessed 06 October 2022].
Porter, G., et al., 2021. Women's mobility and transport in the peripheries of three African cities: Reflecting on early impacts of COVID-19. Transp. Policy 110, 181–190.
Reza, F., Kawsar, E., Mahabub, T.B., 2020. COVID-19 impact and responses: Bangladesh. Build Bangladesh, s.l.
Ssali, S.N., 2020. Gender, Economic Precarity and Uganda Government's COVID-19 Response. African Journal of Governance & Development 9 (1.1), 287–308.
Starkey, P., 2016. *The benefits and challenges of increasing motorcycle use for rural access.* Mombasa, Kenya, International Conference on Transport and Road Research.
Stobierski, T., 2020. *Willingness to pay: What it is & how to calculate* [Online] Available at: https://online.hbs.edu/blog/post/willingness-to-pay [Accessed 17 January 2022].
Teixeira, J.F., Lopes, M., 2020. The link between bike sharing and subway use during the COVID-19 pandemic: The case-study of New York's Citi Bike. Transportation Research Interdisciplinary Perspectives 6, 100166.
The World Bank, 2020. *GDP per capita, PPP (current international $) - Bangladesh, Uganda.* [Online] Available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=BD-UG [Accessed 05 December 2021].
Thombre, A., Agarwal, A., 2021. A paradigm shift in urban mobility: policy insights from travel before and after COVID-19 to seize the opportunity. Transp. Policy 110, 335–353.
Tirachini, A., Cats, O., 2020. COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs. J. Public Transp. 22 (1), 1–21.
Traets, F. & Gil, D., 2020. *Package 'idefix': Efficient Designs for Discrete Choice Experiments.* [Online] Available at: https://cran.r-project.org/web/packages/idefix/idefix.pdf [Accessed 2021 May 03].
Wadud, Z., 2020. The effects of e-ridehailing on motorcycle ownership in an emerging-country megacity. Transp. Res. A Policy Pract. 137, 301–312.

Wadud, Z., Rahman, S.M., Enam, A., 2022. Face mask mandates and risk compensation: an analysis of mobility data during the COVID-19 pandemic in Bangladesh. BMJ Glob. Health 7 (1), e006803.
WHO, 2020. *Q&A: How is COVID-19 transmitted?*. [Online] Available at: https://www.who.int/vietnam/news/detail/14-07-2020-q-a-how-is-covid-19-transmitted [Accessed 25 November 2021].
Worldometer, 2022. *COVID-19 Coronavirus pandemic.* [Online] Available at: https://www.worldometers.info/coronavirus/ [Accessed 11 October 2022].
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.
Zhang, J., Hayashi, Y., Frank, L.D., 2021. COVID-19 and transport: Findings from a world-wide expert survey. Transp. Policy 103, 68–85.