Modelling the exposure risk trade-off between public transit and private paratransit for transport decision making in the era of COVID-19

Summary Findings

Aims

This project aims to provide a science-based answer for transport policymakers in developing countries to the questions – a) which is the safest publicly available transport mode (including paratransit modes) to move people during an epidemic, b) how to make travelling in paratransit modes – especially motorcycle taxis – safer, and c) how travel choices and preferences have changed during the pandemic?

Methods

Computational Fluid Dynamics model was used to understand airflow and virus-laden droplet/aerosol dispersion from the driver to the passenger in a motorcycle taxi. The effects of a barrier between a passenger and a driver on mitigating airborne exposure of the virus is then investigated.

Questionnaire surveys were carried out (using intercept survey or household survey) in three cities in the partner countries (Dhaka in Bangladesh, Kampala in Uganda and Owerri in Nigeria) with around 1200 responses each in order to understand their travel preferences during COVID-19.

Key Finding 1 CFD simulations predict the presence of a strong down draught of air between the driver and passenger which ultimately determines the fate of the virus-carrying aerosols depositing or being inhaled by the passenger (Fig. 1). The draught let the aerosols flow nearer to the passenger's inhalation zone.

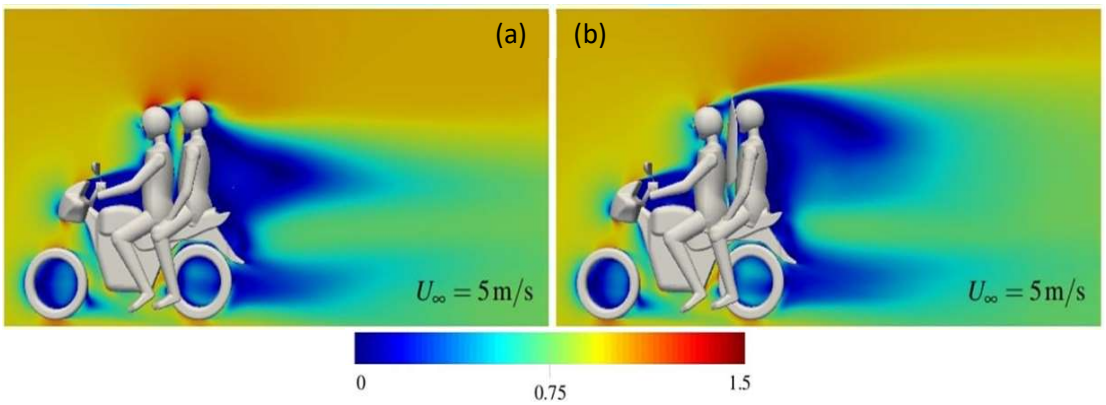


Fig.1: Visualisation of airflow around the motorcycle with driver and passenger at 18 kmph (5 m/s): a) without shield, b) with shield. The colours represent the speed of the air as a fraction of the motorcycle speed.

A shield or barrier between the passenger and the driver can disrupt this strong down draught (Fig 1). This prevents the virus-carrying droplets and aerosols from reaching the passenger's inhalation zone near the mouth and nose (Fig. 2), thereby eliminating the risk of breathing in the infectious aerosols. Three shield shapes were investigated and all showed the disruption potential.

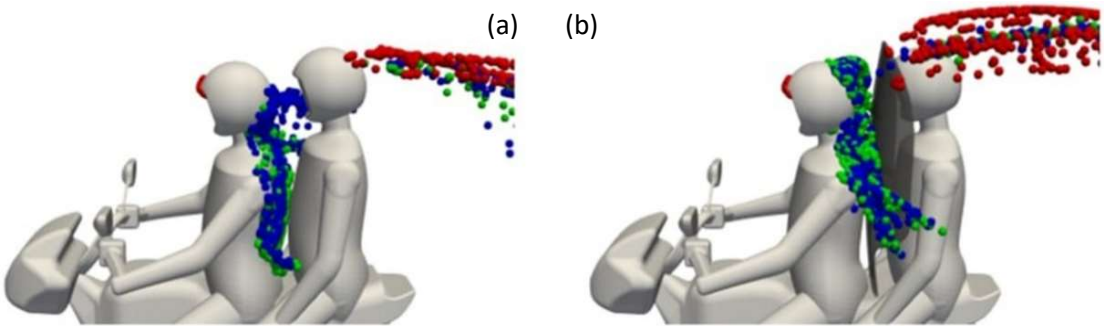


Fig. 2: Particle distribution snapshots in time at 18 kmph speed: a) without shield, b) with shield. Particles are coloured by diameter according to blue (1 μm), green (10 μm), and red (50 μm).

The additional drag due to the barrier was the least for the convex shape of the shield (convex for driver, concave toward passenger, Fig. 2b). Our *opinion* is that, given the low speed of urban travel, the barriers should not pose significantly higher handling or accident risks. See output 7 for proposed barrier design.

While modelling of airflow and droplet dispersion in buses could not be completed due to resource constraints, comparison with similar models in the literature shows passenger exposure in motorcycles is lower than the *total* exposure in a bus, considering the enclosed nature of the bus and the higher number of passengers. See output 1 for further detail, output 7 for the proposed barrier design.

Key Finding 2 Questionnaire survey responses of public transport and paratransit users show a strong preference toward measures to enhance COVID-19 related safety measures, such as maintaining distances, wearing of facemasks by other passengers and presence of hand sanitization facilities in buses, or adding passenger shields/barriers (as above) and cleaning of helmets in motorcycle taxis. While travel costs, time and convenience were the most important factors in mode choice pre-COVID-19, distancing in buses and face-mask wearing by all passengers became equally, if not more, important during the pandemic (Fig. 3). Especially in Dhaka and Owerri, COVID-19 related safety measures were *more* important compared to traditional mode choice factors during the pandemic.

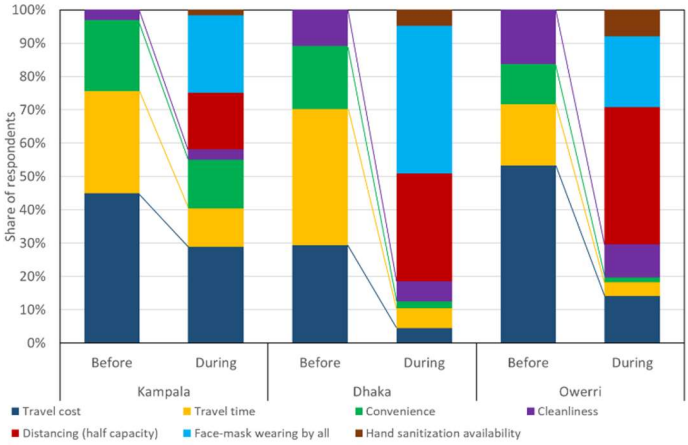
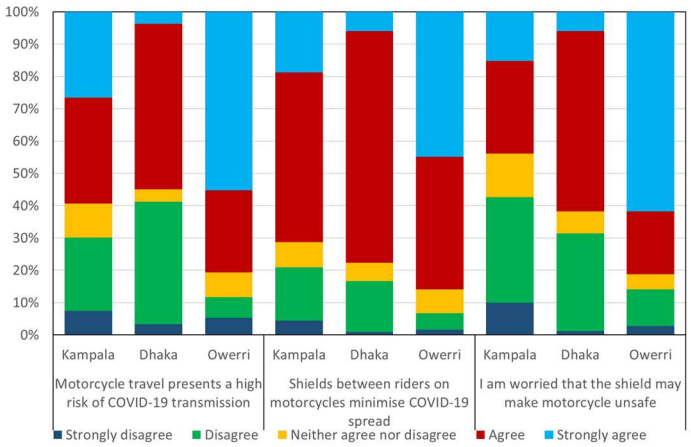


Fig. 3: Distribution of the most important factors affecting travel mode choice decisions before and during the COVID-19 pandemic in three cities: Kampala (Uganda), Dhaka (Bangladesh) and Owerri (Nigeria)

Choice experimentation and subsequent modelling show that respondents were willing to pay *extra* for safety measures such as distancing or hand sanitizers in buses or shields in motorcycle taxis. This shows that there is a potential *market* for safety, and transport operators could potentially pass on the costs of these provisions to the passengers and defray some of the costs, or could compete on the basis of safety features.

Adding shields or barriers between the driver and the passenger in motorcycle taxis was viewed positively by more than 70% of the respondents in all three cities (Fig.4), although there were some concerns about aerodynamic safety and potential for infections via the fomite route. Choice modelling shows that respondents in Kampala (Uganda) and Dhaka (Bangladesh) were – on average – willing to pay around UGX 2,200 (approx. USD 0.62) and BDT 54 (approx. USD 0.63) per trip for the barriers in motorcycle taxis. This also shows that – even in the absence of any government policies – such initiatives could help mitigate the exposure to risk and recoup the costs for the operators of motorcycle taxis. See output 2 for further detail.

Fig. 4: Distribution of attitudes toward shields for preventing COVID-19 exposure in motorcycle taxis in three cities: Kampala (Uganda), Dhaka (Bangladesh) and Owerri (Nigeria)



Key Finding 3 The public transport and paratransit drivers in Owerri and Dhaka, who often rent the vehicle from an owner on a contract basis, reported immense hardship during the lockdown due to the bans on operations and/or lack of passengers, eliminating or reducing their only opportunities for earning a livelihood. Drivers either had to use the little savings they had or borrow money to cover their costs of living, further reducing their opportunities for escaping poverty the future. Some had to continue driving stealthily in order to feed their families. These had knock-on effects on self-esteem and physical and mental well-being, and escalated their perception about a rich-poor divide. In some instances, passengers' reluctance to follow rules increased health risks for the drivers. Lack of support from the vehicle owners or the government also meant that the additional costs of the safety measures aggravated the situation and led to low adherence to COVID-19 related regulations.

Targeted financial and food support for the vulnerable drivers and transport workers, along with free supply of sanitization and protective measures is important. Good governance is also crucial to ensure that the support reaches the intended beneficiaries. Conditioning some of the financial and food support on driver trainings or skills trainings can have longer term benefits through reduced accidents and better job prospects in future. Information campaign targeting transport workers is also important to secure buy-in for the implementation of the safety measures, rather than the heavy-handed approaches to policing and enforcement seen in some countries. See output 3 for further detail.

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Output

1) R Hetherington, ABMT Hasan, A Khan, D Roy, M Salehin and Z Wadud, 2021. Exposure risk analysis of COVID-19 for a ride-sharing motorbike taxi, *Physics of Fluids,* 33(11), p. 113319

2) A Bwambale, C Uzondu, F Rahman, M Islam, Z Batool, P Mukwaya and Z Wadud 2021. User willingness to pay for COVID-19 mitigation measures in public transport and paratransit in developing economies: Evidence from Uganda and Bangladesh, Transportation Research Part A (under review)

3) Z Batool, C Uzondu, M Islam, F Rahman and Z Wadud 2021. The Effects of COVID19 on Public and Para-Transit Drivers in Developing Countries – A Case Study of Dhaka, Bangladesh and Owerri, Nigeria (under preparation)

4) C Uzondu, P Mukwaya, M Islam, F Rahman, A Bwambale, Z Batool and Z Wadud 2021. Mitigating COVID-19 pandemic in Public Transport and Paratransit Operations in the Global South: Lessons from Nigeria, Bangladesh and Uganda (under preparation)

5) R Hetherington, ABMT Hasan, A Khan, D Roy, M Salehin and Z Wadud, 2022. Proposed geometric design of motorcycle taxi shields for motorcycle taxis to reduce COVID-19 risk exposure to passengers,

6) Z Wadud, A Khan, A Bwambale, C Uzondu, ABMT Hasan, F Rahman, R Hetherington, Z Batool, M Islam, D Roy, M Salehin 2022. Modelling the exposure risk trade-off between public transit and private paratransit for transport decision making in the era of COVID19: Summary Findings

7) A Khan and Z Wadud 2022. Can shields between riders reduce COVID19 exposure in motorcycle taxis and save thousands of jobs? https://bit.ly/3zs6P3W

8) Video: How to reduce COVID19 exposure in motorcycle taxis, available here: https://www.youtube.com/watch?v=QK6UrKaGqQs

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