



# Revealed and future travel impacts of COVID-19 in sub-Saharan Africa: Results of big data analysis and a Delphi panel survey

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**Background:** After coronavirus disease 2019 (COVID-19) was declared a pandemic, movement restrictions were implemented across sub-Saharan Africa. There has been much speculation on what the long-term impacts on urban transport might be.

**Objectives:** The aim of this paper is to identify the revealed and future travel impacts of the pandemic.

**Method:** To pursue this aim, evidence was compiled from two sources: secondary big data; and a ( $n = 15$ ) two-wave Delphi panel survey of experts in the region.

**Results:** It is predicted that longer-term impacts will take the form of: reduced travel by, and accessibility for, low-income households residing in peripheral locations because of decreased welfare; reduced transport service availability; operator reduction (particularly amongst unsubsidised formal operators); increased remote activity participation for a minority of better resourced households with white-collar workers; and disrupted trip distributions as the mix of city-centre land use changes in response to business attrition in economic recession rather than to disrupted bid rents.

**Conclusion:** The major impact of the pandemic is likely to be on welfare, rather than on trip substitution. There is a need, therefore, to focus policy on the mitigation of these impacts and, more particularly, on ways of measuring changes in transport disadvantage and exclusion so that reliable data are available to inform mitigation strategies. The mitigation strategies considered should include investment in affordable 'digital connectivity' as a means of complementing accessibility from physical proximity and mobility. The pandemic also highlights the need to develop more robust transport planning practices to deal with uncertainty.

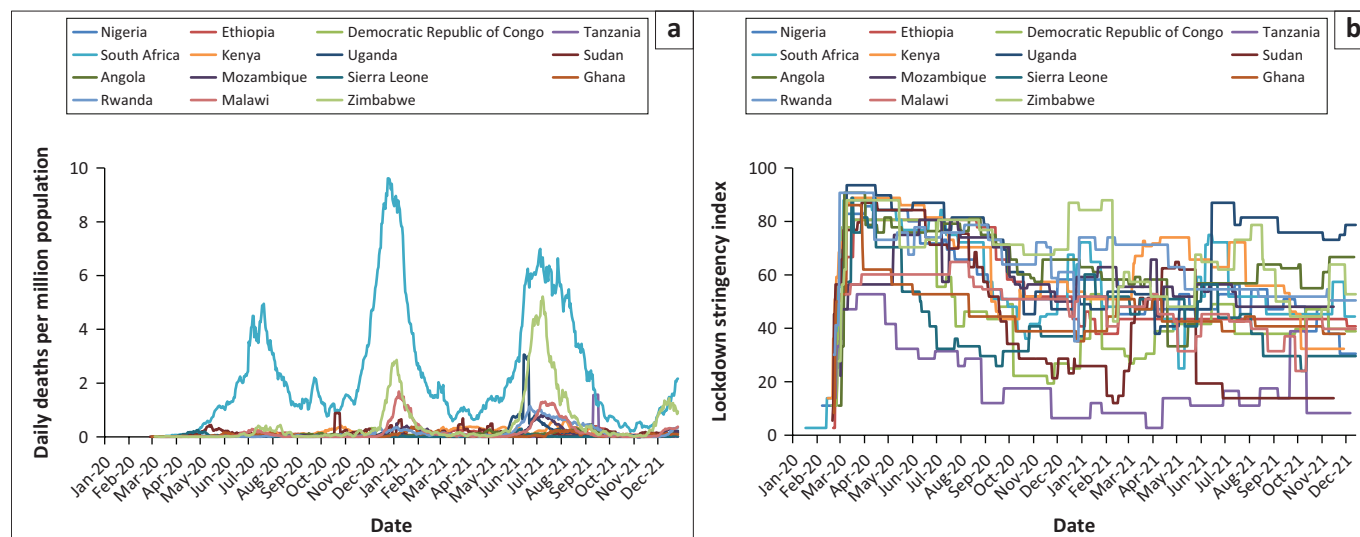
**Keywords:** COVID-19; lockdown restrictions; sub-Saharan Africa; Delphi panel survey; travel patterns; passenger transport operations; livelihoods and exclusion.

## Introduction

There has been considerable heterogeneity in the spread of coronavirus disease 2019 (COVID-19) across sub-Saharan African countries. Figure 1(a) plots the normalised daily recorded fatalities of 15 selected countries (between January 2020 and December 2021). These countries include the 10 most populous nations in the region, as well as the home countries of a Delphi survey panel discussed later in this paper. Whilst representing only 33% of sub-Saharan countries, together they account for 72% of the regional population. These contagion data suggest that South Africa and, to a lesser extent, Zimbabwe have recorded significantly higher fatalities per million.

After the World Health Organization declared COVID-19 a pandemic in March 2020, lockdown restrictions were implemented across the region. Figure 1(b) illustrates that whilst the introduction of lockdown regulations occurred within a small window of time, the adjustment of lockdown levels over time has been variable. All the selected countries introduced restrictions of varying strengths in the first 3 weeks of March 2020. Lockdown restrictions typically took the form of combinations of activity station closures (particularly education and work activities), reductions of public transport service and vehicle capacities, stay-at-home requirements, movement restrictions (domestic and international) and limitations on the size of public gatherings (Diouf et al. 2020;

**Note:** Special Collection: Impact of COVID-19 on the transport and logistics management.



Source: Our World in Data (<https://ourworldindata.org/coronavirus>); Centre for Systems Science and Engineering (<https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9c6f6>)  
 Note: (1) Sub-Saharan African country selection includes the top 10 largest populations and the home countries of Delphi panellists; (2) The 'lockdown stringency index', developed by the Oxford Coronavirus Government Response Tracker project, is calculated as the mean score of nine response metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements and international travel controls. Scores take a value between 0 and 100 (100 = strictest response).

**FIGURE 1:** Normalised COVID-19 contagion and lockdown stringency in selected sub-Saharan African countries ( $n = 15$ ).

Elbany & Elhenawy 2021). Whilst the initial intent of governments was to adjust stringency levels to match risk, the trajectories of the 'stringency index' values relative to fatalities suggest that, in some countries at least, once 'political capital' was spent, restrictions were adjusted to match both risk and public acceptability. Some countries endured more stringent lockdown conditions – and the associated economic hardship – for longer than others. The stringency index values for Tanzania and Malawi, for instance, are significantly lower than for Uganda and Zimbabwe.

There has been considerable research attention given to the short-term impacts that lockdown restrictions have had on transport service provision and trip-making patterns (e.g., Aaditya & Rahul 2021; Barbieri et al. 2021; Beck & Hensher 2021; De Haas, Faber & Hamersma 2020; Scorrano & Danielis 2021), and there has been widespread speculation that mandatory remote activity participation and trip substitution may alter attitudes and preferences and lead to long-term changes in activity schedules and travel behaviour (e.g., Jain, Currie & Aston 2022; Van Wee & Witlox 2021). As will be demonstrated in the brief review of literature that follows, there are geographical and temporal gaps in the existing body of knowledge that need to be filled.

The aim of this paper is to report the results of a study undertaken to identify and compare the revealed impacts of the COVID-19 pandemic on urban transport in sub-Saharan African contexts and to consider the future, longer-term disruptive impacts of the pandemic. The paper focuses on intracity movement and travel modes, and the movement of people.

The paper is divided into six sections. The extent of the available literature in the field is discussed in Section 2. The data collection methods used in the study are described in

Section 3. Insights into the impacts of the pandemic to date are given in Section 4. Propositions on likely future impacts that are common across sub-Saharan African contexts are presented in Section 5. Conclusions are drawn, and policy implications are discussed, in Section 6.

## Literature review

Much has been written about the impacts of lockdown regulations on urban transport systems. Most of this literature has focused on cities and countries in the global north. Two bibliometric studies provide insight into the geographical focus of transport-related COVID-19 literature. Of the 6969 general transport COVID-19 papers found by Benita (2021), 194 focused on passenger travel behaviour. Of these, 30% were international comparisons, 48% focused on countries in the global north and 22% focused on countries in the global south. Only three papers (2%) focused on sub-Saharan African countries. Kutela, Novat and Langa (2021) found a similar pattern. Of the 488 transport COVID-19 papers they identified, 21% were focused on countries in the global south and only eight (2%) were on sub-Saharan African countries.

A search for literature reporting empirical observations of the impacts of COVID-19 on urban passenger transport systems in sub-Saharan Africa yielded 21 published peer-reviewed studies. The search parameters for identifying publications included: inclusion of a sub-Saharan African empirical context; consideration of the mobility and access (or lack thereof) of people in urban areas; and attention to observed or anticipated impacts of the COVID-19 pandemic. Most of these studies focused on the geographical contexts of South Africa (60%) and Nigeria (17%), with the remainder dealing with sub-Saharan African conditions more generally. The research methods applied ranged from analysing secondary big data on mobility and lockdown restrictions (e.g., Asweto et al. 2020; Lawal & Nwegbu 2020) to primary

data collection in the form of quantitative surveys (e.g., Adeke, Zava & Etika 2021; Balbontin et al. 2021) or qualitative interviews (e.g., Jennings & Arogundade 2021; Porter et al. 2021). Some papers focused on policy implications (e.g., Jobanputra & Jennings 2021; Odendaal 2021) rather than the measurement of impacts.

The major substantive themes covered in this body of literature included the following:

- travel behaviour in the form of trip substitution because of working from home (e.g., Balbontin et al. 2021) and mode use switching due to movement restrictions and changes in service supply (e.g., Barbieri et al. 2020, 2021)
- disproportionality in reduced mobility and intensified economic hardship across socioeconomic groups and genders as a result of the pandemic (e.g., Carlitz & Makhura 2021; Porter et al. 2021)
- public transport service availability and utilisation, and consequences for operator viability and fares (e.g., Elbany & Elhenawy 2021; Mogaji 2020)
- local air pollution impacts because of changed travel behaviour patterns (e.g., Lou et al. 2021)
- agent-based model simulation of the impacts of movement lockdown scenarios on viral transmission (e.g., Bossert et al. 2020; Schröder et al. 2021).

Almost all publications focus on impacts in the present or near term. Relatively little attention has been given to future, long-term impacts. Therefore, there are gaps in the literature with respect to both the geographical context and the time dimension of impacts.

## Research method

Evidence of impacts was compiled from two data sources: a fusion of available secondary big data; and a two-wave panel survey of local experts.

### Secondary data fusion

Secondary datasets are available on how the pandemic has impacted sub-Saharan Africa countries, how governments have responded and how urban transport systems have been impacted. Secondary health data on COVID-19 infections, fatalities, vaccinations and excess deaths were sourced from the University of Oxford-affiliated Our World in Data, and the Johns Hopkins University-affiliated Centre for Systems Science and Engineering and Worldometer. Secondary data on the severity of lockdown restrictions were sourced from the University of Oxford-affiliated Our World in Data. Secondary data on changing activity participation and travel patterns were sourced from Google COVID-19 Community Mobility Reports. Calendar date data records were used to fuse datasets.

### Delphi panel survey

The two-wave panel survey of sub-Saharan African urban transport planning practitioners and academics sought both retrospective and prospective perspectives on the impacts of

COVID-19. A Delphi survey was identified as a suitable method for this objective. The Delphi technique was originally developed in the 1950s by the Rand Corporation in the United States for technology forecasting (Dalkey 1969). The method involves a sequence of two or more surveys used to gather the informed opinions of a panel of experts. The method is especially useful in forecasting exercises in which expert opinions are the only available source of information. Expert panel interaction is structured around rounds of response and feedback, providing opportunities for individuals to modify their earlier views and for groups to shift towards a consensus. In the later rounds, panellists are provided with the results of the earlier round so that they can revise their original opinion if they are influenced by the opinions of others.

For the Delphi method to be effective, the anonymity of panellists is essential. Advocates of the method hold that direct confrontation can either lead to the irrational defence of a position once it is taken (to avoid losing face) or to a predisposition to be swayed by persuasively stated opinions of others without sufficient independent thought (eds. Linstone & Turoff 2002). Anonymity is argued to promote independent and unbiased thought and to avoid 'bandwagon' and 'halo' effects.

The panel of experts was recruited from a network formed through the Volvo Research and Educational Foundations' Mobility and Access in African Cities Programme. Of the 37 experts invited to participate in the study (14 women and 23 men from 16 countries), 15 (from 10 countries) agreed to participate. The panel was comprised of university researchers (10), nongovernmental organisation practitioners (2), private consultants (2) and a government official (1). The home cities of the Delphi panel included Accra, Blantyre, Cape Town, Dar es Salaam, Freetown, Harare, Kampala, Kigali, Kumasi, Lagos and Nairobi. Fifteen experts completed the first wave (circulated on 29 July 2021) and 14 (93%) completed the second wave (circulated on 31 August 2021).

The purpose of the first-wave survey was to search for common positions on the current and future transport impacts of COVID-19 in different countries and regions. Through an online questionnaire, it was intended to provide insights into the observed impacts of COVID-19 on travel behaviour and trip substitution, operations, livelihoods and poverty and possible long-term disruptive effects on future public transport service supply, travel behaviour and how impacts might vary across socioeconomic and demographic groups. The second-wave survey was comprised of summary feedback on first-wave responses and an accompanying further online questionnaire. The purpose of the second-wave survey was to seek consensus on propositions regarding the future impact of COVID-19 on urban transport and to explore policy implications for aiding public transport recovery and mitigating social exclusion. Research ethics approval (20210708223855) was obtained from the Ethics in Research Committee in the University of Cape Town's Faculty of Engineering and the Built Environment.

## Revealed impacts

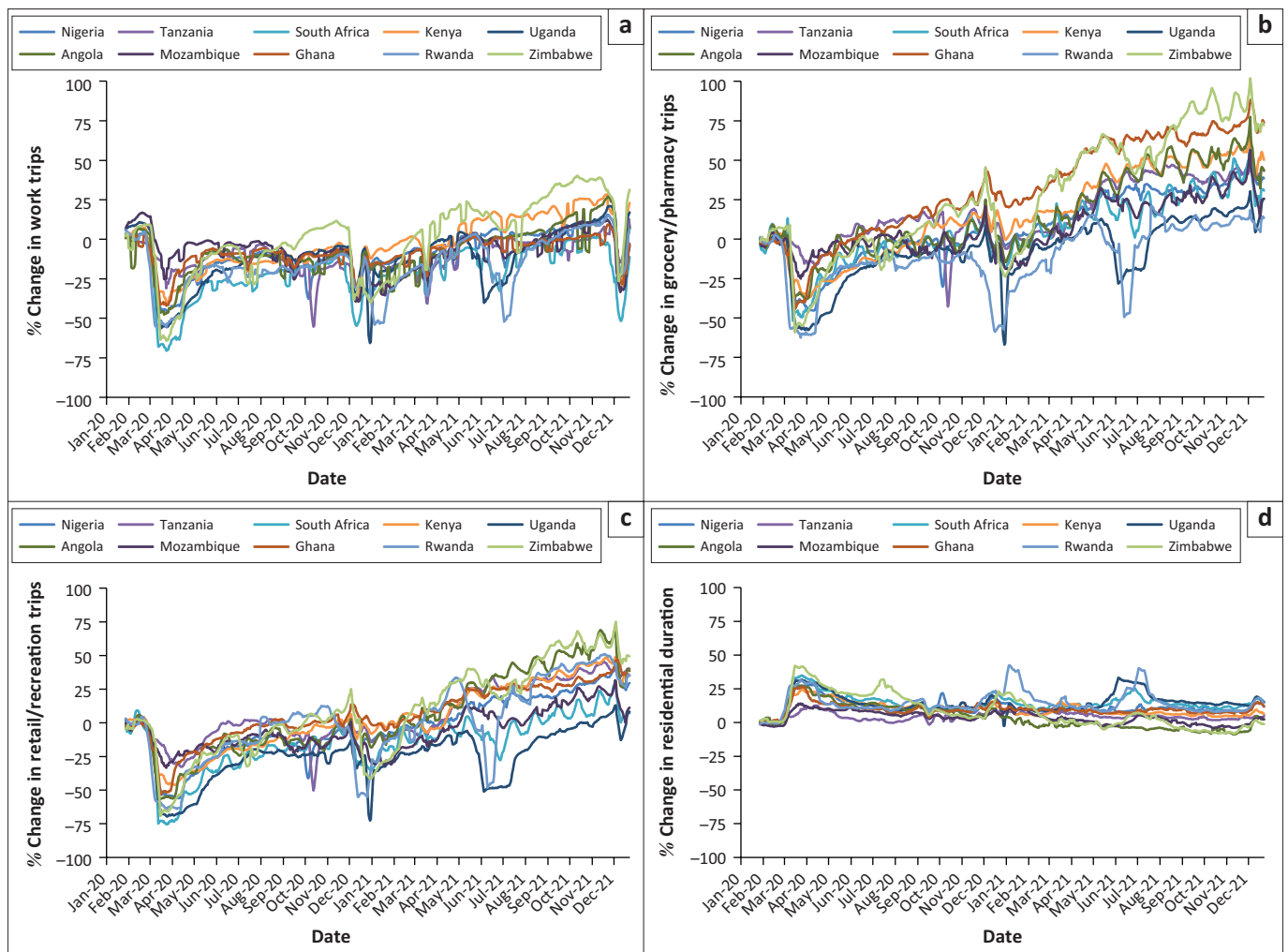
Revealed impacts, derived from the available secondary data and the first wave of the Delphi panel survey, are discussed in terms of travel patterns, passenger transport operations, and household livelihoods and social inclusion.

### Travel patterns

Google has assembled comparative quantitative data on the impacts of lockdown restrictions on trip-making from the location tracking functionality of smartphones (and other mobile devices), with trip purposes imputed from land use geography information overlays. The shortcoming of these data is that they are limited to a subset of the population that uses smartphones. In countries with lower household incomes, this means that the data are skewed towards wealthier socioeconomic groups. Whilst many, if not most, people in the selected sub-Saharan countries own mobile phones, smartphones are owned by a minority. For example, in Rwanda, the latest comparative data indicate that there were 76 mobile phones per 100 people (in 2019), but only 9%

of the population owned a smartphone (in 2017) (Onkokame, Schoentgen & Gillward 2018; Silver & Johnson 2018).

With the above caveat in mind, changes in trips to workplaces compared on a percentage basis before and after lockdown restrictions were imposed are illustrated in Figure 2(a). The before-lockdown baseline (i.e., the 0 value on the vertical axis) was set as the median value for each day of the week, calculated from daily measurements over a 5-week period between 03 January and 06 February 2020. The data suggest that, in the short term, reduction in trips to workplaces varied in scale across countries. South Africa and Zimbabwe, for instance, saw a reduction of around 60%, whereas in Mozambique and Tanzania, the maximum reduction was considerably lower (at around 25%). The reduction was short-lived in some countries (e.g., Mozambique and Zimbabwe returned to pre-lockdown levels within 3 or 4 months), whilst others remained below the baseline for up to 20 months (e.g., South Africa). The spiked reductions of Uganda, Rwanda and South Africa mirror the arrival of second, third and fourth infection waves (see Figure 1).



Source: Google COVID-19 Community Mobility Reports (<https://www.google.com/covid19/mobility/>)

Note: (1) Sub-Saharan African country selection includes the top 10 largest populations and the home countries of Delphi panellists. Data were not available for Ethiopia, Democratic Republic of Congo, Sudan, Sierra Leone and Malawi; (2) 'Grocery and pharmacy' trips are to destinations like grocery markets, farmers markets, speciality food shops, drug stores and pharmacies; (3) 'Retail and recreation' trips are to destinations like restaurants, cafés, shopping centres, theme parks, museums, libraries and movie theatres.

**FIGURE 2:** Change in trips to workplaces and shopping activities and residential duration in selected sub-Saharan African countries ( $n = 10$ ).

Changing frequencies for two categories of shopping trips are tracked in Figure 2(b, c). The figure reveals that shopping trips for essential items returned to baseline frequencies much sooner than trips for nonessential items. Figure 2(b) plots trips to obtain food and medication essential for household survival. Short-term reductions in essential shopping trips ranged between 25% and 60%, with a return to, or a surpassing of, baseline levels occurring within 3 and 13 months. After 18 months, all of the selected countries had exceeded baseline trip frequencies by between 10% and 80%. Figure 2(c) plots trips to purchase nonessential items and to participate in other discretionary recreational activities. The figure reveals short-term reductions in nonessential shopping (and recreation) trips ranging between 25% and 70%, with a return to baseline levels occurring later than essential shopping trips (but slightly earlier than trips to workplaces) for most of the countries observed. For all but Uganda and South Africa, baseline trip-making had been exceeded after 18 months.

Figure 2(d) presents the corollary of parts (a – c). It illustrates that as trips to out-of-home activities were foregone (and to some extent substituted for remote work, education, social or entertainment activities), the amount of time people spent at home increased. Apart from Angola, Mozambique and Zimbabwe, all countries continued to show higher-than-baseline time spent at home, i.e., 22 months from when lockdown restrictions were first introduced.

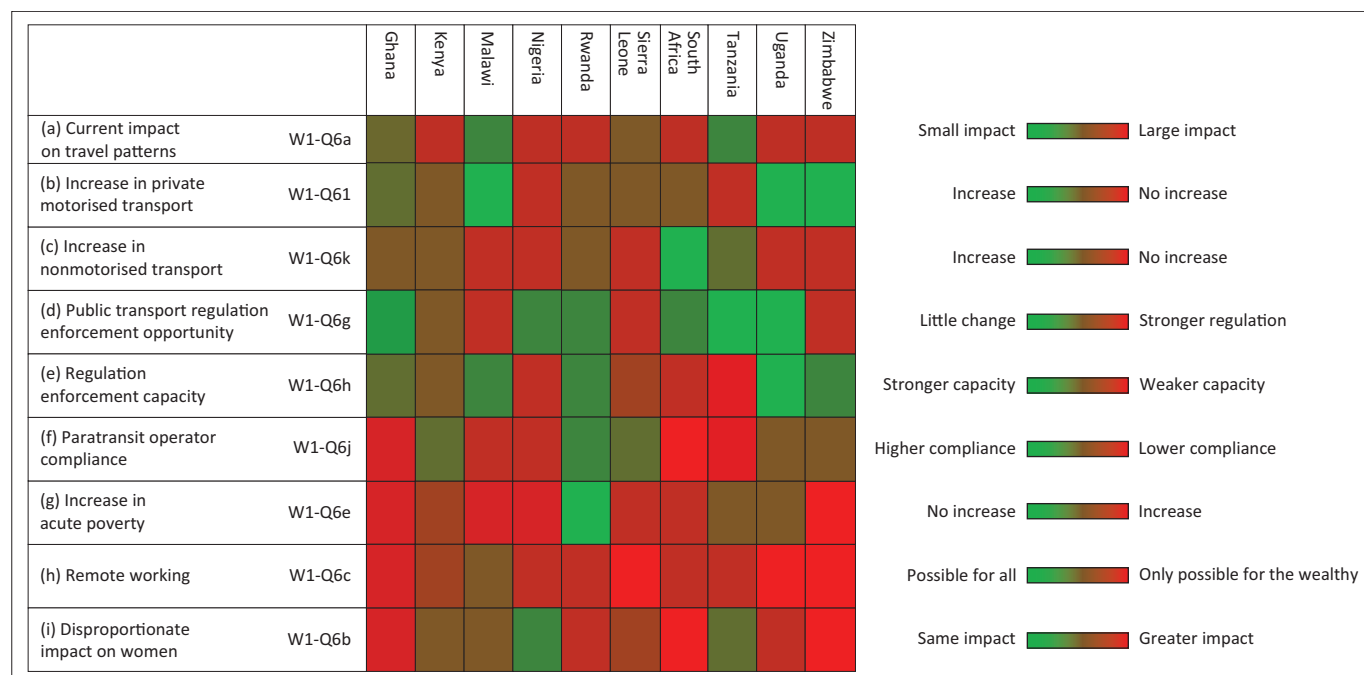
Figure 3(a, b, c) presents the perceptions of the Delphi panellists provided in the first-wave survey, regarding the impact of lockdown restrictions on travel patterns. Panellists from countries with the least stringent regulations (Tanzania

and Malawi) reported the least impact (see part a). Half of the panellists (47%) were undecided on whether the segment of individualised private mode use had increased (see part b), but half (47%) perceived the segment of walking and cycling to have increased (see part c), which is consistent with other observations in sub-Saharan Africa (Bird, Kriticos & Tsivanidis 2020). These perceptions refer to the relative segments of modal splits, not to an increase in trip generation, which is likely to have declined (Barbieri et al. 2020, 2021).

### Passenger transport operations

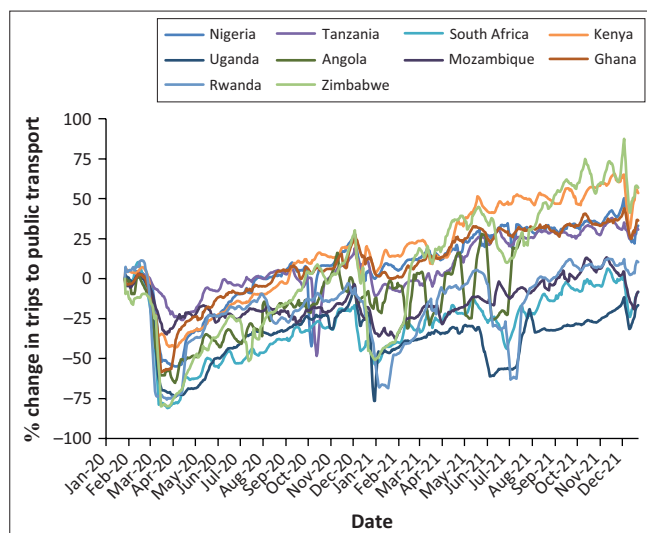
The most common public transport restrictions in the 11 home cities of the Delphi panellists were reported to be reduced vehicle occupancy (73%) and reduced frequency, if not cancellation, of services (60%). The impact of these lockdown restrictions can be observed in comparative secondary data on the trips to public transport stations presented in Figure 4. Apart from Uganda, Mozambique and South Africa, all the selected sub-Saharan African countries had surpassed baseline levels after 22 months. Using the same dataset, Brondum et al. (2021) showed that low-income and lower-middle-income countries returned to baseline frequencies earlier than higher-income countries (in December 2020).

The decline in number of passengers indicated in Figure 4 had an impact on farebox revenue and service viability and operator compliance with lockdown restrictions. Brondum et al. (2021) note, as do Venter, Hayes and Van Zyl (2020), that the data may be skewed in countries where the origins of public transport trips are often not formal public transport interchanges, ranks, stations or stops. As a result, it is difficult



Note: W1 – Q6a: COVID-19 has had a minimal impact on urban travel patterns, and livelihoods have continued as normal; W1 – Q6l: The mode share of cars and motorcycles has increased because of COVID-19; W1 – Q6k: The mode share of walking and cycling has increased because of COVID-19; W1 – Q6g: Authorities took the opportunity of increased regulatory power during COVID-19 lockdowns to enforce existing public transport regulations more strongly; W1 – Q6h: The capacity of public authorities to enforce lockdown regulations in public transport services is weak; W1 – Q6j: The only way for informal public transport operators to survive the COVID-19 lockdown was to not comply with vehicle occupancy and/or other restrictions; W1 – Q6e: The proportion of the urban population experiencing acute poverty has increased during COVID-19; W1 – Q6c: Remote working during COVID-19 is only possible for a wealthy minority; W1 – Q6b: The mobility and access enjoyed by women has been worse affected by COVID-19 than men.

FIGURE 3: Perceived impacts on travel behaviour, public transport regulation enforcement and compliance and livelihoods, by country (Delphi Wave 1, n = 15).



Source: Google COVID-19 Community Mobility Reports (<https://www.google.com/covid19/mobility/>)

Note: (1) 'Transit stations' trips are to destinations like public transport service hubs such as subway, bus and train stations; (2) Sub-Saharan African country selection includes the top 10 largest populations and the home countries of Delphi panellists. Data were not available for Ethiopia, Democratic Republic of Congo, Sudan, Sierra Leone and Malawi; (3) Diouf et al. (2020) perform a similar analysis with a different country selection (adding Burkina Faso, Cameroon, Ivory Coast, Mali, Senegal and Zambia), finding no significant outliers.

**FIGURE 4:** Change in trips to transit stations in selected sub-Saharan African countries ( $n = 10$ ).

to distinguish between the loss of passengers experienced by formal and informal operators.

Calnek-Sugin and Heeckt (2020) contend that COVID-19 undermined the business model for unsubsidised informal paratransit operators that are reliant upon farebox revenue for viability. Half of the Delphi panellists (47%) reported in the first-wave survey that sub-Saharan public transport operations became either less or much less viable with the other half indicating either no change (20%) or insufficient evidence to judge (13%). For South Africa, Fobosi (2020), Jennings (2020), Luke (2020) and McLachlan (2020) all report that informal paratransit operators incurred significant losses. This led to various forms of protest and widespread non-compliance with a 70% vehicle occupancy restriction, and the national government eventually removing the vehicle occupancy restriction for informal paratransit operators. Venter et al. (2020) suggest that removing the restriction allowed passenger ridership in informal paratransit services to recover more quickly because the restriction largely affected a captive market. By contrast, formal bus and train services, often serving markets where passengers have greater choice, experienced an almost tenfold reduction in ridership. Luke (2020) and Baffi, Boudet and Mene (2021) note that sedan and motorcycle electronic hailing service providers experienced viability constraints as well.

Figure 3(d, e, f) presents perceived enforcement and compliance in the 11 home cities of the Delphi survey panellists. The figure illustrates that some governments took the opportunity presented by lockdown conditions to increase their regulatory control over public transport operations (see part d), but that this was not necessarily

matched with enforcement capacity (see part e). Most panellists (53%) agreed that compliance with lockdown restrictions amongst informal paratransit operators was low (with 27% indicating they had insufficient evidence to judge).

## Livelihoods and exclusion

Emerging fragments of socioeconomic data indicate that the unintended impacts of lockdown restrictions on economic livelihoods have been devastating. Many economies have shed jobs in large numbers and entered into recession, which will have impacted activity participation and mobility as well as the incomes and expenses (and societal inclusion) of households in complex ways. Figure 3(g) presents the perceptions of the Delphi panellist on the impacts of the pandemic on poverty. There was near consensus that the proportion of the urban population experiencing acute poverty has increased. Drawing from several secondary data sources, Teachout and Zipfel (2020) estimated that an additional 9% of the sub-Saharan African population fell into extreme poverty as a result of the pandemic and associated lockdown restrictions. They estimated that, at the end of the first 8 weeks of lockdown, 19% of the population could no longer afford their pre-COVID-19 level of food consumption, and 4% of the population was severely food deprived.

Most of the available data on the economic welfare impacts on sub-Saharan African households are focused on South Africa. Insights into the extent of job losses can be derived from several metrics. Spaull et al.'s (2020) analysis of the National Income Dynamics Study Coronavirus Rapid Mobile (NIDS-CRAM) survey data estimated that between 2.5 million and 3.6 million South Africans lost their jobs between February and April 2020. Adding a spatial dimension, Turok and Visagie (2021) found that the percentage of adults in paid employment living in 'suburbs' dropped from 58% in February 2020 to 52% in June 2020 and that in 'townships' dropped from 51% to 42% over the same period. Carlitz and Makhura's (2021) analysis of Statistics South Africa survey data found that 2% of permanently employed respondents reported losing their jobs in the first 6 weeks of lockdown, whilst 5% reported having to close their businesses. For respondents who remained employed during this period, 21% reported reduced income.

Perhaps the most tangible impact on daily household activity schedules was the requirement to stay at home. In a ( $n = 1056$ ) consumer panel survey, undertaken as part of an international comparative study (Balbontin et al. 2021), Venter, Van Zyl and Cheure (2021) found that in November of 2020, 40% of employees were working 5 days a week from home. However, as confirmed by the Delphi panellists (see Figure 3[h]), remote working during COVID-19 was only a possibility for a wealthy minority. Using the same residential location categories as Turok and Visagie (2021), Carlitz and Makhura's (2021) analysis of Statistics South Africa survey data found that in 'suburbs' 88% of respondents were able to work from home, whereas in 'townships' only 5% were able to do so. As a result, low-income households were less able to comply

with lockdown restrictions (Carlitz & Makhura 2021; Pedan & Kobusingye 2020). Aside from the need to obtain food and water, in a ( $n = 20990$ ) telephonic survey of 20 African Union member countries, PERC (2020) found that the most commonly cited barriers to stay-at-home compliance were fears of running out of money and losing a job.

Figure 5(a) presents the perceptions of the Delphi panellists regarding which socioeconomic and demographic groups experienced the greatest impact on their welfare. Low-income households and women top the ranking. Numerous authors have argued that women were more likely than men to have lost their jobs, and that this hardship was compounded by increased demands to provide family care (Casale & Posel 2021; Jennings, Allen & Arogundade 2020; Jennings & Arogundade 2021; Porter et al. 2021). Analysing the NIDS-CRAM data from a gender perspective, Casale and Posel (2021) found that employment of adult South African women declined by 10 percentage points between February and April 2020 (from 46% to 36%), whereas adult male employment dropped by 5 percentage points (from 59% to 54%).

The Delphi panellists highlighted reduced accessibility (particularly to work, health care and education activities) as a feature of the impact of lockdown regulations on economic welfare (see Figure 5[b]). Disproportionality in impacts on accessibility is illustrated by Bird et al. (2020), who estimated that lockdown restrictions in Nairobi resulted in five times fewer job opportunities within 1 h for people reliant on

nonmotorised modes than people with access to cars. The lockdown period may therefore have lasting economic effects that make vulnerable and excluded segments of the population more vulnerable and excluded.

## Future impacts

Possible future impacts, derived from the second wave of the Delphi panel survey, are discussed in terms of changes in travel patterns, disruptions to passenger transport operations, and household livelihoods and social inclusion.

## Travel patterns

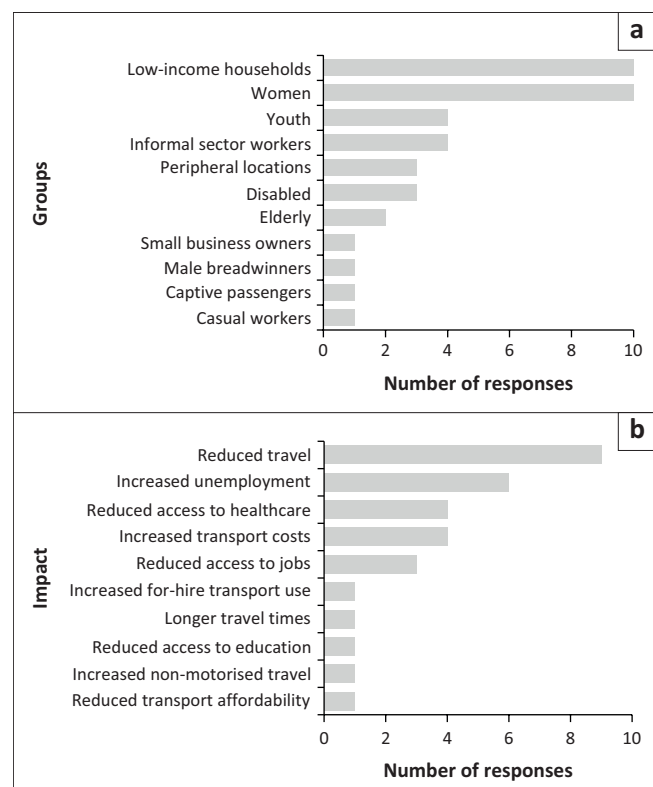
Bem's 'self-perception theory' provides a useful lens through which to consider the long-term impacts of temporarily imposed lockdown restrictions on patterns of trip generation and trip substitution (Bem 1972). Applying this theory, the imposed (or at least encouraged) increase in remote activity participation during more stringent lockdown periods – provided the experience is good – can make attitudes towards remote working, schooling and shopping more positive and subsequently lead to enduring trip substitution after activity destinations are fully opened and restrictions on movement are removed.

Based on first-wave survey perceptions, a proposition was formulated to test this theoretical perspective in the second wave. The first-wave survey did not establish a majority view on whether travel behaviour patterns would return to what they were before the pandemic (50% yes, 36% no and 14% undecided; see Figure 6[a]). In contrast to studies elsewhere (Barbieri et al. 2021), there was also uncertainty on whether individualised private motorised transportation would increase (21% yes, 28% no and 50% undecided; see Figure 6(b)) and on whether there would be greater online shopping and personal business transactions after COVID-19 has passed (34% yes, 33% no and 33% undecided; see Figure 6[c]).

The first-wave survey nevertheless established a consensus view that a relatively small portion of a city's population would have the resources to engage productively with remote activity participation platforms (see Figure 3[h]) and a majority view that the activities most likely to be participated in remotely would include work and business meetings (identified by the most panellists), followed by shopping and tertiary education. A proposition was formulated as follows:

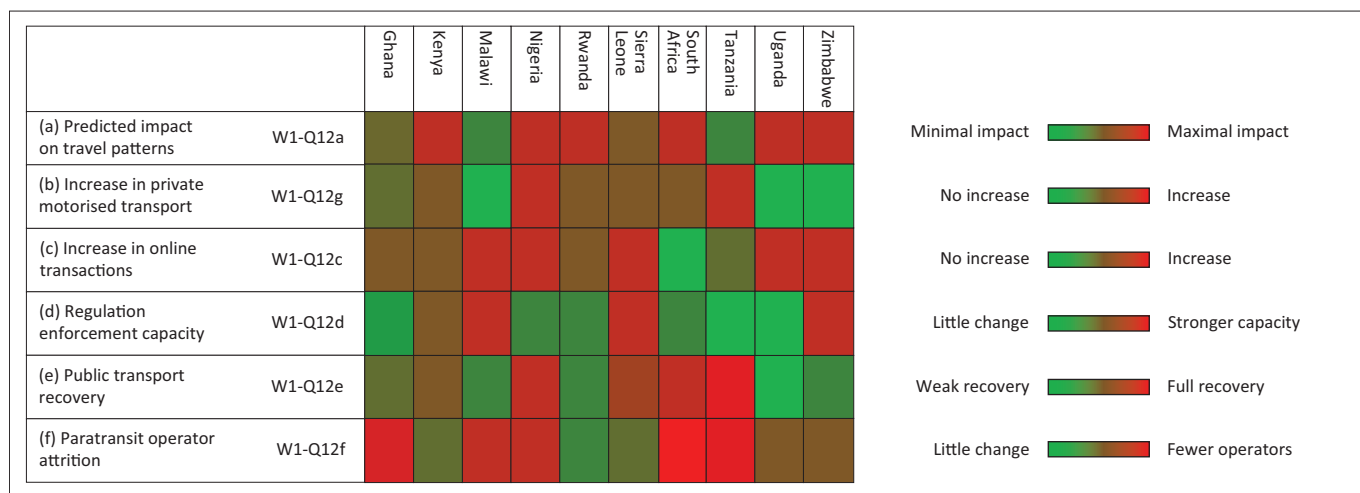
There are likely to be post-pandemic increases in remote working, shopping and education as a lasting result of COVID-19 disruptions, but this will only occur amongst a wealthy minority of the population in sub-Saharan African cities with access to prerequisite resources. Whilst this segment of urban populations will enjoy greater time-space flexibility to cope with hyper-congestion, city-wide impacts from remote activity participation on traffic congestion and passenger volumes will be small.

There was no disagreement with this proposition: 12 (86%) panellists agreed (43% agreed strongly). The two panellists who abstained were based in Nairobi. The accompanying



Note: W1 – Q2: Which passengers (in terms of household income, gender, age and residential location) have been most affected by COVID-19 lockdown regulations, and what have the main impacts on their mobility and access been?

**FIGURE 5:** Perceived impacted groups (Delphi Wave 1,  $n = 15$ ). (a) Socioeconomic and demographic groups most impacted and (b) Impacts on mobility and access.



Note: W1 – Q12a: Once COVID-19 has passed, travel behaviour patterns will resume to what they were before; W1 – Q12g: The mode share of individualised travel via cars and motorcycles will increase after COVID-19 has passed because of disruptions to public transport service capacity; W1 – Q12c: There will be greater online shopping and personal business transactions across the entire population after COVID-19 has passed; W1 – Q12d: The regulatory and enforcement capacity of public transport authorities will be stronger than before, after COVID-19 has passed; W1 – Q12e: Public transport operations will recover to what they were before the COVID-19 pandemic started; W1 – Q12f: There will be fewer illegal or unregulated public transport operators after COVID-19 than before.

**FIGURE 6:** Predicted impacts on future travel behaviour and public transport regulation enforcement and recovery, by country (Delphi Wave 1,  $n = 15$ ).

explanation indicated that there are confounding contextual dynamics in Nairobi that make it difficult to predict the causes of future changes, even if it is evident that remote activity participation has increased and congestion levels have returned to base conditions:

‘In Nairobi, traffic congestion is back to [the] pre-COVID situation. However, there is an increase in remote working, shopping, and education. Part of the congestion is attributed to the ongoing Nairobi expressway construction – therefore confounding the observations.’ (Panellist 02, academic, Nairobi)

Alonso’s ‘land rent theory’ provides another theoretical perspective from which to consider long-term disruption to trip patterns (Alonso 1964). Applying this theory, the emergence of large-scale ‘hybrid’ work practices and increased online retailing, entertainment and dining as a result of COVID-19 stay-at-home restrictions might decrease the sensitivities of some business and commercial land uses to the cost of physical access. This would enable them to survive on less accessible, cheaper land (or at least to reduce their land area requirement) and thereby disrupt the ‘bid rents’ of competing land use activities in city centres. This might lead to new land uses emerging in the place of some shops, offices, theatres, restaurants and parking garages, which would in turn change the distribution of trip attractions and productions across cities and alter travel patterns.

Based on first-wave survey perceptions, a proposition was formulated to test this theoretical perspective in the second-wave survey. The first-wave survey did not establish a large majority view on whether businesses would maintain greater online or virtual business operations after the pandemic (53% yes, 40% no and 7% undecided) and whether this would impact city centre land rents and land use distributions. The two diverging perspectives are illustrated as follows:

Referring to Nairobi: ‘Many are expected to maintain online and virtual operations with drastic effect on the rental businesses.

Many offices are not occupied, other renters have moved to better and cheaper premises, while others have fully shifted to working from home. This applies to both middle- and high-income groups, including international agencies, many who are still working abroad.’ (Panellist 15, academic, Nairobi)

Referring to Kigali: ‘Most of the businesses will resume physical operations ... I see not much effect on city centre land rents and land use distributions. Possibly what I see might grow is home deliveries of goods that gained momentum during COVID-19 times.’ (Panellist 01, government official, Kigali)

As indicated earlier, the first-wave survey did nevertheless establish a consensus view that a portion of a city’s population will have the resources to engage productively with remote activity participation platforms and that economic impacts have been severe. A proposition was formulated as follows:

Whilst there are likely to be post-pandemic increases in remote working and shopping amongst a wealthy minority, they are unlikely to cause a large enough shift to remote business and retail activity to significantly disrupt land use distributions in sub-Saharan African city centres. Changes in post-pandemic city centre land use mix will more likely be the result of business attrition resulting from COVID-19-induced, or accelerated, economic recession. These changes may be significant in the countries that were hit hardest economically.

There was consensus on this proposition: all panellists agreed (29% agreed strongly). One panellist did, however, offer the following caveat:

‘This is the general truth, although there wasn’t much business attrition in Dar es Salaam except those linked to international trade.’ (Panellist 07, academic, Dar es Salaam)

## Passenger transport operations

Gwilliam’s ‘regulatory cycle’ provides a useful lens through which to consider the long-term disruptive effects of



lockdown regulations on public transport operator attrition and changes in service mix (Gwilliam 2008). In terms of this conceptualisation, the reduced financial viability resulting from reduced ridership and farebox revenue during the pandemic, if unmatched by sufficient compensatory state subsidy, might nudge a change in cycle phase and lead to a growth or decline in informal operators.

Based on first-wave survey perceptions, a proposition was formulated to test this theoretical perspective in the second wave. The first-wave survey did not establish a majority view on whether public transport operations will recover to pre-pandemic levels (47% yes, 40% no and 13% undecided; see Figure 6(e)). It did, however, establish a (weak) majority view that, despite efforts to assert greater control during the pandemic, the regulatory and enforcement capacity of public transport authorities would not be strengthened in the long term (53% agree, 20% disagree and 27% undecided; see Figure 6[d]) and that there would not be a thinning of illegal or unregulated public transport operators (53% agree, 20% disagree and 27% undecided; see Figure 6[f]). Common perspectives on paratransit recovery are illustrated as follows:

Referring to Blantyre: 'Already the paratransit is going back to normal operations with normal carrying capacities. There are more entrants into paratransit, not because of COVID-19, but because of lack of formal public transport, hence an opportunity for paratransit operators. I do not [envision] any long-term impact on the current services.' (Panellist 04, academic, Blantyre)

Referring to Harare: 'The informal sector will bounce back. The bus company will no longer be able to provide a reliable efficient and demand-responsive service and there will [be no] justification [to] not allow minibuses to operate.' (Panellist 14, academic, Harare)

A proposition was formulated as follows:

Whilst impacted by reduced farebox income during the pandemic, and experiencing some attrition, the informal public transport sector will be sufficiently agile and atomised to recover service supply to pre-COVID-19 levels when passenger demand increases. The informal public transport operators will be more resilient, and will recover quicker, than formal public transport operators burdened by service-level agreements and labour regulations.

There was no disagreement with this proposition: 10 panellists (72%) agreed (43% agreed strongly). However, there were three panellists who were undecided, and one panellist abstained. The accompanying explanations indicate that the reason for doubt was an absence of formal public transport undertakings in the city to compare paratransit with:

'In Malawi ... there is no formal public transportation within the cities. ... Informal public transport is conspicuously surviving, albeit [with] emerging competition from other [informal transport] modes, e.g., motorcycles and small engine sedan vehicles.' (Panellist 04, academic, Blantyre)

'In Kenya, we have only informal public transport systems. These systems are likely to recover with the relaxation of COVID-19 ... [and] social distancing. The vehicles now carry to full capacity, while charging increased fares (raised during COVID-19).' (Panellist 02, academic, Nairobi)

## Livelihoods and exclusion

Hägerstrand's 'time geography' provides a useful lens through which to consider reduced mobility and access and associated impacts on livelihoods and economic and societal inclusion (Hägerstrand 1987). Applying this theory, the increased 'capability constraints' amongst the most vulnerable and marginalised households (i.e., the reduced ability to pay for private and public mobility), resulting from job losses and reduced incomes stemming from the pandemic's impact on the local economy, might reduce activity participation 'domains' and increase social exclusion.

Based on perceptions expressed in the first-wave survey, a proposition was formulated to test this theoretical perspective in the second-wave survey. The first-wave survey did not establish a majority view on whether access and mobility (and associated livelihood) impacts would be disproportionate across socioeconomic groups (36% yes, 29% no and 36% undecided). The two diverging perspectives are illustrated as follows:

Referring to Cape Town: 'It seems that public transport and the minibus-taxi sector (except for strikes) are back to "normal," but people who depended on rail will have a challenge (which was already in the pipeline). Reduced mobility is more likely to be an outcome of reduced income rather than reduced options.' (Panellist 09, consultant, Cape Town)

Referring to Blantyre: 'In terms of transport, no. I believe the situation will go back to normal. Of course, some will have lost their jobs but in regard to transport I do not think much will change.' (Panellist 04, academic, Blantyre)

The first-wave survey established a majority view that the proportion of the urban population experiencing acute poverty has increased (73% yes, 14% no and 13% undecided) and that women have been more adversely impacted by COVID-19 with respect to mobility and access than men (60% yes, 14% no and 27% undecided). A proposition was formulated as follows:

There are likely to be increases in economic hardship resulting from COVID-19 disruptions, and poorer households will travel less than they did before the pandemic started. But this reduction in (motorised) mobility will be due to increased unemployment, reduced informal sector markets and reduced household income, rather than trip substitution resulting from shifts to remote activity participation. Social exclusion amongst poor and vulnerable households, particularly women, will increase as a result.

There was majority agreement with this proposition: 10 panellists (72%) agreed (22% agreed strongly). Two panellists disagreed. The accompanying explanations suggest that the basis for disagreement was limited disruptions during less stringent lockdowns:

'There was almost no disruption to public transport in Dar es Salaam during COVID-19, at least up to this third wave of delta virus.' (Panellist 07, academic, Dar es Salaam)

'Here in Accra, life seems to be going on as usual, regardless of the pandemic. COVID-19 has not prevented people (especially those being referred to as "poor") from engaging in their day-to-day activities.' (Panellist 12, consultant, Accra)

A further two panellists abstained. The accompanying explanations suggest that households developed coping strategies to deal with transport system disruptions:

Referring to Sierra Leone: 'While poorer households are likely to travel less, many in Sierra Leone are substituting to walking. For longer travels (e.g., to attend family programs or other ceremonies in distant places) they can put resources together and send one or two representatives to attend.' (Panellist 11, academic, Freetown)

Referring to Blantyre: 'I know of some women in the low-income category who are willing to travel more frequently and cover more distance to employment than they did before the pandemic. And the link between social exclusion, gender, travel and employment may not be a simple one to establish.' (Panellist 04, academic, Blantyre)

## Conclusion

This paper set out to identify observable impacts of the COVID-19 pandemic on travel in sub-Saharan African cities and consider the long-term disruptive impacts of the pandemic on mobility and access in this context.

Regarding observed impacts, although incomplete and biased towards certain socioeconomic groups, the available evidence does indicate that the mobility and access impacts of lockdown regulations varied across sub-Saharan Africa. Trip-making appears to have returned to base condition levels much sooner in some countries in the region compared to others. Eased traffic congestion externalities were probably also relatively short-lived. The evidence indicates that the largest impacts on mobility and access in the more highly affected cities have taken the form of:

- lower trip generation due to increased remote activity participation amongst the wealthy and due to reduced economic activity amongst the poor
- decreased accessibility amongst passengers reliant on public transport due to reduced service availability
- decreased transport service operator viability due to decreased ridership and farebox revenue
- increased social exclusion due to increased economic hardship and decreased travel capability, disproportionately for low-income households and women.

Regarding predicted long-term urban transport impacts, multiwave consensus-seeking in the Delphi expert survey led to the formation of propositions that did not depart significantly from the trends revealed earlier. In these propositions, it is predicted that the largest impacts felt by sub-Saharan African city populations will take the form of:

- reduced travel by, and accessibility for, low-income households (particularly women) residing in peripheral locations due to decreased economic welfare
- reduced transport service availability due to operator attrition, particularly amongst unsubsidised formal operators
- increased remote activity participation and fewer work and business trips for a minority of households with

more resources, such as households comprised of white-collar workers, with the extent of this impact depending largely on how extensively 'hybrid' work and business practices become embedded

- disrupted trip distributions as the mix of city-centre land uses changes, more in response to business attrition in a COVID-19-induced, or accelerated, economic recession than to disrupted bid rents.

What then are the implications of these findings for urban transport policy and practice? It is argued that the disruptive impacts of the pandemic on trip substitution, which have been the focus of much policy debate elsewhere, are less significant in the sub-Saharan African context. Policy should of course respond to such disruptions to nudge changes in desired directions, but this should not be the primary motivation for intervention. The evidence considered in this study indicates that the major impact of the pandemic in the sub-Saharan African context will be on economic welfare rather than on disrupted business operating practices, leading to increased poverty, a shrinking middle class, small-business closures and an enlarged informal sector. No matter how minor the disruptions to trip-making during the pandemic are, no country will be immune from long-term global economic impacts. Therefore, urban transport policy attention in sub-Saharan Africa should focus on mitigating these impacts. An important implication for transport planning practice is developing ways of measuring and then monitoring increases in transport disadvantage and social exclusion. As the economic ramifications of the pandemic are felt, it will be important for city transport planning authorities to monitor how the accessibility of vulnerable groups to key livelihood activities changes so that reliable data are available to inform mitigation strategies. Investment in affordable 'digital connectivity' as a means of complementing accessibility derived from spatial proximity and physical mobility, and buttressing resilience, should be amongst the mitigation strategies considered.

A further implication for transport policy relates to providing financial support to public transport operators to help them survive periods of reduced ridership and farebox revenues. Financial support to informal public transport operators should be used as leverage for introducing reforms that lead to better-integrated, safer, higher-quality and greener services.

A final more fundamental implication for transport planning practice emerging from the pandemic is the need to develop city transport planning practices that are better able to deal with uncertainty. The pandemic has highlighted the limitations of long-range travel-demand forecasting as a basis for planning city transport system improvements. A shift to a more flexible 'decide and provide' transport planning process, in which a robust course is charted towards a preferred future, capable of negotiating uncertainty along the way, would be beneficial.

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## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this paper.

## Authors' contributions

Roger Behrens framed the research problem and developed the theoretical framework. Alexandra Newlands extracted secondary big data and performed the data analysis. Roger Behrens drafted the manuscript. Alexandra Newlands reviewed the manuscript.

## Ethical considerations

Research ethics approval (no. 20210708223855) was obtained from the Ethics in Research Committee in the University of Cape Town's Faculty of Engineering and the Built Environment.

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## Data availability

The data that support the findings of this study are not openly available for reasons of respondent anonymity and are available from the corresponding author, Roger Behrens, upon reasonable request.

## Disclaimer

The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency.

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