Initial insights into the effect of mobility restrictions in the Democratic Republic of the Congo using anonymised and aggregated mobile phone data

Mobility analysis to support the Government of the Democratic Republic of the Congo (DRC) in responding to the COVID-19 outbreak

Vodacom Congo
Flowminder Foundation
May 2020

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This analysis was performed by Vodacom Congo in partnership with the Flowminder Foundation.

About Vodacom Congo

Vodacom Congo is a Mobile Network Operator offering innovative telephony, messaging, Internet and electronic money services to more than 1,000 localities throughout the Democratic Republic of Congo and aiming at digitizing the entire country. With more than 13 million subscribers, Vodacom has invested more than $ 1 billion in telecommunications infrastructure, deployed more than 1,463 radio sites on 2G, 3G and 4G technologies, more than 5,000 km of radio-relay systems and connected more than 4000 companies.

Vodacom stands ready to assist the government, the Presidential Task Force, the Ministry of Health, the Multisectoral Technical Secretariat for the fight against COVID 19 as well as the provincial health authorities in combating the spread of COVID-19, by providing information on location and population movements.
www.vodacom.cd

About Flowminder

Flowminder is a non-profit foundation that specialises in the analysis of anonymised mobile phone data, satellite imagery, and household survey data for humanitarian and development purposes. Flowminder researchers were the first to respond to a large-scale infectious disease epidemic using mobile operator data (Haiti cholera outbreak in 2010), and Flowminder researchers were the first to show that mobile operator data can predict the spatial spread of an infectious disease (Nature Sci. Rep. 2015). Flowminder analysts have been working for over ten years, whilst preserving the privacy of mobile network subscribers. Flowminder provides information and capacity strengthening to governments, MNOs, national and international agencies and researchers. Flowminder has developed sustainable partnerships with numerous mobile network operators in low- and middle-income countries. Flowminder's multidisciplinary team of experts includes epidemiological researchers, data scientists, software developers and humanitarian practitioners. Flowminder is one of the implementing partners of the GRID3 programme, currently active and delivering in DRC.
www.flowminder.org | covid19.flowminder.org | grid3.org

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Mobility analysis to support the government of the Democratic Republic of the Congo (DRC) in responding to the COVID-19 outbreak

Flowminder Foundation
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May 2020

Executive summary

Anonymised and aggregated data from Mobile Network Operators (MNOs) is a key data source for understanding mobility patterns of populations, providing insights that can improve decision-making and scenario planning during the COVID-19 epidemic. This data can be analysed in near real-time to provide an overview of mobility patterns across the Democratic Republic of the Congo (DRC). Vodacom Congo, supported by Flowminder, is using mobile operator data (Call Detail Records, also known as CDR) to produce mobility indicators, whilst fully preserving the privacy of Vodacom subscribers.

The focus of this report is on the effects of the measures taken by the Government against COVID-19 on population movements in Kinshasa. There is a particular emphasis on Gombe, where the confinement has been imposed; Ngaliema and Kintambo, believed to have had a high COVID-19 prevalence; and the N'Djili International Airport, where passenger flights were restricted from March 20th.

The period analysed starts on 16th February 2020, i.e. 30 days before the first measures in response to Covid-19 were taken (March 18th), and finishes 18th April 2020. For some results, the period of analysis extends to the 30th of April. All results are expressed as % change compared to the 30 day baseline period, i.e. normal conditions. We provide results aggregated at municipality level.

[1] Authors acknowledge Flowminder Foundation colleagues Linus Bengtsson, Tom Clark, Sophie Delaporte, Elsa Dufay, Alina Game, Michael Harper and Apphia Yuma for their contribution to the production of this report.

Our key finding is a large reduction in the number of subscribers present in Gombe (-65%) and in the number of weekday trips into and out of Gombe (-70% and -74%).

The drop in the number of subscribers present in Gombe seems to be mainly driven by a fall in the number of subscribers commuting to Gombe during weekdays, presumably for work or other activities. Those subscribers whose income depended on their presence in Gombe may have suffered income losses.

Movements from Gombe to Ngaliema decreased by 68% (65% in the reverse direction) and movements from Gombe to Kintambo decreased by 62% (56% in the reverse direction). The top destinations of Gombe subscribers' flows remained the same before and during the confinement: Ngaliema, Lingwala, Kinshasa, and Barumbu, which are the municipalities bordering Gombe. However, the top destination from Ngaliema changed from Gombe to Mont Ngafula during the confinement. Top destinations from Kintambo, previously Ngaliema and Gombe, became Ngaliema and Bandalungwa during the confinement.

Furthermore, the effect of the restrictions was very significant at the international airport, with a 90% drop in subscribers recorded in the airport terminal building after the introductions of travel restriction measures.

Finally, after the announcement of confinement on March 27, mobile recharges spiked by almost 70% in Kinshasa. This is likely the result of precautionary purchases in preparation for the confinement. Following the imposition of confinement in Gombe on April 6, mobile recharges across the city fell by 30% and was still 10% lower than baseline by April 30.

Vodacom Congo and Flowminder Foundation are ready to support the Presidential Task Force with regular updates of these results and on-demand bespoke analysis (Annex 2 lists possible insights and applications for CDR analysis in the COVID response). For instance, in order to determine best interventions to delay the spread of COVID-19, an analysis of national mobility patterns could be conducted to identify areas which are likely to have new outbreaks sooner than other areas.

Vodacom Congo and Flowminder Foundation also encourage other MNOs to provide information to the Presidential Task Force in order to build a more comprehensive picture. Market shares vary across the DRC territory, as well as the sociodemographic characteristics of the subscribers of the various MNOs. Flowminder Foundation, with the support of Vodacom Congo, has the required experience and resources to support the production of consistent outputs and information from the other MNOs.

Lastly, method improvement over the next few days will provide finer results, notably on the final destination of trips, the call/SMS volume, and the approximate areas in which subscribers reside. This information will further support the response to the COVID-19 outbreak.

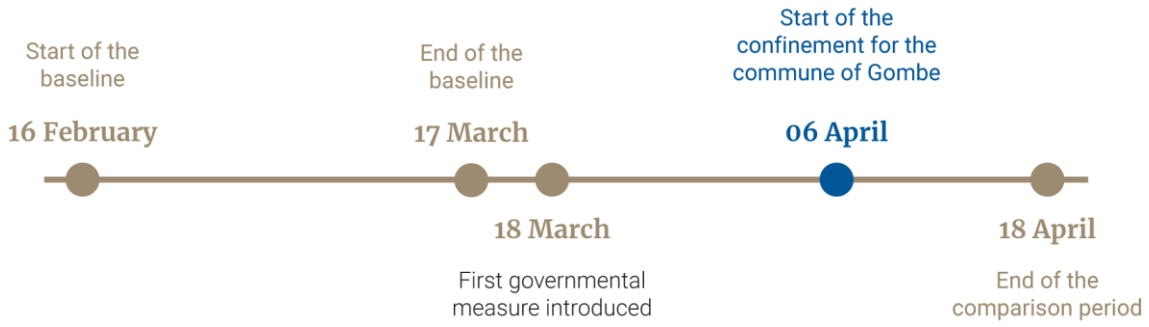
Introduction

Anonymised and aggregated data from Mobile Network Operators (MNOs) is a key data source for understanding the mobility patterns of populations, and improving decision-making and scenario planning during the COVID-19 epidemic. This data can be analysed in near real-time to provide an overview of mobility patterns across the Democratic Republic of the Congo (DRC). Vodacom Congo, supported by Flowminder, is using mobile operator data (Call Detail Records, also known as CDR, see annex 1) to produce mobility indicators, whilst fully preserving the privacy of Vodacom's subscribers. These indicators can be used by the government and public health experts to inform response efforts (see annex 2 for more use cases).

The work has been conducted rapidly to provide timely, high-level insights into a fast-changing situation. The aim of this first report is to facilitate discussion and decision making amongst members of the Presidential Task Force responding to COVID-19 as well as solicit feedback to deliver informative and regular standardised reports on mobility.

The focus of this report is on the effects of the measures taken by the Government against COVID-19 on population movements in Kinshasa. There is a particular emphasis on Gombe, where the confinement has been imposed; Ngaliema and Kintambo, believed to have had a high COVID-19 prevalence; and the N'Djili International Airport, where passenger flights were restricted from March 20th.

The period analysed starts on 16th February 2020, i.e. 30 days before the first measures were taken, and finishes 18th April 2020 (annex 3 provides a timeline of the measures). Some results are presented until the 30th of April. All results are expressed as % changes compared to the 30 day baseline period, i.e. normal conditions. We provide results aggregated at the Health Zone level where possible, and municipality level otherwise.



Baseline period used for analysis: 16 February - 17 March inclusive
Confinement period used for analysis: 06 - 18 April inclusive

The key questions addressed are:

- Has the number of active subscribers in Gombe and at N'Djili International Airport decreased?
- Have movements in and out of Gombe, and particularly from and to Ngaliema and Kitambo, decreased?

Results

Decrease in the number of active subscribers in Gombe and at N'Djili International Airport

Figure 1 shows the unique subscriber count in each municipality of Kinshasa Province compared to the baseline period (the period before measures were introduced). The vertical axis shows the % change in the count of active subscribers compared to the baseline. A value of 0 on the vertical axis means that the counts are equal to the median[2] of the baseline period. A value of -50% means that the counts are 50% lower than the baseline period (see annex 4 for more details on the method). The horizontal axis shows the date. The dates on which key measures were taken by the government are shown by the vertical dotted lines. The % change in the number of subscribers present in Gombe and at the N'Djili International Airport terminal cell site are highlighted in blue and green respectively. The grey lines in the background show the results for the other municipalities of Kinshasa.

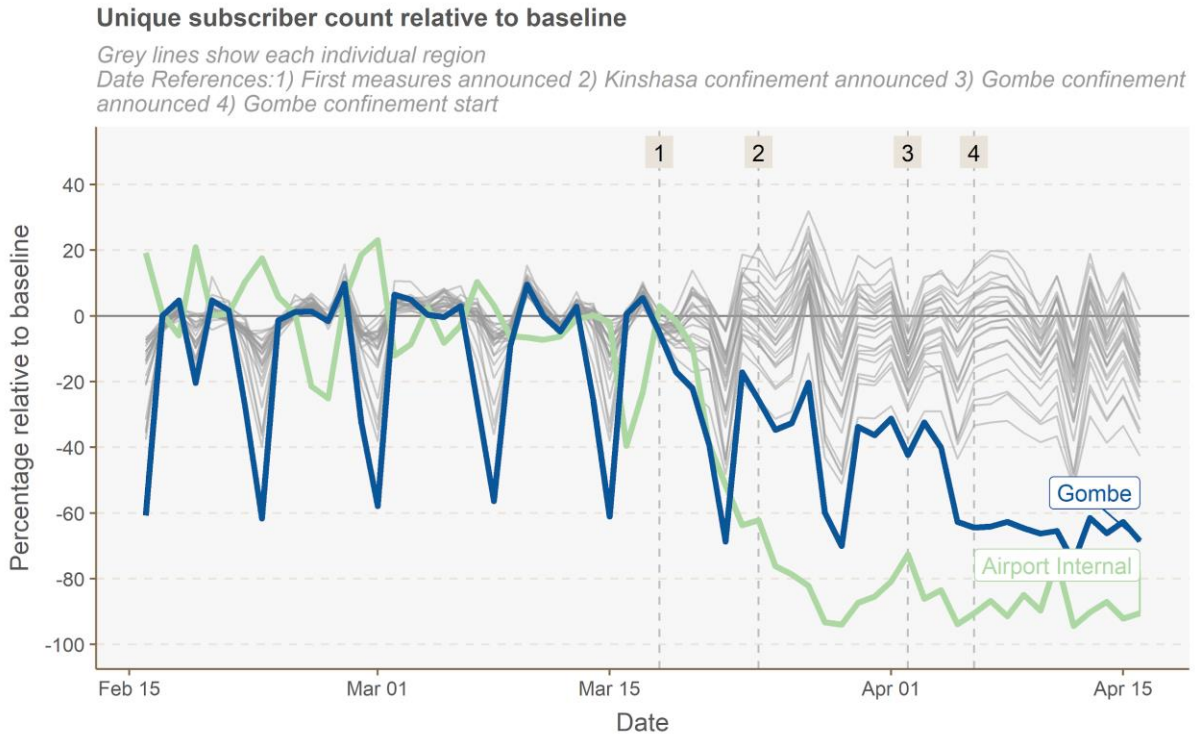


Figure 1: Unique subscriber count (%) relative to baseline for each Kinshasa municipality and for the airport cell site.

The regular drops observed before the first governmental measures correspond to normal weekends, when there are fewer people in Gombe. The series of government measures starting on

[2] In order to define normal conditions over the baseline period, the *median* was preferred to the *average*. Unlike the average, the median remains stable even if one of the baseline days happens to be unusual. This is because the median value of a set of numbers is the 'middle', i.e. the value to which the first half of the set is smaller and the second half of the set is larger. The median is therefore more appropriate than the average to define the baseline, i.e. a value considered as *normal*.

18 March (grey vertical dotted lines) led to a consistent reduction of 65% in the total number of active subscribers in Gombe.

Furthermore, a sharp decline in subscribers visiting the N'Djili International Airport terminal building is observed from 20 March, the date from which all flights from countries at risk (and transit countries) were suspended. On 24 March, prohibition of all domestic passenger flights between Kinshasa and the Provinces began, resulting in a 90% reduction of subscribers visiting the airport terminal building compared to the baseline[3].

Additional observations

- Prior to the first measures being announced, we can see a typical weekly pattern at weekends of reduced numbers of active subscribers in Gombe (-60% on Sundays) and neighbouring municipalities (down to -40%). The difference in subscriber density between weekdays and weekends is by far the largest in Gombe compared to any other municipality of Kinshasa.

- Major changes in the number of active subscribers are seen across all municipalities (grey lines in the background of Figure 1) from the announcement of the first measures on 18th March.

- Gombe sees a reduction of 30 - 40% in weekday subscribers present in the period between the announcement of the first measures (18 March 2020) and the start of Gombe confinement (06 April 2020). This is likely the result of the closure of schools/universities/official institutes/restaurants/bars and other areas, effective since the 19th of March, which meant far fewer commuters to Gombe than usual.

- The start of Gombe confinement (06 April 2020) marks the start of a consistent 65% reduction in the number of active subscribers for the Gombe municipality, compared to the weekday baseline. However, the number of active subscribers during the confinement period is only slightly lower than the number subscribers active during the weekends (Sundays) before the confinement. This could indicate that Gombe residents may not have left in large numbers, unlike what has been observed after the announcement of confinements in other countries.

Figure 2 maps the % change in the number of subscribers present in each Kinshasa municipality between the baseline and confinement periods. Areas in blue are municipalities where the number of subscribers has not changed significantly, areas in green to orange are municipalities where the number of subscribers present decreased, and Gombe is in red with the largest decrease in number of subscribers compared to its baseline.

[3] In contrast to the cell site serving serving customers *inside* the terminal building, an airport cell site located *outside* the terminal building only observes a 10% reduction in subscribers, which can be attributed to this site being located on the busy N1 highway, so continues to serve road users and other customers in the vicinity (not shown).

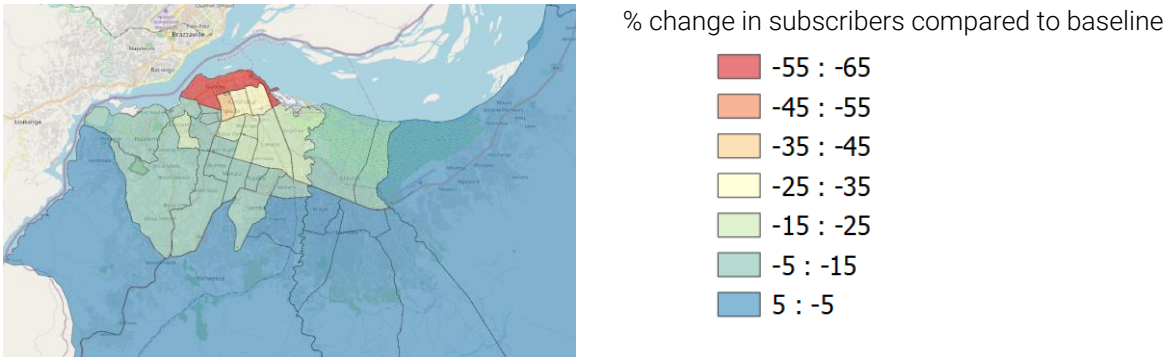


Figure 2: The % change in subscriber count for each municipality during the confinement period relative to its baseline, highlighting the effect of confinement from 6th April to 18th April.

Following the confinement, the number of active subscribers in Gombe decreased by 65%. By contrast, the number of subscribers decreased less in other inner Kinshasa municipalities, and remained constant in outer municipalities. The reductions seen in Gombe and other inner municipalities is likely due to workers not commuting into Gombe and to (or via) the city centre for work any longer, while outer municipalities have been less affected by the confinement in terms of the number of visitors they receive.

Changes in movements to and from Gombe

Figure 3 shows the movements out of Gombe to other Kinshasa municipalities compared to the baseline period. Ngaliema and Kitambo municipalities are highlighted orange and blue, respectively. The total of the flows from Gombe to all municipalities is highlighted in green.

Weekends experience a regular drop in the number of movements into and out of Gombe with a decrease of about 50% compared to weekdays. This reflects the fact that a large number of people visit the municipality only during weekdays and for work-related reasons.

After the 6th of April, when the confinement of Gombe was introduced, movements out of the municipality decreased by 74%. The movements from Gombe to Kintambo (-62%) and Ngaliema (-68%) followed similar trends.

The confinement not only reduced weekday commuting but also other movements in and out of Gombe over the weekend. This is shown by the effect of the measures compared to normal weekends. We found a decrease of 40% in the movements out of Gombe compared to baseline weekend activity.

Furthermore, it is important to note that these estimates likely underestimate the true reduction in movements, as subscribers who remain in the municipality can appear to have left because their calls are routed by cell towers outside of Gombe.

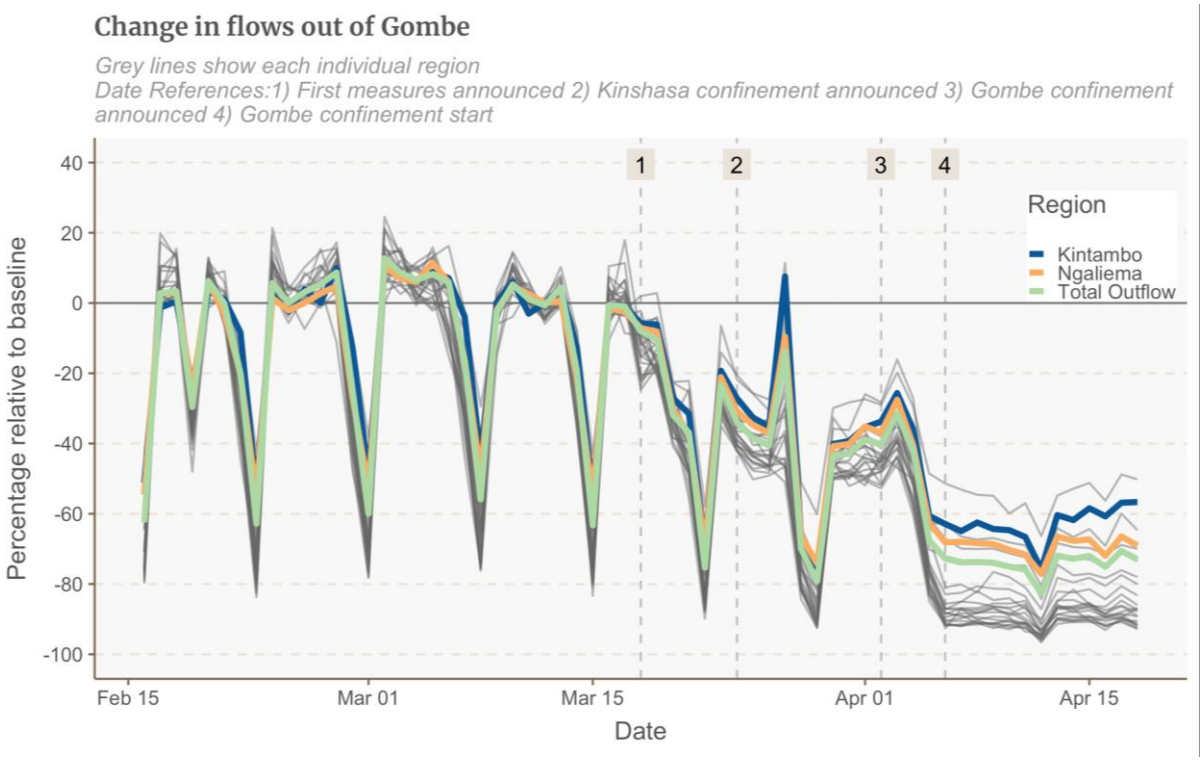


Figure 3: Changes in flow out of the Gombe municipality (%) relative to the baseline. The blue line shows the flows from Gombe to Kintambo, the orange one from Gombe to Ngaliema. The green line is the total outflow from Gombe to all municipalities.

Similar trends for flows *into* Gombe were found: there is a drop of 70% in the total flow of subscribers travelling to Gombe after the confinement (65% for Ngaliema to Gombe and 56% for Kintambo to Gombe).

Figure 4 shows the top destinations from Gombe, ranked by the number of movements to each municipality during the baseline period. The figures are given as the proportion (%) of movements to each municipality over the total movements out of Gombe, for the baseline and for the confinement periods.

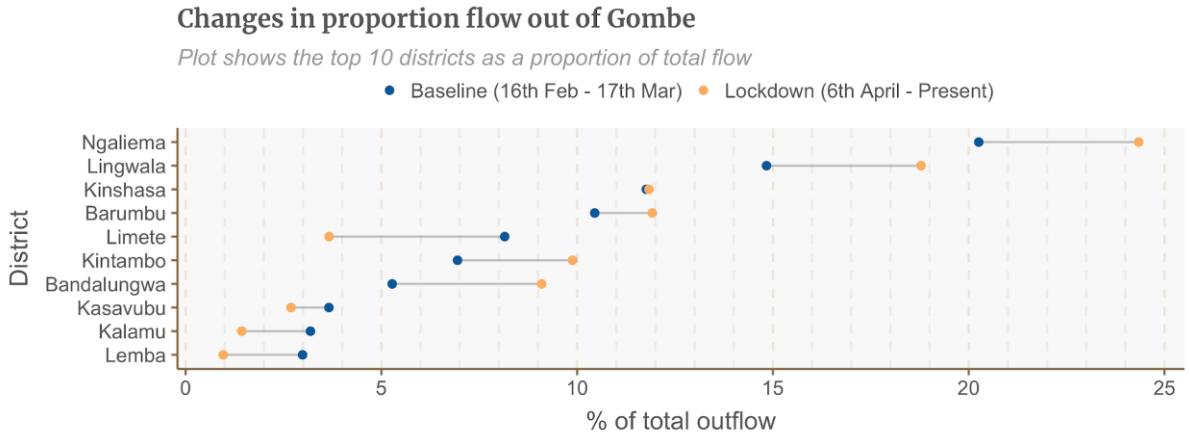


Figure 4: Proportion of flows out of Gombe to the top destinations during the baseline and confinement periods

Subscribers' travel range from Gombe to other municipalities has decreased. Indeed, the proportion of flows out of Gombe for neighbouring municipalities (Ngaliema, Lingwala, Barumbu, Kintambo, Bandalungwa) increased during the lockdown, while the proportion of flows into municipalities

further away (Limete, Kasavubu, Kalamu, Lemba) decreased[4]. Therefore, while trips of all lengths decreased in number, those of a longer distance decreased to a greater extent than those which were shorter[5].

Figures 5 and 6 show the top origin municipalities of flows into Ngaliema and Kintambo respectively, ranked by the number of movements from each origin municipality during the baseline period. The figures are given as the proportion (%) of movements from each municipality over the total number of movements into Ngaliema and Kintambo respectively, for the baseline and for the confinement periods.

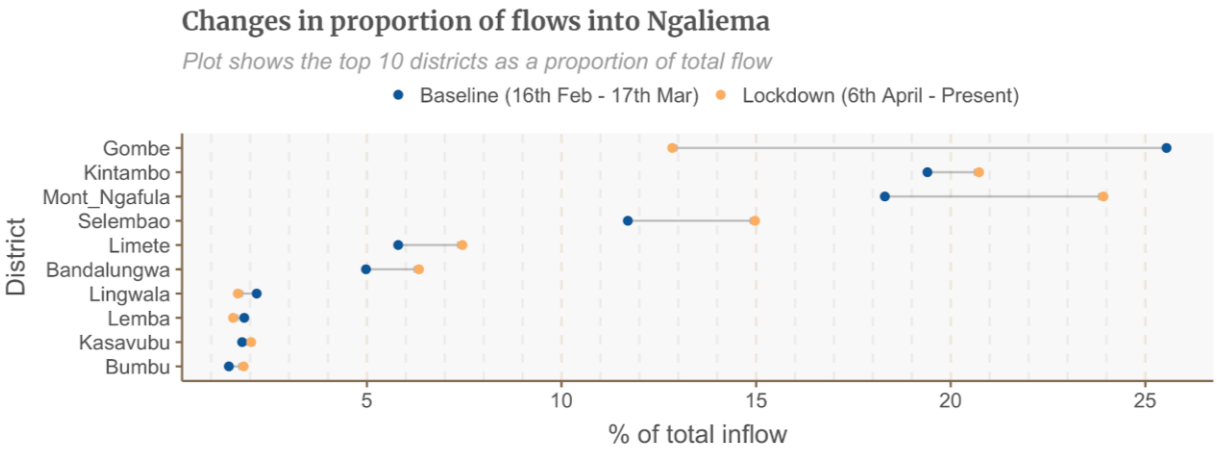


Figure 5: Proportion of flows into Ngaliema from each the top origins during the baseline and lockdown periods

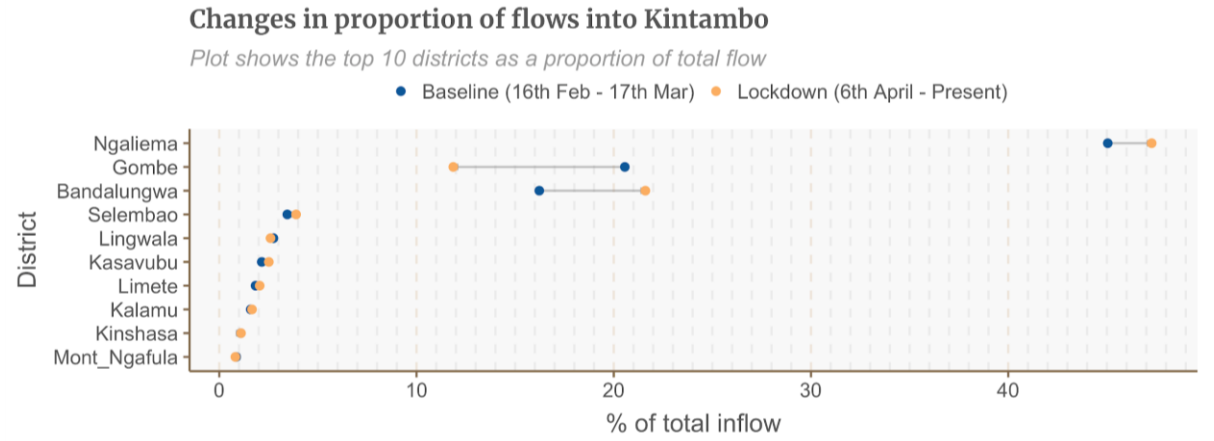


Figure 6: Proportion of flows into Kintambo from each of the top origins during the baseline and lockdown periods

For both municipalities we observe that the proportion of flows from Gombe decreased during the lockdown period, and that as a result the proportion of subscribers coming from other municipalities increased.

[4] It is important to note that while the proportion of flows into the neighbouring municipalities over the total number of flows out of Gombe increases, the absolute number of subscribers leaving Gombe to each municipality (both near and far) decreases significantly, as shown in Figure 3.

[5] It is also possible that this effect is also due to an increase in calling frequency, and/or that most 'movements' out of Gombe could be attributed to nearby towers outside of Gome routing subscribers' calls.

Decrease in total expenses on mobile phone recharge

Figure 7 shows the evolution of the value of the total recharge expenses incurred by subscribers. The vertical axis shows the % change in the value of the total recharge expenses incurred by subscribers compared to the baseline. The horizontal axis shows the date.

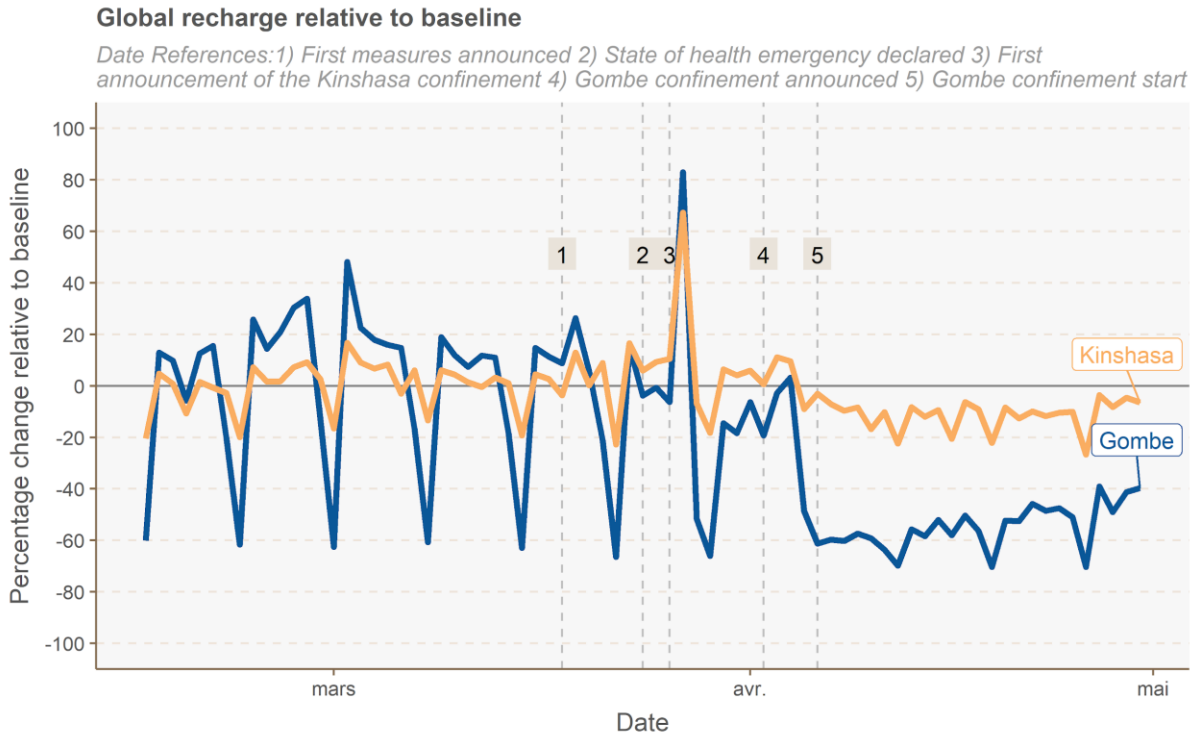


Figure 7: Changes in subscribers' total recharge expenses relative to the baseline (%) .

There is a large spike in the value of the total recharge expenses on March 27, the day following the announcement of the three-week lockdown of Kinshasa by the Governor of Kinshasa. The spike is likely the result of precautionary purchases in preparation of the confinement. The confinement was subsequently postponed amid fears of price speculation on essential goods.

On April 06, when the lockdown was eventually imposed in Gombe, the value of the total recharge expenses in Gombe dropped by 60%. This is equivalent to the value on an ordinary pre-lockdown Sunday. This drop also matches the reduced number of subscribers in Gombe on a Sunday (similarly a 60% decrease compared to weekday figures). By April 30, the value of the total recharge expenses had gradually bounced back to a level 40% lower than baseline[6].

The value of the total recharge expenses in Kinshasa dropped by up to 30% following April 06 and was 10% below the baseline on April 30. This decrease could be due either to drop in recharge

[6] The drop in the value of total recharge expenses in Gombe is likely due to the lower number of subscribers in Gombe rather than to a decrease in expenditure *per* subscriber. Indeed, the number of subscribers in Gombe was still 65% lower than in the pre-lockdown period on April 30 (not shown).

expenses *per subscriber* or to a lower number of subscribers in Kinshasa[7]. In both cases, the value of the total recharge expenses dropped in Kinshasa. As expenditure on communication, an essential good[8], has decreased, expenditure on non-essential goods might have also decreased. In other words, the decrease in the value of the total recharge expenses in Kinshasa may indicate an economic slowdown across the capital concomitant of the measures against COVID-19.

Caveats

- A limitation of this analysis is the nature of CDR data and the method used to identify the final destination of the trips. CDR data provides information about the location of the cell towers which are used when subscribers send or receive a call or SMS, or use data. Hence, for example, a subscriber travelling from Gombe to Ngaliema will be identified as doing so only if the subscriber first makes a call from Gombe and then makes a second call from Ngaliema. If the subscriber makes calls during his journey back, for instance at the Kitambo bus station, our results will show two trips: one from Gombe to Kitambo, one from Kitambo to Ngaliema, but no trip from Gombe to Ngaliema. Therefore the present results may only capture portions of travel and not full trips.
- Movements within Gombe may have been wrongly identified as movements out of Gombe due to cell site coverage potentially spanning both Gombe and the neighbouring area(s). Whereas in this report flows were analysed for each municipality, in further analyses we will work on groups of cell sites so that we can study border sites to assess this bias.
- There are exceptions to mobility restrictions (e.g. movements of key workers with exemptions) and these cannot be quantified.
- Further analyses will include the number of unique subscribers present within Kinshasa over time, in order to understand whether a significant number of subscribers left the city.

Next steps

Vodacom Congo and Flowminder Foundation are ready to support the Presidential Task Force over the course of the response with regular updates of these results and on-demand bespoke analysis, extended to the rest of the country. For instance, in order to determine best interventions to delay the spread of the SARS-CoV-2, an analysis of national mobility patterns could be conducted to identify areas which are likely to have new outbreaks sooner than other areas.

Vodacom Congo and Flowminder Foundation also encourage other MNOs to provide information to the Presidential Task Force in order to build a more comprehensive picture. Market shares vary across the DRC territory, as well as the sociodemographic characteristics of the subscribers of the various MNOs. Flowminder Foundation, with the support of Vodacom Congo, has the required

[7] The drop in recharge expenses per subscriber may be linked to the unusually high recharge observed on March 27. It could also be linked to the fact that subscribers prefer to hold back on their communication expenses for fear of inflation in prices of essential goods, or because income fell. Lastly, it may be due to a lower number of subscribers in Kinshasa as some may have chosen to leave the Province.

[8] The Minimum Expenditure Basket (MEB) computed by the World Food Program (WFP) has five components: food, health, education, rent, non-food expenditure (the largest share is food). Communication expenses for a typical household in urban Kinshasa represent the largest share of the non-food MEB component (23%, WFP 2018).

experience and resources to support the production of consistent outputs and information from the other MNOs.

Lastly, method improvement over the next few days will provide finer results, notably on the final destination of trips, the call/SMS volume, and the approximate areas in which subscribers reside. This information will further support the response to the COVID-19 outbreak.

Acknowledgements

Vodacom Congo and the Flowminder Foundation acknowledge the Autorité de Régulation de Poste et de Télécommunication - RDC, the Digital Impact Alliance (DIAL) and GSM Association (GSMA).

Annexes

Annex 1: About Call Detail Records (CDR data) and mobility estimates

The mobile phone data that are most commonly used for studying mobility in low- and middle-income countries are 'Call Detail Records' (CDRs). CDRs are generated each time a mobile phone subscriber makes or receives a call, sends or receives a SMS, or uses mobile data. Each record includes an identifier of the subscriber, a timestamp, and the cell site that the transaction was routed through. The location of the cell site can be assumed to be a good proxy for the location of the subscriber. A CDR dataset therefore contains a history of each subscriber's movements, which can be leveraged to generate insights about the mobility behaviour of the population of mobile phone subscribers.

Annex 2: Insights and applications from CDR analytics for the COVID-19 response

Mobile operator data can support government and public decision making during the COVID-19 pandemic. We have identified below five key areas of applications which would benefit from mobility insights extracted from CDR data:

1. Monitoring the primary effects of mobility and social distancing interventions

We propose indicators that aim to provide a measure of change in mobility following specific government interventions and their announcement. These indicators may be used to assess whether restrictions have had the expected effect of reducing travel, dispersion, and population mixing.

They are not a measure of the number of people who do or do not comply with mobility restrictions. Restrictions have a number of exemptions which cannot be quantified using CDR data. Exemptions include, for example, key workers (e.g. health sector, law enforcement, military, maintenance of essential services, supply chain of essential products, etc..), people returning home, people supporting their families, people in need of health care, and so on.. Therefore, as we cannot quantify exemptions, we cannot quantify compliance.

2. Monitoring the side effects of interventions

Interventions designed to reduce mobility and increase social distancing may have the unintended opposite effect, which negatively impact the controlling of COVID-19 or have broader social impacts. For example, research conducted in New York showed that the introduction of school closures in New York resulted in increased activity at grocery, shopping, food and outdoor places. In addition, evidence from Italy, France and Ghana demonstrated that there were large scale movements of people before lockdowns were implemented.

We propose indicators that aim to provide a measure of unintended side effects following government interventions. These indicators will help planners assess whether interventions should

be modified or ceased. In addition, such indicators would also help planners form a more accurate estimate of the likely impact an intervention would have, accounting for these side effects and supporting longer term planning efforts.

3. Identifying routine mobility patterns (to plan interventions and assess risk levels)

We propose indicators which extract current patterns of mobility, helping to identify hotspots (places with receiving large crowds and with high population mixing), most travelled routes and secluded regions. This information can help decision-makers to plan interventions and restrictions, and to target areas to send information messages to. In addition, the indicators will enable planners to conduct scenario testing for different types of measures (restrictions on travel, closures of public places) and for the staged relaxation of measures.

4. Monitoring changes in density of population (dynamic population mapping)

There can be large scale movements of populations as a result of the COVID-19 epidemic, with, for example, countries experiencing high levels of movements from urban to rural areas. Such changes can have unintended consequences on public services, food supplies and other critical infrastructure.

We propose indicators that monitor the changes in population densities from CDRs which, combined with existing population estimates, will help provide more accurate estimates of population during the epidemic. This will provide a useful indicator both during the outbreak and after restrictions have been lifted, as planners will be able to understand how long it takes for populations to return to the pre-crisis state.

5. Mobility data as an input to predictive models and analyses with ancillary data

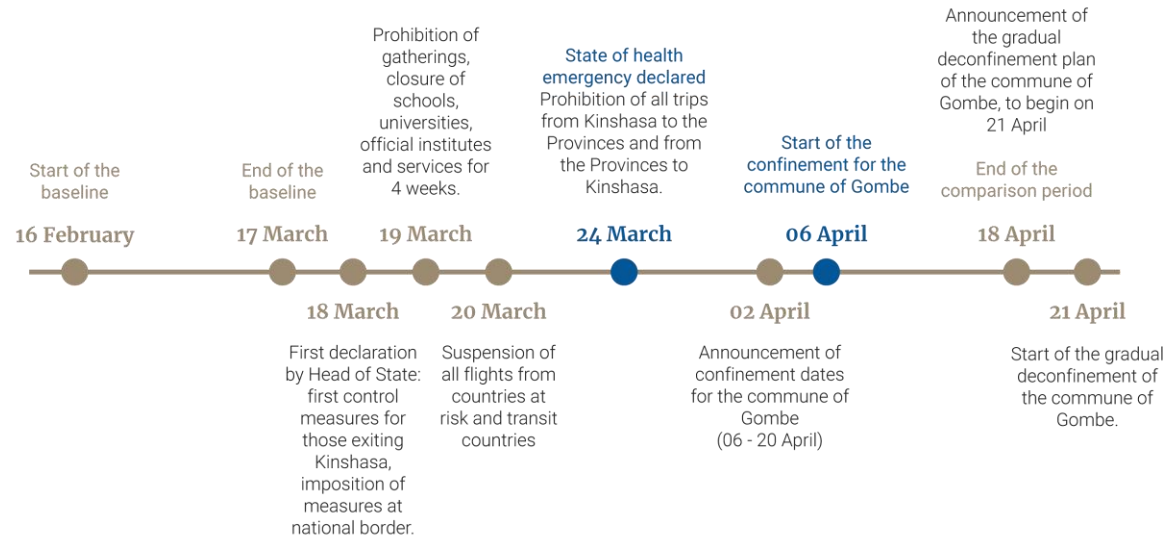
The indicators we propose can be used in further analyses, predictive modelling and research. The indicators reflect all dimensions of mobility and can be used to support decision-making and investigations across a wide range of domains. This may include epidemiological modelling, resource planning, provisioning of services, and longer term research into preparedness for epidemics or the effect of mobility restrictions on the environment.

Annex 3: Timeline of the Government measures

The government of DRC declared a state of health emergency on 24 March 2020, and actioned a series of measures between Wednesday 18 March and Tuesday 21 April 2020.

Wednesday 18 March	First declaration by Head of State: first control measures for those exiting Kinshasa, imposition of measures at national border.
Thursday 19 March	Prohibition of gatherings, closure of schools/universities/official institutes and services for 4 weeks.

Friday 20 March	Suspension of all flights from countries at risk and transit countries
Tuesday 24 March	State of health emergency declared: Prohibition of all trips from Kinshasa to the Provinces and from the Provinces to Kinshasa.
Thursday 02 April	Announcement by Gentiny Ngobila Mbaka, Governor of Kinshasa, that the commune of Gombe, considered as the epicenter of the coronavirus pandemic in the city of Kinshasa, will be in confinement from April 6 to April 20.
Monday 06 April	Start of the lockdown for the commune of Gombe
Saturday 18 April	Announcement of plan for the gradual deconfinement of the commune of Gombe, to begin Tuesday, April 21.
Tuesday 21 April	Start of the gradual deconfinement of the commune of Gombe.



Baseline period used for analysis: 16 February - 17 March inclusive
Confinement period used for analysis: 06 - 18 April inclusive

Annex 4: Method

Unique subscriber count (%) relative to baseline

1. Calculate the counts of unique active subscribers seen each day at each municipality within Kinshasa Province
2. For each municipality calculate the median value of active subscribers, over the baseline period from 2020-02-16 to 2020-03-17, inclusive.
3. Normalise the value for each day and municipality by (3) i.e. (active subscribers - baseline) / baseline
4. Multiply by 100 to get a percentage.
5. Plot the time series

Changes in flows (%) out of Gombe

1. Extract the number of flows FROM Gombe TO each connected municipality
2. For each municipality calculate the median number of flows out of Gombe, over the baseline period from 2020-02-16 to 2020-03-17, inclusive, to get a baseline value
3. Normalise the value for each day and municipality by (2) i.e. (number of flows to municipality X for each day - baseline for municipality X) / baseline for municipality X, to get a time series of normalised change from baseline
4. Multiply by 100 to get the percentage of change in flow compared to the baseline period.
5. Plot the time series of % change for each municipality
6. Compute the total flow from Gombe to all municipalities by summing flows to each municipality, normalise as above and add to plot

Changes in proportion of flows (%) to/from a municipality

1. Calculate the median number of flows in/out of the municipality from/to each connected municipality, over the baseline period from 2020-02-16 to 2020-03-17, inclusive, to get a baseline value
2. Sum the baseline number of flows, over all connected municipalities, to get the total baseline flow
3. For each municipality divide the baseline flow by the total baseline flow, to get a proportion of visitors for the municipality
4. Multiply by 100 to get the percentage of flows to/from each municipalities for the baseline period
5. Calculate the average (median) number of flows in/out of the municipality from/to each connected municipality, over the confinement period from 2020-04-06 to 2020-04-18, inclusive, to get a confinement value
6. Apply steps 2-4 to the confinement value, to get a % of flows to/from each municipalities for the confinement period

Annex 5: Data privacy

General

- No personally identifiable information, such as an individual's identity, demographics, location, contacts or movements, will be made available to the government or any other third party at any point.
- All of the outputs produced for the government by the Vodacom Congo and Flowminder Foundation are aggregated data (e.g. density of subscribers in a given municipality), meaning that they do not contain any information about individual subscribers, they are fully anonymised.
- This approach is compliant with the EU General Data Protection Regulation (EU GDPR 2016/679)

Details

- Data is processed by Vodacom Congo on their facility and behind their firewall, no individual level data ever leaves the Vodacom Congo facility.
- The data being processed are routinely collected by the Vodacom Congo for billing purposes and the management of their network (e.g. time of the call/SMS, cell tower from which call/SMS were sent).
- No personal information is shared with the government: only percentage changes compared to normal in the population density and the population flows are shown.
- It is not possible to identify any subscriber with these statistics: areas with fewer than 15 subscribers are filtered out even before the data processing starts at the Vodacom Congo facility
- Low spatial and time resolution: the number of people in a given neighbourhood over a given day are expressed as % of normal.
- The code used by the Vodacom Congo and Flowminder Foundation to produce the results is openly available on GitHub so that anyone can review (here).