

Mobility analysis to support the Government of Ghana in responding to the COVID-19 outbreak

Insights into the effect of mobility restrictions in Ghana using anonymised and aggregated mobile phone data

Report #2

15 May 2020

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Overview

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 and provide an overview of mobility patterns across all of Ghana. Flowminder is working with Ghana Statistical Service (GSS) to produce mobility indicators from aggregated and anonymised data provided by Vodafone Ghana. These indicators can be used by the government and public health experts to inform response efforts.

We published a [report](#) with initial insights on 3rd April, showing how population movements had been affected by nationwide school closures and a nationwide ban on public gatherings, and then by a lockdown in parts of the Greater Accra Metropolitan Area and the Greater Kumasi Metropolitan Area. [In this second report, we extend our previous analyses to show how population movements have changed since lockdown measures were lifted.](#) Details of the analysis methods are included in the Annexes at the end of this report.

At the date of publication, Ghana Health Service reports the number of confirmed COVID-19 cases in Ghana to be 5530.

Timeline of COVID-19 interventions in Ghana

The timeline of events in Ghana is as follows:

- | | |
|--------------------------|--|
| Monday 16th March | Initial restrictions - school closures and bans on public gatherings - introduced nationwide. |
| Friday 27th March | President announces that lockdown measures will be introduced in parts of the Greater Accra Metropolitan Area and the Greater Kumasi Metropolitan Area the following Monday. |
| Monday 30th March | Lockdown measures are imposed on parts of the Greater Accra Metropolitan Area and the Greater Kumasi Metropolitan Area. |
| Sunday 19th April | President announces that lockdown measures will be lifted the following day, although nationwide school closures and bans on public gatherings will continue. |

Monday 20th April Lockdown measures lifted, nationwide school closures and bans on public gatherings still in place



Baseline period used for analysis: 17 February - 15 March inclusive

Understanding the graphs

In all of the figures in this report, we show the time period between Monday 17th February and Sunday 3rd May. This corresponds to a period starting **four weeks before the first restrictions were introduced and ending two weeks after lockdown measures were lifted**. The vertical dashed gold lines in each figure mark the following dates: the date when initial restrictions were introduced (Monday 16th March), the first day of lockdown (Monday 30th March), and the first day after lockdown measures were lifted (Monday 20th April). In addition, we include a vertical dashed green line to show the date when lockdown measures were announced (Friday 27th March).

The values for all metrics are displayed as a percentage change relative to the baseline value. The baseline value is calculated as the median value of the metric during the four weeks prior to the introduction of the first restrictions. We refer to this four-week period as the 'baseline period'. We use the median to define the average, rather than the mean, as the median is not strongly affected by outliers.

For context, we have included below a map showing the regions of Ghana.



Changes in travel within regions

We analyse travel within each region by counting the number of trips that are made between each pair of districts in that region. These trips will mainly comprise **short-distance, routine daily trips that correspond to activities such as commuting to work, shopping, and entertainment**. The method used to count these trips is described in Annex 1.

The number of trips between any two districts in Greater Accra:

- Decreased by 20-30%, relative to the baseline value, during the period when initial restrictions were in place.
- Increased slightly but not significantly, relative to the previous days, after lockdown measures were announced.
- Decreased to 50-60% below the baseline level during the lockdown period.
- Increased significantly, relative to the lockdown period, immediately after lockdown measures were lifted. However, this level is still around 40% below the baseline level and has remained consistently at this level for the entire period since lockdown measures were lifted, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.

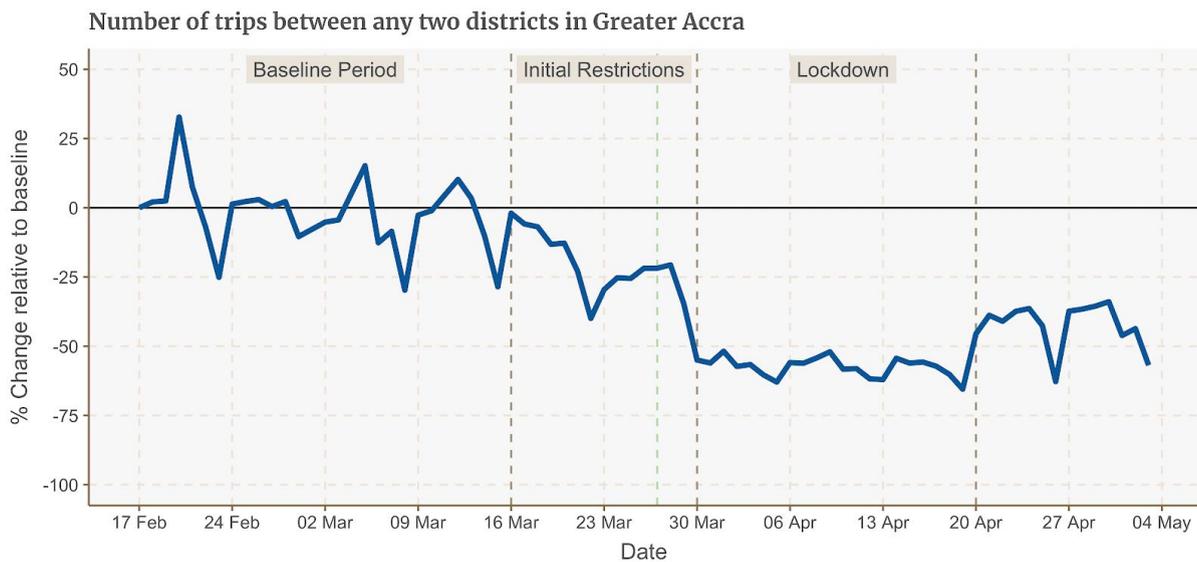


Figure 1: Percentage change in the number of trips between any two districts in Greater Accra, each day, relative to the baseline value.

The number of trips between any two districts in Ashanti:

- Decreased by around 20%, relative to the baseline value, during the period when initial restrictions were in place.
- Increase slightly but not significantly, relative to the previous days, after lockdown measures were announced.
- Decreased to around 50% below the baseline level during the lockdown period.
- Increased significantly, relative to the lockdown period, immediately after lockdown measures were lifted. However, this level is still 30% below the baseline level and has remained

consistently around this value for the entire period since lockdown measures were lifted, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.

Number of trips between any two districts in Ashanti

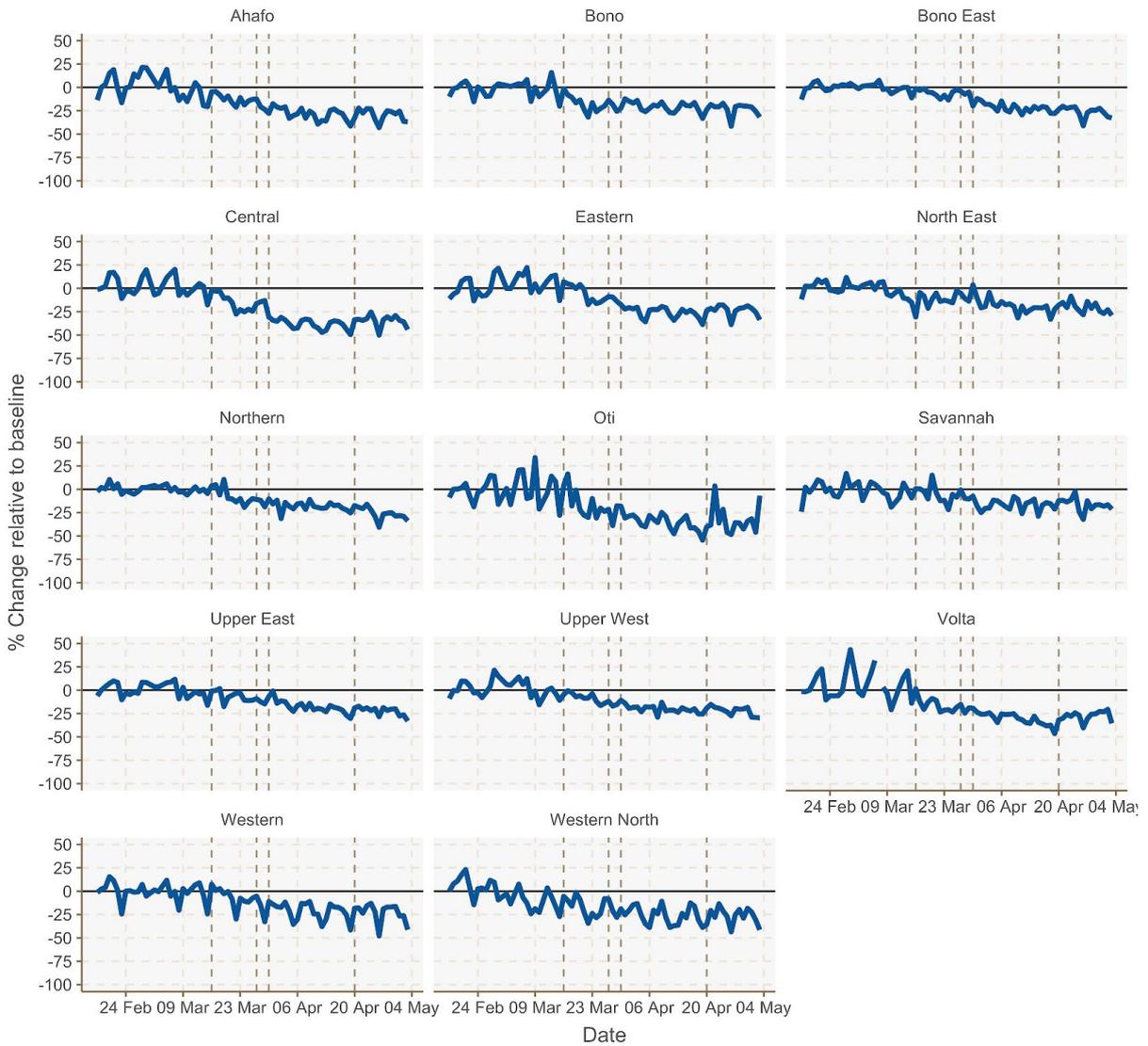


Figure 2: Percentage change in the number of trips between any two districts in Ashanti, each day, relative to the baseline value.

The number of trips between any two districts in each region, excluding Greater Accra and Ashanti:

- Decreased in all regions, by 10-30%, relative to the baseline value of each region, during the period when initial restrictions were in place.
- Did not change significantly, relative to the previous days, after lockdown measures were announced.
- Decreased further, in all regions, after lockdown measures were introduced. The largest decrease was in the Central region. This may be partly attributed to the town of Kasoa, in the Central region, being included in the lockdown (Kasoa is a popular commuter town for Accra). The smallest decrease was in the Savannah region.
- Increased in all regions, relative to the lockdown period, once lockdown measures were lifted. These levels are still below the baseline levels for all regions. The exception is a spike to above the baseline level in the Oti region, on 22nd April, which may have been a response to the first case in Oti being confirmed on 21st April. The level in the Savannah region reached a few percent below its baseline level on 24th April.

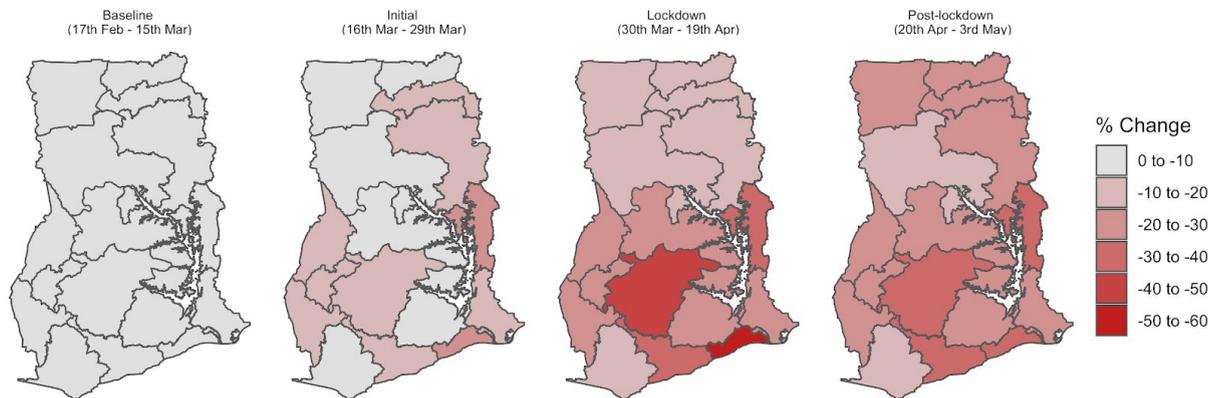
Number of trips between any two districts in each region



Analysis by Flowminder. Data from Vodafone Ghana

Figure 3: Percentage change in the number of trips between any two districts in each region, each day, relative to the baseline value for each region.

Change in the number of trips between any two districts in each region



Analysis by Flowminder. Data from Vodafone Ghana

Figure 4: Maps showing the median daily percentage change in the number of trips between any two districts in each region, each day, relative to the baseline value for each region, during the following periods: the baseline period, the period when initial restrictions were in place, the period when lockdown measures were in place, and the period since lockdown measures have been lifted.

Policy implications

▣ *The surveillance mechanisms implemented within the Greater Accra and Kumasi were effective, resulting in a dramatic decline in mobility between districts. While the partial lockdown was not imposed on most parts of the country, reduced intra-regional mobility was observed, generally, across the country which could be attributed to the population's understanding of how infections could be controlled. The approach employed in communicating the lockdown and reasons for it should be sustained in getting many more Ghanaians to adhere to the restrictions. ▣*

Professor Samuel Annim, Government Statistician, Ghana Statistical Service

Changes in travel between regions

Journeys between regions comprise a **mixture of long-distance trips, and short-distance, routine daily trips** made by, for example, people who live or work near a regional border. The method used to count these trips is described in Annex 1.

The number of trips starting in Greater Accra and ending in any other region:

- Decreased by 10-20%, relative to the baseline value, during the period when initial restrictions were in place.
- Increased slightly but not significantly, relative to the previous few days, immediately after the announcement of lockdown measures.
- Decreased to 40% less than the baseline value during the lockdown period.
- Immediately increased, relative to the lockdown period, by around 15% after the lockdown was lifted. However, this was still below the baseline level, and the number of trips has consistently remained 25-30% below the baseline value since lockdown measures were lifted, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.

Number of trips starting in Greater Accra and ending in another region



Analysis by Flowminder. Data from Vodafone Ghana

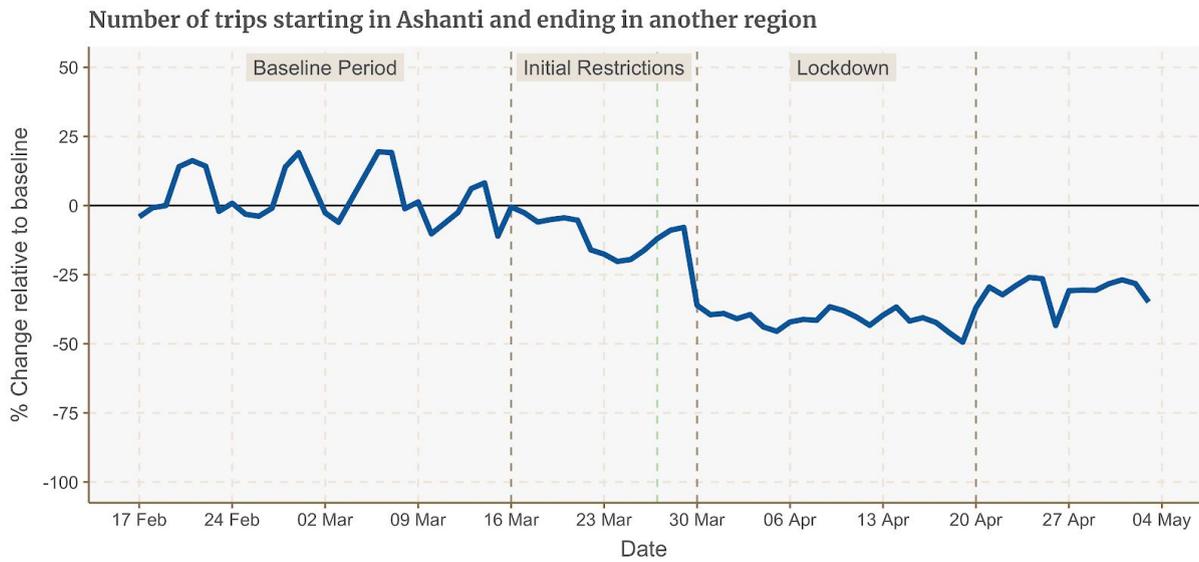
Figure 5: Percentage change in the number of trips starting in Greater Accra and ending in another region, each day.

The number of trips starting in Ashanti and ending in any other region:

- Decreased by up to 20%, relative to the baseline value, during the period when initial restrictions were in place.
- Increased slightly but not significantly, relative to the previous few days, immediately after the announcement of lockdown measures.
- Decreased to around 40% less than the baseline value during the lockdown period.
- Immediately increased, relative to the lockdown period, by around 15% after the lockdown was lifted. This was still below the baseline level, and the number of trips has remained 25-30%

below the baseline value since lockdown measures were lifted, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.

These trends are very similar to the ones we observe for Greater Accra.



Analysis by Flowminder. Data from Vodafone Ghana

Figure 6: Percentage change in the number of trips starting in Ashanti and ending in another region, each day.

The number of trips starting in one region and ending in another region, excluding Greater Accra and Ashanti:

- Decreased by up to 25%, relative to the baseline value, during the period when initial restrictions were in place. This is a larger decrease than for Greater Accra and Ashanti.
- Did not change significantly, relative to the previous few days, immediately after the announcement of lockdown measures.
- Decreased to around 30% less than the baseline value during the lockdown period, despite neither the origin or destination regions being included in the lockdown. This is a smaller decrease than for Greater Accra and Ashanti.
- Immediately increased, relative to the lockdown period, by around 5% after the lockdown measures were lifted. This was still below the baseline level, and the number of trips has consistently remained 20-25% below the baseline value since lockdown measures were lifted, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period (see Annex 2).

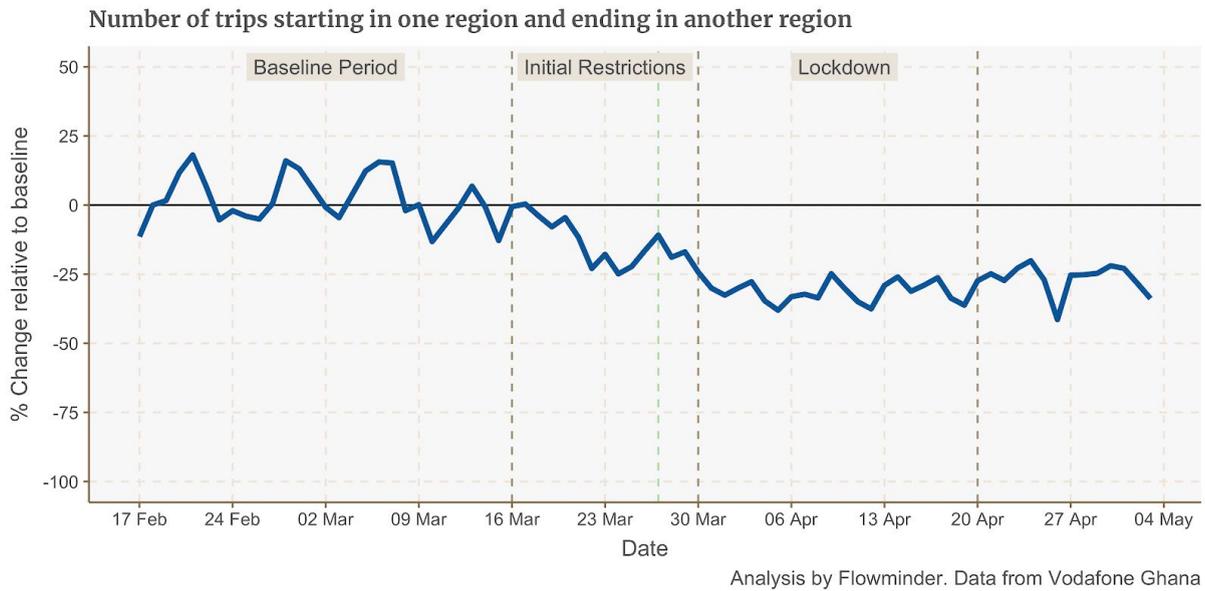


Figure 7: Percentage change in the number of trips starting in one region and ending in another region, each day, excluding Greater Accra and Ashanti.

Policy implications

▣ The observation that mobility after the lift of the partial lockdown remains at levels well below mobility during the periods of the baseline and the initial restrictions (including sanctioning social distancing and adherence to public health hygienic protocols) endorses the effectiveness of the use of moral suasion as a complementary intervention in the fight against COVID-19.

Residents in Ghana deserve commendation for not reverting to the ways of living prior to the imposition of the initial restrictions and are therefore urged to continue with change in behaviour in order to contain the pandemic. ▣

Professor Samuel Annim, Government Statistician, Ghana Statistical Service

Changes in dispersion

The ‘dispersion’ out of a region is a measure of how people ‘spread out’ from that region.

Dispersion is calculated by counting the total number of subscribers that travel out of the focal region each day (the ‘total outflow’), and then calculating the proportion of that total number who travel to each of the destination regions. We choose to focus on longer distance trips rather than short-distance, routine trips (e.g. between neighbouring regions), by estimating the initial and final locations of each subscriber each day, and using these to define ‘trips’. Details of the method are provided in Annex 1.

In order to show both how the ‘spread’ over regions has changed, as well as how the overall volume of travel has changed (similar to Section 2), we calculate all proportions relative to the total baseline outflow. This means that the average proportions for each day will sum to one during the baseline

period, but not for the other periods because the total outflow will have changed relative to the total baseline outflow.

Dispersion out of Greater Accra

- The total number of trips decreased by up to 25% after initial restrictions were introduced, relative to the baseline. This decrease was fairly consistent across all destination regions, meaning that each region received up to 25% fewer travellers from Greater Accra.
- After lockdown measures were announced, there was a temporary increase in travel, particularly to the Eastern, Central, Ashanti, and Volta regions, that brought the number of trips back to close to the baseline value for those regions.
- After lockdown measures were imposed, the number of trips to the Eastern and Central regions decreased further to around 50% of the baseline value for those regions. The decrease was even greater for some other regions including the Ashanti and Volta regions, where the number of trips decreased by 80-85%, relative to the baseline.
- After lockdown measures were lifted, travel to all regions increased relative to the lockdown period, but has remained around 35% below the baseline value, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.
- The relative 'importance' of each region has remained fairly constant for the whole time, such that the Eastern and Central regions have remained the regions that receive 80-90% of all travellers from Greater Accra each day. This may be due to the travel times and distances that are required to reach parts of the country from Greater Accra - we are only studying journeys made within a single day, and travellers may stop overnight in the Eastern and Central regions as an intermediate stop before continuing their journey the following day. So the Eastern and Central regions will not necessarily be the final destinations of all these travellers.

Policy implications

▣ *The observation on the dominant places for inter-region mobility engenders the determination of routes for increased surveillance to ensure reduced mobility. Specifically, the high mobility between Greater Accra and Eastern regions suggests the need for an enhanced restricted mobility between the two regions.* ▣

Professor Samuel Annim, Government Statistician, Ghana Statistical Service

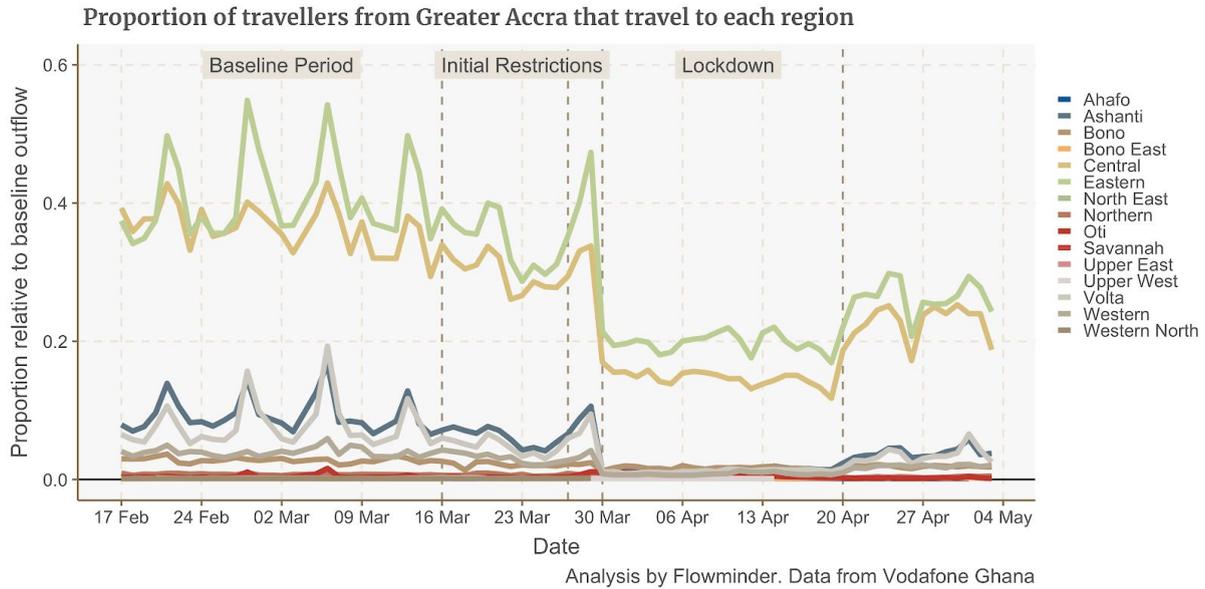


Figure 8: Proportion of travellers from Greater Accra that travel to each region, relative to the baseline number of travellers that leave Greater Accra each day.

Average daily proportion of travellers from Greater Accra that travelled to each region

Greater Accra indicated in brown

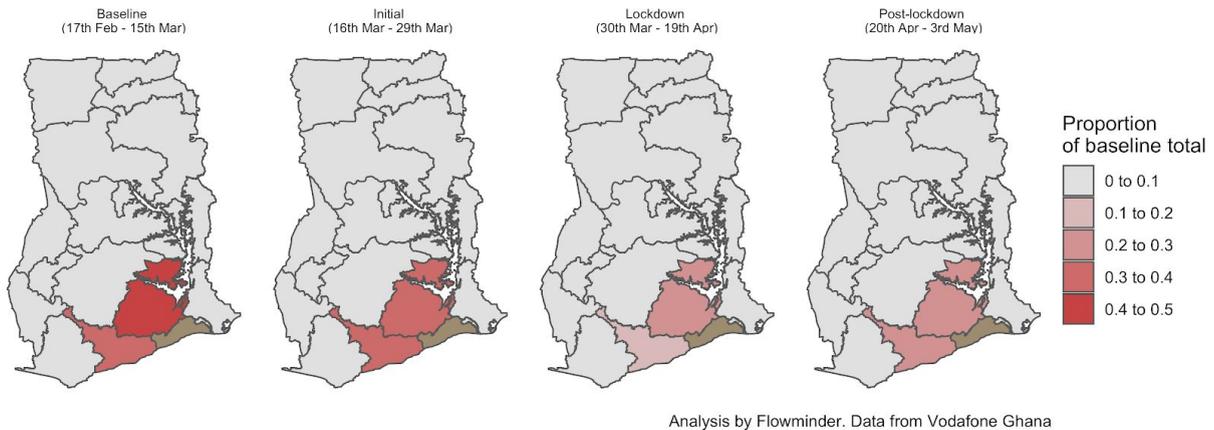


Figure 9: Maps showing the average daily proportion of travellers from Greater Accra (shown in brown) that travelled to each region, relative to the baseline number of travellers that leave Greater Accra each day, during: the baseline period, the period when initial restrictions were in place, the period when lockdown measures were in place, and the period since lockdown measures have been lifted.

Dispersion out of Ashanti

- Due to its central geographical location, travel out of Ashanti is widely dispersed across many regions.
- Ashanti is most strongly 'connected' to Greater Accra. After initial restrictions were introduced, travel from Ashanti to Greater Accra decreased by up to 40%, relative to the baseline value. There was a small increase of a few percent after lockdown measures were announced. This was followed by a decrease of 85-90% relative to the baseline value after lockdown measures were introduced. Since lockdown measures have been lifted, travel to Greater Accra has

increased relative to the lockdown period but remains 60% below the baseline value, although some part of this decrease may be due to a decrease in phone activity relative to the baseline period.

- Travel between Ashanti and all other regions exhibited trends that are similar to those we observed for travel from Ashanti to Greater Accra, although the sizes of the decreases during the periods of initial restrictions and lockdown measures were not as large. There was a significant increase in travel to the Ahafo region on 6th-7th April.
- The Central and Eastern regions were the most population destinations from Ashanti, during the baseline period. However, after initial restrictions were introduced, the relative proportion of visitors to the Eastern region decreased far more than for the Central region, and then decreased further again during the lockdown period, such that the Bono East and Ahafo regions started receiving a larger proportion of visitors.

Policy implications

▣ Surveillance mechanisms implemented during lockdown on routes connecting Ashanti region with neighbouring regions indicates that it was more pronounced on the Ashanti region - Eastern region corridor than the others, hence the surge in mobility to border boundaries regions (Bono East and Ahafo regions). This suggests that equally strong surveillance / mobility restrictions must be observed on all corridors to regions targeted to reduce mobility. ▣

Professor Samuel Annim, Government Statistician, Ghana Statistical Service

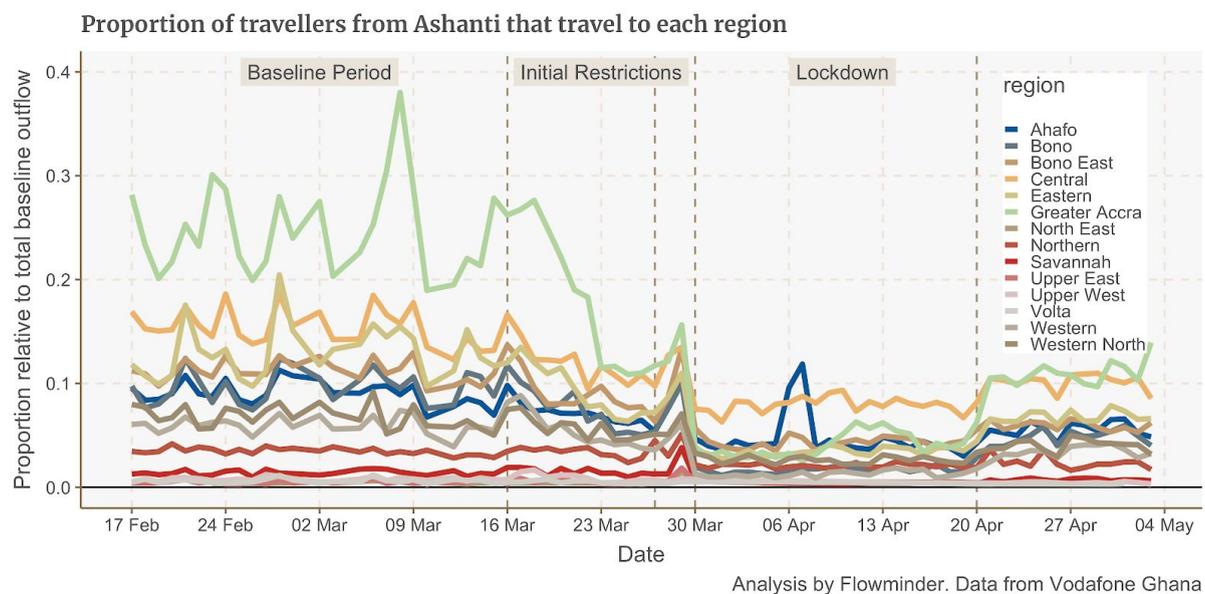
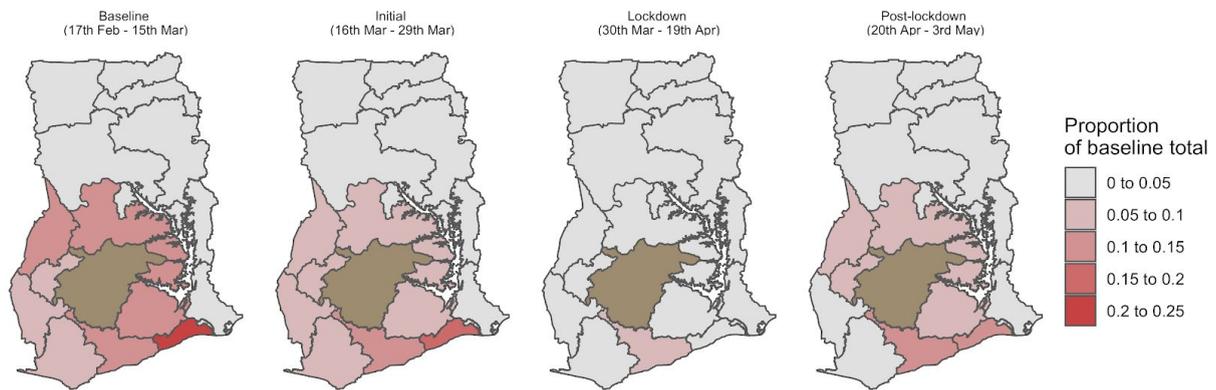


Figure 10: Proportion of travellers from Ashanti that travel to each region, relative to the baseline number of travellers that leave Ashanti each day.

Average daily proportion of travellers from Ashanti that travelled to each region
 Ashanti indicated in brown



Analysis by Flowminder. Data from Vodafone Ghana

Figure 11: Maps showing the average daily proportion of travellers from Ashanti (shown in brown) that travelled to each region, relative to the baseline number of travellers that leave Ashanti each day, during: the baseline period, the period when initial restrictions were in place, the period when lockdown measures were in place, and the period since lockdown measures have been lifted.

Analysis limitations

The anonymised and aggregated data used in this report is from Vodafone Ghana. This dataset is unlikely to be perfectly representative of the entire population of Ghana. In spite of these limitations, the dataset can still provide a good indicator of changes in a population’s movements because a significant proportion of the population are included in the dataset. Whilst further work is needed to understand the extent to which analyses of telecommunications datasets result in biased estimates of population movements, the limited studies which exist have shown that such analyses have a high degree of validity. A telecommunications dataset also has the significant advantage that it can be analysed to generate very timely insights about the entire country - information can be made available about the nationwide situation as it was just a few days ago, as demonstrated in this report.

About the authors

This analysis was performed by the Flowminder Foundation, in partnership with Ghana Statistical Service (GSS). Access to de-identified (anonymised) mobile telecommunications data is being provided by Vodafone Ghana. Flowminder, GSS, and Vodafone Ghana have been working together, since 2018, on a Data For Good project that aims to strengthen capacity within GSS in order to enable the types of analysis described in this report to be performed more routinely and easily. The work is being funded by the William and Flora Hewlett Foundation and the Vodafone Foundation.

www.flowminder.org | www.statsghana.gov.gh | vodafone.com.gh

Annexes

Annex 1: Origin-destination matrices and 'trip' definitions

All the analyses in this report are based on an 'origin-destination matrix' (OD matrix). An OD matrix is an anonymised, aggregated data structure that is produced by counting the number of subscribers that have made a trip between any two localities - the first locality being the 'origin' and the second the 'destination'. In this report, we have used either districts or regions as the 'localities'.

A 'trip' can be defined in many different ways, and the OD matrices that result from using different definitions therefore encapsulate different aspects of mobility behaviour. The analyses in this report are based on two different definitions:

'Consecutive localities' OD matrix

In this matrix, a 'trip' is defined to be an event where a subscriber is recorded to have used their phone consecutively in two different localities, within a single day. For example, if a subscriber uses their phone in District A and they next use their phone in District B, and then in District C, a trip is recorded for the pair [A, B] and one for the pair [B, C]. This is different from the intuitive definition of a 'trip', where only the start and final destination (but not any intermediate 'stops') would be counted.

The majority of trips that are included in this matrix will be routine, short-distance trips, since there are many more of these types of trips than there are long-distance trips each day. In order to remove high-frequency 'oscillatory' movements, which are movements of subscribers that seem to be moving rapidly and frequently between a pair of localities, when in actual fact they are situated close to the border of those localities but are not moving, we only count one trip per subscriber for each pair of localities. So a subscriber who moves in the sequence A -> B -> A -> B -> A -> C will be counted *once*, for each of the pairs [A, B], [B, A], and [A, C].

A 'consecutive localities' OD matrix is used in the analysis in Section 1, using districts to define the localities. In Section 2, we also use a 'consecutive localities' OD matrix, but use regions to define the localities. In both of these sections, the respective matrix is used to produce an indicator of how the amount of travel is changing each day.

'First locality - last locality' OD matrix

In this matrix, a 'trip' is defined by the localities in which a subscriber used their phone for the first time on a day, and the last time that day. This eliminates a lot of routine daily movements since most people will start and finish their day at the same locality, although they may visit many localities during the day. Therefore, the longer distance 'one-way' trips become more prominent.

This trip definition enables us to count a subscriber at the locality that we estimate to be their final destination for the day, rather than at an intermediate stop.

A 'first locality - last locality' OD matrix is used in the dispersion analysis in Section 3, using regions to define the localities.