Commute and mobility patterns evidenced from telecommunications data can inform reopening strategies after COVID-19 lockdowns

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Over the coming months, governments around the world will be looking to loosen COVID19-related restrictions on movement, such as remote work, school closures, and limits on non-essential shops

These restrictions have been effective in slowing the spread of the virus, yet have taken a significant toll on local and national economies, disproportionally affecting the most vulnerable.

Safely relaxing restrictions to allow residents to return to work, while minimising congestion and unnecessary travel, is a key consideration. While there are multiple ways to reopen economic and social activities, here we explore a strategy to mitigate risk by localising it. This involves partitioning geographic areas of a city into what we call "communities". Increased levels of movement within those communities would be permitted, while movement between them would be discouraged or restricted. The strategy effectively lessens the risk of citywide outbreaks and allows significant proportions of the population to return to work and school.

In this Scoping Brief, we will apply this technique to the metropolitan area of the Aburrá Valley as a case study. The area contains the city of Medellín, and a population of approximately 3.7 million people [1]. To do so, we will utilize mobile phone data from 2019 (geolocated call detail records, or CDRS), from which we extract common origin destination patterns as well as other fine-grain mobility measures.

Using mobile phone data from 2019, we extract spatially disaggregate origin-destination information for the metropolitan area of the Aburrá Valley (which includes Medellín) in Colombia. We use this data for a simulation in which movement within spatially demarcated "communities" is mostly allowed, while movement between them is restricted – showing that such a strategy could allow many people to return to work while limiting the spread of the COVID-19 virus.

How can we determine where metropolitan residents live and work?

Anonymised mobile phone data allows us to identify residents' most common workday and evening time locations, as well as deduce metropolitan-wide home/work commute patterns.

Since early March, the COVID-19 outbreak has spread throughout all 10 municipalities of the metropolitan area of the Aburrá Valley, with over 1500 cases reported to date [1]. In response, the local metropolitan government has mandated a stringent lockdown policy, which has slowed the contagion yet is causing significant financial distress to residents. While government subsidies for the poor have helped to ease the burden, the local government is eager to pursue policies that spur economic activity.

We identified the home locations for 42,000 users in the metro region from January to June 2019 by examining anonymized records that show the location of the closest transceiver tower each time a user makes a call. This is achieved via an algorithm that associates a user's home with their most common night-time location. Similarly, we identified work locations with persistent weekday working time locations. We used this information to designate home-work commute patterns for residents of 171 spatially demarcated areas "tower cells" in the region. These areas tend to be smaller for more dense regions, and larger in more suburban and rural areas.

Figure 1 shows the approximate tower locations, with points scaled to the relative size of the numbers of detected residents, along with associated tower cells and administrative borders.

Figure 2 depicts the out/in-flow of commuters at the municipal level, estimated by scaling up the number of detected commutes by 2018 census population [2].

Figure 1

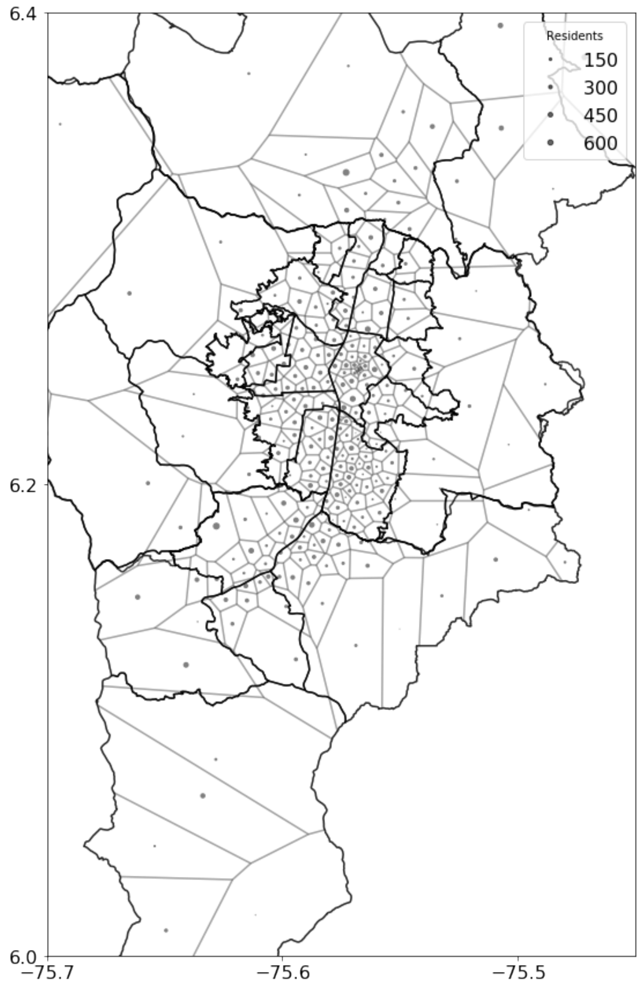
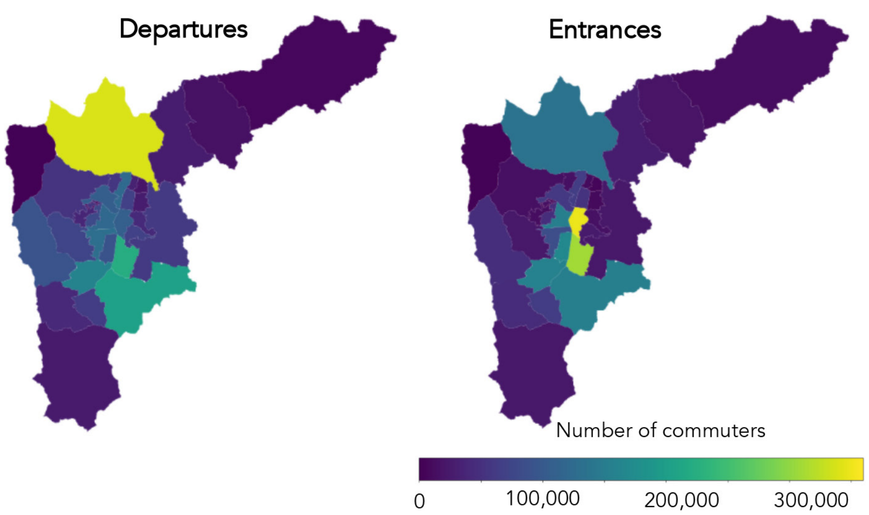


Figure 2



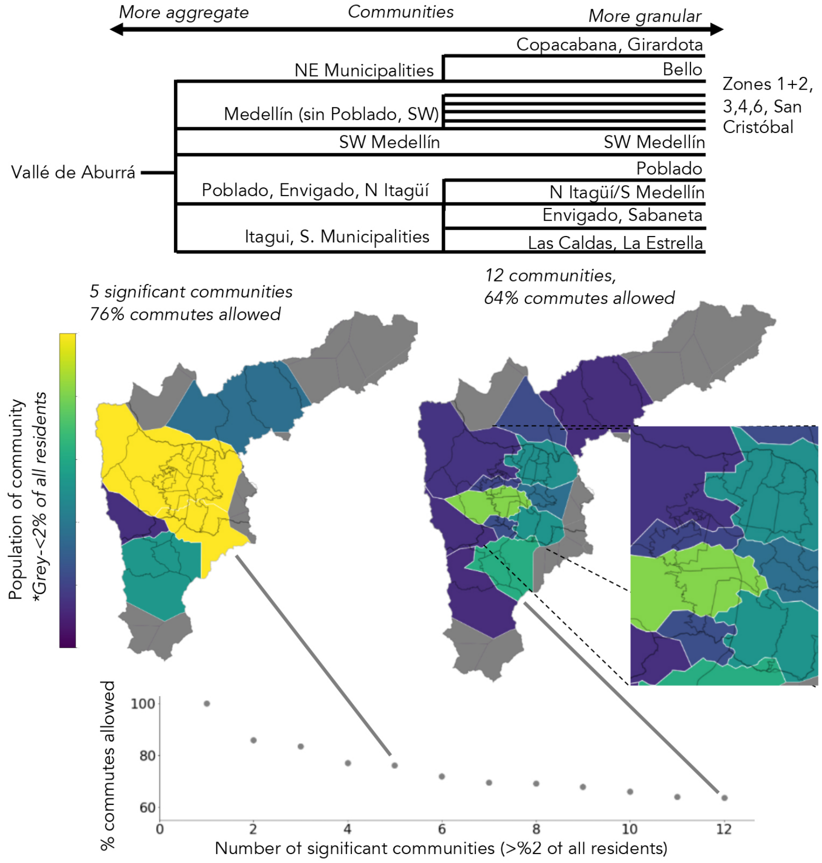
Using metropolitan commuter patterns to identify 'defensive communities': localized enclaves where people live, work and study.

While relaxing social distancing measures, it is of interest to identify regions of the metropolitan area that are linked to one another, as they connect many residents' home and work locations. Identifying these regions can help the local government bolster economic activity, while minimising unnecessary travel that can increase viral contact between people. Many residents stay within a limited area of the city, often the areas where they live and work. Therefore, one containment strategy proposed by leading physical and social scientists involves keeping people localised in "defensive communities" where economic activity and education are allowed, while external travel is restricted [3].

The "defensive community" strategy has the advantage of lessening the economic and social costs of lockdown, while restricting viral spread. Even if the outbreak within any given community is quite severe, the overall negative citywide effect could be minimised, as only that community would need to be locked down to confine spread (rather than the entire metropolitan area). A version of this strategy has already been employed in New York City with the creation of a 'containment zone' in the New Rochelle area [4]; in Bogotá with the creation of 'high alert zones' [5]; and on a more a massive scale in India with the creation of 1200 zones nationwide [6] in which in-and out-flow is restricted for some time. Here, we delineate these containment or defensive "communities" in order to optimise the number of work commutes allowed, while preserving restrictive borders.

In order to detect these communities from the commuting network, we deployed a commonly used algorithm that partitions the metropolitan area into regions of tower

Figure 3



cells with high home-work commutes between one another [7,8]. Importantly, we use this algorithm to detect communities at different scales, ranging from fine (many smaller communities) to aggregate (few larger communities).

In Figure 3, we display the results of this detection at a variety of scales, along with the percentage of all permitted commutes, if commutes between communities are restricted. Generally, we find, as expected, that as the number of communities increases, there are more "borders" and a higher number of commutes restricted. Specifically, we present two scenarios: first, we partitioned the metro area into 12 communities, seven of which contain parts of Medellín, preserving 64% of work commutes; and second, we partitioned the metro area into only five communities, effectively cutting off municipalities to the north/south of Medellín, and preserving nearly 80% of work commutes.

Does this approach affect all residents in a similar way?

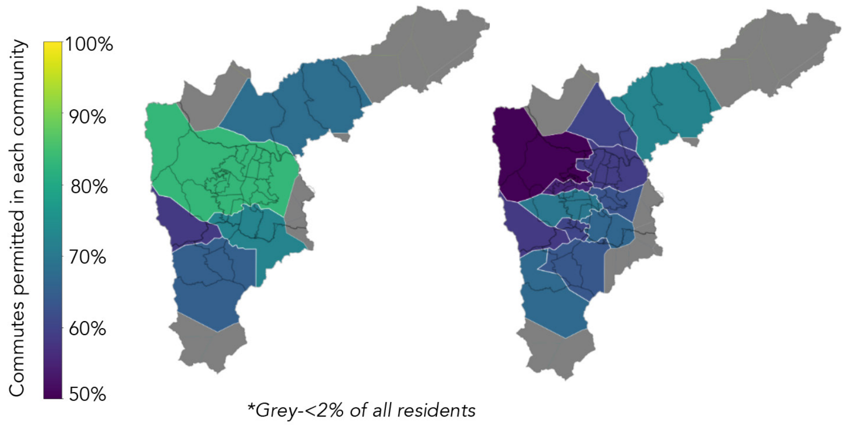
No, there are regions within the city that are more adversely affected when we try to preserve the highest levels of commuting volumes.

While our strategy preserves overall high levels of commute volumes while limiting viral spread, on a metropolitan scale, residents of some communities would be more disrupted from their usual commute patterns than others.

In Figure 4 (right) only 50-65% of residents in the communities located in north-western Medellín and Bello may still go to work under the fine partition of 12 communities. Meanwhile, 65-75% of residents of southern Medellín and Envigado municipalities and 80% of residents of Girardota and Copacabana municipalities can.

These results have socioeconomic implications that merit consideration, as north-western Medellín and Bello have a higher density of poor residents in stratum 1 and 2, while southern Medellín and Envigado residents are richer, mostly stratum 4 to 6. In the coarse partition into five communities, residents of the community composing most of Medellín — except the Poblado neighbourhood — experience the least interruption to their commute patterns, while other communities are more restricted.

Figure 4



Conclusions and Future Work

This brief demonstrates how the metropolitan region of cities can be divided into geographically defined "communities" that limit the spread of the COVID-19 virus, while preserving significant proportions of economic activity. The case of the metropolitan area of Aburrá Valley, which includes the city of Medellín, shows that most residents are allowed to maintain normal levels of commute patterns without traveling to another community. Importantly, it has been shown in previous epidemiological work [2] that such a localised strategy can serve to minimise and better manage risks of viral outbreaks.

The risk to citywide outbreaks in this scenario depends largely on the frequency of travel between communities. Keeping this frequency low presents a logistical challenge, as some trips between communities will always be necessary. Instructing people to stay within a given "community" would require an aggressive strategy for generating public buy-in. However, Medellín is well-positioned to do so: the local government has already built an impressive campaign for limiting viral spread that has centred around the use of a mobile phone app that helps residents procure groceries and receive government aid, while helping public health officials identify potential cases.

Currently, we are working to track changes in mobility using Call Detail Records that extend past the introduction of lockdown measures. This more recent data can be used to understand the extent to which lockdown measures have been effective in limiting gatherings in different regions of the Medellín metro area as well as other cities in Colombia, and to understand whether they have remained consistently effective over time. We are investigating the extent to which municipally directed “pico y cédula” policies have effectively reduced urban mobility. Additionally, more recent commute data can help to determine which travel patterns have persisted through lockdown, perhaps indicating work commutes for key workers, though these are indistinguishable from other unpermitted commutes.

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About us

The PEAK Urban programme aims to aid decision-making on urban futures by:

1. Generating new research grounded in the logic of urban complexity;

2. Fostering the next generation of leaders that draw on different perspectives and backgrounds to address the greatest urban challenges of the 21st century;

3. Growing the capacity of cities to understand and plan their own futures;

In PEAK Urban, cities are recognized as complex, evolving systems that are characterised by their propensity for innovation and change. Big data and mathematical models will be combined with insights from the social sciences and humanities to analyze three key arenas of metropolitan intervention: city morphologies (built forms and infrastructures) & resilience; city flux (mobility and dynamics) and technological change; as well as health and wellbeing.

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Our framework

The PEAK Urban programme uses a framework with four inter-related components to guide its work.

First, the sciences of **Prediction** are employed to understand how cities evolve using data from often unconventional sources.

Second, **Emergence** captures the essence of the outcome from the confluence of dynamics, peoples, interests, and tools that characterize cities, which lead to change.

Third, **Adoption** signals to the choices made by states, citizens and companies, given the specificities of their places, its resources and the interplay of urban dynamics resulting in changing local power and influence dynamics.

Finally, the **Knowledge** component accounts for the way in which knowledge is exchanged or shared and how it shapes the future of the city.

PEAK Urban is managed by the Centre on Migration, Policy and Society (COMPAS)

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