

# Making a case for the use of digital footprint data for evidence-based policies in response to human mobility changes after COVID-19 in Latin America

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**Abstract.** Text for abstract

## Introduction

Digital footprint data (DFD) are increasingly becoming a vital component of the data ecosystem to measure and monitor human mobility. DFD are digital traces left as a result from social interactions on digital platforms, such as the Internet through web search engines (e.g. Google), social media networks (e.g. Twitter and Facebook), commercial systems in the way of transactions (e.g. payment systems), sensor networks to capture environmental and human changes (e.g. fitness trackers, temperature and sound sensors), and imagery collected via satellites, cameras, drones, CCTV and imaging devices. Digital traces encoding location recorded through Call Detail Records (CDRs), eXtended Detail Records (XDR), Global Positioning System (GPS), Bluetooth and smart card data have been particularly valuable to reconstruct a traceable digital representation of human mobility.

These forms of DFD offer three key opportunities to capture human mobility (1) at higher geographical and temporal granularity; (2) over extensive geographical coverage comprising entire population systems or geographical areas; and (3) in real or near-real time [REF]. These attributes have enabled to complement traditional data sources to capture human mobility at various geographically scales, including urban mobility [REF], internal migration [REF] and international migration [REF]

Yet, the use of DFD poses significant challenges. These data are a by-product of administrative processes. They are not collected for research purposes. Their use involves major conceptual, methodological, data and ethical challenges [REF]. For instance, turning raw DFD into actionable, usable information requires significant data engineering, embracing data-driven hypotheses, accounting for data biases, ensuring privacy and anonymity, and integrating and validating the resulting outcomes with external data sources [REF]. These challenges to be overcome to unleash the opportunities offered by DFD.

An increasing number of “Data for Good” initiatives have been developed to leverage the potential positive social impact of DFD. These include data governance, data strategy and data sharing initiatives

(European Commission. Joint Research Centre. 2022). Data governance initiatives involve efforts focused on the provision of guidance about best practices for the collection, storage, share and use DFD for the social good. Data strategy initiatives focus on building capacity in civil society by designing data strategies for nonprofits and government agencies, such as Data-Pop Alliance and the Open Data Institute. Data sharing initiatives entail the creation and facilitation of access to datasets by data providers for organisations seeking to generate data solutions and positive social impact. These initiatives include [Data for Good at Meta](#) and [Waze Partner Hub](#).

Enabled by these initiatives, the use of DFD seems to have been - much more promising in less developed countries given data scarcity.

- Discuss how digital footprint data have been used in more developed countries or global north
- Highlight the limited use of digital footprint data in the global south
- Aim: Use of digital footprint data for mobility and policy response
- Argue case for COVID and mobility
- Structure

## Background

### The impact of COVID-19 on internal population movements

Globally, there is evidence that the COVID-19 pandemic constrained both shorth- and long-distance movements within national boundaries (Nouvellet et al. 2021; González-Leonardo, Rowe, and Fresolone-Caparrós 2022; Wang et al. 2022; Rowe, González-Leonardo, and Champion 2023). Declines were documented across the Global North during the first year of the pandemic, in the United States (Ramani and Bloom 2021), some European countries, Japan and Australia (Rowe, González-Leonardo, and Champion 2023), from 2.5% in Spain to 8.5% in Australia. Drops mostly occurred when governments implemented non-pharmaceutical interventions, such as stay-at-home requirements, travel restrictions, mobility restrictions, business and school closures. Levels of human mobility within countries, however, recovered pre-pandemic values following the elimination of lockdowns and other stringency measures. Declines on human mobility were attributed to lockdowns, increasing teleworking and restrictions of movements, but also to a loss of labour market dynamism as a consequence of the economic recession during the pandemic (Perales and Bernard 2022). In addition to evidence in the Global North, drops in internal population movements were also found in Latin American, declining by about 10% during periods of severe stringency measures (Aromí et al. 2023). The highest declines occurred in Bolivia, Ecuador and Argentina, ranging from 16% to 19%, while they did not reach 3% in Paraguay and Venezuela.

In global north countries, the COVID-19 pandemic also modified the patters of internal population movements between large cities and areas with lower population densities (Rowe, González-Leonardo, and Champion 2023). Variations were found in the United States (Ramani and Bloom 2021), United Kingdom (Rowe, González-Leonardo, and Champion 2023; Wang et al. 2022), Spain (González-Leonardo et al. 2022; González-Leonardo, Rowe, and Fresolone-Caparrós 2022), Germany (Stawarz et al. 2022), Sweden (Vogiazides and Kawalerowicz 2022), Norway (Tønnessen 2021), Australia (Perales and Bernard 2022) and Japan Kotsubo and Nakaya (2022). Net-migration rates in large cities declined in the United States, Germany, Norway, Sweden and Japan during 2020, while they increased in their

suburbs. (Ramani and Bloom 2021) called this phenomenon as “donut effect”, reflecting a decrease in population inflows to urban centers (urbanization) and a growth of movements from cities to their suburban rings (suburbanization). Nonetheless, there is no evidence of a “donut effect” in the United Kingdom, Spain and Japan, as net-flows in suburbs did not show significant changes. However, inflows to large cities also declined and counterurbanisation movements increased, reflecting unusual population gains in rural areas. In Spain, Sweden, Japan and Germany, holiday town with second homes of wealthy individuals were also found as popular destination for people leaving large cities during the pandemic. It suggests that wealthy populations and professionals who are able to work remotely seems to underpin movements from large cities to areas with lower population densities where they own second residences (Haslag and Weagley 2021; Tønnessen 2021).

Despite the above-mentioned changes to the human mobility system during the pandemic, research suggests that pre-existing macro-structures of internal population movement across the rural-urban continuum were not altered, since the majority of movements continued to occur within and between urban areas, and changes are not likely to endure (Rowe, González-Leonardo, and Champion 2023). For instance, mobility patterns returned to those registered before the pandemic after the lockdown in the United Kingdom (Rowe et al. 2022; Wang et al. 2022). The pandemic caused minor impacts on spatial patterns of internal population movements in Australia, and variations attributed to COVID-19 disappeared in late 2020 (Perales and Bernard 2022). Urbanisation levels returned to those register prior to the pandemic in Spain when the lockdown ended in mid-2020 (González-Leonardo et al. 2022), although unusually high levels of counterurbanisation persisted over 2021, despite decreasing over the year (González-Leonardo, Rowe, and Fresolone-Caparrós 2022).

Previous work provided a good understanding on how human mobility across the rural-urban hierarchy was affected by the pandemic in the Global North. However, less is known about COVID-19 impacts on movements between cities, suburbs and rural areas in the Global South and the durability of potential changes. Anecdotal evidence, based on small surveys carried out in India (Irudaya Rajan, Sivakumar, and Srinivasan 2020) and South Africa (Ginsburg et al. 2022), pointed out that flows from large cities to less populated areas increased due to the return of workers to their hometown, while movements of labour force to cities decreased. Both surveys saw that the economic downturn caused by non-pharmaceutical interventions during the pandemic (Ghosh, Seth, and Tiwary 2020) underpinned declining inflows of workers to cities and increasing returns among people who lost their jobs. The above-mentioned anecdotal evidence suggests that vulnerable populations seem to have played a role in movements to and away from large cities during the pandemic in the Global South.

Nonetheless, a recent study demonstrated that wealthy individuals from large cities in Brazil, Colombia, Indonesia, Mexico, Philippines and South Africa moved to less populated areas during the first wave of COVID-19 (Lucchini et al. 2023). On average, residents from high-wealthy neighborhoods were 1.5 times more likely to leave cities compared to those from low-wealthy areas. These finding is in line to results in Global North countries. Despite anecdotal evidence suggesting pandemic impacts on the patterns of internal population movements across the rural-urban hierarchy in some Global South countries, lack of data has not allowed for quantifying the magnitude and durability of potential impacts on the human mobility system. To fill the gap, we use Facebook data to analyse the effect of COVID-19 on the patterns of internal population movements in Argentina, Chile, Colombia and Mexico.

## **Human mobility across the rural-urban continuum in Latin American countries**

Currently, Latin America has the highest urbanization rate in the world after North America, totaling 81% (Nations” 2019). It means that the population is highly concentrated across space within Latin Amer-

ican countries, particularly in large cities with more than one million inhabitants, where half of urban residents are settled (Pinto da Cunha 2002; A. E. Lattes, Rodríguez, and Villa 2017). High urbanization rates are due to massive levels of population redistribution from rural settlements to cities until the 1980s, mostly during the fast industrialisation period from early-1950s to late-1970s, when population gains were mainly observed in chief cities (Firebaugh 1979; A. Lattes 1995; J. Sobrino 2012). Internal population movements in Latin America have been declining since the 1980s, as rural population stocks were depleted (Chávez Galindo et al. 2016) and the industrial crisis led to deconcentration trends in large cities, such as Santiago de Chile [González Ollino and Rodríguez Vignoli (2006)] or Mexico City (Jaime Sobrino 2006), where long distance inflows have declined. In sum, middle size cities became more attractive to internal migrants as a consequence of increasing domestic and foreign investment in export-oriented industries or tourism activities, leading to geographic economic dispersal (Brea 2003; Pérez-Campuzano 2013; Chávez Galindo et al. 2016). Nowadays, movements between cities dominate the internal migratory system in Latin American countries (Bernard et al. 2017; Rodríguez-Vignoli and Rowe 2018; Nations” 2019). About 80% of internal migrants moved between cities, according to the 2010-11 census round (Rodríguez-Vignoli and Rowe 2018). Medium-sizes cities from 500.000 to 1 million residents showed the highest population gains by internal migration, while large cities with more than 1 million residents registered balanced rates and small cities with less than 500.000 inhabitants lost population by internal mobility (Rodríguez-Vignoli and Rowe 2018).

Latin American cities have shown a significant growth in terms of land development in their urban peripheries. Since the 1970s, large cities, such as Santiago de Chile, Buenos Aires or Mexico City, but also middle and small cities have experienced suburbanisation (Graizbord and Acuña 2007; Chávez Galindo et al. 2016). Suburbanisation flows comprise middle- and high-class families moving from cities to auto-segregated areas in the periphery (Borsdorf 2003; Rodríguez Vignoli and Rowe 2017). Low-income individuals also settle in slums across suburbs but, in this case, in those areas where the land cost is cheaper (Janoschka 2002; Rodríguez Vignoli and Rowe 2017). Both residents in auto-segregated areas and slums commute daily to cities, mainly for work reasons (Chávez Galindo et al. 2016). Most recently, reurbanisation trends have been identified in central areas due to gentrification dynamics, although suburbanization flows continue to dominate short distance movements (J. Sobrino 2012; Chávez Galindo et al. 2016). In this report, we explore COVID-19 impacts on the patterns of human mobility across the rural-urban continuum in Latin America.

## Data

Description of the Meta-Facebook Data - Population and movement

Description of the COVID stringency data

Description of the WorldPop data

## Methods

Describe the distinction of movements of different distances and rationale

Describe and display population density classification

Description of the analysis using the baseline

Description of the netflows, inflows and outflows

Description of flow maps

## Results

### Population movements early 2020 and 2020 following the COVID-19 outbreak

Describe the violin / box plots. Key points:

- Decline in mobility following the implementation of COVID-19 stringency measures in early 2020. The decline follows a gradient: stronger in the most density areas, smaller in the least dense areas. Describe differences across countries and types of moves when relevant.
- Recovery in 2022 following the relaxation of COVID-19 restrictions. Describe differences across countries and types of move when relevant.

### Spatio-temporal patterns of population redistribution during COVID-19

#### > 50km

- Negative net balance in the highest density regions of the metropolitan area in early 2020 for Chile - support of urban exodus but temporarily. The negative net balance in the highest density areas coincides with increases with positive balances in low density areas (class 2 and 3)
- Different patterns in Argentina, Colombia and Mexico - a trend of positive net balances coinciding with negative balances in low density areas (class 2 and 3) - particularly in Colombia and Mexico
- A systematic pattern of negative net balance in medium size cities across all countries (class 7)
- The temporal patterns in the intensity of outflows and inflows are remarkably similar with differences in magnitude.

#### < 50km

- Negative net balances in the highest density areas of Argentina, Colombia and Mexico - evidence of a donut effect i.e. negative balance in the core of metropolitan cities
- This pattern coincides with positive balances across different places in the urban hierarchy in these countries.
- Chile reports a different pattern - relatively little change - remarkable is the large negative balance in class 8.

## Movements from and to capital cities

## Discussion

### Summary of key findings

- Decline in mobility intensity after the outbreak of COVID-19
- Support of urban exodus for Chile - but temporary - recovery to pre-pandemic levels
- Donut effect in Argentina, Colombia and Mexico

### Interpretation

### Policy implications

- for housing, transport and planning
- for data

## Conclusion

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