

New Data, New Directions: A Commentary on Emerging Big Geospatial Data for Population Research.

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Abstract

This commentary primarily discusses new data sources featuring fine-grained spatio-temporal data that have emerged in recent years from a variety of sources that previously did not exist or that were not easily accessible either from public or commercial entities. The focus here is on mobile phone location data (MPLD) as one avenue for potential new directions that have emerged and become increasingly relevant to a constellation of thematic areas across population research. I also discuss how new data sources, principally MPLD, aid in addressing some of the longstanding challenges and limitations of existing secondary data sources, while simultaneously creating both opportunities and limitations for researchers.

Furthermore, a discussion of some salient potential applications and pitfalls of big geospatial data are articulated when these are applied to population research internationally, but also in Aotearoa New Zealand. It could be argued that there is an explicit challenge to the longstanding conceptualisation of static residence-based measures applied to a range of thematic areas across population research, such as understanding movement or migration. We further posit that it is timely to (re)consider the role that big geospatial data, specifically MPLD, plays in understanding central questions in both geography and demography, such as where, when and why do people move?

It can be demonstrated that there is a wealth of big geospatial data that now can be exploited leading to opportunities for better understanding of the dynamic processes related to people and places. It could be argued that it is time for a more fulsome engagement with MPLD and other big geospatial data sets and techniques to grapple with both the opportunities and challenges for understanding

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population dynamics, as well as the patterns and processes that give rise to inequalities and inequities between people and places in Aotearoa New Zealand and further afield.

Keywords: Aotearoa New Zealand, big geospatial data, population dynamics, GIS

Whakarāpopotonga

Ngā kupu matua:

This commentary primarily discusses new data sources featuring fine-grained individual spatio-temporal data that have emerged in recent years from a variety of sources that previously did not exist or that were not easily accessible either from public or commercial entities. Additionally, this commentary – which is situated within a special issue on geospatial techniques on population research – focuses on a specific data source, mobile phone location data (MPLD), as one critical avenue for potential new directions that have emerged. MPLD is likely to become increasingly relevant to a constellation of thematic areas across population research. We discuss how new data sources, principally MPLD, aid in addressing some of the longstanding challenges and limitations of existing secondary data sources, whilst simultaneously creating both opportunities and limitations for researchers.

Furthermore, the commentary discusses some salient potential applications and pitfalls of big geospatial data when applied to population research internationally, and also here in Aotearoa New Zealand. It could be argued that there is an explicit challenge to the longstanding conceptualisation of static residence-based measures applied to a range of thematic areas across population research, such as understanding movement or migration. We further posit, that it is timely to (re)consider the role that big geospatial data, specifically MPLD, plays in understanding central questions in both geography (Christaller & Baskin, 1966) and demography, such as: where, when, why and how do people move? The main aim of this commentary is, therefore, to discuss MPLD and outline both the opportunities and challenges when it is applied to population research.

What is mobile phone location data?

Briefly, mobile phone location data (MPLD) can be defined as containing two primary components, as a minimum: location (e.g., latitude and longitude), and time. That is, MPLD is an example of spatio-temporal data. In addition, there can be aggregations or anonymisations of this raw MPLD provided as a derived product, often by commercial entities. Examples of such products include Safegraph,¹ NEAR mobility,² and the Dataventures population density product in New Zealand, used during the COVID-19 response, but since disestablished (Campbell, Marek, Wiki, et al., 2021). These MPLD are updated on a regular basis; for example, daily, weekly or monthly updates of data. Some of the data are temporally sporadic, while other sources are curated into regular hourly, daily or other regularly sampled temporal intervals. Thus, MPLD is, or could be described as, a relatively straightforward and rudimentary spatio-temporal data source. The mobile phone in this instance is used as the platform for collection of individual spatio-temporal data, though we concede that terminology may evolve and progress. MPLD can also be linked to other sensed or imputed variables such as altitude or speed, which adds to the complexity and dimensionality of the data source. Furthermore, we suggest that ‘big geospatial data’ collected from mobile applications such as social networks (e.g., Facebook, twitter/X, Instagram), tourism/travel (e.g., Airbnb, Flightradar24), navigation (e.g., Uber, Lime, Google Maps), or fast-food delivery (e.g., Uber Eats), can also be usefully categorised into the orbit of MPLD that could be useful for population research. This is primarily due to the same underlying structure of the data from mobile applications often containing the core components of location and time – though occasionally MPLD is linked to objects (e.g., taxis, scooters) rather than individuals. Such big geospatial data may include additional linked data features; for example, social, economic

and demographic data. There is some debate around the ontological dimensions of big data (i.e., volume, velocity and variety (Kitchin & McArdle, 2016)) and the specific composition and meaning of big geospatial data, hence our aim to focus more specifically on MPLD.

After defining MPLD and outlining the key aim of this commentary, we move to outline the nature of the potential challenge or complementarity of MPLD with more conventional secondary sources of data for population research. Here, we seek to extend engagement with MPLD or indeed other big geospatial data as emergent data sources, that if properly understood can significantly aid in understanding population trends and processes in almost real-time. Furthermore, if MPLD is derived from objects (e.g., planes, ships, taxis), we can discover and observe potential patterns and trends in the flows of both people and goods (Erlström et al., 2022).

Next, we point to the tension between the rudimentary aspects of MPLD, that when combined with volume, velocity and variety – the 3 V's of big data – can add considerable complexity to the research process. Previous research demonstrated that an absence of MPLD data had important consequences for the conceptualisation of place and produced significant misclassification (Campbell, Marek, Hobbs, et al., 2021) where the research demonstrated that occupation and age of participants was an important determinant of exposure misclassification using MPLD. This commentary extends this ongoing debate by discussing how similar issues may apply to a broad range of population research topics. The census is considered the benchmark data set in terms of data analysis for population research and official statistics. Furthermore, the census is a critical indicator of potential bias in other emergent data sources such as MPLD, so it is necessary to understand the precise limitations of MPLD, and where and for who bias may be present. A limitation is that as census data is collected

at variable intervals internationally, intra-country comparison can be a challenge. Moreover, there is often a considerable lag between collection and publication as well as ongoing debates around the need for a census (Boyle & Dorling, 2004; Baffour et al., 2013) which are problematic. A very specific challenge is that certain phenomena, such as disasters or wars (Leasure, Kashyap et al. 2023), occur in close to real-time and as such, need a policy or governmental response matching the immediacy of the event. Population trends and processes are dynamic. It follows that more rapidly available and precise spatio-temporal data is critical in better understanding and responding to these challenges and that MPLD is one source of potential 'solutions'. To help further illuminate the importance of the emergent data sources discussed, we now thematically explore some of the myriad ways in which new data could, or perhaps should, lead to new directions in population research.

Selected thematic applications of mobile phone location data in population research

Demographic patterns and processes

First, we turn the focus to how MPLD could address two key demographic processes: *ageing* and *fertility changes*. Ageing, the drift upwards in the median age of the population, is now well established in many economically developed countries – for example, in parts of Western Europe (Zheng et al., 2022) and in Japan (Higo, 2022) – but is also occurring globally. Ageing can lead to important changes in daily travel patterns or environmental impacts (Zheng et al., 2022), to frequency of healthcare access, and often changing preferences in residential location. Simultaneously, alongside ageing, the number of children is declining, with profound potential changes predicted for the economy from modelled demographic projections (Liu & McKibbin, 2022). In Aotearoa New Zealand, and many places worldwide, demographic

changes have the potential to alter how places are shaped as movement patterns can be fundamentally altered by family structures during periods of childhood and as we age (Yan et al., 2022). MPLD may give early indications as to the nature of changing movement patterns in populations, whether at work, education or play, and alone or in groups.

Interactions between environment and populations

Turning the focus to themes in the *environment* (built or natural), several overlapping salient issues could alter population trends and processes: trends in urbanisation, climate change and environmental impacts on population health and wellbeing. An important process that impacts unequally across places is the movement of populations to urban areas. More than 50 per cent of the world's population is now urbanised (United Nations, 2019), a proportion which is important in terms of how places are shaped, and which alters how populations interact with each other and travel through the environment. Understanding how populations live, work and play on a daily basis, requires MPLD or fine spatio-temporal data to address research questions more accurately. This may also utilise techniques such as agent-based models (Fazio et al., 2022) or spatial microsimulation (Campbell, 2011; Campbell & Ballas, 2016) in combination with MPLD to better understand and advance our understanding of such patterns. It is possible that movement by populations towards urban areas could have benefits for emissions, transport patterns and, therefore, climate change (Luqman et al., 2023). Linked to the urbanisation process is the challenge of environmental sustainability and climate change. That it is possible to link our precise travel behaviour, mode, duration and carbon emissions should afford new opportunities to better understand the travel-behaviour-related impacts on the environment. Moreover, as the environment changes, interactions between population health and wellbeing and the environment are also

affected (Bowie et al., 2013). As previously argued, understanding the differences in exposure to salutogenic or harmful aspects of the environment requires precise spatio-temporal location information to determine exposure (Campbell, Marek, Hobbs, et al. 2021). It could be argued that using MPLD affords new data and leads to new understandings of environmental considerations in population research. For example, we may be able to illuminate how travel changes alter environmental exposure(s), leading to changes in population health and wellbeing, while simultaneously being attentive and being able to measure the unequal impacts created by differing levels of uptake of alternative transport modes, whether e-bike or electric vehicle.

Population movement patterns and processes

Arguably, the most intuitively applicable area of application for MPLD is in the area of understanding *daily movement(s)*, *travel behaviour(s)* and *migration*. First, there is a difference between longer- and shorter-term migration; for example, compare the movement of refugees or temporary movement of people following a disaster with longer-term more permanent and planned migration behaviour. However, even with more permanent migration, this change can occur at any point during the intercensal period. Data on long-term movement is collected – for example, through the IDI,³ rental bond data, or the electoral roll, to name a few data sources in New Zealand – allowing understanding of relocation during the intercensal period. However, MPLD can give a rapid assessment when such official sources of data lag, take time to release, or are unavailable (Deville et al., 2014). For example, the case of refugee movements (Alencar, 2020; Beine et al., 2021) can be understood using MPLD, highlighting specific routes and patterns, which allows humanitarian intervention and planning to occur. Refugee movements are often transnational, cyclical and unpredictable; in other words, unlikely to be captured by

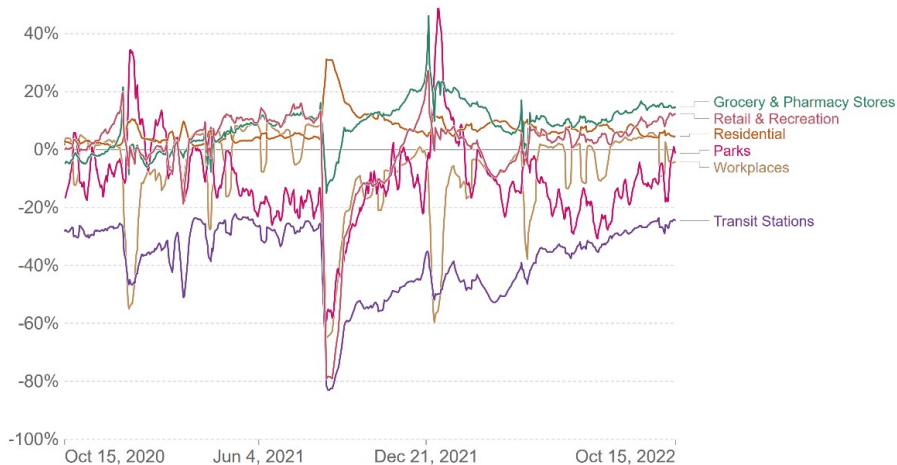
‘official’ statistics. When disruptions to longer-term trends and patterns occur – for example, during disasters – this can have an immediate impact on movement by population(s) which is often unable to be detected using only administrative data for quite some time. Specifically, when ‘normal’ movements are temporality disrupted, such as changes observed during the COVID-19 pandemic (Campbell, Marek, Wiki, et al., 2021; Conrow et al., 2021). Temporary disruptions may also have unequal impacts across population groups or for particular places, destinations or environments (see Figure 1). As the climate changes, we may further see the confluence of climate change and refugees (Lu et al., 2016), creating movement unequally around the planet.

Figure 1: Daily movement and environmental interactions shift

How did the number of visitors change since the beginning of the pandemic?, New Zealand



This data shows how community movement in specific locations has changed relative to the period before the pandemic.



Source: Google COVID-19 Community Mobility Trends - Last updated 24 July 2023

Note: It's not recommended to compare levels across countries; local differences in categories could be misleading.
OurWorldInData.org/coronavirus • CC BY

In a similar vein, travel patterns that may alter on a daily basis – for example, commuting behaviour as roads are open, closed or altered – and data like these are also captured in a snapshot way. However, MPLD allows the detection of

important trends in a much finer spatio-temporal way than the census can at a fraction of the cost. MPLD could apply to remote working altering commuting patterns, or for those who own multiple residences for example. In New Zealand, a subset of interest for movement patterns is tourism. There is a paucity of information on where tourists go, when and how. Some select examples exist (Shoval & Ahas, 2016); for example, in transport (Buning & Lulla, 2021) or tracking of wine tourists (Lewis et al., 2021). And we also have both financial transactions and MPLD to give us a clearer picture, with much larger sample sizes. Studies that can estimate the whole of population are likely to be even more useful for economic development and infrastructure planning. It also is likely to give an early indication of shifts in established patterns that lead to ‘overtourism’. In New Zealand, tourism electronic card transactions (TECTs) data gave a reasonably rapid indication of tourism spend and where it is occurring, whether from domestic or international sources. However, especially since the release of TECTs data has been recently discontinued, there is further room to utilise MPLD in this area and explore further fundamental questions on daily movement patterns across a range of applications and domains..

Understanding emerging innovation and disruption to population trends and processes

Data from innovative mobile platforms and applications (e.g., scooters, Uber, Airbnb) that impact on populations and places have been remarkably absent from official or administrative sources during their initial emergence. Innovations arising from mobile platforms and applications (scooters, Uber, Airbnb) that impact on populations and places are remarkably absent from ‘official’ or ‘administrative’ sources for a period during their initial emergence. This is understandable; however, it means that the specific social and spatial impacts on populations are often poorly understood for quite some time

and based on ‘anec-data’ rather than an official register. We argue that MPLD is one avenue for grappling with understanding how innovations and disruptions can be understood promptly – whether from a new mobile application, social media platform or a pandemic. Adding MPLD to the population researchers’ toolkit may help in any response as a critic and conscience when, rather than if, the next trend or innovation arises.

Where to for population research?

A key aspect of big geospatial data is that there is a paucity of understanding the nature and extent of bias. Furthermore, bias cannot, or is not, well understood without a reference point such as the census. Future research should also consider the development of MPLD standards as an overlooked but important component of creating and maintaining social licence for the use of MLPD. We argue the census or administrative data is critical in terms of both understanding and correcting for any bias in MPLD. A key proposition is that MPLD can be deployed usefully to understand changing patterns and processes in the population, particularly where there is an intersection between thematic domains of application in population research as outlined above. In closing, four questions that could benefit from a more fulsome engagement with MPLD and other forms of big geospatial data are articulated.

- Where are people (currently) located?
- Where, when and how do people move?
- Where, when, how and with which environment(s) do people interact?
- Where, when, how and with which population(s) do people interact?

A key conclusion is that any of the questions outlined above could be more rapidly and precisely answered using big geospatial data such as MPLD.

Conclusion

It can be demonstrated that there is a wealth of big geospatial data, particularly MPLD, to be exploited, leading to opportunities for better understanding of key population processes impacting on both people and places. We argue that it is time for a more fulsome engagement with big geospatial data sets and techniques to understand both the opportunities and challenges such data may present for understanding population dynamics, as well as the patterns and processes that give rise to inequalities or inequities between people and places, both in Aotearoa New Zealand and further afield.

Notes

- 1 <https://www.safegraph.com/>
- 2 <https://near.com/platform/>
- 3 <https://www.stats.govt.nz/integrated-data/integrated-data-infrastructure/>

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