Estimating temporary populations: a systematic review of the empirical literature

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# Background

Conventional population estimates capture a population at a single point in time. Such estimates ignore the short-term dynamism of many populations caused by temporary population mobility, territorial movement which does not result in a permanent change of usual residence (Bell and Ward [2000](#ref-bellComparingTemporaryMobility2000)). Temporary population movements are defined as moves of one or more night’s duration, but can be broadened to include diurnal movements such as daily commuting (Smith [1989](#X5d18d719e819976492524d0b6418e90ee55777d)). Temporary mobility can have a large impact on the size and composition of small area populations (Charles-Edwards and Panczak [2018](#Xb06a0e7b4af98e29fbb35fb88a1cad7b6630f34)) impacting traffic, housing, retail sales, medical services and emergency preparedness to name a select few (Smith [1989](#X5d18d719e819976492524d0b6418e90ee55777d); Smith and House [2007](#ref-smithTemporaryMigrationCase2007)). As a consequence, there is growing interest and need for temporary population estimates across a broad range of purposes including the planning and delivery of goods and services, fiscal equalisation (Graebert, Wyckoff, and Bretz [2014](#X590de3fbaf7cd79061325b9c513d8723b1f966e)), retail analysis, transport demand, emergency preparedness, and as better denominators for crime and epidemiological models (Charles-Edwards et al. [n.d.](#Xf9990a8be581a58576ed12142d89533c13b9be5)).

# Methods: Protocol and capture

To supplement the key search terms listed above, inclusion and exclusion criteria were developed. These included:

* Studies were excluded if they focused their analyses on certain population bases (for instance, social media or mobile phone users) without any extrapolation to the total population of a region.
* Studies were required to detail their methodology for at least one geographical region and capture non-resident populations.
* Studies estimating tourist arrivals and crowds were also excluded given that our interest here is one to establish more complete and stable populations in the areas in contrast to subgroups (such as tourists) or highly transient populations (such as crowds or pedestrians).
* Studies were included if they produced estimates or forecasts of temporary populations.
* Book reviews and magazines were excluded.
* Only studies published in English were included.

These criteria were designed to capture studies that offered in-depth empirical analysis of temporary population estimation rather than either theoretic development/debate or studies that presented descriptive analyses. Beyond the aforementioned criteria, there were no restrictions based on publication date, or publication status (for example, a published article versus an unpublished thesis). In cases where the same or similar methodology was used in several studies we selected one representative article to present in the review and collected further references in supplementary materials.

Information extracted from the studies was split into two major groups and included (*Appendix 2*):

1. Publication details: Publication metadata included: authors, title, source, year and publication type. We classified studies according to the primary source of data: mobile phones (MP), remote sensing (RS), social media (SM), transport (e.g. cordon counts, traffic and smart card data), administrative data (e.g. national censuses, health care records or various registries such as a registry of second homes), surveys (e.g. time use survey, holiday accommodation occupancy surveys), Wi-Fi and data from utility providers (e.g. electricity consumption). Studies could belong to more than one category.
2. Estimation: characteristics of estimates in the study including whether estimates captured daytime or overnight populations, the country and region for which estimates were made, data sources, methods and software, data and population size, number of spatial and temporal units, validation of estimates and the purpose for which they were produced.

# Results and Discussion: Estimating temporary populations

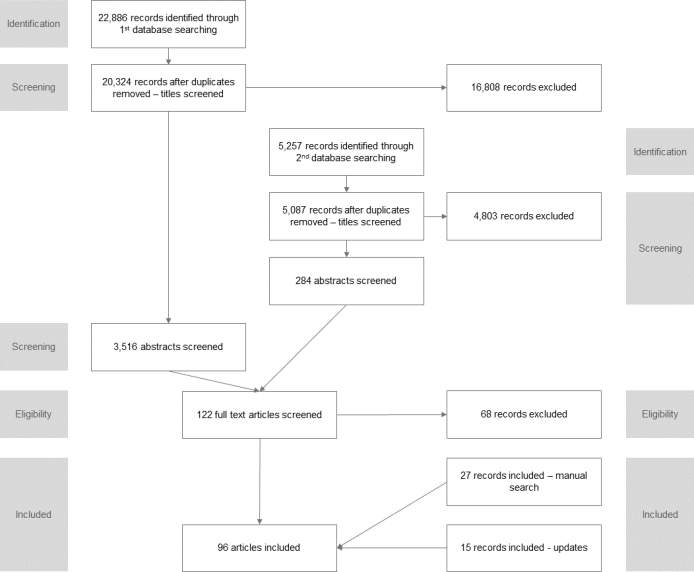
## Publications time frame, sources and reasons for estimates

Collectively, our initial search strategy initially identified around 22.9 thousands documents. After removing duplicates, titles and abstracts were screen for eligibility resulting in the set of 122 articles. The final stage involved a screening of full texts resulting in the removal of a further 68 articles. Additional 27 articles were identified from other sources and 15 - captured by scaning updates of the search results. A total of 96 studies were taken forward to form part of the analysis (*Appendix 2*). Figure 1 summarises the results of the search.

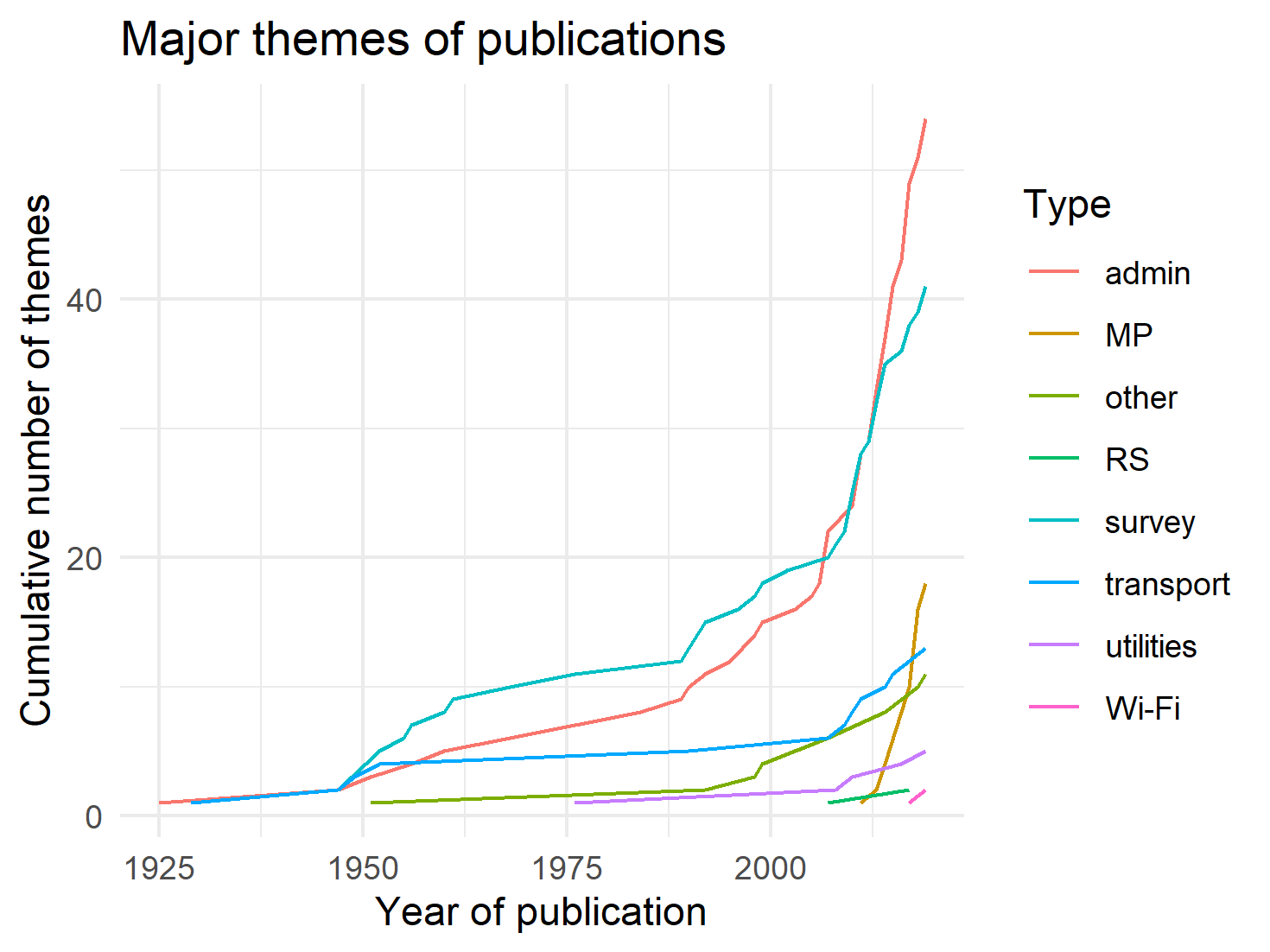
# Contribution

# Figures

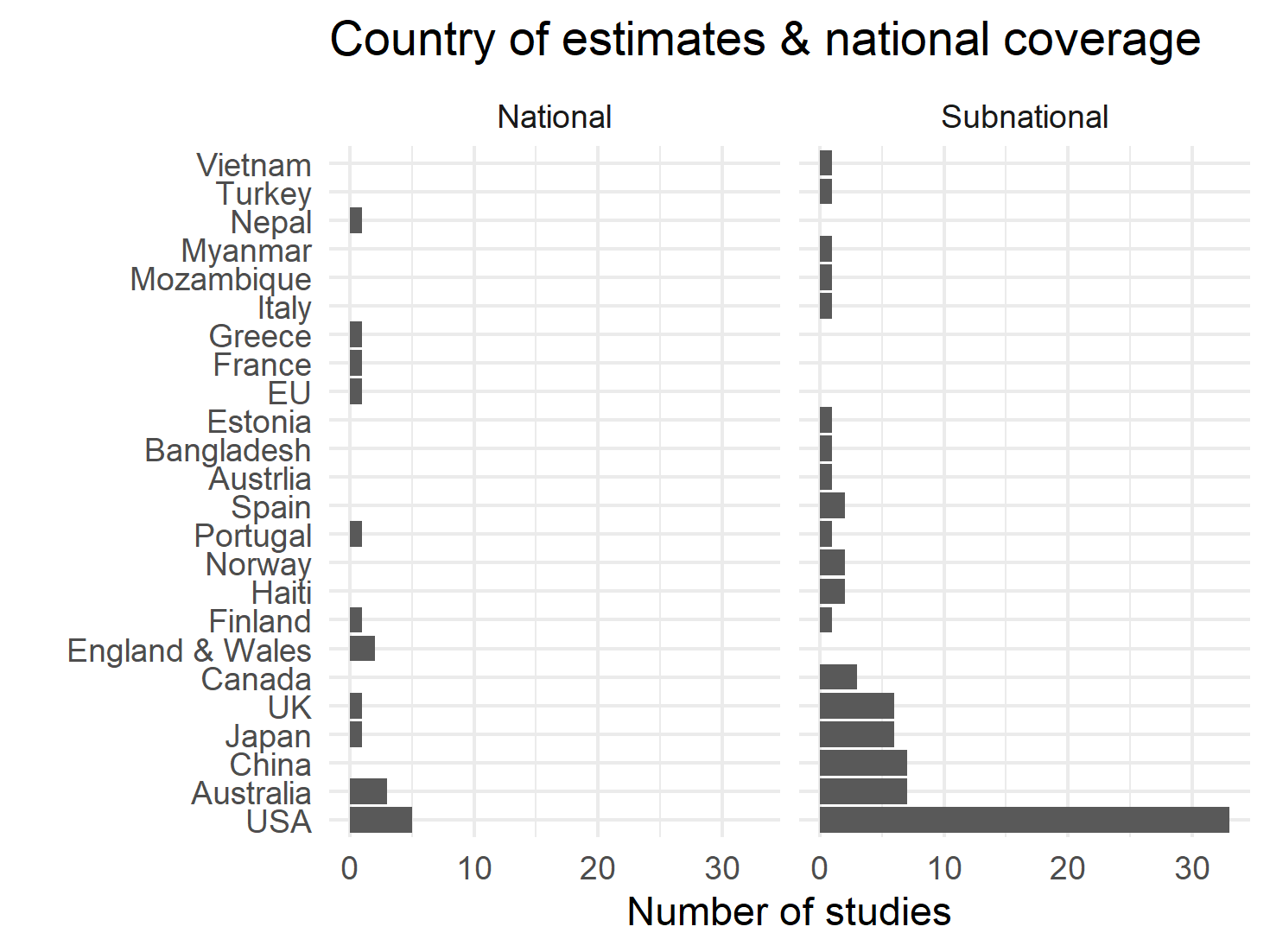
**Figure 1.** Flowchart of study selection.



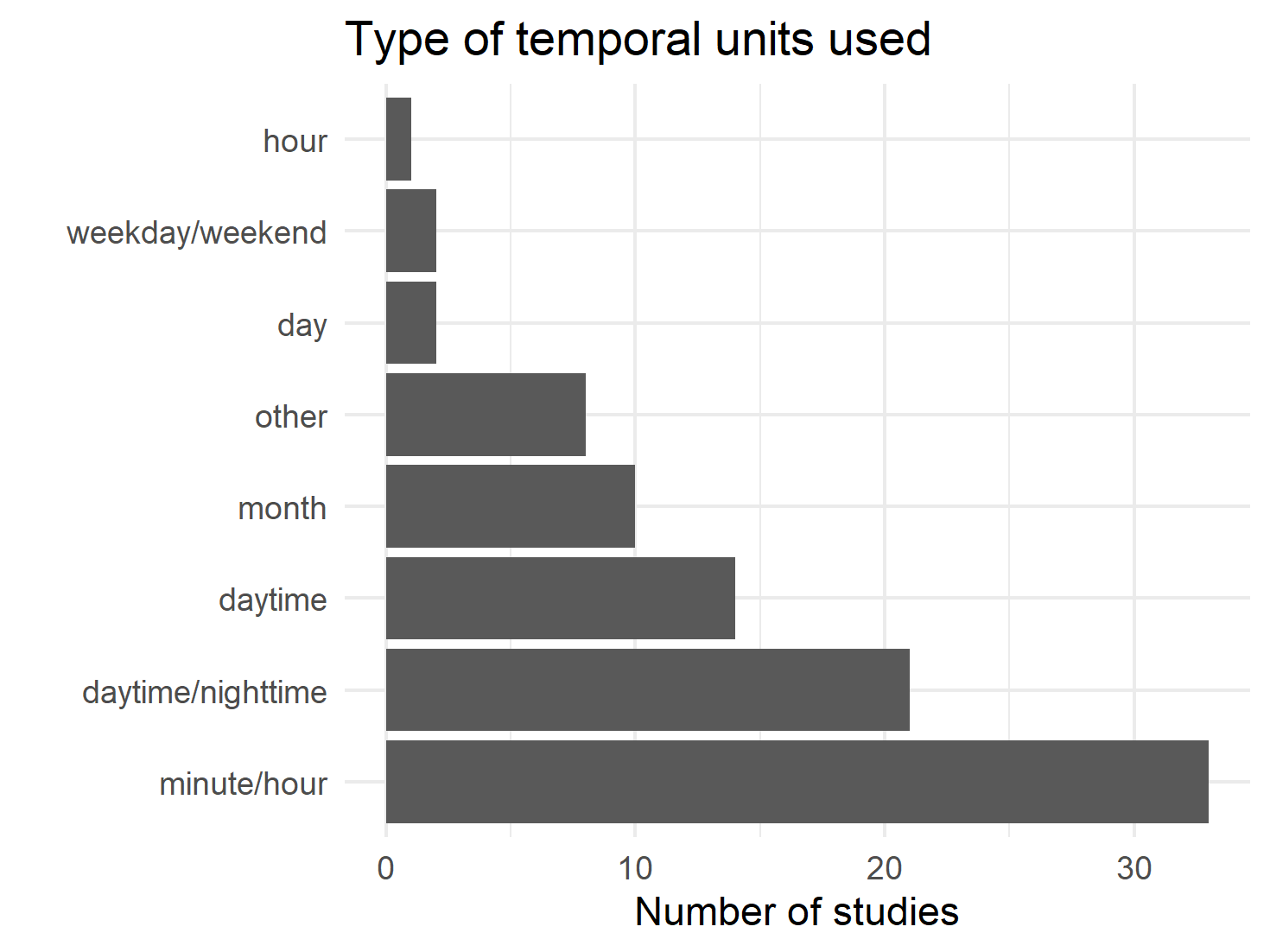
**Figure 2.** Cumulative distribution of year of publication across main themes. Note: Studies can belong to more than one category. ‘Social Media (SM)’ category has been excluded as it only has one member.



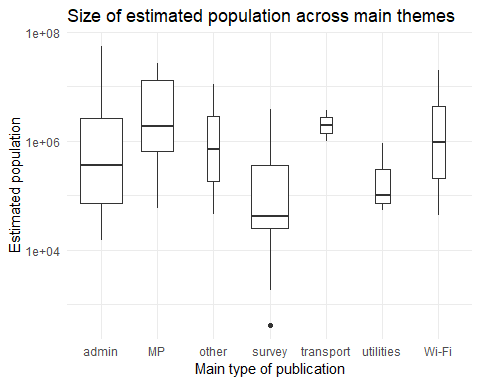
**Figure 3.** Country of temporary population estimates and national coverage. Note: one study describes more than one country.



**Figure 4.** Temporal units used for estimates.



**Figure 4.** Size of population by theme. Note: The Main category used. Box width is proportional to the total number of studies. Studies that did not report on an estimated population size using the size of dataset whenever possible.



# Tables

**Table 1.** Main characteristics of included studies. Note: \* indicates that study can belong to more than one category.

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic | Value | n / median | % / min; max |
| Year of publication |  | 2011 | 1925; 2019 |
| Source of publication | systematic | 54 | 56.25 |
|  | manual | 27 | 28.12 |
|  | update | 15 | 15.62 |
| Type of publication | article | 54 | 56.25 |
|  | report | 21 | 21.88 |
|  | conference | 11 | 11.46 |
|  | thesis | 7 | 7.29 |
|  | chapter | 3 | 3.12 |
| Purpose of publication\* | emergency planning | 22 | 22.92 |
|  | service population | 8 | 8.34 |
|  | other | 7 | 7.3 |
|  | epidemiology | 4 | 4.16 |
|  | commuting | 3 | 3.12 |
| Study region | single city | 51 | 53.12 |
|  | country | 17 | 17.71 |
|  | admin region | 15 | 15.62 |
|  | multiple cities | 10 | 10.42 |
| Regions for estimates\* | admin | 56 | 58.34 |
|  | grid | 27 | 28.12 |
|  | custom | 7 | 7.3 |
|  | points | 7 | 7.3 |
|  | building | 3 | 3.12 |
|  | Voronoi | 2 | 2.08 |
|  | node | 1 | 1.04 |
| Number of regions for estimates |  | 32 | 1; 52,000 |
| Size of estimated population |  | 343,956 | 1,868; 53,349,074 |
| Size of dataset |  | 722,000 | 422; 55,963,096 |

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