Toivakka, M., Pyykönen, M., Repo, T., Leminen, A., Martikainen, J. & Laatikainen, T.

Mobile networks and electronic health records can reveal mobility changes during the COVID-19 pandemic

An example from the study in eastern Finland

Keywords: Mobility, health geography, COVID-19, mobile network data, electronic health record, chronic disease

1 Introduction

The novel SARS-COV-2 coronavirus that has caused the COVID-19 pandemic, the major global spread of the disease, has resulted in major changes in human mobility and everyday life all over the world during 2020. The mobility of people, goods and information are an integral part of the modern world. At its simplest, mobility refers to movement between places (Cresswell 2006). In Finland, the Finnish government imposed the Emergency Powers Act (1552/2011) on 16th of March (calendar week 12) to control the spread of the coronavirus (Eduskunta/Riksdagen 2020). As a result, the number of people in public gatherings was limited, schools and universities switched to distance learning, people aged 70 and over were obliged to self-isolate themselves, and the public sector started to work remotely. These restriction measures have affected people's mobility, restricting both everyday activities and work and leisure related domestic travel and travel abroad.

Health geography with spatial and spatiotemporal analysis, predictive modelling and web-based mapping has become a relevant field to interpret and study the COVID-19 phenomenon (see for example Cuadros *et al*. 2020; Desjardins *et al*. 2020; Franch-Padro *et al*. 2020; Guan *et al*. 2020; Harris 2020). Studies focusing on the associations of the COVID-19 and mobility have observed large areas, such as, country level in Sweden (Wetter *et al*. 2020), NUTS3 (Nomenclature of Territorial Units for Statistics) administrative level in Europe (Ruktanonchai *et al*. 2020), state level in the United States (Nguyen *et al*. 2020) and county level in the United States (Borqonovi & Andrieu 2020). The changes in mobility patterns can be studied using mobile network data and geospatial techniques (Poom *et al*. 2020). Woody *et al*. (2020) have projected COVID-19 deaths based on aggregated mobile-phone GPS traces about the social-distancing predictors, such as visitation patterns and home activity. In Finland, blog texts have been published about the changes in mobility flows by using municipality level mobile phone network data from the time of the first COVID-19 outbreak (Järv *et al*. 2020; Kotavaara *et al*. 2020).

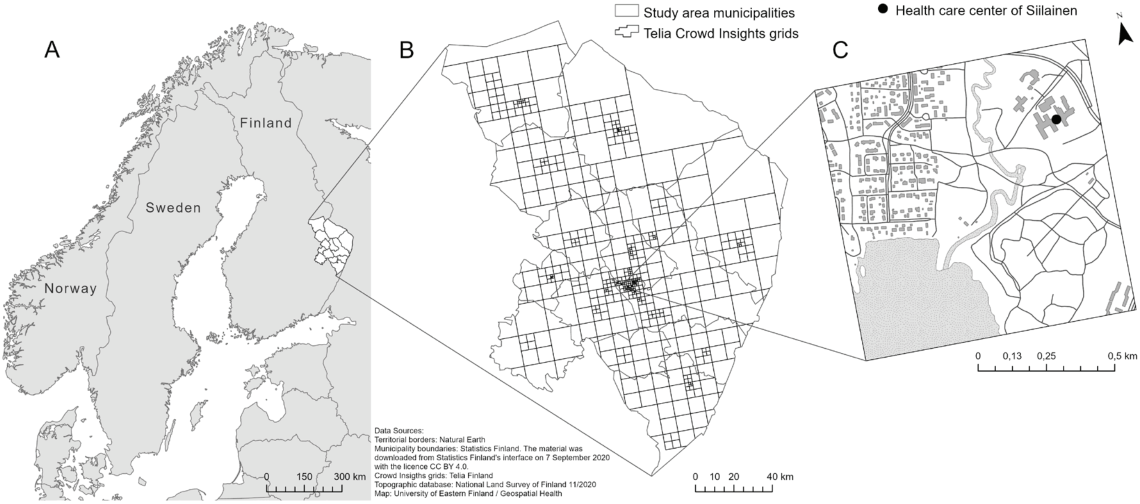

Figure 1. The study area (A) and the study grid containing Siilainen health care center (C) are located in eastern Finland. The size of the grids for the mobile network data varies depending on the population density (B).

Understanding the population mobility and its changes is important from the perspectives of society, wellbeing and health. The assessment of mobility patterns offers useful information for monitoring and managing unusual situations, such as COVID-19. Opportunities and tools for this can be found from health geography and geographic information system (GIS) approaches, and new data collection methods can be used to study the mobility flows more accurately than ever before. Several sources, such as Google and mobile network operators, have produced data on mobility. During the COVID-19 pandemic, for example the mobile phone network data of Telia Company has been utilized in decision making, and it has helped to improve the overall situational awareness in Nordic countries (Telia Finland 2020; SVT Nyheter 2020; Via Ritzau 2020). Based on this work, the mobile network data is proven to be useful in detecting the up-to-date changes in people's mobility during the distinct stages of the disruption, or in showing how, for example, guidelines, restrictions, and holidays are affecting the mobility.

In the present study, we use the mobile network data to analyze the COVID-19 related mobility change within one health care center located in the county of North Karelia in eastern Finland (Figure 1). We will compare the mobility situation of 2020 with the temporally matching information from 2019. We are interested in both the possible reduction in mobility and the recovery after the first wave. In addition, we have a first glance to the changes in health care service use during the COVID-19 pandemic by using electronic health record (EHR) data from the regional patient information system. This study is just one example and demonstration of what it is possible to achieve with these datasets, when we continue our research in the future.

2 Data and intended approach

2.1 Mobile network data

We use Crowd Insights data produced by mobile network operator, Telia Company. As the name suggests, this data includes information about the crowd movement patterns. This information is based on anonymized and aggregated relay data from Telia's mobile networks, and it has been generalized by Telia to represent the general population. The data from our research area covers the following periods: 2.3.–15.5.2020; 3.8.–25.9.2020; 4.3.–17.5.2019; and 5.8.–27.9.2019. These time periods in 2020 have been selected according to the first wave of the epidemic in Finland, as well as the stabilization phase during August and September, and they will be compared with the matching calendar weeks from 2019.

The geographical unit for this mobile network data is a map grid with varying size, which is based on population density (Figure 1B). The grid size is smaller, 500 *m* × 500 *m*, in the densely populated areas, but it can be as large as 16,000 *m* × 16,000 *m* in remote rural areas. The temporal resolution can be, for example, one hour, day, week or month. The data tailored to our study purposes includes the number of trips (called activities) to each map grid (minimum stay of 20 minutes) summed at the weekly level (Monday-Friday). In addition to the destination, also the origin grid of these activities is available. In our data, the origin is always the first location, where a phone connects to a cell tower early in the morning, and in most cases, it can be interpreted as a home location. Thus, respectively as grid-to-grid activities from one grid to another, also the home zone activities can be tracked, in cases where both origin and destination are located in the same grid.

2.2 Patient data

In our study, we also use electronic health record (EHR) data at the regional health care district level (the region of joint municipal authority for North Karelia social and health services, *Siun sote*). The use of patient data for research purposes was approved by the ethics committee of the North Savo Hospital district. The health care district of Siun sote comprises 12 municipalities, which belong to the county of North Karelia, and one municipality, which is part of the county of South Savo. In 2019, the total population of this health care district was 164,465 (Official Statistics Finland 2020).

We collected primary health care contacts (visits and phone calls) of several chronic disease patient groups for *Siilainen* health care center (see the location from Figure 1). This data was extracted from the regional patient information system, *Mediatri*, which is used commonly between the municipalities of *Siun sote* health care district. The selected group of patients included patients having atrial fibrillation, type 2 diabetes, type 1 diabetes or acute coronary heart disease. For this group, we used all primary health care contacts without considering, whether the contact (visit or phone call) was related to these chronic diseases.

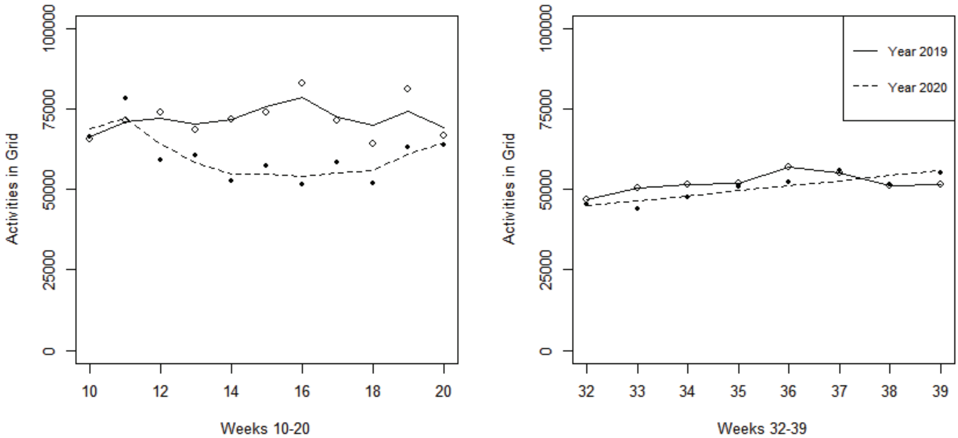

Figure 2. The number of grid-to-grid activities in the study grid for the study periods in 2019 and 2020. The data consists of weekly level activities based on Telia Crowd Insights data.

2.3 Intended approach

In this study, we illustrate the mobility change in one example grid and the changes in primary health care contacts during COVID-19 within a single health care center (*Siilainen*). Telia's mobile network data cannot be linked directly with EHRs. However, the mobile network data from the time period of the pandemic is used to reveal, whether the number of trips to the map grid containing *Siilainen* health care center has changed compared with the previous year. The electronic health record data, on the other hand, is used to evaluate, whether similar trends can be detected in primary health care service use among the selected patients.

3 Results

The mobility of people according to the mobile network data has decreased after week 13 in 2020 compared with the previous year (Figure 2, weeks 10–20). The number of grid-to-grid activities in the grid containing *Siilainen* health care center evened out to previous year's level during the autumn (Figure 2, weeks 32–39). The home zone activities were analyzed separately (Figure 3). During the early phase of the pandemic, the number of home zone activities increased (Figure 3), while the mobility in general started to decrease (Figure 2). The number of home zone activities in 2020 approached the previous year's rates during the spring (Figure 3, weeks 10–20) and later, in August and September, the rates began to match each other (Figure 3, weeks 32–39).

The total number of contacts (visit or phone call) in *Siilainen* decreased especially in spring 2020 compared with the matching calendar weeks in 2019 (Table 1). In addition, a clear change exists in how patients have been in contact with the primary health care services in *Siilainen*. The share of phone calls increased during the outbreak of the COVID-19 pandemic (Table 1).

Figure 4 illustrates the effect of CO-

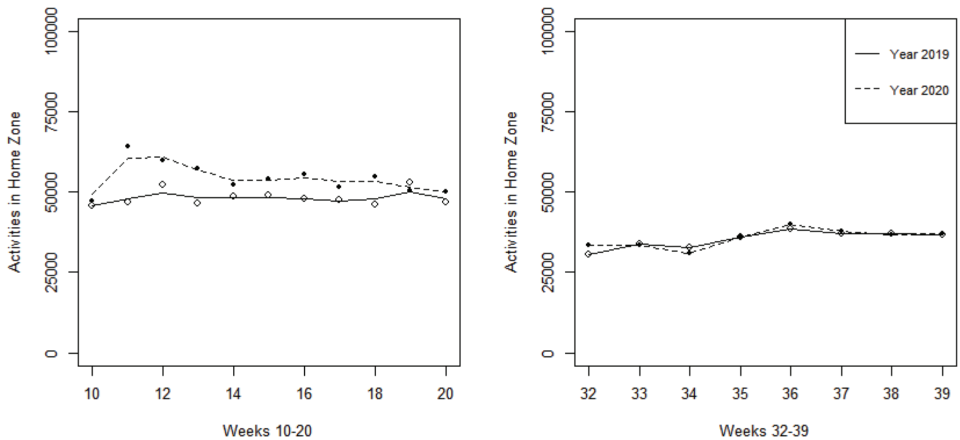

Figure 3. The number of home zone activities in the study grid for the study periods in 2019 and 2020. The data consists of weekly level activities based on Telia Crowd Insights data.

VID-19 pandemic on the number of health care contacts. The time series of primary health care visits for the studied patient group are shown in Figure 4A and 4C, and the phone calls in Figure 4B and 4D. The number of face-to-face visits to *Siilainen* decreased considerably after the week 12 in 2020 (Figure 4A and 4C). The total number of phone calls remained roughly at the same level in 2019 and 2020 (Figure 4B), only showing a slight increase in the trend between the weeks 12–25 in 2020 (Figure 4D).

4 Discussion and future plans

In this study, we used electronic health records from the regional patient information system and the mobile network data produced by Telia Company to analyze the COVID-19 related mobility change. We took *Siilainen* health care center as an example to study these changes in eastern Finland. Our study demonstrates that the mobility flows of people and the visits to primary health care services have decreased during the first outbreak of the COVID-19 pandemic in the study area. On the other hand, the increased share of

Table 1. The Summary of the number of contacts in Siilainen health care center on the calendar weeks 10–20 and 32–39 in 2019 and 2020.

	Total contacts	Visits	Phone calls	Visits (%)	Phone calls (%)
Weeks 10–20, 2019	3123	1988	1135	64	36
Weeks 32–39, 2019	2291	1403	888	61	39
Weeks 10–20, 2020	2114	936	1178	44	56
Weeks 32–39, 2020	2108	1119	989	53	47

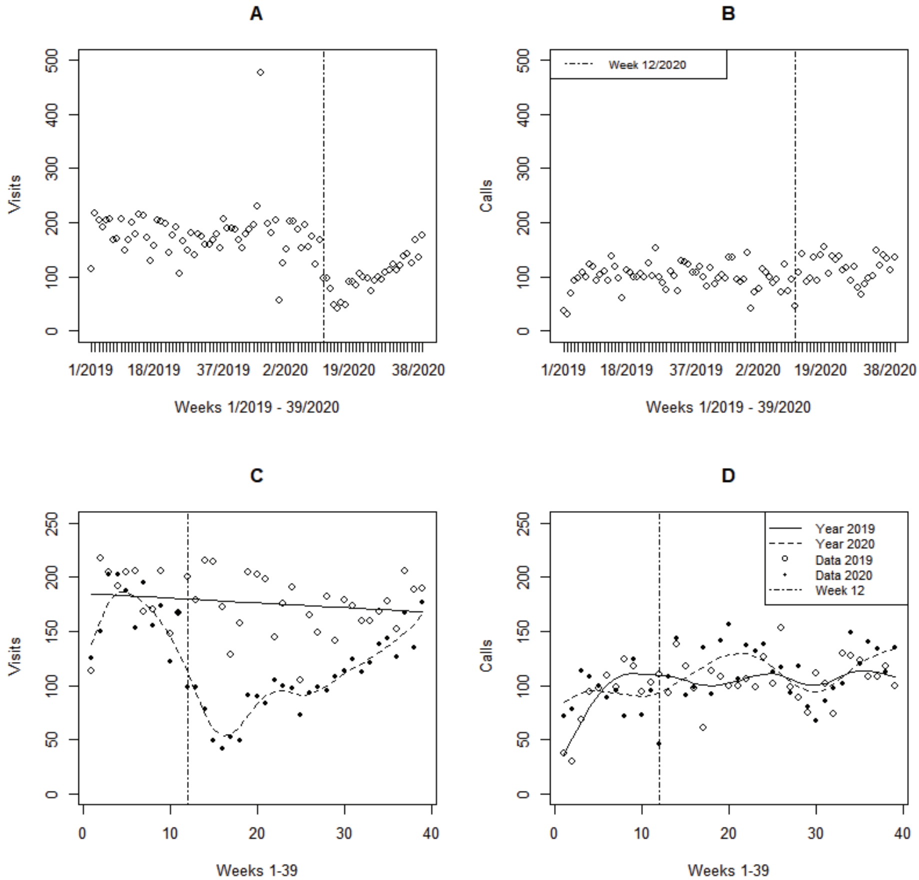

Figure 4. The primary health care visits (A and C) and phone calls (B and D) for the studied patient group in Siilainen health care center. The smoothed horizontal lines show the temporally adjusted trends of these events in 2019 and 2020.

phone calls in the health care contacts in the spring of 2020 partly replaced the decline in visits. In addition, while the number of activities in general decreased in the study grid compared with previous year's levels, the number of home zone activities increased during the early phase of the pandemic, indicating that people spent more time at home. These changes in the mobility flows and the health care contacts are in accordance with the recommendations and restrictions the Finnish government imposed on week 12 in 2020.

In our datasets, the decrease in grid activities and health care contacts in the same map grid was not equal, which is a logical consequence of different data types. Firstly, the mobile network data measures activities in the study grid as a minimum stay of 20 minutes. The short-term stays in the grid are not recorded in the data. Other activities, such as the CO-

VID-19 testing, which is performed in *Siilainen*, might have increased the mobility flows in the area. Secondly, we used primary health care data, which consisted of visits and phone calls of the certain group of chronic patients. These chronic patients are only one part of the people and patients who visit the health care services in the area. These aspects should be considered when interpreting the results.

It is worth noticing that the COVID-19 rates in the study region were low compared with the national situation (THL 2020), let alone many other areas in Europe (WHO 2020). The biggest change in mobility happened in the early phase of the pandemic, when there were only few confirmed COVID-19 cases in the region. Due to the low number of COVID-19 cases, we could not see any complete lockdown elements from the used mobility data or the primary healthcare visits. When the second wave of the pandemic started to take place in the late summer and early autumn in Finland, the mobility did not change in the study grid compared with the previous year.

Our preliminary results confirm the general usability of mobile network data in the research of indirect impacts of COVID-19 pandemic, at least in the selected map grid. However, when a more detailed insight of mobility is needed, the limitations of the data become apparent in rural regions, like North Karelia. The geographical aggregation creates large spatial areas in remote parts of the region making it impossible to accurately distinguish the home zones of specific population groups or chosen travel destinations. Still, when spatially accurate information is derived from EHR, the mobile network data provides valuable addition for comprehensive analyzes. In addition to observing changes during the pandemic, similar datasets could also be used in predictive modelling. For example, decision makers would benefit from the information of, how different restrictive measures affect the social distancing, or how the pandemic indirectly alters the treatment outcomes of different patient groups by changing their behavioral patterns.

The study is part of the *Improved Knowledge Base and Service Optimization to Health and Social Services* (IMPRO), a research project funded by the Strategic Council at the Academy of Finland. In the future, we plan to combine the mobile network data on mobility with other GIS data sources. These data linkages will allow us to analyze how aspects, such as, the type of living area, local demographic composition, and the accessibility of services, are affecting the mobility during the pandemic. Furthermore, additional information can be derived from electronic health records to study more broadly, how the health care service use has changed compared with the previous year before the pandemic. The early proactive measures, such as, the closure of schools, the restrictions to the social contacts of elderly people, and the prioritization of the health care probably prevented the wider spread of the disease in the region, but this may have also brought adverse effects on wellbeing and gaps in the screening of chronic patients. These aspects will also be covered in further studies.

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Toivakka, M., Pyykönen, M., Repo, T., Leminen, A.*
Department of Geographical and Historical Studies, University of Eastern Finland,
P.O. Box 111, FI-80101, Joensuu, Finland
E-post: maija.toivakka@uef.fi

Martikainen, J.
School of Pharmacy, University of Eastern Finland,
P.O. Box 1627, FI-70211, Kuopio, Finland

Laatikainen, T.
Joint municipal authority for North Karelia social and health services
(Siun sote), Tikkamäentie 16, FI-80210, Joensuu, Finland
Institute of Public Health and Clinical Nutrition, University of Eastern Finland,
P.O. Box 1627, FI-70211, Kuopio, Finland
Department of Public Health Solutions, National Institute for Health and Welfare
(THL), P.O. Box 30, FI-00271, Helsinki, Finland

[*] *Corresponding author*