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Special Issue 2.2022

Mobile phone data for exploring spatio-temporal transformations in contemporary territories

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Special Issue 2.2022

MOBILE PHONE DATA FOR EXPLORING SPATIO-TEMPORAL TRANSFORMATIONS IN CONTEMPORARY

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Impacts of the Covid-19 pandemic in inner areas

Remote work and near-home tourism through mobile phone data in Piacenza Apennine

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Abstract

While the impacts of the Covid-19 outbreak on urban areas have been deeply investigated, the effects of the virus on sparsely populated and marginal areas are still poorly explored. In Italy, those "inner" areas are often characterized by processes of marginalization due to aging and loss of population, low occupational rate and income, a progressive deprivation of local know-how, and the shrinking of essential services. Yet, a reverse migration from urban centers to rural and peripheral areas has been reported worldwide among the main effects of the Covid-19 pandemic, being in some cases an opportunity to slow down and even reverse the process of marginalization. By combining mobile phone and socio-spatial data, this paper aims to analyze the space-time variability of human presence before and during the Covid-19 lockdown in the Apennine area of the province of Piacenza, a representative case of Italy's inner areas, to read if and how the pandemic has contributed to modify the rhythms and trends of those territories. Two dynamics have been investigated: remote and near-home tourism. In addition to provide a picture of the changes that occurred in these marginal contexts, the outcomes have shown the great potentiality of mobile phone data, along with some limits that may prejudice their usability, particularly for territorial research in low-density areas.

Keywords

Marginal territories; Covid-19; Mobile phone data; Remote working; Near home tourism.

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1. Introduction

The transformations produced by the Covid-19 Pandemic in major urban areas have been deeply described in the literature, focusing on how the effects of the pandemic and the consequent policies for social and physical distancing and lockdown impacted people's behaviors and urban contexts (Banai, 2020; Chandran, 2020; Klaus, 2020; Kunzmann, 2020; McFarlane, 2021; Sharifi and Khavarian-Garmsir, 2020; Shenker, 2020). Many of these studies have analyzed the sudden changes in mobility and social interaction patterns by making use of big digital data produced in increasing quantities by humans living in urban environments, as in the case of Bonaccorsi et al. (2020) and Beria & Lunkar (2021) who exploited data provided by Facebook ¹. However, few studies focused on low-dense and marginal areas (Boterman, 2020) to describe how far those territories have changed under the effect of the virus. Nevertheless, massive waves of reverse migration were reported worldwide, from urban centers to rural areas (FAO, 2021), also fostered by the widespread affirmation of remote working (Manzini Ceinar and Mariotti, 2021; Petrillo et al., 2021).

The Eurofound's Covid-19 survey also demonstrates the same trend, showing that 39% of EU employees in 2020 started to work from home due to the Pandemic (Sostero et al., 2020) and the rules imposed on social distancing and the restriction of mobility. Indeed, the observation of mobility flows in Italy during March-April 2020 lockdown revealed a significant migration from the main cities' centers toward the outskirts (Beria and Lunkar 2021), as well as in France, where more than one million residents moved away from Paris in one week in March 2020 (Untersinger, 2020). These studies, showing that the first lockdown caused a temporary migration flow from main cities toward rural areas, also identify several factors influencing this dynamic. Among them, the housing factors, as rural houses are on average larger than city apartments and equipped with external and green spaces, thus, more suitable for home working (Tomaz et al., 2020, p.9) and more comfortable to handle the rules of social distancing and the periods of lockdown. The development of local near-home tourism had represented another important factor when the opportunities for movement outside regional or national boundaries were severely restricted.

Even if the pandemic outbreak started a significant crisis in leisure travel, impacting forms of tourism-based and sharing economies, with up to a 100% decrease in accommodation occupancy rate registered for the week of 21st March compared to previous years (Gössling et al., 2021), several countries reported an increase in rural tourism and staycation. This trend was registered in France² and Italy in 2020, with 72% of tourists that preferred destinations nearby their residence and 59% choosing less crowded and famous destinations (ANIASA, 2020). In addition, a new feeling of proximity is rising that pushes people to be part of these territories more than only tourists or villagers (Barca, 2021).

In Italy, these trends appear of particular interest when affecting rural territories marked by constant depopulation since the second half of the XX century to continue hitherto as a consequence of the internal migrations toward areas with better accessibility to services and a better welfare system (Colucci, 2018, p.329). Along with population decline, many Italian rural inner areas suffered a process of progressive deprivation of local know-how, tradition, and culture, hand in hand with the abandonment of built heritage and the shrinking of essential services such as schools, health services, and public transport, but also local services such as small stores, banking services, libraries, bars, jobs as well as a more generalized loss of sense of community. Small demographic growth due to the arrival of amenity migrants (Moss, 1994) or mountaineers by choice (Dematteis, 2012) in some cases have inverted depopulation trends, such as in the French western Alps (Löffler et al., 2016, p.491), or in the eastern part of the Italian Alps (Borsdorf et al., 2012) but did not start a veritable regeneration process.

¹ <https://dataforgood.facebook.com>

² <https://www.francebleu.fr/infos/economie-social/l-annee-2020-a-ete-exceptionnelle-pour-les-gites-de-france-en-dordogne-1608308951>

Assuming that the Covid-19 outbreak may have represented an opportunity for the revitalization of inner areas after many years of crisis, the paper aims to investigate if and how this disruptive event has prompted an increase in territorial attendance related to remote working and near-home tourism by making use of mobile phone data tracking human presence in the Apennine area of the province of Piacenza, Emilia Romagna region. The Piacenza Apennine area (around 2,200 km²) occupies the central and southern portions of the province (Fig.1) and is marked by different orographic and settlement conditions. While the northern side is primarily flat and hilly, with larger centers and higher population density, the environment becomes typically mountainous while proceeding southward along the major valleys (Val Trebbia and Nure). In this remote and rural part of the territory, which we refer to as the high valleys, the main centers are usually located on the valley floor, along the main roads, surrounded by many small, dispersed hamlets at higher altitudes. Thus, the Apennine high valleys are orographically complex territories with low settlement density where, in the last ten years, significant shrinking processes have affected the mountain villages more than the municipalities in the hilly area and the plains. As for many Italian inner areas, the depopulation process was mainly induced by internal migration towards more dynamic contexts of the province or the Country, only partially contrasted by the arrival of young inhabitants, the return of the old ones after retirement, and the strenuous resistance of those who have always remained here (SNAI report, 2018). As a consequence, the municipalities of the high valley are today characterized by an aging population, low income and educational rate, unemployment, and work/study-related mobility practices over long distances and at high speed, revealing low levels of attractiveness and significant dependence on more dynamic areas of the region (Vendemmia et al., 2021).

These trends also explain why some of the municipalities in the high valleys were classified as peripheral according to the Italian National Strategy for Inner Areas (SNAI), an Italian national policy for territorial cohesion and development that classifies the Italian municipalities based on the level of accessibility to three citizenship rights: mobility, education, and health. According to the SNAI, the level of accessibility to these rights is proxied by the driving distance from three essential services: a small/medium size train station mainly served by local trains (defined as *silver-level* stations according to the official classification provided by RFI, the national railway system manager), secondary schools, and hospitals with an emergency room. The resulting classification further identifies three types of peripheral territories: intermediate, peripheral, and ultra-peripheral areas (Materiali Uval, 2014), suitable for the implementation of local policies for territorial revitalization.

Although the Apennine area of the province of Piacenza is affected by complex and long-standing problems common to many other rural and mountainous inner areas, several studies also show that these contexts have high resilience and adaptability to crises (Phillipson et al., 2020). This was the case, for example, during the 2008 financial crisis, and is confirmed for the Covid-19 Pandemic and the climate crisis we are currently experiencing. In this regard, a project conducted in 2020 on Val Nure³ highlighted that the area might potentially attract new inhabitants from the province of Milan, 100 km far, intercepting different population profiles based on the characteristics of the territory: the most remote and mountainous areas, requested mostly for holiday homes and short stay; central and hillsides, more attractive for remote workers; municipalities on the valley floors which are the most attractive for permanent residents who may also commute toward the main urban centers (Lucatelli and Sonzogno, 2021).

Therefore, a return to these territories as spontaneous migratory flows, such as those that may have occurred since the 2020 lockdown, could represent an opportunity to revitalize these areas and strengthen their role in facing present and future crises.

The remainder of the paper is as follows. Firstly, it introduces the methodology used to measure the space-time variability of human presences in Val Trebbia and Val Nure before and during the Covid-19 lockdown

³ Appennino in salute, <https://fondieuropei.regione.emilia-romagna.it/piani-programmi-progetti/cittadinanza-europea/progetti-2020/enti-locali/appennino-in-salute>

through mobile phone data (section 2). Subsequently, it investigates if two dynamics induced by the pandemic, namely the increase of remote working in sparsely populated, low-connected, poorly accessible territories (section 3) and near-home tourism (section 4), were prompted in the study area and to which extent. Moreover, by analyzing and comparing mobile phone data with conventional data sources, a plurality of trends in the different portions of the study area are unveiled and linked to the intrinsic qualities of the contexts (orography, accessibility and provision of services). Finally, the great potentialities of mobile phone data for territorial research are discussed, along with the significant limits that may prejudice their usability, particularly for research in low-density areas (section 5).

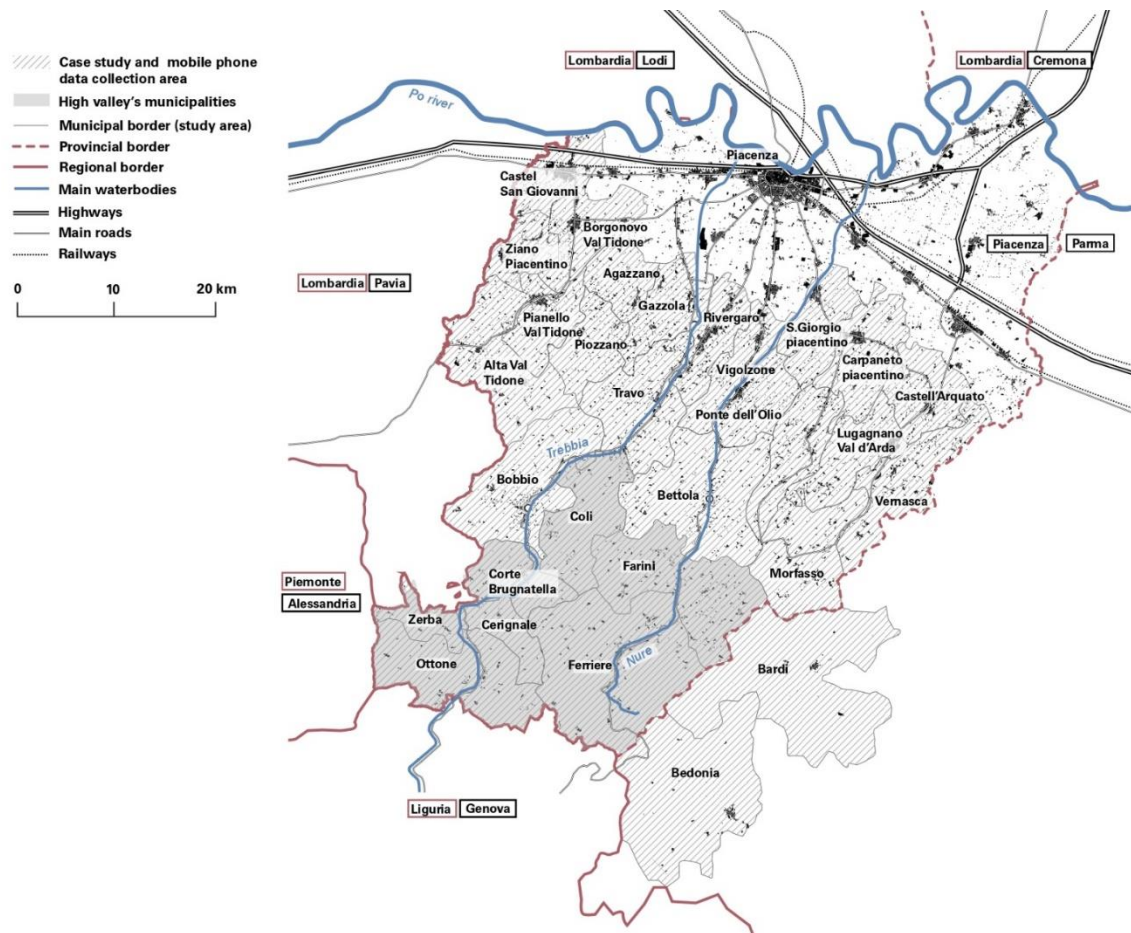


Fig.1 Territorial framework of the municipalities included in the study area

2. Mobile phone data for describing remote working and near-home tourism: the methodology

The paper explores the changes induced by the Covid-19 pandemic in the time-space variability of human presence, focusing on remote working and near-home tourism in the Piacenza Apennine and its high valleys municipalities.

The measurement of these phenomena and their variation, which occurred suddenly and unexpectedly, required the use of different data. In previous work⁴, conventional socioeconomic and demographic spatial data were coupled with an accessibility assessment to essential services to build a baseline knowledge of the

⁴ The accessibility analysis has been conducted by a research group lead by P. Pucci in 2020 for the General plan of the province of Piacenza 8PTAV) cfr. (PTAV 2020) Dotazione di Servizi, accessibilità e rango dei centri in Piano Territoriale di Area Vasta Piacenza – Quadro conoscitivo. Pp 157 – 164. Source: <https://ptavpiacenza.it/wp-content/uploads/2021/05/2021-05-PTAV-Quadro-ConoscitivoWEB.pdf>

territory before the pandemic and identify the most marginal areas that could be most positively affected by a revitalization process. More in detail, the socio-demographic profiling of the inhabitants and the evaluation of the levels of accessibility to the basic local and territorial services in the study context allowed the preliminary construction of a "static" overview that confirmed an imbalance between the plain, the hilly area and mountain municipalities.

The latter are in particular affected by a well-known process of depopulation, an employment rate under 20% that is specifically low for the youth, a percentage of NEET up to 20% in some villages, a meager average income, and a high percentage of residents aged more than 75 y.o. (Fig.2).

Additionally, the accessibility analysis confirmed the disparity between the northern plains and the high valley municipalities in terms of the availability and accessibility to daily services due to the low population and high dispersion of the hilltop settlements generating an insufficient demand for the maintenance of local activities and reliable public transport systems.

This study also confirmed the crucial role of Bobbio (Trebbia Valley) and Bettola (Nure Valley) as the major centers and poles of reference for the marginal areas of the mountain, thanks to the availability of a good range of essential services.

The small data processed for the first analysis provides an outdated and static framework of the trends affecting the territory, unable to describe the impact of disruptive phenomena such as the Covid-19 Pandemic and to show their longitudinal evolution with a high spatial and temporal resolution in the areas of analysis.

For this reason, conventional data have been combined in this research with mobile phone records tracking human presence provided by TIM, one of the leading telecommunication operators in Italy.

Data were supplied covering 31 municipalities, 29 in the province of Piacenza and 2 in the neighboring province of Parma, in Ceno's valley, but with similar socioeconomic characteristics to the Piacenza province high valleys. Not all the municipalities included in the case study area fall within the geography of the high Apennine valleys (see Fig.1). Indeed, some are located in the intermediate hilly area, but they were considered in the analysis because, although they do not suffer from the same problems as the mountain villages, they are part of the same territorial system and have continuous relations with the more peripheral area of the province.

Thus, their inclusion in the analysis is useful in comparative terms to identify how certain phenomena manifest differently according to the settlement and socioeconomic characteristics that co-exist in the study context.

The TIM data used for the present research work record the absolute number of telephone users located within a territorial unit of analysis (the municipality)⁵ at 15-minute intervals. Together with the measurement of human presence, TIM data offer demographic information of the users (age, gender) and define profiles corresponding to users' nationality and travel behaviors.

The latter are defined by TIM based on the user's prevalent location during daytime and nighttime to determine if they can be classified as residents, commuters, intra/extra regional or foreign visitors of the municipality where they are registered.

Putting in value the preliminary socio-spatial framework provided by statistical data and the spatial analysis showing the peculiar territorial morphology characterized by the presence of municipalities with wide territorial extensions, scattered and small hamlets, and sprawled settlements, two different analytical scenarios were foreseen:

- a so-called *standard scenario*, with mobile phone data collected and aggregated at the municipality level;
- a *custom scenario*, in which the municipalities were divided into sub-areas based on the settlement characteristics (main centers, hamlets, industrial areas) to better reproduce the distribution of human presence at the micro-scale, particularly for low-density areas.

⁵ For a description about the TIM Data processed, see Manfredini et al. in this special issue.

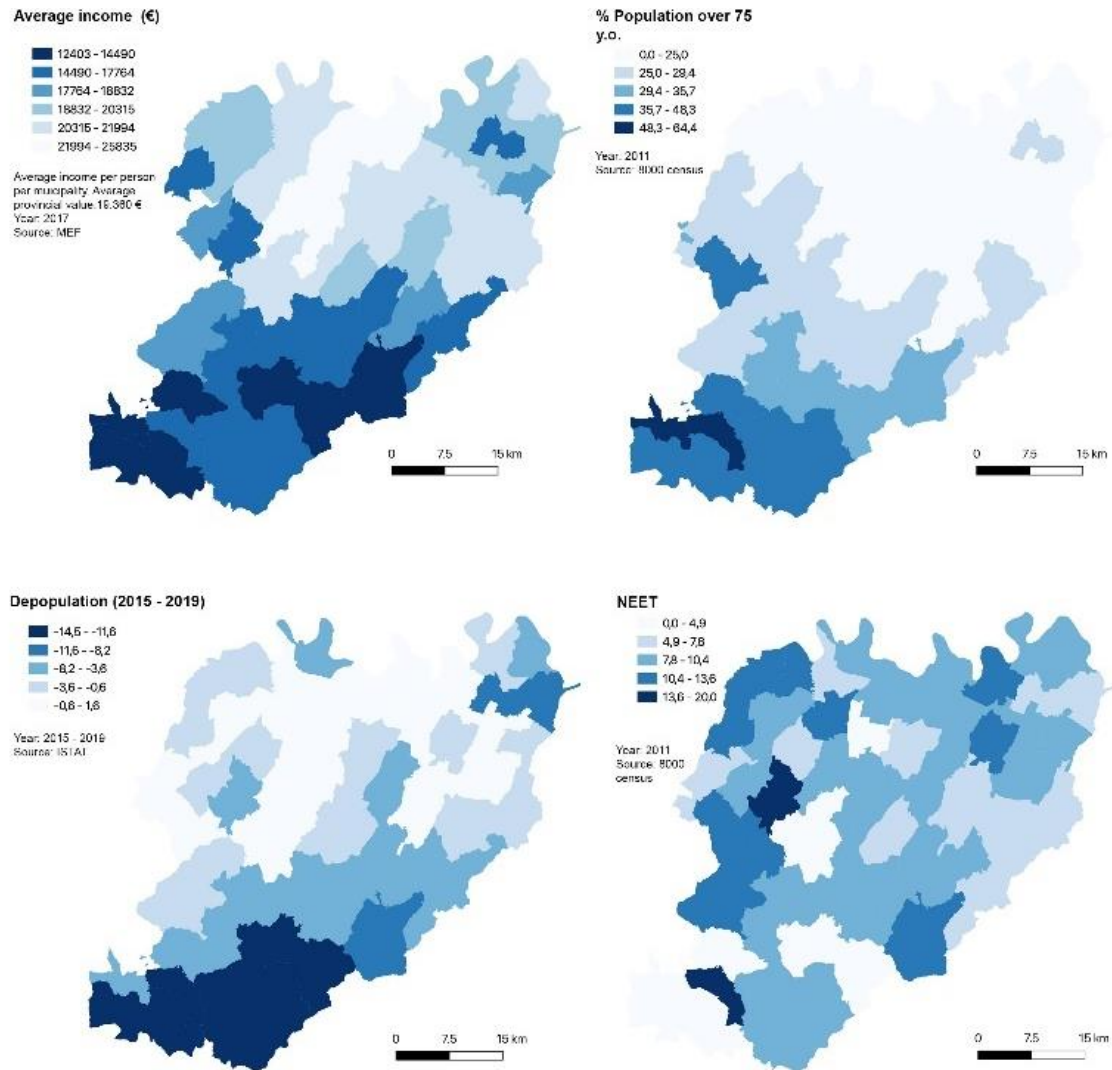


Fig.2 Demographic and socioeconomic data in the Province of Piacenza (source: our elaboration on Istat and MEF data)

The latter scenario posed evident interpretative problems due to the TIM data features (see paragraph 5). Therefore, it was excluded from the present analysis, even if it could have provided relevant information to measure how human presence is distributed in time across the territory with a greater level of detail.

Data were collected over five weeks: 15-21 July 2019 (pre-lockdown summer break), 23-29 September 2019 (pre-lockdown working week), 23-29 March 2020 (lockdown period), 13-19 July (post-lockdown summer break), 21-27 September (post-lockdown working week), aggregating the presence value by 15-minute time slots. We selected the 23-29 September period as a typical pre-pandemic working week serving as a reference baseline for the analysis. Events recorded along the baseline week, such as weekly markets, festivals, long weekends, school openings, and holidays, showed common trends that allowed comparison between different areas of the territory.

As previously described, the present analysis focused on the changes in human presence related to remote working and near-home tourism straddling the Covid-19 Pandemic, identifying these as phenomena that might have increased over the lockdown period. To carry out the investigation, mobile phone data were analyzed to understand the general variability of human presence in the baseline week and then compared with lockdown and post lockdown periods.

Regarding the analysis on remote work trends, human presence variability was observed on a daily basis in five different time slots: early morning (from 6 a.m. to 8 a.m.), morning (from 9. a.m. to noon), afternoon (from 1 p.m. to 6 p.m.), evening (from 7 p.m. to 10 p.m.) and night (from 11 p.m. to 5 a.m.), focusing on

working days (Monday to Friday). We have then considered the variability of the average number of human presence in the different timeslots. This operation allowed profiling the municipalities based on their propensity to be "stable", "attractors", or "generators" of daily human presence. The comparison between the baseline week, the lockdown working week (23-29 March 2020), and the post-lockdown working week (21-27 September 2020) helped to understand how remote working and learning may have contributed to modify the rhythms of presence and mobility in the study area during working hours, and if those practices may represent a potential driver for the repopulation of some municipalities with new inhabitants occupying family or holiday houses and working remotely.

To investigate the near-home tourism during July 2020, when the freedom to travel entered a period of enforced abeyance, we compared the trends described by mobile phone data during the baseline week (23-29 September 2019) assumed as a period with limited amounts of tourists, with two summer break weeks in July 2019 (pre-Covid-19) and July 2020 (during the Covid-19 pandemic). The aim is twofold. On the one hand, data can help highlight the extent of the pre-Covid tourism in the study area, measured as the difference in the amount and spatial distribution of human presence between typical pre-pandemic vacation and working periods. On the other hand, the aim is to measure the variation between a pre and post-Covid outbreak summer break to highlight the possible increase of near-home tourists during Covid-19 and the potential impact on the further development of tourism in these territories.

3. Variability of the human presence and the role of the remote working

TIM mobile phone data analysis described the variability of human presence in each municipality of the study area during working days considering five timeslots, as explained in the methodology section. Therefore, based on the trends detected during the baseline week period before the pandemic outbreak, three main profiles were identified – Stable, Attractor and Generator - regarding the attractiveness of each municipality based on the variation of human presence on different hours and weekdays. Stable municipalities are characterized by a non-significant variability of human presence between the different moments of the day. Municipalities are defined as attractors when the average human presence increases from the early morning until the evening (working hours). Conversely, generators are municipalities that lose population from the early morning to grow back in the afternoon until night when the peak is registered. These profiles also implicitly describe the characteristics of the offer of jobs and services in the different municipalities.

In a typical pre-pandemic baseline week (September 2019), among the 31 municipalities considered only Castel San Giovanni, in the North-West of the province, is gaining population from early morning, reaching a peak of human presence in the afternoon, defining the city as 1) attractor. The capacity to attract people during the day is due to the presence of platforms for transport and logistics that generate important job mobility toward this city. On the contrary, we have identified some municipalities as 3) stable, as they are subject to non-significant variability of human presence during the different moments of the day. Those are mainly mountainous villages located in the high valleys, with high depopulation and unemployment rate and a high percentage of elders. The remaining municipalities have been defined as generators because the highest number of people has been registered at night. In contrast, the number of human presence decreases in the early morning to grow again in the late afternoon and at night. It is still possible to notice that some of the generator municipalities, mainly the ones located on the valley floors, such as Gazzola, Bettola, and Bobbio, even losing presence in the morning, are characterized by a peak of presence in the evening, suggesting that they attract small flows of users for leisure and nightlife.

Generally, those generator municipalities are located on the foothill, in the outskirts of Piacenza and Castel San Giovanni, because their inhabitants are probably moving every day to those more attractive places for work or study reasons. Nevertheless, even though education is one of the most important commuting reasons, the low percentage of the population under 18 y.o. living in the area and the lower diffusion of mobile phones

among the youngest population groups⁶ do not allow to make relevant considerations about commuting for study reasons in this work.

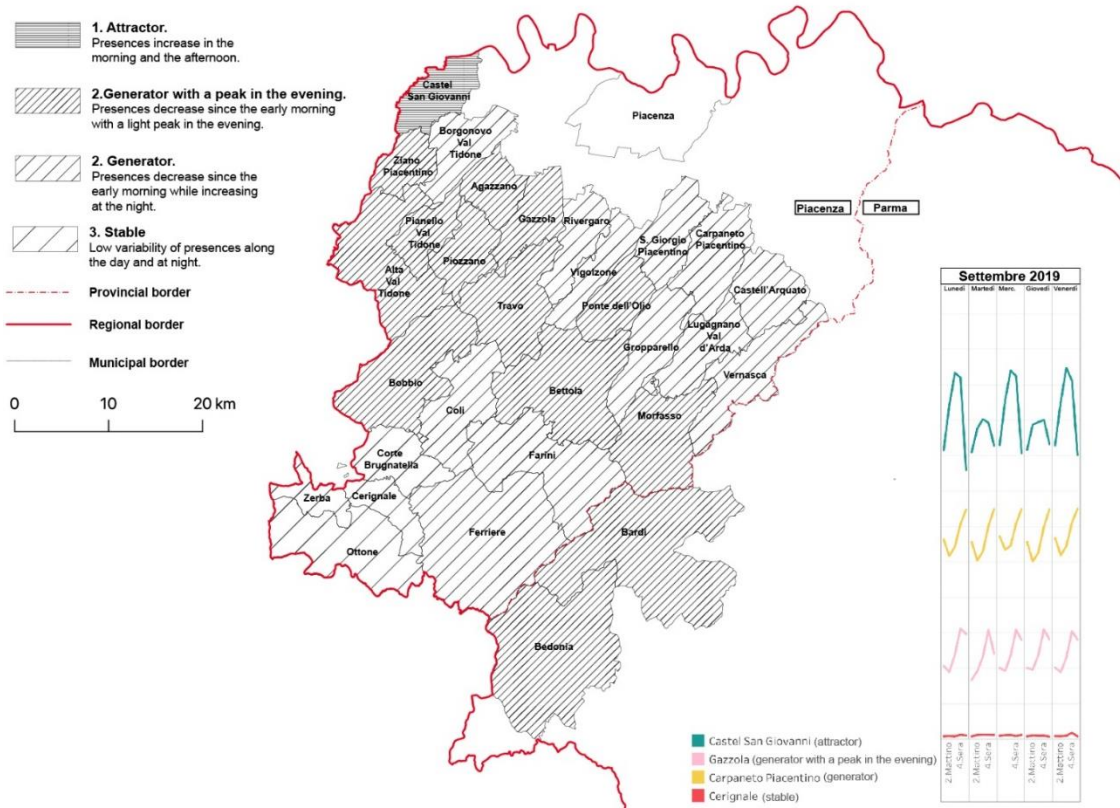


Fig.3 Four profiles of the municipalities and the trend of human presence (source: our elaboration on TIM data)

Comparing the baseline week with March 2020, the first lockdown in Italy, and September 2020 (Fig. 4), it is evident that Castel San Giovanni registered only a slight reduction of presence in March 2020 during the day, with unvaried human presence at night, but a significant increase in September 2020. As stated before, Castel San Giovanni hosts important transport and logistic platforms requiring employees to work on-site both day and night, even during the lockdown. At the same time, the post-Covid-19 growth in delivery, transportation, and warehouse jobs related to the e-commerce sector (Mckinsey Global Institute, 2021) may explain the increase in local presence registered in September 2020.

The data show that among the municipalities considered stable, the most geographically marginal high valleys municipalities such as Zerba, Corte Brugnatella, and Ottone lost population in March 2020 and registered a further general decrease in September 2020. It is possible to guess that the low accessibility of these territories caused a migratory flow toward the cities and the villages of the plain during and after the lockdown to have better access to basic services. On the opposite, Cerignale, despite its remoteness, gained population in March 2020 and still in September 2020.

The municipalities defined as generators are generally characterized by low variability of presence in March 2020 and September 2020, apart from San Giorgio Piacentino and Bettola, where the population increased

⁶ Tim data on human presence are classified based on the age of the sim card owner, including the age range 0-18. According to Census data in 2018 the 54,6% of this group was using a mobile phone (the 17,6% of population aged 4-10, the 90,8% of population aged 11-17, while population 0-4 is not reported) although only the 47,9% of the group was owning the device. The percentage of use rises to 97,2% for population aged 18-34 y.o. and 85,8% for population aged 35-64 y.o. While decreases to 27,8% for population over 65 y.o. Source: 1° Rapporto Auditel-Censis. Convivenze, relazioni e stili di vita delle famiglie italiane, Roma, 25 Settembre 2018. Available at: https://www.censis.it/sites/default/files/downloads/Sintesi_3.pdf. Accessed 04/01/2022. Furthermore, children under 8 are not allowed to buy a TIM sim card, while until 16 years is needed the consent from both parents, which are in many cases the official owners of the sim for their kids.

during the lockdown and still registered a higher number of human presence in September 2020 compared to the same month in 2019.

The analysis highlights the following trends: in some municipalities, such as Bobbio, Travo, Ponte dell'Olio, and Carpaneto Piacentino (see Fig.4), a smaller delta between night and morning during the lockdown suggests that fewer people were commuting every day from those municipalities to work taking advantage of remote working⁷, to return at pre-Covid trends in September 2020 (see for example Carpaneto Piacentino, Fig. 4). In other cases, a general increase in human presence was registered in September 2020 (see, for example, Gazzola in Fig.4), with a significant delta between day and night and a decrease in presence in the early morning.

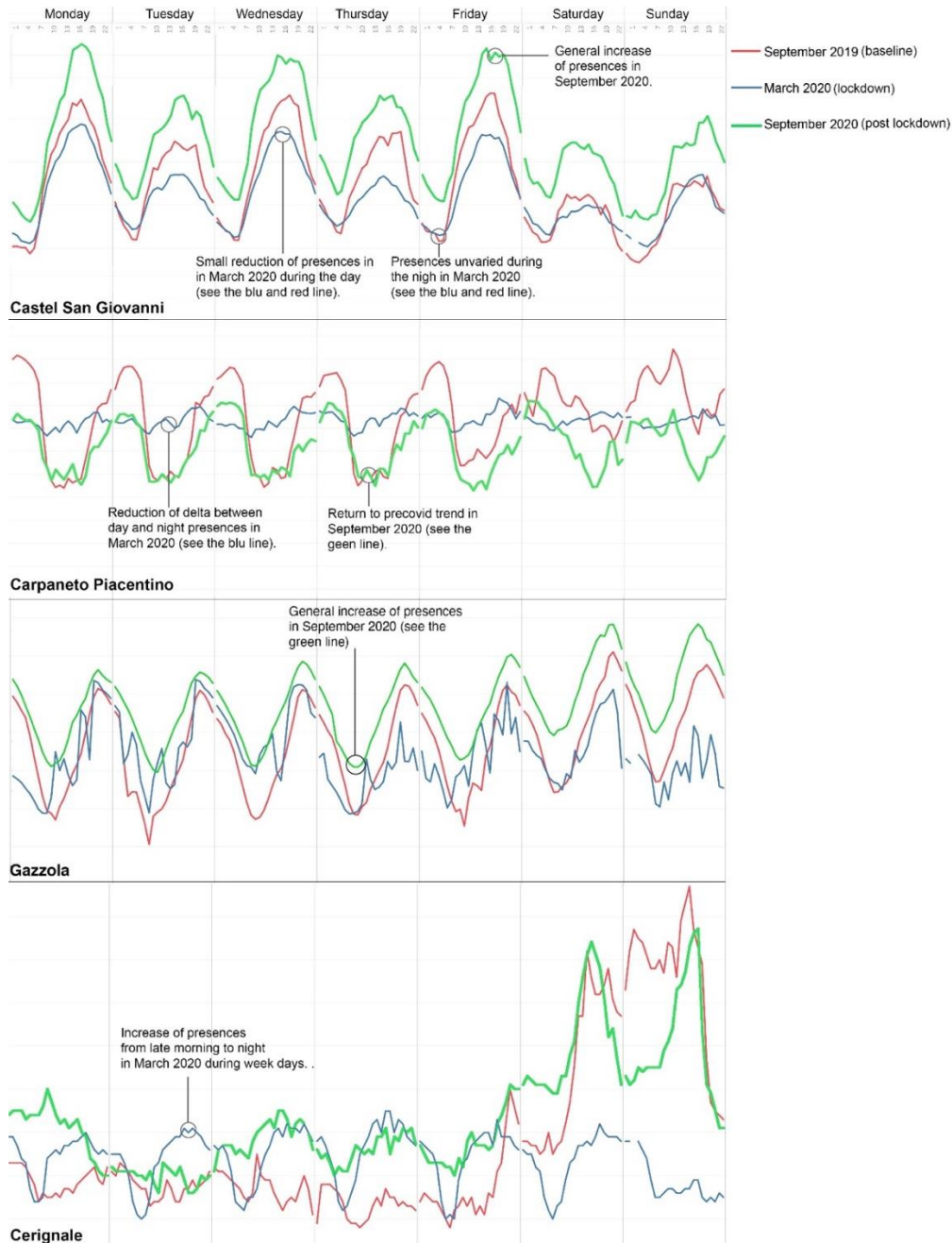


Fig.4 Human presence values in four municipalities of the study area. Comparison between September 2019, March 2020 and September 2020. (source: our elaboration on TIM data)

⁷ Data collected in Italy show that the percentage of employees working remotely increased during the first lockdown in March and April 2020 and afterward, going from 58% to 97% in large companies and from 16% to 94% in public administrations (Osservatorio Smart Working, 2020), with 60% of workers that would like to continue remote working after Covid. Source: <https://www.ilsole24ore.com/art/lavoro-cgil-8-milioni-italiani-smart-working-epidemia-covid-19-AD7aAMR?refreshce=1>, accessed 16/09/2021

These cases suggest that new residents that commute every day for work and study-related reasons might have oriented their residential choices toward those generator territories following the Pandemic outbreak. Undoubtedly, the reduction of the differences between day and night in human presence in March 2020 in nearly all the municipalities of the study area with higher numbers during the morning confirms that "confinement measures are fomenting remote working practices, remote learning and e-services" (OECD, 2020, p. 4).

Additionally, the most remote municipalities, which have limited internet and transport connections, lose presence in favor of the municipalities on the high valley floors and along the main roads. On the one hand, this last trends exacerbate pre-existing problems related to the abandonment and depopulation of mountainous inner areas. On the other, it suggests that forms of smart working can still redirect residential choices toward lower-density areas in the high valleys and may also be extended to the most remote municipalities, provided that physical and virtual accessibility to goods and resources is improved and ensured.

4. Near-home tourism

Studying the near-home tourism during the Covid-19 Pandemic can reveal "aspects of holidaymaking practices, possible path dependencies, prospects for habit changes, and indications of holidaymaking adaptation to a post-pandemic and conceivably also a low-carbon future" (Jens et al., 2021). In the study area, it represents an additional topic to analyze the potentialities for increasing the attendance and touristic attractiveness of the territory, especially the high valleys, and supporting new economies for these marginal areas. In fact, the high Val Trebbia played a significant role as a vacation destination in the past, offering valuable equipment for tourists⁸.

Based on this perspective, the pandemic could be a starting point to transform tourism activity (Cheer, 2020; Nepal, 2020) and offer an opportunity for more sustainable forms of near-tourism (Lew et al. 2020; Romagosa, 2020), enabling the future economic and social development of these valleys.

The comparison between the baseline week (23-29 September 2019), the summer weeks in July 2019 (15-21) and July 2020 (13-19) of intra-regional, extra-regional, and foreign visitors' presence highlights a slight increase in the attendance during the pandemic, especially on the weekend and in particular on Sundays. These trends affect the study area differently: in the northern hilly area, the July 2020 trend is similar to the baseline of September 2019, highlighting a non-touristic vocation of these territories. Conversely, in the high valleys, a relevant increase in human presence in July 2020 in all the municipalities emerges, particularly during the weekend and starting from Friday evening. In these mountain areas, forms of near-home tourism prevail that are concentrated on the weekends, with human presence coming almost exclusively from the same region and characterized mainly by daily attendance. This trend may be a consequence of the diffused presence, in the high valleys, of sports and leisure equipment (Fig.5), trekking opportunities, and cultural events organized during the summertime.

Therefore, the Covid-19 has led to a general slight increase in summer human presence in the municipalities of the study area, specifically concentrated on weekends and in some more attractive centers such as Bobbio, where the weekly market on Sunday attracts many visitors (+26% in weekend attendances). However, the increase is not equally distributed since the most peripheral and mountainous villages of the high valleys (Ottone, Ferriere, Farini, Cerignale, Zerba, Coli, Corte Brugnatella), characterized by a lack of services and facilities and low accessibility, were affected by a slight drop in presence during July 2020 compared to the previous year. However, if these figures indicate that the more peripheral municipalities were less affected by the propulsive effect of Covid-19 on the increase in tourist attendance, a comparison between the presence values during the summer break and the baseline (September 2019) in the same centers still shows that

⁸ Spas in Bobbio, beaches in Bobbio and Marsaglia equipped also for the canoeing, horseback riding.

mountainous villages are more populated and lively during summertime and steadily attractive for vacationers regardless the effect of the pandemic (Fig.6, right side).

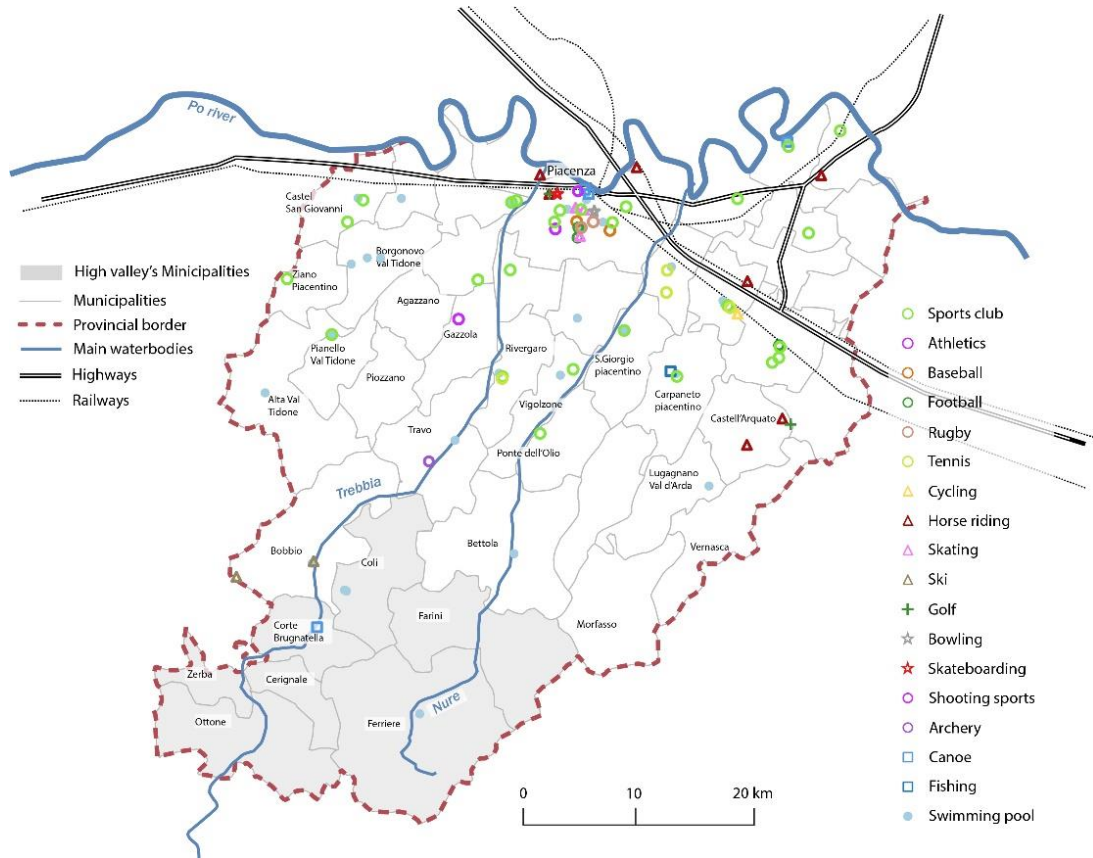


Fig. 5 Map of localization and typology of sports equipment in the province of Piacenza, affecting near-home tourism

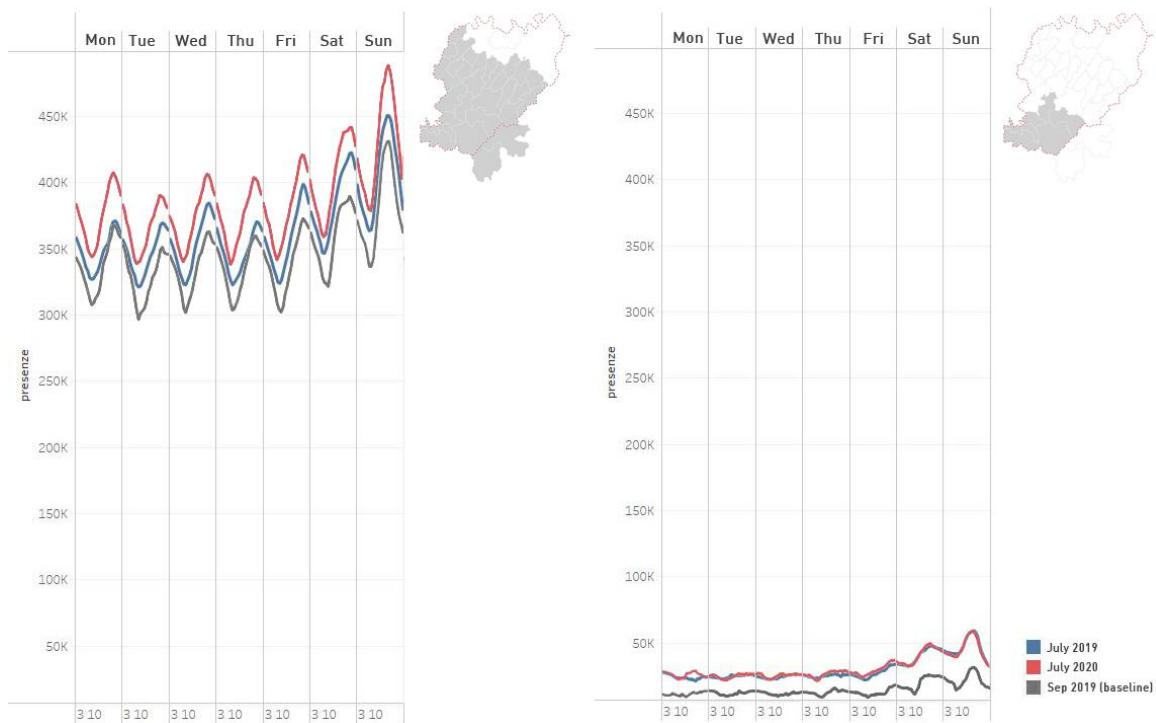


Fig.6 Total human presence values in the whole study area (left) and the high valleys (right). Comparison between July 2019, September 2019 and July 2020

Still, the study area and the high valleys municipalities are mainly a destination for short-range tourism, as visitors from the Emilia Romagna region are significantly more than those outside. Foreigners - in modest numbers in July 2019 - are almost absent in 2020 also due to the restrictions on international travels that were in place during that period. Visitors inside and outside the region confirm the pre-pandemic trend, although there is a slightly more significant presence on weekdays than in July 2019. This trend implies that, alongside daily tourism, a slight increase in sedentary tourism could be noticed, which involves significantly more visitors from the region (Fig. 7).

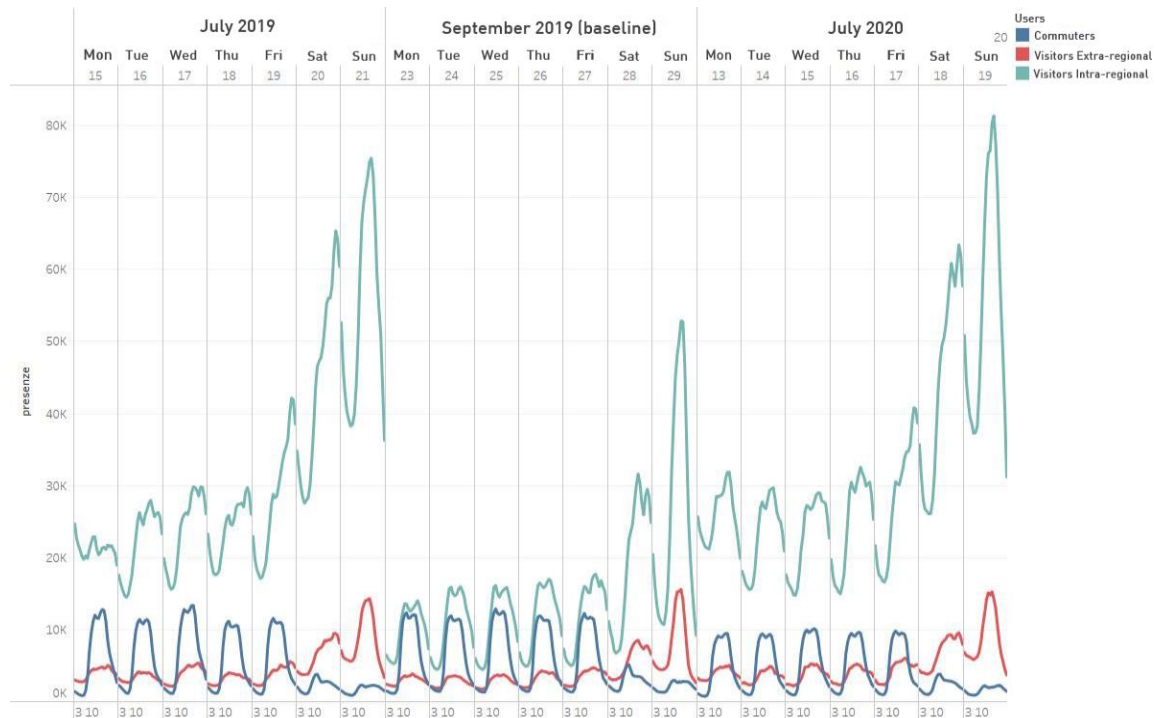


Fig.7 Human presence by type of user in the highr valleys

Considering the profiles by age in July 2019 and July 2020, the human presence mainly concerns people over 60 years old, with a stable trend. The other age groups, albeit less represented in the high valleys, were more present in July during the pandemic than the baseline week in September, with significant peaks on weekends. In conclusion, the trends measured through mobile phone data do not show substantial transformations in the touristic uses of the area of study. The main exception concerns a general increase in the number of presence that proved to be almost uniquely concentrated in specific parts of the territory such as major high valleys urban centres (Bobbio) and in the municipalities that offer a wider availability of sports and leisure-related activities. The marginality of these changes between a pre and post-lockdown period confirms that "path dependencies towards second homes and spatially stretched social obligations, as well as the emphasis on freedom of movement, ostensibly constrain vacation travel habit discontinuities at this time of the year" (Jens et al., 2021).

5. Limits and potentialities of mobile phone data in sparsely populated areas

The research approach based on mobile phone analysis has shed light on several aspects related to the potential contribution of these sources of information for scientific research on inner areas, their fragilities, and the existing spatial-temporal dynamics of human presence and mobility. More precisely, it emerged how digital data could support the analysis of territorial phenomena otherwise challenging to identify and investigate with conventional sources based on "small" data, as in the case of the remote working during the lockdown and post-lockdown and the near-home tourism during the pandemic, when displacement restrictions pushed many families to change travel programs in favor of closer destinations.

Concerning remote working, the use of mobile phone data revealed the higher human presence in nearly all the municipalities of the two valleys, except for the very remote ones, during the Covid-19 lockdown and in some cases also after. This result highlights the potentiality of promoting remote working in these territories, confirming the existence of municipalities more attractive for remote workers, and others that are more likely to host new residents that could commute to big cities (Lucatelli and Sonzogno, 2021). These results are also confirmed by other research on the topics. Beria and Lunkar, (2021) thanks to the use of Facebook data for good, have measured a massive displacement from the big cities in March 2020 toward intermediate territories and, to a lesser extent, toward peripheral and ultra-peripheral areas, suggesting that the increase of population in suburbs and rural areas was a consequence of the lack of commuting. This pattern is also confirmed by more qualitative works. A recent research based on a survey of residents and remote workers on Campo Ligure, a small village in the province of Genova, highlighted that during and after the lockdown of March 2020, many residents avoided commuting, while workers from abroad temporarily moved to live in the town thanks to remote working (Larsen et al., 2021). Nevertheless, the lack of transport, fast connections, and the distance from the workplace were among the main reasons not to move permanently to live in the village, suggesting that improvements need to be made to turn remote working into a compelling opportunity for recovering rural areas.

In this perspective, mobile phone data analysis offers the opportunity to understand the spatial and social patterns of frequentation of the valleys and whether these dynamics can represent a resource in the medium-term period for these territories and their economies. Simultaneously, the approach has shown that data-driven research requires essential management and analytical skills coupled with the careful construction of methodological frameworks. These are necessary conditions due to the characteristics and, above all, the intrinsic limits of mobile phone data, which may prejudice their usability in research aimed at exploring complex mobility patterns.

The first relevant limitation encountered in this work concerns the relationship between a research question and the possibility that the data, as they are collected and made available by owners and providers, can offer valuable and rigorous answers. The problem, already raised by Miller (2010), is related to the fact that digital data, expensive to generate, process, and store, are produced in very controlled ways using sampling techniques that limit their scope, size, and temporal detail. For this reason, the possibilities for researchers to customize and query preconfigured data provided with some easy-to-use basic features are minimal, making them not always adequate to answer complex research questions except through intensive processing or data fusion (Calabrese et al., 2010). Exploring the phenomena of interest in the case of the Piacenza Apennines required the use of preliminary analysis on socioeconomic and accessibility conditions based on conventional data necessary to contextualize and interpret the spatiotemporal patterns emerging from the data (Alexander, 2015). Therefore, mobile phone data analysis was not considered a stand-alone research methodology but became a compendium of a more comprehensive mixed-method research approach.

A second limitation relates to the low spatial flexibility of the data and the available high level of aggregation. Since Telecommunication operators gather mobile phone data unrelated to scientific research, the collected and processed data by TIM are not entirely suitable for spatially disaggregated analysis at the sub-municipal scale. At the same time, these data offer a somewhat limited spectrum of options for socio-demographic profiling (Calabrese et al., 2010). If, in the latter case, the in-depth analysis of individual characteristics and behaviors would raise critical issues due to privacy concerns and the limited scope of socio-demographic data collected by the operators, increasing the spatial disaggregation of the data represents a more concrete opportunity. In the Piacenza Apennine case study, an attempt was made to measure human presence at the sub-municipal scale to explore their temporal variations in rural areas and the sparsely located hamlets. Given the technical complexity of the request, the attempt did not return valid results, effectively limiting the significance of the contribution of mobile phone data to the analysis of micro-scale dynamics such as differences in the presence patterns of tourists and workers in different areas of the same municipality.

Finally, a third limitation concerns the reliability of the mobile phone data collected and processed in a low density and aging context as that of the Apennines of Piacenza. When compared to dense urban environments, rural areas present a sparser distribution of antennas that are the basic infrastructure to infer user location, with the risk of underestimating the movements of individuals and returning spatially incorrect results (Williams et al., 2015) in the municipal-level redistribution of hourly tracking. Such a problem is reflected in the significant occurrence of outlier values in more remote and less populated municipalities, which the algorithm used to translate the raw data into geospatial position is not always able to correct. Also entrusted to recalculation algorithms is the quantification of presence based on the market share of the telephone company, a step that can, in turn, create bias linked to the uneven territorial distribution of customers (Salat et al., 2020). This aspect is also reflected in the representativeness of different age groups, especially in territories inhabited by high percentages of youngsters and the elderly. However, this latter bias seems to become less relevant thanks to the steady growth of mobile phone penetration in all age groups in Italy and other countries around the world (Deloitte, 2019).

The limitations encountered, even if significant, can be overcome or, at least, mitigated by fruitful collaboration and negotiation between the data provider and the research institution and by referring to the numerous experiences in the literature that confronted these well-known issues ⁹.

At the same time, the awareness of limitations can lead to a more mature use of these data, which can have interesting implications in the field of academic research and for multisector policy making. In fact, mobile phone data proved to be valuable in the analyzed case to describe specific trends with a higher speed of update and detail than conventional data, potentially providing public administrations with a more complete picture of what is happening within the territory in terms of attendance, socio-demographic profiles of the users and inhabitants of the territory, use of services and infrastructure, and seasonality of these usually hidden dynamics. Possible applications relate, for example, to the provision of services to attract populations capable of working remotely, to be implemented as a priority in those contexts that have shown an ability to attract these professionals, by designing policies that promote the creation of coworking spaces in rural areas, supporting a significant trend already developed in many European countries (Flipo and Ortar, 2020; Capdevila 2021). The most urgent action, in this perspective, concerns the extension of the internet network and the provision of spaces with high-speed Internet (often unavailable in the study context). However, these "basic" actions, already undertaken through the fiber optic extension plan¹⁰, should be followed by a substantial improvement of local proximity services for daily subsistence in the most peripheral villages whose current absence hinder the possibility for remote workers to moving permanently into the territory and represent a factor generating profound territorial inequalities. This proposal is also consistent with the objectives of local policies that are under implementation in the study area (e.g., the SNAI strategy) that could profitably use the information provided by the exploitation of digital data for designing strategic interventions.

More geographically precise data could also allow the observation of more minute phenomena of human presence related to work activities, even at a sub-municipal scale, identifying the potential for attractiveness even in more peripheral areas found to be poorly affected by the increase in remote working observed at the aggregate provincial level.

Instead, the analysis confirmed the general attractiveness of the area and the high valleys, especially for near-home tourism. The information gathered through mobile phone data can be useful in tourism service planning, identifying the most attractive areas of the province, measuring the impact of public gathering events, and profiling the frequenters of different parts of the territory according to seasonality and local events. This is a basic knowledge that, combined with data on the territorial supply of leisure facilities and accommodation,

⁹ For an account, see Manfredini, Lanza and Curci in this special issue.

¹⁰ To this regard, refer to BUL (Broadband extension plan) adopted by Regione Emilia Romagna. <https://digitale.regione.emilia-romagna.it/notizie/archivio/2017/settembre/banda-ultra-larga>

can support the development and targeting of the services for tourists and, more generally, assist the strategic development of this sector by making it a resource for the revitalization of the Apennine area.

Undoubtedly, telephone data still represent a relevant opportunity to be further explored to analyze "hidden" spatio-temporal practices both in dense urban settings and in dispersed, low-density territorial contexts, provided that researchers and public administration can get easy access to high-quality data. As a matter of example, future research prospects could include the analysis of existing forms of immobility - by gender and age - in the municipalities characterized by low accessibility and lack of daily services where the use of mobile phone data provides insights for reading the possible inequalities in the access to urban opportunities, and the profiling of the use and consumption, diversified by timing, for updating the land-use classification without the burden of a direct survey.

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