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Leisure mobility changes during the COVID-19 pandemic – An analysis of survey and mobile phone data in Sweden

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ABSTRACT

The COVID-19 pandemic affected travelling in general, and the leisure mobility and the spatial distribution of travellers in particular. In most parts of the world, both domestic and international travel has been replaced by restrictive policies and recommendations on mobility. A modal shift from public transport towards private cars and micro-mobility was also observed. This study seeks to trace the implications of the COVID-19 pandemic for leisure mobility. We use a unique Swedish database containing daily mobility patterns of pseudonymised mobile phone users, combined with a survey on vacation transport behaviour. By contrasting mobility patterns for selected holiday days during the unaffected summer of 2019 with corresponding dates in 2020 and 2021, we are able to model and detect the pandemic effects on tourism and recreational mobility. Moreover, by identifying the general mobility patterns, we analyse whether and how the transport mode has changed. Using data on the spatial distribution of recreational amenities, we identify locations that were favoured during the pandemic. In Sweden, even though the pandemic decreased in spread and severity during the summers, most travel restrictions were still enforced, international vacations uncommon, and larger vacation spots, such as amusement parks and cultural institutions, were closed down. Swedish vacation homes in remote or rural areas were quickly booked. This change in recreational behaviour, where less populated areas, open air and nature recreation were favoured over indoor or crowded urban cultural activities, was more substantial in 2021 than in 2020. This result shows how policies can effectively be developed, so that Swedes respond properly to recommendations and adjust their vacation plans.

1. Introduction

Since the middle of 2020, numerous scientific papers have been published on the COVID-19 pandemic. A Quick search on Google Scholar yielded an estimated 4.3 million scientific results for COVID-19, and, though far from all listed research is peer reviewed and even fewer are relevant from the perspective of mobility, numerous papers discuss daily mobility (see, for instance, Dahlberg et al., 2020; Toger, Kourtit, Nijkamp, & Östh, 2021). For example, Sulyok and Walker (2020) study the correlation between daily mobilities and confirmed corona cases for several countries by Google's Community Mobility Reports. In another study, Galeazzi et al. (2021) track the mobility behaviour of 13 million Facebook users in France, the UK and Italy and find that lockdown policies caused mobilities to be more localized (see also Beria & Lunkar, 2021). Doorley et al. (2021) develop mobility metrics with telecom data in Andorra and show the correlation between mobility (including indoor activity) and infection rates. However, few papers discuss the pandemic's effects on leisure mobility patterns and modes of transport. As one of the exceptions, Moslem et al. (2020) show that preferences for transport modes have changed from public to private transport during the pandemic in Italy. The chief difference between mobility during leisure time and mobility during working periods is that during working periods the main flow takes place between known or at least predictable commuting origins and destinations, so that most pandemic-related deviations in mobility can be related to expected flow patterns (e.g., Toole, de Montjoye, González, Pentland, & Sandy)., 2015; Yang,

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Herrera, Eagle, & González, 2015). During leisure time however, neither the temporal regular behaviour nor the typical OD patterns are to be expected (Adam, 1995; Cohen, 1979; Dickinson & Peeters, 2012; Gonzalez, Camarero-Orive, González-Cancelas, & Guzman, 2022; Hibbert, Dickinson, & Curtin, 2013; MacCannell, 1989; Maltese, Gatta, & Marcucci, 2021; Merriman, 2012; Selwyn, 1992). Moreover, due to the pandemic most regular leisure destinations experienced fewer visitors (e.g., Mertens, Gerritsen, Duijndam, Salemink, & Engelhard, 2020; UNWTO, 2020; Wen, Kozak, Yang, & Liu, 2020). Study of leisure mobility changes during the pandemic depends on several conditions. These conditions include, among other things, access to relevant empirical data to analyse. But in order to better understand how choices and behaviours have been developing during the pandemic, a country that allowed the population to be mobile needs to be studied. Swedish public agencies have developed health recommendations rather than restrictions, which meant that available options, rather than lack of choice, determined how and if individuals moved for recreative purposes – this is also a key reason for using Swedish data in order to better understand how leisure-related mobility changed during the pandemic (Josefsson, 2021; Narlikar & Sottilotta, 2021).

In order to establish how leisure mobility has changed during the pandemic in Sweden, we use survey responses, as well as the rich longitudinal phone network detail records (NDR) data. The survey asks specifically about the pandemic's effect on mobility, as a stated change in behaviour of the tourists or visitors. These changes are then followed up as observed behaviours by analysing phone users' mobility during the summers of 2019, 2020 and 2021. The anticipated behavioural change is related to the magnitude of spread of the pandemic, as well as to the public restrictions enforced during the summers of 2020 and 2021. We note here that, as big data source, mobile phone data is often being used in leisure and tourism research. For instance, Qian, Li, Duan, Yang, and Ran (2021) study tourists' behaviour at destinations regarding rest places and transportation hubs in Shanghai. Xu, Xue, Park, and Yue (2021) analyse mobile phone trajectories of tourists and behavioural characteristics of individual travellers in South Korea. Timothy, Michalkó, and Irimiás (2022) underline that mobile phone data has also the potential of providing insights into unconventional tourism mobility (unregistered tourism mobilities). Our work builds upon this growing literature, but also contributes to it by combining survey data with phone network detail records. This way we are able to make use of primary data (gathered through surveys) and support it by a big data source to study changes in mobility behaviour of tourists during COVID-19. The novelty of this paper is primarily connected to the use of geocoded and longitudinal Big Data containing mobile phone data that is matched to land-use characteristics. This enables us to associate changes in location patterns, including the context of stay before and during the COVID-19 pandemic, but also to improve our understanding whether Swedish vacation mobility patterns are similar or dissimilar to those of countries having more far-reaching COVID-19 related stringencies.

The paper is organised as follows. After this introductory section, in Section 2 we provide a selective literature review that sets the scene for our research. Next, in Section 3 some empirical information on travel demand and responses is given so as to provide an appropriate framing for our empirical research. The next section then presents our research hypotheses, followed by an application to Sweden. This will allow us to identify changes in mobility patterns and in modal travel as a consequence of the pandemic.

2. Literature review

It is evident that COVID-19 has left deep traces in the leisure sector. According to the UNWTO Tourism Barometer, in the period between January to July 2021, international tourism mobility dropped by 40% compared with the same period in 2020, and by 80% compared to the same period in 2019. The way the pandemic has affected the hospitality industry is both well-known and well-observed, but the effects of the pandemic were not evenly distributed seen from a geographical and activity-oriented perspective. Bartik et al. (2020) showed how firms of different size and firms in different sub-sectors have performed differently in response to official regulations. Studies have also indicated that companies -with a lower enterprise value (suggesting smaller firms) acting in regions with clear and strong public agency recommendations and restrictions were more resilient, while companies targeting interregional experiences were more vulnerable (Kaczmarek, Perez, Demir, & Zaremba, 2021; Lin & Falk, 2021). In addition to the public regulation effects, there are also several studies which indicate that the leisure industry was affected by a shift in leisure preferences and risk perceptions among consumers. For instance, Rahman, Gazi, Bhuiyan, and Rahaman (2021) show that the pandemic has altered tourists' perceptions regarding travel management and risks, which has several implications for destination cities including reduced demand and corresponding changes in service delivery and transportation. Rahman et al. (2021), and a few others find that leisure consumers now avoid crowded destinations, and favour small scale and more relaxing activities (Bratić et al., 2021; Peluso & Pichierri, 2021; Więckowski, 2021). The pandemic not only altered the preferences of tourists but also affected the risk perceptions of the residents in destination cities. Qiu, Park, Li, and Song (2020) estimate residents' willingness to pay for reducing the pandemic-related risks generated by tourism activity in their cities and identify substantial social costs in three major cities in China.

From both a demand and a supply perspective, we see that preferences regarding tourism have undergone a few recent drastic changes. For instance, Airbnb booking patterns also reveal that the consumers' interest in activities in the central parts of larger cities have dropped worldwide, but retained a relatively strong market foothold in the suburban parts, while many traditional tourism destinations developed mitigation strategies to cope with decreasing destination interest (Cvelbar, Farčnik, & Ogorevc, 2021; Kourtit, Nijkamp, Osth, & Turk, 2022; Liang, Leng, Yuan, & Yuan, 2021; Türk & Sap, 2021). In a recent review study, Sharma, Thomas, and Paul (2021) find that well-being, sustainability, and climate action were keywords in studies on the resilience of leisure firm resilience in the post-pandemic era. The study also suggests that the leisure industry will not return entirely to the pre-pandemic state. All in all, the studies indicate that the pandemic has led to a shift in the leisure focus from large-scale and interregional to local, small scale and more wellbeing oriented (Lew, Cheer, Haywood, Brouder, & Salazar, 2020). This shift has also affected leisure-related travel in the short run, but potentially also in the post-pandemic era (Škare, Soriano, & Porada-Rochoń, 2021).

3. Transport, leisure and the pandemic

As a direct consequence of the pandemic, most public transport services were either halted or reorganised in ways that limited these services, which meant that most countries saw a rapid drop in the use of public transport and usage, except among captive groups with no or few alternatives (see, for instance, Wielechowski, Czech, & Grzęda, 2020; Beria & Lunkar, 2021; Jenelius & Cebecauer, 2020; Almlöf, Rubensson, Cebecauer, & Jenelius, 2021; Cahigas, Prasetyo, Persada, Ong, & Nadlifatin, 2022). The immediate consequences for the leisure industry were similar, experiencing a decrease in the demand for leisure-related travel organised and provided especially by planes, cruise ships, buses, and trains (Škare et al., 2021; Wielechowski et al., 2020). Several studies have indicated that fear of health risks associated with crowds was the main reason, besides public restrictions, for limiting personal travel. The results revealed a leisure travel pattern that was different from *regular* leisure mobility patterns, and that promoted the use of private modes of transport (Pearce, 1996; Wielechowski et al., 2020). In this respect, Li, Nguyen, and Coca-Stefaniak (2020) find that Chinese tourists intend to travel by private cars rather than public transport when they take their next holiday (roughly six months after the pandemic is brought under control). However, to what extent the pre-pandemic mobility behaviour has changed among leisure travellers remains to be seen over the coming years. Recent studies suggest that currently there is *binge* travel behaviour in the USA, where flight bookings are increasing strongly, and at the same time especially smaller airports in close to outdoor activity destinations are chosen (Johnson, Malik, & Circella, 2021; Miao, Im, Fu, Kim, & Zhang, 2021). Outdoor activities, and the many different modes of transport used for outdoor leisure activities, such as biking, jogging, canoeing, etc., have also become more common (Johnson et al., 2021). However, access to outdoor recreational activities may have varied both spatially and socioeconomically during the pandemic (Dashper & King, 2021). This could mean that groups who already have access to a plethora of modes of transport also have more alternatives in terms of outdoor activities, and vice versa. However, in a recent New Zealand study by Degarege, Espiner, Stewart, and Espiner (2021), a survey revealed that access to transport was of less importance for participation in outdoor recreation compared with most other pandemic-related problems of participating in these activities, but that there were problems with restricting access. It seems plausible that a more differentiated travel pattern of leisure travellers is arising. This will now be tested for Sweden.

4. Sweden during the pandemic

Sweden has a welfare system in which the majority of the population strongly supports public agencies and science. This means that public health recommendations are usually followed well, if they are considered as fair and impartial (see, for instance, Rothstein & Stolle, 2003). Starting from mid-March 2020, the Public Health Agency in Sweden held frequent press conferences in which they made public recommendations about how to limit the effect of the pandemic as much as possible. During the week 8–15 March 2020, WHO declared the COVID-19 was spreading as a pandemic, and public media in close collaboration with the public health agency and other public institutions announced several restrictions to the public[1]. In the evening news (SVT – Swedish Public Television) on 14 March 2020, a representative of the Swedish hospitality industry indicated that between 80 and 100% of all bookings had been cancelled after the WHO announcement (SVT, 2021a). Other studies showed that, though many of the Swedish recommendations were not mandatory, most individuals followed the recommendations closely, which led to substantial reductions in commuting and mobility, and gradually also led to closing or restricting access to restaurants, cultural amenities, and other recreational facilities (see, e.g., Almlöf et al., 2021; Toger et al., 2021; Dahlberg et al., 2020). The effects on the hospitality industry were massive, especially for restaurants and bars, where approximately 1/3 of the staff lost their jobs due to the pandemic (SVT, 2021b). However, parts of the hospitality industry managed better than others. According to Josefsson (2021) and Englund (2020) the shift towards taking vacation in Sweden ('staycation'), rather than travelling abroad, meant that around 60% of the population would remain in their home doing their daily activities during the vacation, and that around 90% indicated that they would spend more time in nature. As a consequence, hospitality activities oriented towards outdoor, or otherwise "safe", Swedish activities saw an increase in demand for their services during the pandemic summers.

The two first pandemic summers (in 2020 and 2021) saw few incidences compared to the month leading up to the holiday seasons. In Fig. 1, the development of the pandemic in Sweden is illustrated. The chief period of spread happened between November 2020 and May of 2021, with a wave pattern that is indicative for the spread of different variants and the introduction of mass-vaccination. The spring 2020 sees few cases, but due to the lack of vaccines and lack of knowledge about the virus, the societal stringency was relatively restrictive, with more or less full closure of public tourist destinations such as amusement parks and museums. In the subsequent summer, the vacation decisions are made on the basis of high spread of the virus, but with vaccines curbing the severity of the pandemic.

5. Empirical framing of the research

The responsiveness of travellers during a leisure trip in the period of the COVID-19 pandemic has often been described anecdotally. To provide a basis for formulating testable research hypotheses, here we utilise a recent survey among Swedish holiday travellers conducted in the summer of 2021.

The survey data were collected in a rural region in the south-central parts of Sweden – around Lake Vänern. Each response represents a travelling group, and the respondents were instructed to include answers from all co-travellers in their group. The population surveyed is similar in composition, age and origin to that of the Swedish population.[1]

The survey contains three questions about mobility that are useful for this study. These questions[2] contained multiple answer options and were as follows:

1. Has the pandemic affected your holiday choices?
2. Which modes of transport did you use today?
3. How has the pandemic affected your behaviour?

The survey was answered by 88 travelling groups (the median size of each group was 2 individuals; the average size was 3.8 individuals). The survey responses form the basis for the creation of hypotheses in relation to how vacation-related mobility behaviour has changed over time. The survey results are described in Table 1. The relationship between the answers are arranged so that stated changes in behaviour (last year, this year, next year, and not at all) are listed in columns, and statements relating to how the pandemic has affected the choices, and which modes of transport were used, are listed as rows. There are clear differences between the parties who responded that they changed behaviour last year and/or this year and the other remaining categories. Those parties who altered their behaviour due to the pandemic were more numerous and more risk averse. Crowds or crowded areas were avoided, and nature or outdoor activities were preferred. Private cars and other private modes of transport were used by the risk-averse groups. However, public transport (bus) was never an option for any of the surveyed parties. It should be noted that parties who responded that they will change their behaviour next year and/or not at all selected fewer alternatives. Since these parties changed their behaviour to a lesser extent, it makes sense that the surveyed alternatives were marked less. The responses indicated that risk-averse individuals were more active in their mobility choices, while less risk-taking individuals were less likely to check alternatives – most likely because these parties were not behaving differently from before.

The questionnaire is unique in the sense that it surveys the relationship between mobility/transport and land-use and kinds of activities during the pandemic. However, the limited size of respondents and the small area of data collection is a concern. However, if we resonate our results in the light of separate surveys/studies over the transport and vacation development, we find similar results. For example, in a study of the mobility changes among individuals in the same county as the survey was conducted, Roos (2021) concludes that car usage and walking becomes more dominant, while public transport is decreasing in use. In a report from the Swedish Agency for Economic and Regional Growth (Tillväxtverket, 2020), the change in vacation booking patterns confirms that urban areas are losing in attractiveness, while especially

[1] Under the header – "Specialprogram om coronaviruset", Public Swedish television broadcast a programme about the pandemic on the day of the WHO declaration. https://www.svt.se/nyheter/inrikes/svt-sander-specialprogram-om-coronaviruset. This was followed by daily updates in the media.

[2] The survey copy is available as supplementary material.

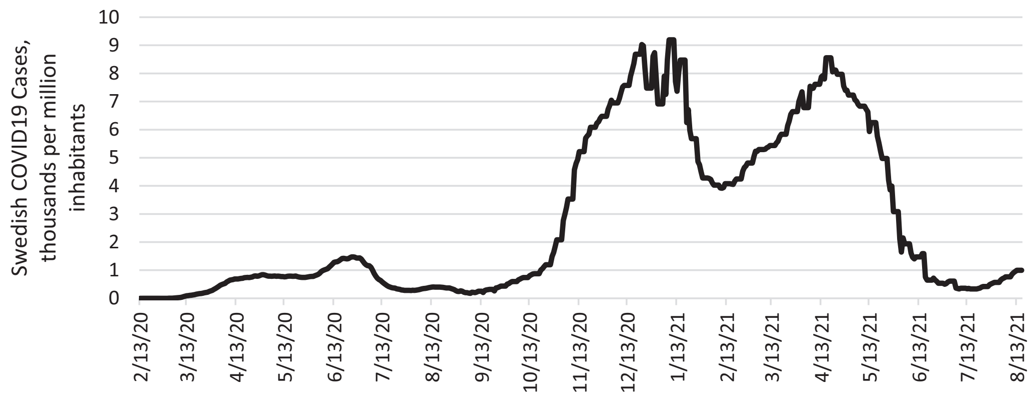

Fig. 1. Development of COVID-19 incidences from first report (2020) in Sweden until the end of the vacation period, summer 2021.

Table 1
Summary of the survey responses from the Island of Torsö in Lake Vänern, collected during the main vacation period in the summer of 2021.

Changed behaviour				
How did the pandemic affect?	Last year	This year	Next year	Not at all
Using Car	32%	40%	8%	18%
Using ferry	41%	47%	13%	16%
Using boat	1%	1%	0%	2%
Using canoe	1%	1%	0%	0%
Using bike	38%	43%	11%	14%
Using camper	2%	1%	1%	1%
Using bus	0%	0%	0%	0%
Walking	8%	8%	2%	3%

nature-close venues are becoming more popular. Our survey, together with the literature sources, enabled us to formulate hypotheses about the effect of the pandemic. Then, we analysed mobile phone mobility patterns to test the hypotheses and to measure the strength and direction of the effects of the pandemic. In contrast to the survey data, the phone data is more extensive and covers all parts of Sweden, which means that changes in phone density over time and in different kinds of locations can be traced before and during the pandemic. The mobile phone data were drawn from the MIND database. MIND contains the space-time behaviour of pseudonymised phones from one of the major GSM (Global System for Mobile Communications) providers in Sweden (representing between 10 and 20% of the mobile phone users in Sweden). Using the MIND database and, owing to ethical considerations, we can follow antenna-connections of pseudonymised phones for a maximum of 24 h.[3] Phone locations are determined by geographical locations of the antenna to which each phone is connected, and phone-location records are generated regardless of phone activity as long as the phone is turned on. However, the precision of the location is conditioned on the density of antennas, which means that phones in urban areas and in proximity to infrastructure hubs are localized with greater precision compared to phones in rural areas, since the density of antennas is greater in population dense areas. In this study, we estimate the location of phones using two main steps:

1. We record the antenna locations and duration of stay (in 5-min intervals) for each pseudonymised phone over a 24 h window separately for each of the three years (see also Hedman, Kadarik, Andersson, & Östh, 2021; Östh, Shuttleworth, & Niedomysl, 2018). MIND contains a scrambled IMSI code (unique identifier for each SIM-card) that can be used to separate users. For each scrambled ID code, there is information indicating which GSM-element/mast is connected to each phone. In a separate register, the location of each mast is indicated, and this information is used to match the location of phone.

   Using all observed GSM positions of each phone for each hour during the three dates we can pool the duration averaged position per hour, allowing us to generate hourly positions. Since we are not allowed to match data longitudinally, the phone identifier is only used in the estimation of hourly locations, after which the identifier is deleted.

2. By aggregating the estimated hourly positions to larger spatial units (1 km × 1 km in size) we can collect and compare the count of phones per hour over time on a spatial resolution that allows us to be relatively precise in terms of land-use, at the same time as the phone location estimations are acceptable in quality (locations of sub-1kmx1km levels are too unprecise to be trustworthy – see for instance Ogulenko, Benenson, Toger, Östh, and Siretskiy (2022) for further discussions about location precision quality). The aggregation allows us to compare counts of phones between hours and years.

By analysing a large number of phones during vacation times and comparing the mobility behaviour of the phones' users before the pandemic with their mobility behaviour at corresponding dates during the pandemic, we determine whether there are patterns in the deviation that correspond to the hypotheses constructed from the small survey. July is the main vacation month in Sweden, and during week 29 most Swedes would be engaged in leisure activities. The mobile phone data represents phone behaviour during the Thursday of week 29 in July during 2019, and with corresponding dates from both 2020 and 2021. During the vacation, the weather affects the spatial behaviour. On average, the weather was similar for the three dates used in our study (18/7–2019, 16/7–2020, 15/7–2021), though minor local variations existed. The choice of days with similar weather has been deliberate, since recreational activities are dependent on the weather. Summer's rain in Sweden is commonly originating from Cumulus Nimbus clouds which typically create local showers, resulting in substantial local variation in precipitation and temperature. We assume that substantial local variation in precipitation will have a strong but localized effect on recreational behaviour, which risks making tourism mobility studies difficult. For this reason, we have selected fair weathered days where weather predominately is sunny and where the potential for activities (indoor and outdoor) are similar regardless of location.

The estimated location of phones at the different times (every hour) of the three dates used in our study were enriched using GIS-derived data. By matching the phone locations to the contextual data, we determined in what kind of area the phone was active. The GIS data were collected for the year 2020 and therefore represents the time of the events relatively well. Two contextual data collection methods were

[3] Usage of phone data is regulated by the Research Ethics Directive (DNR2017–205 B). Permission to use this data is granted by the Ethics Board Commission, and is available upon request).

used for the contextual modelling:

1) Kernel density estimations of the concentration of specific features were used on amenities that had a known location, but only cover smaller areas. Using a kernel density approach, we are able to estimate the spatial concentration of cultural and event-oriented amenities, such as museums and stadiums, but also the concentration of, on the one hand, restaurants and bars, and, on the other everyday service facilities such as shops and pharmacies. The data drawn for these analyses came from OpenStreetMap and are represented by coordinates from which the kernel density is estimated. The estimated phone location is thereafter matched to the kernel density output using GIS. The kernel density variables express the estimated number of establishments per km^2. The constructed variables are: a) **Restaurants Bars** (including all bars, cafes and restaurants); b) **Service** (including all schools, kindergartens, pharmacies, kiosks, and grocery stores); c) **Culture** (including all museums, theatres, and cinemas)
2) Domination of land use features within a radius was employed to estimate how dominating specific land use features are in the surroundings. The radius varied between features due to their spatial distribution and the function of the features (for instance, nature reserves are located away from people requiring a large radius, and the sounds and effects of railways are usually limited to the nearby locations requiring a smaller radius). The resulting values fall between 0 and 1, where: 0 is meaning no presence of the feature within the area; and 1 indicating that the entire area is covered with the feature. The variables measured using domination variables are: a) **Freshwater** (lakes and streams within a radius of 200 m); b) **Sea** (within a radius of 1000 m); N**ature reserves** (within a radius of 5000 m); P**arks** (within a radius of 300 m); and finally, R**ailways** (within a radius of 200 m). The measures were constructed using spatial analysis tools and raster image analyses available in GIS-software. The data were derived from OpenStreetMap.

In order to compare output from different dates and between specific locales, we aggregated the statistics to km^2 units for the statistical analyses. Thus, we were able to describe the number of unique visitors per km^2 and hour, and to compare the density of phones over time, with specific attention to kernel density and land use domination variables.

Analytically, we make use of OLS-regressions where the dependent variable is the first difference per-hour count of phones, comparing 2019 with 2020, and 2019 with 2021. This means that the dependent variable will hold a first-difference value per hour and km^2 for both 2019/2020 and 2019/2021. In order to capture the difference between night and day activities, two separate regressions (per first difference variable) analyse the annual changes for day-only and night-only.

6. Research hypotheses

The emergence of the COVID-19 pandemic has obviously induced mobility changes as a result of both the perceived health risk of collective forms of transport and government stringency measures (Nijkamp & Kourtit, 2022). These effects manifest themselves in the frequency, trip length, and modal choice of travellers. From the literature, as well as from the survey response, we are able to build hypotheses of expected mobility behaviour during the vacation. The survey responses clearly distinguish between individuals who state that they have changed their behaviour and those that have not, in the way that they act during the vacation.

- H1: *Population density*. The literature indicates that crowds are being avoided, and that most individuals are spending their leisure time in outdoor environments. We expect to see a relative increase in population density in rural areas, and a decrease in urban areas. However, population densities in rural areas will always be considerably lower than those in urban areas also during the pandemic.
- H2: *Environment*. The literature suggests that recreative outdoor activities are becoming more important. We would expect to see an increase in the number of phones and in the duration of stay of mobile phones in rural areas dominated by recreational activities. These areas include those with proximity to water and nature reserves.
- H3: *Transport*. The literature suggests that the use of public transport (for any purpose) decreases during the pandemic. No one in the survey was using public transport, and those who stated that they were changing their behaviour were choosing private vehicles as well as selecting outdoor vehicles such as bikes, to a greater extent. We would expect to find more mobile phones in outdoor areas with no or few large-scale infrastructures such as railways and highways, and we would expect to see fewer stops in transportation hubs.

7. Empirical results

Three days of mobile phone behaviour were used in this study, and the spatial realms of the study population consist of a full population data set covering all of Sweden, and a subset limited to the same area wherein the survey was conducted. The latter ensures that the survey area can be used to represent the changing behaviour of the full population during the pandemic. In order to facilitate comparison between dates, we aggregated the data to km^2 levels. In Figs. 2 and 3, the changes in phone density are shown using a 1st difference approach where the average count of unique phones per day and km^2 is contrasted for the reference date in 2019 (before the pandemic) and the summers 2020 (Fig. 2) and 2021 (Fig. 3). The dots on the map are coloured red if the population increases, and blue if the population decreases, while the size of the mapped objects reflects the size of the population. The maps, that are confined to the south-central most populated parts of Sweden (including Stockholm and Göteborg, which are the most populous urban areas in Sweden) clearly show that population counts decrease in the major urban areas, and that also highway traffic is reduced (the blue lines stretching from some of the urban areas). At the same time, almost all other areas are covered in smaller red dots indicating that the population has increased. The symbol sizes also indicate that the populous parts are losing phone users, while the scarcely populated areas are gaining phone users but the numbers are rarely very large.

If we regress the first difference values for the two time periods (2020–2019, 2021–2019) for the full population data sets using the kernel and domination variables to describe the environment, we are able to see to what extent the hypotheses can be validated, and by taking into account the time each day, we can also test whether the behaviour can be used to say something about the daily behaviour each day. In Table 2 the results from the regressions are described. Model 1 shows the results when first difference results between phone density per hour in 2020 and 2019 are used as the dependent variable, and when the day and night models depict the results of selecting the localisation patterns for individuals at different times of the day. Model 2 shows similar results for first difference values between 2021 and 2019 (day and night models are available in the Appendix, Table A1). The values in Model 1 show that areas with services, restaurants and bars, and cultural amenities score strongly negative, which indicates that these areas were getting far fewer visitors in 2020 compared with 2019. Some natural amenities such as parks and the sea, were getting more visitors in 2020, while nature reserves, lakes and streams and rivers were seeing fewer visitors. An explanation for this pattern could be that parks and the seafront represent outdoor recreational areas that are considered to be safer environments during the pandemic.

It should also be noted that the significance of parks and sea is far greater than it is for the corresponding negative values for the other natural amenities. The negative values for streams and rivers as well as for lakes, can possibly be explained from an urban planning perspective.

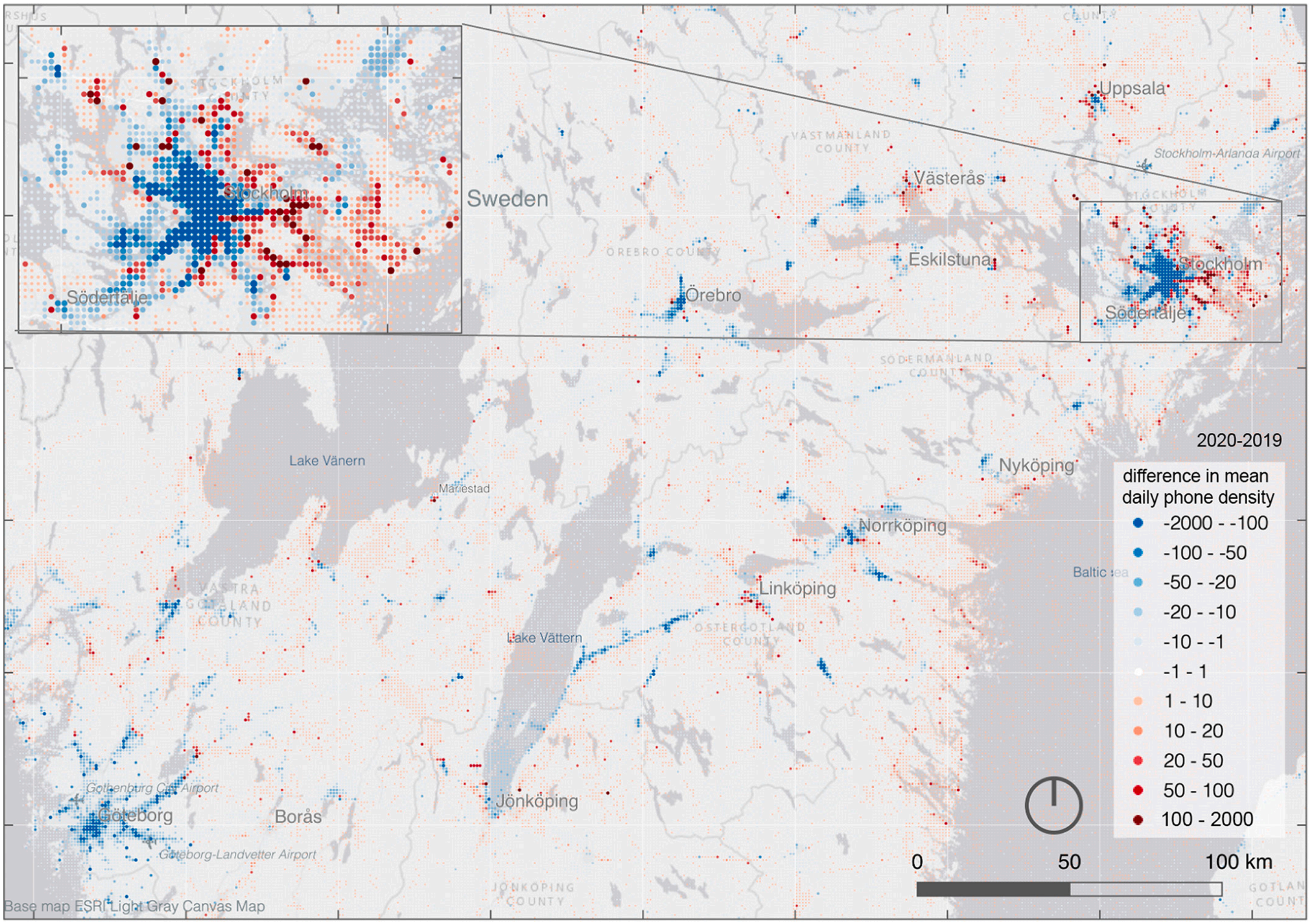

Fig. 2. July 2020: reduced presence in urban areas; 1st diff means density of phones per km 2020–2019. Source: MIND data (located at Uppsala University), data analytics and visualization created by authors.

Most urban areas were historically built around streams, rivers and lakes, when access to fresh water constituted a necessity for urban formation, morphology and transport. When contrasting the results for night and day with the overall results, it also becomes clear that the night results are less different compared with the day values. This makes sense if we consider that most recreational activities are day-based, while night rest typically takes place in the home and has seen less change compared with the day activity patterns. The day results also reinforce the negative trends for activities that can be associated with urban, or dense, areas. Services areas and cultural areas are strongly negatively and significantly associated with a diminishing number of phones, and urban natural amenities that can be associated with central parts of the urban landscape (streams, rivers and fresh water) are also more negatively associated with population loss during the day. In contrast, restaurants and bars are losing most of their guests during nights. This makes sense considering the policy interventions which restrict opening hours and number of guests at restaurants during the pandemic. Interestingly, the results in Model 2 (and in Model 2 Day and Model 2 Night available in the Appendix), which represents the differences between 2021 and 2019 largely emphasise the results between 2020 and 2019.

Our results are interesting in many ways; first they clearly show that the restrictive response has not been limited by pandemic-fatigue; and, secondly, it also underlines the response from the survey results as presented in Table 1. The results from the survey indicate that a larger share of the population stated that they are changing their behaviour more during the vacation 2021 compared with the share stating the same for the year 2020. This suggests that people are being more careful and avoiding crowded areas to a greater extent during the second pandemic vacation compared with the first vacation. A possible explanation for this may be that many individuals planned their vacations before the pandemic became a reality during 2020, while since then, most individuals have had the opportunity to adapt and rearrange their vacations according to the restrictions enforced to limit the effects of the pandemic in 2021.

8. Summary, conclusions, limitations and future studies

In this study we have used responses from a survey containing questions about mobility behaviour and vacation destination choices during the pandemic in order to formulate and test hypotheses about how people are changing their mobility behaviour during vacations before and during the two summers when pandemic-related restrictions affected what, when, and where we can go during the vacation. Previous research has suggested that private modes of transport will be favoured over public transport solutions, and that the recreational areas will be more rural dominated, when visitors actively avoid locations perceived as crowded, or otherwise risky (; Li et al., 2020; Moslem et al., 2020; Pearce, 1996; Więckowski, 2021). Using larger micro-data repositories describing mobile phone mobility behaviour for 24-h periods for corresponding days in 2019, 2020, and 2021, we were able to test to what extent the Swedish mobile phone behaviour corresponds to international experiences as described in the literature, while in addition, since Swedish agencies adopted a less restrictive and non-mandatory mobility

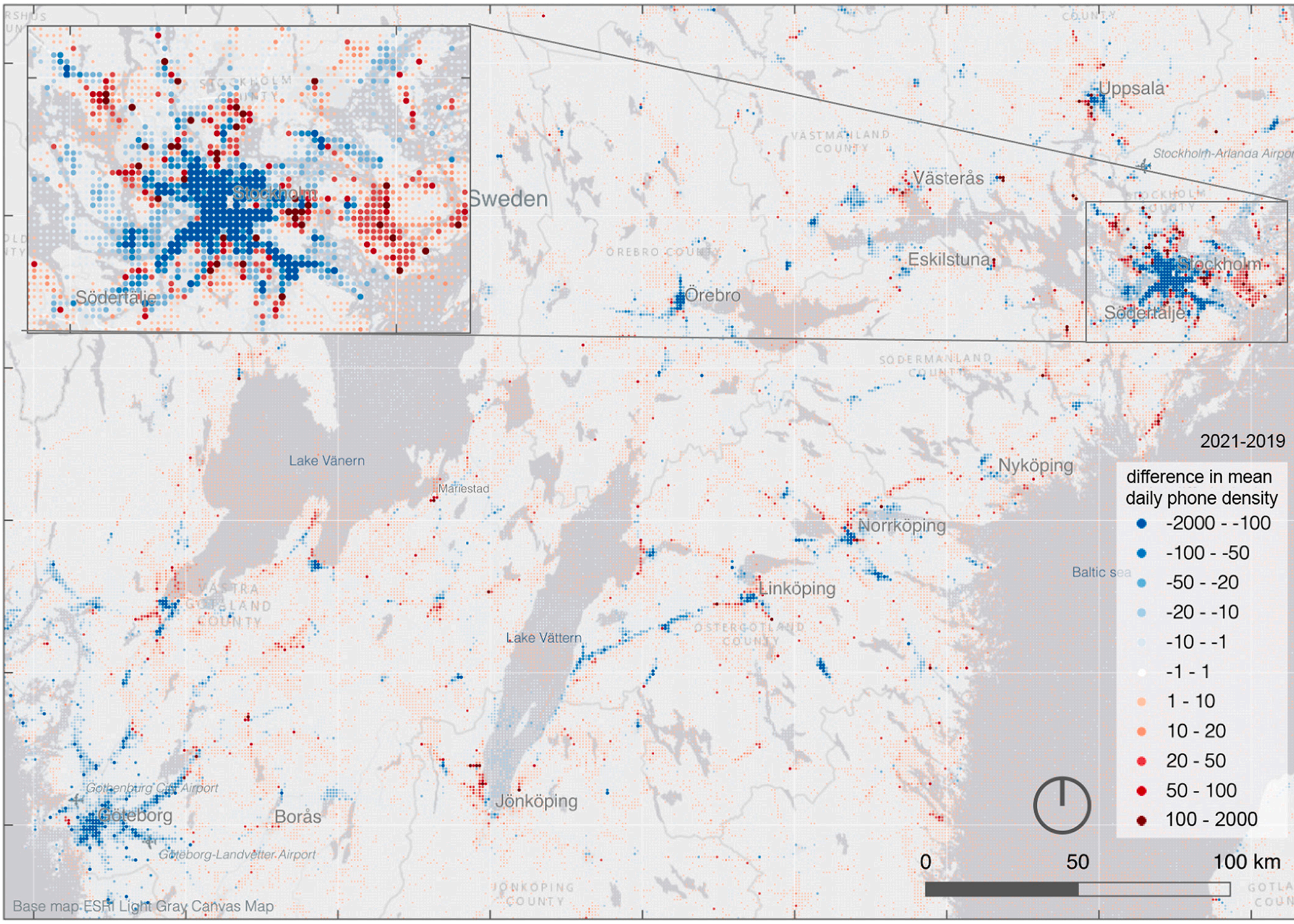

Fig. 3. July 2021: reduced presence in urban areas; 1st diff means density of phones per km 2021–2019. Source: MIND data (located at Uppsala University), data analytics and visualization created by authors.

restrictive approach during the pandemic, the results also have bearings for increasing our understanding of the extent to which personal choice rather than public regulation affects mobility during vacation periods.

The empirical results indicate that the avoidance of dense urban and population areas can also be detected in the phone mobility behaviour. The policy recommendations and/or restrictions also affect the number of leisure choices, which means that the urban vacation-related facilities are fewer. As an effect of COVID-19, individuals are avoiding these areas, and are more commonly found in rural areas close to natural amenities. From a transport choice perspective, the pseudonymisation of phones makes it difficult to detect the choices of an individual. However, from the spatial organisation of transport solutions, we can conclude that individuals are using private transport solutions (cars primarily, but also bikes, ferries and walking are listed as choices) due to the strong increase in activities in areas where trains or buses are not available. What do these results mean? Foremost, the results indicate that international observations regarding tourist behaviour during the pandemic, are similar to the behaviours we observe in Sweden. This is an important finding, since it suggests that also in a relatively unregulated context (people where free to move and act to a greater extent than in most comparable countries), the phone patterns clearly show that recommendations rather than regulations seem to be effective where there are higher levels of trust in public institutions (Rothstein & Stolle, 2003). An interesting finding is the correlation between the survey responses and the empirical findings from the phones in terms of how behaviour is changing over time. Using year 2019 as a point of departure, it becomes clear that the behaviour was more affected in 2021 compared with 2020. Naturally, pandemic-restriction-fatigue would be likely to cause individuals to follow the governments recommendations to a lesser extent compared with what we are seeing in our results. The main difference between 2020 and 2021 is that many of the vacation plans were decided on before the pandemic was a reality in 2020 (booking flights, hotels, etc., is typically conducted during the spring), but consideration of pandemic was part of the plans for the 2021 vacation. The results suggest that there is a substantial planning horizon that has more far-reaching consequences than changes in bookings, but also lagged effects on the tourists' mobility and activity choices. The survey also suggests that most individuals plan to act more *normally* during their next vacation. This means that policy makers and the hospitality industry need to be relatively quick in their response to any changes in pandemic recommendations in order to account for an effect of the choices of the next vacation.

Our study has also some limitations. The survey used for the formation of hypotheses has relatively few respondents from a limited geographical area. Though survey responses are supported by the GSM-analyses, a more extensive survey, with more respondents and with a greater geographical scope, might have rendered alternate results. We are unaware of contemporary surveys with similar contents, why any alternative results are hypothetical but possible. In addition, complementary, but similar data sources to the Phone Mobility dataset could have been used to substantiate our observations. However, since we have not been able to obtain localized statistics describing visitation statistics for individual amenities, booking statistics per hotel, etc., available data-sources have not been available for the association

Table 2
Regressions using first difference phone density values for each hour.

	Model 1	Model 1 Day	Model 1 Night	Model 2
	Coeff(Std. Err.)Sign	Coeff(Std. Err.)Sign	Coeff(Std. Err.)Sign	Coeff(Std. Err.)Sign
Streams Rivers	−0.008 (0.007)	−0.025 (0.010)*	0.005 (0.008)	−0.019 (0.007)**
Restaurants Bars	−484.915 (4.935)***	−50.512 (8.548)***	−751.228 (5.635)***	−552.092 (5.542)***
Service	−1370.899 (2.640)***	−2251.653 (4.588)***	−840.408 (3.007)***	−1760.92 (2.964)***
Parks	0.03165 (0.010)**	0.268(0.018) ***	−0.116 (0.012)***	−0.020 (0.012)
Natural reserve	−0.0002 (0.000)***	−0.0003 (0.000)***	−0.0002 (0.000)***	−0.0004 (0.000)***
Lakes	−0.0002 (0.000)	−0.001 (0.000)**	0.0002 (0.0003)	0.0003 (0.0002)
Culture	−615.300 (30.359)***	−1341.987 (51.774)***	−127.742 (35.006)***	−2178.523 (34.092)***
Railways	−0.165 (0.012)***	−0.137 (0.020)***	−0.179 (0.015)***	−0.0140 (0.014)
Sea	0.007(0.000) ***	0.010(0.000) ***	0.0049 (0.0003)***	0.011(0.000) ***
Constant	−0.125 (0.012)***	0.100(0.019) ***	−0.301 (0.015)***	0.333(0.014) ***
Adj R-square	0.2549	0.3343	0.2154	0.3222
n	3,385,563	1,542,759	1,842,804	3,385,563

Notes: Model 1 contains the regression results for first difference values for 2020–2019 while Model 2 contains first difference results for the years 2021–2019. The day regressions contain results for all hours between ≥ 9.am and < 18 pm, and the night regressions those for the remaining hours during morning and evening. ***, **, * indicate significance at the 99,9, 99, and 95 confidence intervals, respectively.

between over-time changes in location patterns and different stages of the COVID-19 pandemic. This type of research also leads to new research endeavours. At the time of writing, the increase in spread of the COVID-19 variant BA.5 points to the fact that the epidemic spread of COVID-19 continues and develops, although with less severe ill-health effects and with fewer to no societal restrictions. With the strong return of tourists to the pre-pandemic destinations research related to vulnerability and resilience among destinations, will be of interest for future studies, especially addressing the question whether the hospitality sector will bounce back to the pre-pandemic state, or whether the way we travel, and where we spend our leisure time, has changed.

CRediT authorship contribution statement

John Östh: Conceptualization, Funding acquisition, Formal analysis, Methodology, Software, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Marina Toger:** Conceptualization, Funding acquisition, Data curation, Project administration, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Umut Türk:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Karima Kourtit:** Conceptualization, Project administration, Writing – original draft, Writing – review & editing. **Peter Nijkamp:** Conceptualization, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

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Appendix A. Appendix

Table A1
Regressions using first difference phone density values for each hour.

	Model 2 Day	Model 2 night
	Coeff(Std. Err.)Sign	Coeff(Std. Err.)Sign
Streams Rivers	−0.039(0.011)**	−0.003(0.009)
Restaurants Bars	−229.900(9.503)***	−752.643(6.391)***
Service	−2679.124(5.101)***	−1208.158(3.410)***
Parks	0.0891(0.019)***	−0.090(0.013)***
Natural reserve	−0.0007(0.000)***	−0.0004(0.000)***
Lakes	0.0009(0.0004)*	−0.0003)
Culture	−3174.265(57.558)***	−1515.31(39.700)***
Railways	0.019(0.022)	−0.032(0.017)
Sea	0.016(0.000)***	0.007(0.000)***
Constant	0.482(0.021)***	0.223(0.017)***
Adj R-square	0.398	0.286
n	1,542,759	1,842,804

Notes: Model 2 contains regression results for first difference values for 2021–2019. The day regressions contain results for all hours between ≥ 9.am and < 18 pm, and the night values for the remaining hours during morning and evening. ***, **, and *, indicate significance at the 99.9, 99, and 95 confidence intervals, respectively.

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