

# MOBILITY AS CENTRAL ELEMENT IN THE COVID-19 PANDEMIC: FROM ACCELERATION TO CONTAINMENT. EXPERIENCE AND LESSONS FROM GALICIA (SPAIN)

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**Abstract:** The COVID-19 pandemic developed in a context of hypermobility. International globalised financial capitalism has been consolidated at the beginning of the 21st century and it has resulted in an unprecedented increase in mobility. In Galicia (an autonomous region located in the northwest of Spain), as in many other Spanish, European and world territories, mobility restrictions were carried out according to different criteria. Here we will be concerned with showing the effectiveness of the different measures taken by the national and regional governments, linked to mobility and pandemic management. To achieve this objective, in addition to the official reports from the competent authorities, we use detailed data on the number and addresses of those infected during the first wave. We have this information because we were selected by the Government of Galicia to carry out a study on the territorial behaviour of the pandemic in Galicia.

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## Introduction

The current COVID-19 pandemic has been raging for more than three years now, and it has completely transformed the world we live in. The emergence of an unknown and highly contagious coronavirus in late 2019 in the Chinese city of Wuhan and its rapid spread across the globe has led to what it is just one more episode in the long list of plagues and pandemics that humanity has suffered throughout its history (Agamben et al. 2020).

Indeed, although there were sufficient indications in the scientific community to suggest that such a pandemic might occur, the COVID-19 pandemic can be described as a true "black swan". In the social sciences, this terminology refers to an unexpected phenomenon, of large dimensions and negative consequences, which affects the territory and society in a dramatic way (Yarovaya et al. 2022).

In any case, the COVID-19 pandemic has had its precursors – viral epidemics that had more limited effects in space and time. Perhaps the best known was SARS, which had been confined a few years earlier to Southeast Asia, but which had already put the World Health Organisation on alert because of the major consequences that it could have had for the entire planet. Another of the epidemics with great media repercussions in recent years was Ebola, which at the time, aroused great concern throughout the world, although its scope was practically confined to Africa. In any case, it cannot be said that there have been no precedents in the near future (Pigott et al. 2014, Diamond 2019).

If we take a longer view, we must bear in mind that pandemics have always existed. The history of mankind is the struggle to overcome the natural dangers to which the species is exposed. Extraordinary advances in medicine and health research have brought us to a situation where it seems difficult to compare any of the mediaeval plagues that struck Europe with the COVID-19 pandemic. And yet, while there are important differences, there are also great similarities.

Despite great advances in health care, human beings are still exposed to infectious diseases that are transmitted through the air, via airborne particles, from person to person. Nevertheless, the reading of Boccaccio's "The Decameron", written in the 14th century and set in the midst of a plague epidemic in modern-day Italy, is highly topical (Boccaccio 2001). As in Boccaccio's book (2001), the pandemic due to an unknown virus spread amidst the fear of most of the population, the anguish and panic of some, leaving behind a trail of death and destruction. It is curious that in Europe Northern Italy was one of the places most affected by the pandemic, where the images of the overflowing funeral services in the city of Bergamo in the face of the avalanche of the dead became sadly familiar to us (Bernucci et al. 2020).

But while there are similarities between the Middle Ages and the 21st century, it is no less true that there are clear differences, with both positive and negative connotations. On the positive side, we must take into account the great organisational and technical capacity of today's modern societies, which are able to quickly dictate measures, protocols and legislation to try to control the pandemic. Likewise, the speed with which effective vaccines against the coronavirus became available has been fundamental in the fight against the pandemic and in the global strategy to return to normality as quickly as possible.

Among the differential elements with a negative character, one is particularly relevant: the high mobility of the citizens of the countries of the global North. Indeed, the spread of the current coronavirus has occurred at enormous speed precisely because we live in a hyper-mobile world, accustomed to constant, frequent and continuous population movements. This hypermobility is one of the defining characteristics of global north societies, and it can be observed across all scales of geographical analysis (Cohen and Gössling 2005).

We are not only talking about forced mobility on a daily basis or in metropolitan environments; we are referring to mobility on a regional, supra-regional and supra-state level. These continuous mobilities imply constant and continuous population movements between regions, countries and continents, for many different reasons. At the global level, the rapid spread of the virus between Asia and Europe is explained by the existence of a world system with a very high level of integration thanks to the omnipresent and frequent air connections (Gross et al. 2020). In a context of "Jumbo Geography", as Rimmer (1988) put it, the entire planet is interconnected as never before, due to globalisation.

It is a characteristic of our times, therefore, this constant hyperconnection between people living in very distant territories, and the so-called "urban archipelagos" (Romero 2004, Stavrides 2013). Paradoxically, two metropolitan areas located on different continents may be more integrated than one of these metropolitan areas with the surrounding rural spaces. This leapfrog urbanisation and this privileged connectivity between large urban archipelagos explains the initial difficulty in controlling the spread of an airborne virus (Flandoli et al. 2021).

From a geographical point of view, what is therefore characteristic of this pandemic in relation to previous pandemics? Undoubtedly, it has been the great speed at which the virus has spread and affected the entire planet in record time, as never seen before. The speed at which the pandemic has spread and the great disruption it has caused in the economic system and in the living habits of societies accustomed to compulsive mobility characterise this 21st century pandemic, and therefore make it interesting to study it from the perspective of the new paradigm of mobility (Sheller and Urry 2006).

This paper is structured as follows: first, after the introduction and the presentation of the objectives, we will present a theoretical framework on the implications between mobility and the COVID-19 pandemic. Indeed, mobility was one of the great catalysts for the spread of the pandemic, but also one of the main instruments to contain it and to try to stop it. Subsequently, the methods and materials used are presented. It is important to highlight that official data provided by the regional government of Galicia in the framework of a research project obtained in a competitive call for proposals were used. Thirdly, the study area is presented. Fourth, we analyse the main spatial characteristics of the first wave of the pandemic. Fifth, we finally look at mobility during that time and we analyse its territorial significance. Finally, we present the main conclusions of our analysis.

## **Mobility and the COVID-19 pandemic**

From a theoretical point of view, this article agrees with the postulates of the New Mobility Paradigm, enunciated by Sheller and Urry (2006) who are the architects of the formalisation of a new point of view for understanding the social sciences, which gives mobility a central role. In contrast to the classical approaches where analyses adopted an eminently static perspective, the role of movement, change and interaction as constitutive elements of the contemporary world is now highlighted (Pazos Otón 2022).

It is not just that mobility is one of the foundations of the current globalisation process, but that it plays a fundamental role in explaining how the individual and society experience space and territory. In the case of the pandemic and the rapid spread of infection, it is precisely the dependence on mobility at all scales of analysis that explains the rapid evolution of the pandemic (Carteni et al. 2020). Mobility is therefore a key component in the study of the COVID-19 pandemic, as it was in other recent pandemics such as avian influenza or SARS.

In recent years, few words have been gaining as much prominence in the scientific literature related to the territory as the word mobility. In parallel, its use by the general public has become widespread at great speed. Where before we talked about transportation, now we talk about mobility. The previous traffic police officers are now mobility agents. Ministerial transport departments now include the word mobility. This emergence of the concept is related to the crisis of the large infrastructure model, the awareness of the threat of climate and global change and the progressive importance that the individual and his personal variables take on when explaining his movements.

Until the appearance of the Covid-19 pandemic, the progressive and increasing mobility of people seemed to have no limits. Everything was moving faster and faster. It was as if there were no limit to the increase in trips, their duration and their frequency. In this first major pandemic of the 21st century, mobility appeared as one of the great explanatory agents for the rapid spread of the virus throughout the planet.

The globalisation of the economy, the constitution of the planet as a set of urban archipelagos and the growing interrelationships of territories justified the unprecedented global mobility, in which air transport played a fundamental role.

With the outbreak of the pandemic, throughout 2020 and 2021, mobility became a key component in the fight against the expansion of the pandemic. What had accelerated its expansion now became the best tool to contain it. For many months there were home confinements decreed by governments and mobility limitations were put in place depending on the problems of certain territories and certain social groups. The promotion of mobility containment by public powers had its counterpart in the extraordinary development of the application of technology to labour and social relations (Pazos Otón 2022).

The exit from the pandemic throughout the years 2022 and 2023 was progressive and it was accompanied by a growing desire for mobility on the part of the citizens. Isolated and confined to their homes for many months, citizens made use of their freedom of movement as soon as possible. There was an explosion of mobility for work reasons but, above all, for leisure reasons. After the initial months of the end of the pandemic, governments greatly relaxed the restrictions and barrier measures (progressive elimination of masks) until they declared the end of the pandemic as such.

In this context, the population's tendency to move more and more has increased. Contrary to what was prophesied (the pandemic was going to be an opportunity to reinvent ourselves and to stop being so mobile, to decrease), the experience of mobility restriction caused what is called "revenge tourism". This is, in short, a substantial increase in the voluntary mobility of the population, without serious energy or climatic circumstances acting as a brake on the trend.

Be that as it may, in times of pandemic, a series of measures were implemented to try to contain the expansion of the virus, the main agent of which was mobility (Pazos Otón 2022). In Spain, as in other countries as well, extraordinary legislative measures were decreed that annulled one of the basic rights of the citizens – free movement throughout the national territory. The State of Alarm decree of March 2020 was first renewed within 15 days in the Madrid Parliament, and subsequently a continuous state of alarm was decreed from October 25, 2020 to May 9, 2021.

Secondly, the assumption that the evolution of the pandemic would adapt positive cycles to negative ones (the so-called "waves") was associated with the existence of more or less important mobility restrictions. The relaxation of mobility restrictions during the Christmas period of 2020 caused a significant wave of infections in January and February. The greater the mobility, the greater the incidence of infections. The decision to allow mobility during the Christmas period was criticised and it pointed out as one of the causes of the so-called "fourth wave".

Thirdly, a series of fundamental measures were generalised, such as the obligation to maintain one and a half metres of social distance from non-cohabitants. Likewise, it was considered that there should be no type of restriction in the domestic sphere. The generalisation of the mask and the social distance between people were implemented as a confirmation that what was pertinent was to reduce the mobility and interaction of the population.

Fourth, teleworking was promoted to the extent possible, in order to reduce the daily forced mobility of workers. The pandemic meant the explosion of a growing trend, which had been practised in a timely manner and with uneven implementation throughout the world. The generalisation of teleworking has had a clearer consequence of the need for its regulation from a legal point of view. In fact, a law was passed regulating remote work (Agencia Estatal Boletín Oficial del Estado 2021).

Finally, there have been others that were variable and mobile, and that were adapted to the specific circumstances of the evolution of the pandemic. Basically, they were confinement measures (personal), business closure and perimeter (or confinement of different administrative and territorial units). They consisted of restricting mobility and they were popularly known as "closures". Its application also varied depending on different factors (on age groups, on time slots, on the type of activity, on the structures of the premises, on territorial units). There can be multiple cases, from the perimeter closure of a municipality (Igalada, Catalonia, in March 2020, was the first), to an autonomous community or even by health areas. Different levels (1, 2, 3) were also used to restrict mobility between health areas that are in different phases (Galicia in the first quarter of 2021).

In any case, mobility has at all times been a central element in the COVID-19 pandemic, first as an accelerator of the transmission of the virus and, later, as a central element in the containment policies and fight against its spread.

This study contributes to inform the debate on the management response to a pandemic. Specifically, it aims to develop a territorial analysis methodology to identify the geographical behaviour of the coronavirus pandemic in Galicia and, to a greater extent, the influence it had on human mobility (Aràndiga et al. 2020).

## Methodology

### Study area

Galicia is located in the northwest of Spain. It covers an area of almost 30,000 square kilometres and it has a population of 2.7 million inhabitants. The population density is 91.4 persons per square kilometre. Administratively, the region is divided into 313 municipalities distributed over 4 provinces (Figure 1). The population is concentrated

in the two westernmost provinces, reaching average densities of over 140.9 inhabitants per square kilometre in A Coruña, and 209.7 in Pontevedra (INE 2021).

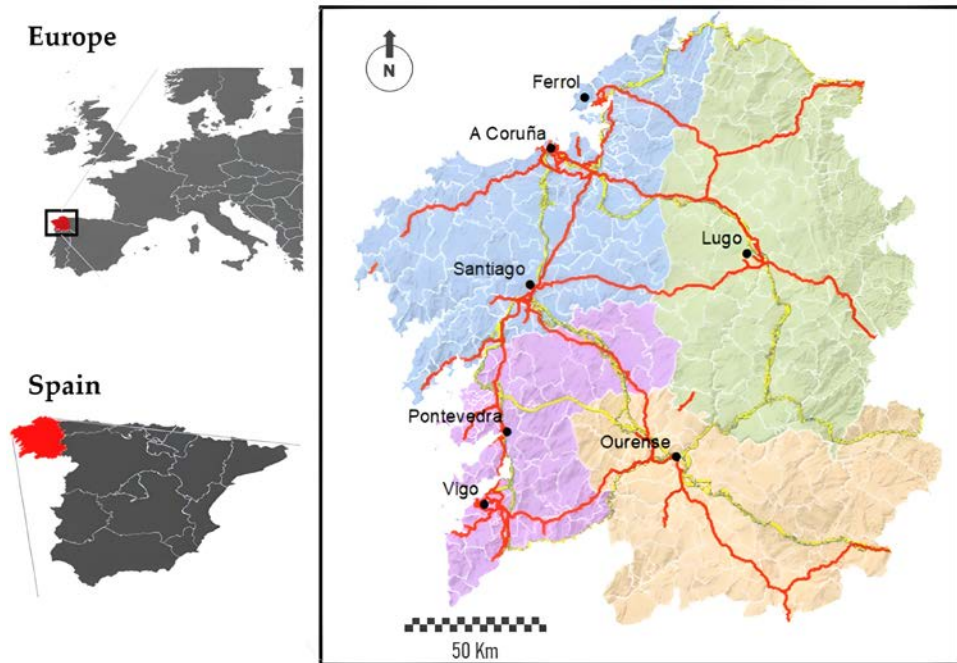


Figure 1. Location and characterisation of the Galician region

In coloured background, distribution of provinces (second-level administrations) and municipalities (third-level administrations). The most populated cities and industrial hubs of each province appear highlighted in bold. Red lines represent the major road infrastructures, i.e., motorways in red and railways in yellow.

Increasing levels of urbanisation have occurred since the 1960s and rural depopulation has contributed to a spatial concentration in some areas within this region. Today, most of the population, economic activity and political power are concentrated in a very small number of cities (Lois and Pino 2015). The most important ones are located along the Atlantic Axis, structured by the AP-9 motorway that crosses the region from north to south. This axis links the cities of Ferrol, A Coruña, Santiago, Pontevedra and Vigo within this region. The largest cities are Vigo and A Coruña, which each have around 300,000 inhabitants. Situated outside this axis, we find two important cities: Lugo and Ourense. These constitute the main centres of economic activity in their respective provinces and both have populations of around 100,000 people.

The region presents a dual population pattern. On the one hand, the main cities account for around 80% of the population and 75% of the regional GDP (Pazos Otón 2003, Lois-González 2004, Lois and Pino 2015), while a vast area is rural and it shows declining



populations. This general pattern is evident at provincial level, with the two western provinces having a greater economic diversity and a higher proportion of the population. In this demographic duality, a very dynamic coast contrasts with a depressed interior region. Of course, the reality is more complex, with some emerging exceptions in certain coastal sectors, such as the Costa da Morte, where population dynamics have been clearly regressive in recent decades.

This territorial structure determines mobility patterns. At the regional level, commuting flows to the main cities and surrounding areas predominate. Internally, a significant number of head cities form the backbone of most of the non-urban territory. These cities are nodes that, despite typically having low populations, function as child-sized cities for vast rural areas (Balsa-Barreiro et al. 2021). Most mobility flows in these predominantly rural areas cover large distances compared to urban areas. In any case, in order to understand the particularity of Galicia's territorial structure and its relationship with population mobility, four fundamental issues need to be taken into account:

a) The population in Galicia has internalised the habit of daily mobility. They have done so in order to continue living in rural areas, and they need to move every day in order to live in today's modern society of advanced services. There are many people who have to travel every day to county seats, towns or cities and they still live in the countryside. They value the quality of life that exists in the countryside, and that is why they want to continue living there. For this reason, in many families in rural Galicia it is very normal to have 2 or even 3 cars. People in rural areas assume that they have to have a car to live in the 21st century, and this means that the rate of motorisation in rural municipalities (less than 10,000 inhabitants) is much higher than in the rest of Spain.

b) The dispersion of the population and the specificity of the settlement system in Galicia means that public and collective transport in general is scarce and not very operational. If we add to this the high levels of motorisation and the availability of 2-3 cars per family unit in rural areas, we can understand that in the middle of the pandemic most of the journeys were made by private car, in an individual bubble in many cases that nullified the risk of contagion during journeys. Unlike in large cities or even in medium-sized and smaller cities that are more dispersed territorially, in Galicia, the high use of cars was fundamental for the low diffusion of the virus in comparison with other territories.

c) The population of Galicia lives in more than 31,000 singular population entities, which represents more than half of the population of Spain as a whole. This explains why they live in very scattered population conditions. Precisely the great distance between population centres in Galicia was a key factor in the pandemic, as it minimised interaction. There are still many population centres, but with a dispersed population structure. In other words, there are many villages, but these villages are not compact. In recent decades, the number of single-family houses around the roads has increased



enormously, and these houses have an adjoining space. Except in the compact cities, in general there is a lot of residential space available in Galicia. In rural Galicia there are few possibilities to interact with neighbours nearby, and in any case these interactions take place in the open air. In many villages there is no longer even a bar or café. There are no places for socialising as there may be in other regions.

d) In Galicia there is a strong link with the rural and agricultural, and livestock areas. Unlike in other parts of Spain, in Galician cities practically everyone maintains strong affective and effective ties with the countryside. In a region that was urbanised very late, the first and, above all, the second generation of urbanites is very numerous. In many cases, they are children of the baby boom who return to their family homes as soon as they have the chance, on holidays, etc. In many cases, they return to homes where their elders live, but in other cases they build new homes. These are second homes to which they try to return whenever they can. Particularly interesting in this respect is the behaviour of people who have emigrated from Galicia, who, even if they live in a large European city, aspire to move to the house they built with all their life savings in a rural Galician village when they retire.

### **Analysis dataset**

This dataset contains information related to all individual cases reported during the first wave of the pandemic, which runs from 1 March to 15 July 2020. This information was officially transmitted to us by the Galician Health Service (SERGAS 2020), the health authority of the region. This was possible because the Galician Innovation Agency (GAIN) of the Xunta de Galicia offered an urgent competitive public call during the month of March 2020, to the entire scientific community (public and private), to propose solutions to "fight" against COVID-19. The project "Risk mapping of COVID-19 in urban and rural areas of Galicia" was selected, the purpose of which was to produce a series of territorial analysis reports on the pandemic and to provide them to SERGAS (2020). This project is the basis for this article. Therefore, these data were transmitted to us by SERGAS (2020) after signing a confidentiality agreement.

The dataset, initially of 11,070 records, includes data related to each patient, such as main data, place of residence and physical address, and some relevant time data that allow checking a complete disease follow-up for each reported case (i.e. admission/death at home/hospital). Knowing that most mobility was restricted during the confinement, case and outbreak tracing may be limited spatiotemporally because health authorities recorded data related to the first symptoms and test results. The official address of each reported case allows us to obtain a very accurate graph of the actual spatial behaviour of the virus.

The raw dataset was initially checked for inconsistencies. The dataset was prepared and cleaned by removing duplicates. We also removed all false positives, as well as all cases

without any address that was untraceable. In summary, 581 records were eliminated. After that, we standardised the formats for the remaining records. All the survey and cartographic representations were done with ESRI technology (mainly ArcGIS Pro and ArcGIS Online). Finally, a complete dataset consisting of 10,583 records was correctly geolocated on a map (Miramontes Carballada and Balsa-Barreiro 2021a).

In any case, we want to emphasise that in this work the objective is not to value the cartography carried out on the territorial behaviour of the pandemic (Gullart Moreno 2020, Sancho Comíns and Olcina Cantos 2021). Nor to carry out a new innovative treatment of this data. But, from its purification and its most basic representation, we aim to detect the influence that people's mobility has had within the pandemic. In this work we intend to link the knowledge on its territorial behaviour and distribution (Carballosa et al. 2021, Cruz Villalón et al. 2021, Miramontes Carballada and Balsa-Barreiro 2021b, Carballosa et al. 2022, Miramontes Carballada and Lois Gonzalez 2022).

### **Spatial behavioural data**

We focus on the first wave, which is unadulterated, contrasted and highly detailed data. We analysed and mapped the data associated with COVID-19 in this Spanish region. Our data contain individual and accurate information on each infected person, including their physical address. These data allow for a very accurate and detailed estimation of the actual spread of the virus in this territory. This information was provided to understand the spatial dynamics and impact of the pandemic, in order to predict its future behaviour and to be able to anticipate and to adapt the appropriate decisions at any given moment.

In fact, our maps were used as a fundamental tool for monitoring the pandemic and for evaluating the subsequent measures, allowing us to identify the spatial patterns of the virus. To this end, we developed several strategies for visualising and mapping the data. This time, we give more importance to population mobility variables and their relationship with the distribution of infected people.

The way in which the information is represented should serve as a basis for the integration of multidisciplinary work teams, not only medical but also from other disciplines, most of which do not have experience in cartographic visualisation. In fact, maps similar to those presented in this work served the purpose of advising the competent authorities responsible for the management of the pandemic in this part of Spain (Andrés López et al. 2021, Carballosa et al. 2021, Cruz Villalón et al. 2021, Lois-González et al. 2021, Carballosa et al. 2022).

### **Mobility data**

However, in this paper, we go even further and, in order to show an analysis of the

spatio-temporal evolution of both virus incidence and human mobility flows during the first wave of the COVID-19 outbreak in Galicia, we also use data on human mobility.

Anonymised mobile data was provided by INE (2021). With this data, it is possible to extract the physical location of mobile users of the three most important operators in Spain. The geographical location of each user can be accurately estimated by deducing the antennas from which their mobile phone receives a signal. This dataset includes the location of more than 80% of the mobile phones that are distributed throughout the region.

The time frame of the data ranges from 15 March to 16 June 2020, which basically corresponds to the first wave of the COVID-19 pandemic. Mobility data are estimated for certain common days according to the methodology proposed by INE (2021). These days correspond to periods of normal educational and work activity, which are part of a week without any intervening holidays that might affect mobility. In all cases, we selected data from the second week of each month. For a broader perspective on this dataset, we included mobility data for November 2019, before the outbreak of the virus (INE 2021).

These data are spatially aggregated, fully respecting user privacy. The data are aggregated and represented on the basis of mobility areas, a particular spatial unit established by INE (2021). Mobility areas are defined on the basis of the administrative division of municipalities, although they have some differences. They are arbitrary areas whose size depends on functional aspects related to mobility and population. The division into mobility areas tries to reflect a more homogeneous distribution of the territory according to population aspects. The borders between these mobility areas mostly respect the original distribution of the municipalities, but they always group together areas with a population between 5,000 and 50,000 inhabitants (INE 2021).

In this paper, we selected the following information from the dataset: resident population; number of people staying in their residence; number of people leaving their residence; and areas of mobility to which they moved and/or they came. It is thus clear that one of the potentials of this work is the two databases used to analyse and to map the COVID-19 pandemic and the population.

The main mobility dynamics have changed dramatically since the emergence of COVID-19 in mid-March 2020. In Spain, national authorities implemented nationwide measures to control the virus. On 14 March, they adopted a hard lockdown with strict mobility restrictions and stay-at-home orders for all. Work activity was reduced to very few essential activities related to human care and the purchase of primary commodities. Between 30 March and 9 April, only essential workers were able to travel to work. Galicia was the first region to ease mobility restrictions and to return to pseudo-normality. This was done in four different phases. On 4 May, some businesses

and activities, mostly outdoors, were authorised. Two weeks later, restaurants and some shops could open, but with partial capacity restrictions. Human mobility was limited within each province. On 15 June, the region began a "new normal" with no restrictions on mobility.

We will now present the main quantitative and qualitative features of the pandemic in Galicia, with special attention to its territorial consequences, in order to understand the relationship between the behaviour of the virus and the main characteristics of the Galician territory and its population.

## Results

In order to better understand the territorial impact of the pandemic in Galicia, we divided the analysis, and therefore this section, into four subsections. We begin with a brief overview of the case of Spain as a whole. Galicia is a territorial administration with competences in health (among others such as education, justice, etc.), and territorial characteristics that are different from those of the other autonomous communities in Spain (there are 17 autonomous communities in total) (Méndez 2020, Cruz Villalón et al. 2021).

Next, we will focus on the specific case of Galicia and on two differentiating territorial processes: the relationship of urban spaces with the pandemic and a study on a larger scale such as the 313 municipalities into which Galicia is divided, which can be classified as an analysis on a local scale.

### Impact in Spain

The first case of COVID-19 in Spain was reported on 31 January 2020 in La Gomera, in the Canary archipelago (Monastiri et al. 2021). A few days later, on 9 February, a second positive case was detected in Palma de Mallorca. The first cases reported on the mainland were recorded in the last week of February in Madrid, Catalonia, the Basque Country and Valencia. All these cases were initially imported from other countries, although EU transmission within the country was already evident in early March. At the time, the national authorities declared the containment (on 14th March) while Spain had 6,332 cases and 193 deaths. The containment decreed by the central government lasted 49 days, followed by a period of 40 days in which restrictions were progressively lifted until the end of the first wave at the end of June. The balance of this first wave was, as of 21 June, of 246,504 cases and 28,313 deaths at the national level, although the actual figures were predictably much higher. According to data published by Instituto de Salud Carlos III (2020), the actual number of COVID-19 deaths could be one third higher than reported (Romero 2020). The results of the first national seroprevalence study estimated that only 5% of Spaniards had been infected with the virus during the first wave (Pollán et al. 2020), although showing great geographical variability, with a

higher prevalence observed in the Madrid area (>10%) and much lower in coastal areas (<3%) (Oliver et al. 2020, Sierra Moros et al. 2021).

### **Impact in Galicia**

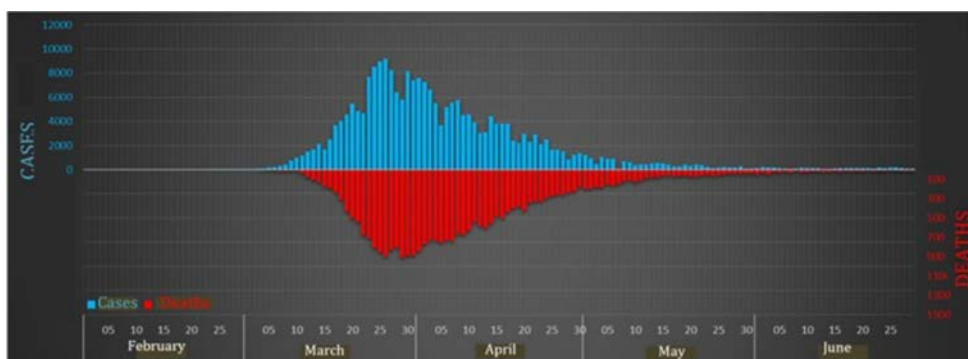
In the case of Galicia, the first official positive report for COVID-19 was made on 4 March and it corresponded to a case imported from Madrid. Between the time this case was reported and the containment decree implemented by the central government, only ten days elapsed during which the virus circulated freely. Most of the cases reported during this period correspond mainly to imported cases from primary foci of infection and cases of community transmission within household circles, as well as dependents.

In Galicia, the first wave left a total of 10,489 cases and 619 deaths. The seroprevalence study carried out during the first wave estimated that only 1.15% of the population had been infected, making it one of the least affected regions in Spain (Carballosa et al. 2021, Miramontes Carballada and Balsa-Barreiro 2021b). Comparatively, the fatality rate in Galicia was much lower than in the rest of Spain. On 30 June 2020, Galicia accounted for 4.2% of cases and 2.2% of deaths nationally, a percentage considerably lower than its demographic weight (5.7%). The cumulative number of cases per 100,000 inhabitants was 388.2, while the number of deaths was 22.9. The fatality rate was 5.9 deaths per 100 reported cases. A comparative analysis between the incidence of the virus in Galicia and Spain is shown in Figure 2.

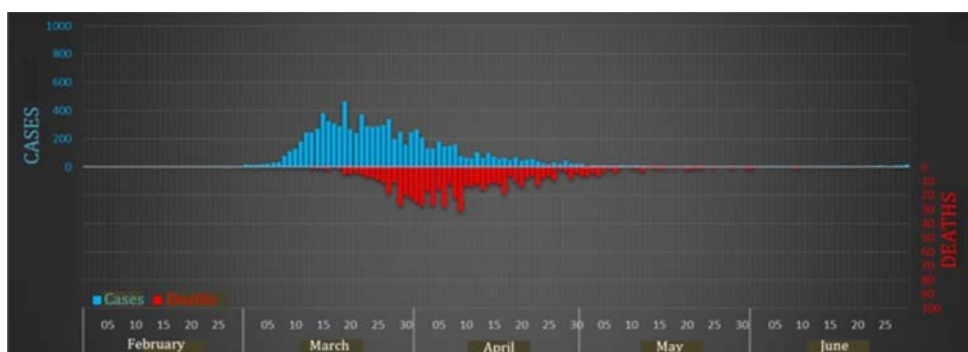
The incidence of the pandemic was lower in Galicia than in the rest of Spain. This could be related to the special characteristics of the Galician settlement system. As argued in the main characteristics of population and mobility in Galicia, the Galician countryside is made up of a large cloud of villages with a high degree of dispersion and territorial overlap. The distance between them and the small number of inhabitants in each of these settlements means that there is less interaction between people than in other Spanish regions. Furthermore, in a large part of Galicia, these singular population centres are characterised by an internal structure that is not very compact. In the Galician countryside it is common to find single-family dwellings with adjoining areas for agricultural and livestock work. Thus, each individual dwelling usually has a plot of land surrounding the house and there is no continuity of construction between different family units. In times of pandemic, this resulted in less interaction between people from different family units, which undoubtedly contributed to a lesser extent of contagion.

Similarly, it is important to note that the degree of compliance with the guidelines, both mandatory and non-mandatory, provided by the health authorities in Galicia was very high, and higher than in other regions. The percentage of refuseniks and non-vaccinators was lower. This fact has logically helped to keep the volume of infection low. We believe that the degree of resilience of the Galician population is higher, and

the capacity to withstand isolation is also higher than in other parts of Spain (Carballosa et al. 2021, Miramontes Carballada and Balsa-Barreiro 2021b).



a)



b)

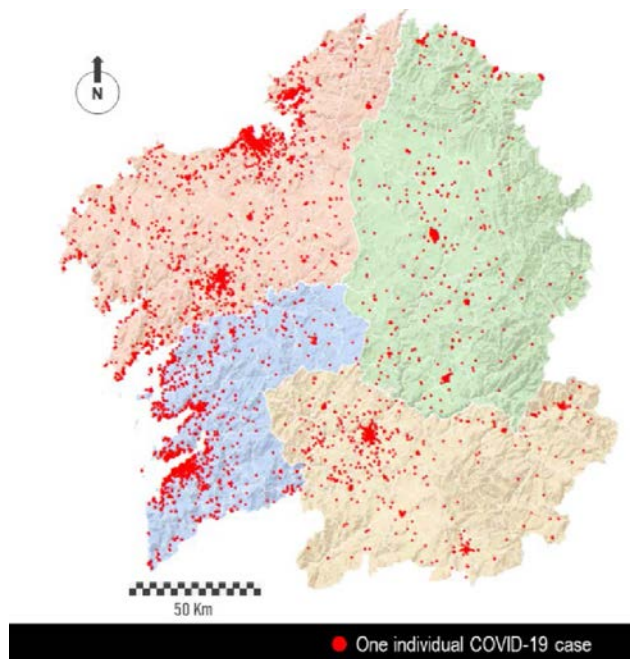
Figure 2. Incidence of COVID-19 in (a) Spain, and (b) Galicia during the first pandemic wave  
Source: Centro Nacional de Epidemiología (2020)

Finally, it should be borne in mind that during the confinement and throughout the pandemic, many of the family homes in "la aldea" (as the traditional family home is called in Galicia, where several generations can still live together) or second homes became main homes. The ability to telecommute and the possibility of commuting a certain number of days to work were key factors in explaining this process. The choice was made to convert "village" housing or secondary residences into primary residences, and many people were provided with internet access in them, when before the pandemic they did not have it. Once again, the Galician particularity of the strong link with the land and the rural environment meant an important economic and social capital in reserve that implied a better situation a priori than in other territories to face the challenges of the pandemic (Miramontes Carballada and Balsa-Barreiro 2021b).

The analysed data indicate that the spread of the coronavirus is mainly associated with urbanisation. Most of the COVID-19 cases were concentrated in more urban Galicia. One out of two cases was registered in one of the seven main cities. Most were



concentrated along the Atlantic Urban Axis, which links five of the seven main cities. In fact, these five cities alone accounted for 36.9% of the cases. Outside this axis, the municipality of Ourense accounted for almost 10% of all cases, which in some way confirms the existence of a second axis of spread of the virus over the territory. As for urban municipalities, Lugo and Ferrol were the least affected with only 3.4% and 2% of cases respectively (Figure 3). It clearly shows a high incidence axis (N-S) in the westernmost sector of the region, and a secondary axis with a SE-NW direction, with less continuity, which would link the urban region of Ourense with the Atlantic Urban Axis. In general, the western and southern sectors of the region show much higher incidence patterns than the rest.



*Figure 3. Territorial incidence of COVID-19 during the first pandemic wave  
Representation of each of the registered cases by nodes. Each node corresponds to an officially reported case.  
The geolocation of cases is based on the residence of the infected person. Source: SERGAS (2020)*

As it can be seen in the map, the first thing that stands out is the absence of red dots in certain areas, which correspond to mountain areas. Particularly noteworthy are the Central Massif of Ourense and the Eastern Sierras of Galicia, as well as the lands of the Galician Ridge. On the other hand, the point cloud is denser in the surroundings of the main cities, and clearly outlines the Atlantic Urban Axis, which extends from Ferrol towards the Portuguese border. The correlation between the degree of urbanisation and the structure of settlements can be seen very clearly in the surroundings of the city of Ourense, southwest of the capital, where we find high population densities. In contrast to Ourense, the other provincial capital of inland Lugo, where there has been



practically no peripheral spread of urbanisation, the area is much more compact.

If we now look at the second map, drawn up with the heat islands, we can see perfectly well what we have just indicated, as well as the importance of the layout of communication routes in general and of the Atlantic Urban Axis, structured by the AP-9, in particular.

### Results by municipality

Aggregating data by municipality allows for a clearer picture of actual incidence. Figure 4 shows how the impact is concentrated in the most important cities, but also in a number of adjacent municipalities. These municipalities concentrate most of the industrial and logistic activity in cities and a very important part of the residential land for many citizens who commute daily to work in the nearest cities. These are areas with great economic diversity and high levels of human mobility, being the origin and destination of a large number of daily commutes (Pazos-Otón et al. 2015, Miramontes Carballada and Balsa-Barreiro 2021b, Varela Cornado and Pazos Otón 2022).

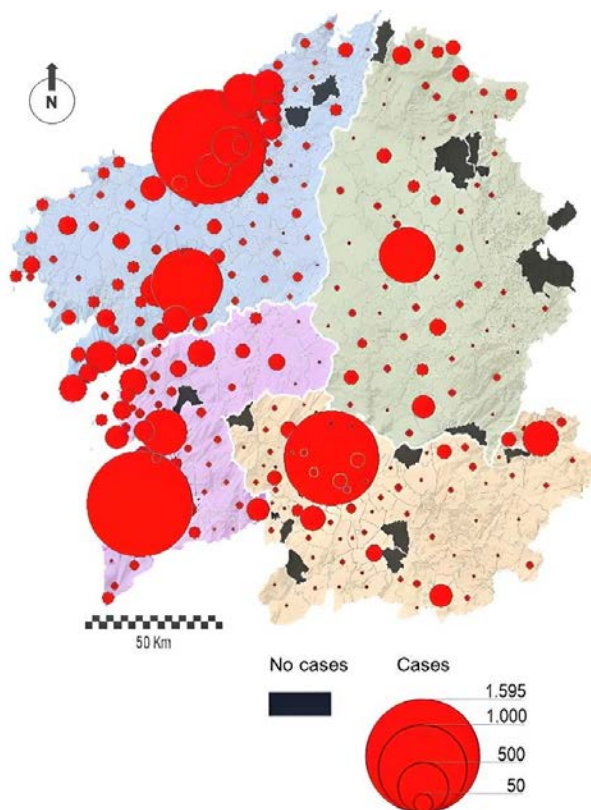


Figure 4. Territorial incidence of COVID-19 during the first pandemic wave. Total number of cases at the municipal level. Source: SERGAS (2020)

In addition, the group of municipalities shaded in black are particularly significant, as they correspond to those municipalities in which no cases were recorded during the first wave. Most of these municipalities are located in mountain and high mountain areas, where the dispersion of the population centres is greater, as well as the absolute population itself and the population densities are among the lowest in Galicia. It is also interesting to note that many of those in the first quartile correspond to mid-mountain areas, with low population densities. These are the municipalities located on the border of the provinces of A Coruña and Lugo, mainly belonging to the mountainous area known as the Galician Ridge. This incidence per 100,000 inhabitants shows a much more heterogeneous territorial pattern, especially in the case of the province of Ourense, where many of the municipalities with higher and lower relative incidence are located.

The idea that COVID-19 was a pathology closely linked to the urbanisation process is confirmed if we take into account that the two municipalities with the highest cumulative incidence during the first wave are the two most populated. A Coruña concentrates 14.7% of the total cases and a cumulative incidence of 649.1 cases per 100,000 inhabitants. Vigo concentrates 12.1% of the cases and a cumulative incidence of 444.5 cases per 100,000 inhabitants. In Vigo, the spread of the virus extends throughout the entire urban area (Figure 5).

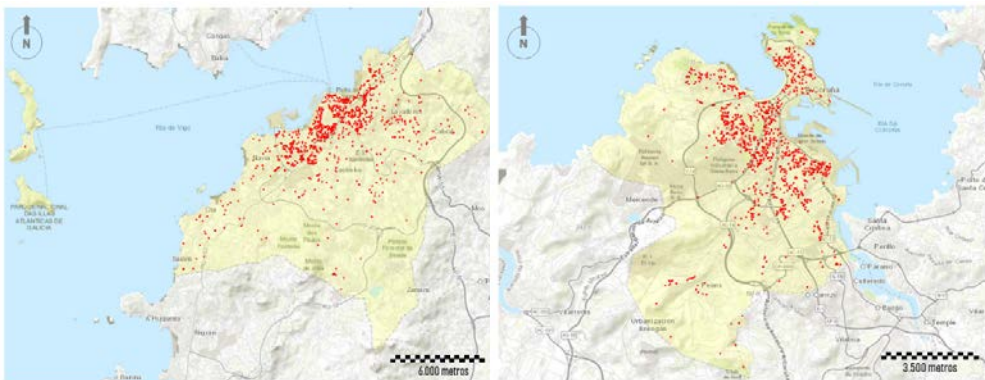


Figure 5. Cases of COVID-19 registered in the two most populated municipalities in Galicia  
a) Vigo, b) A Coruña. Each reported case is represented by a red dot  
Source: SERGAS (2020)

These two cities also correspond to the two main health areas of Galicia, and they have the most complete hospital, medical and care facilities in the region. However, the large number of cases registered in the two main cities of the Galician urban system meant that the emergency hospital care units reached some of the highest saturation levels in Galicia.

On the other hand, in the case of Vigo, it is interesting to note that the spread of the pandemic is much lower in the periurban areas than in the central city. The high

population density in the periurban areas surrounding the urban agglomeration is one of the most significant characteristics of Vigo. In all Galician cities it is a notable phenomenon, but it is in Vigo where we find a more important rururbano, with more than 70,000 inhabitants. This type of settlement is a hybrid between urban and rural spaces. The dwellings are located very close to the central city of Vigo, but their characteristics are more reminiscent of rural spaces. In most cases, the dwellings are single-family homes with adjacent agricultural or livestock plots. Evidently, this minimises population interactions, which reduces exposure to contagion.

For future work, it would be interesting to relate the level of e-commerce use in times of pandemic to the level of urbanisation. Given that urban areas have a higher penetration of broadband and greater use of the internet, it seems logical that they would have made greater use of e-commerce to stock up on basic (and secondary) products during the hardest moments of confinement. Similarly, urban spaces are characterised by a younger demographic structure, another variable that correlates positively with the use of the internet and e-commerce in particular.

From a territorial perspective, the highest virus rates were concentrated around major cities with high population densities. In addition, these same suburban areas are home to most of the industrial and logistical poles. These are areas with a relevant economic diversity and high levels of human mobility, being the origin and destination of a large number of daily commutes. Figure 6 shows the change in mobility due to the impact of the virus and the implementation of restrictions by the central government. It can be seen that many of the patterns of the spread of the virus partially correspond to the predominant direction of presented mobility flows.

The summary of these mobility datasets corroborates to the fact that the largest reduction in mobility occurred in April 2020. According to origin and destination flows, the number of flows and total distance travelled decreased by around 55 per cent and 60 per cent, respectively, in April 2020 compared to November 2019. The recovery was very slight in May, and even in June, while mobility was still about 25 per cent lower than in November 2019. In terms of the average distance travelled per trip, it can be seen how this fell considerably from 7.8 km to 7 km on average at the most severe time.

The mobility maps based on origins and destinations actually show this drop in absolute mobility flows from November 2019 to March 2022, and a recovery is also observed in the third moment – June 2020. Between the first and second moment, not only the weakening of flows is striking, but also the reduction of arcs and linked nodes. Topologically, the network is simpler.

One could say that there is a shift from a classical "network" model of relationship to a more "Christallerian" model, based on the primacy of central places, which regain their nodal character by eliminating non-relevant displacements.

Mobility as Central Element in the Covid-19 Pandemic: From Acceleration to Containment.

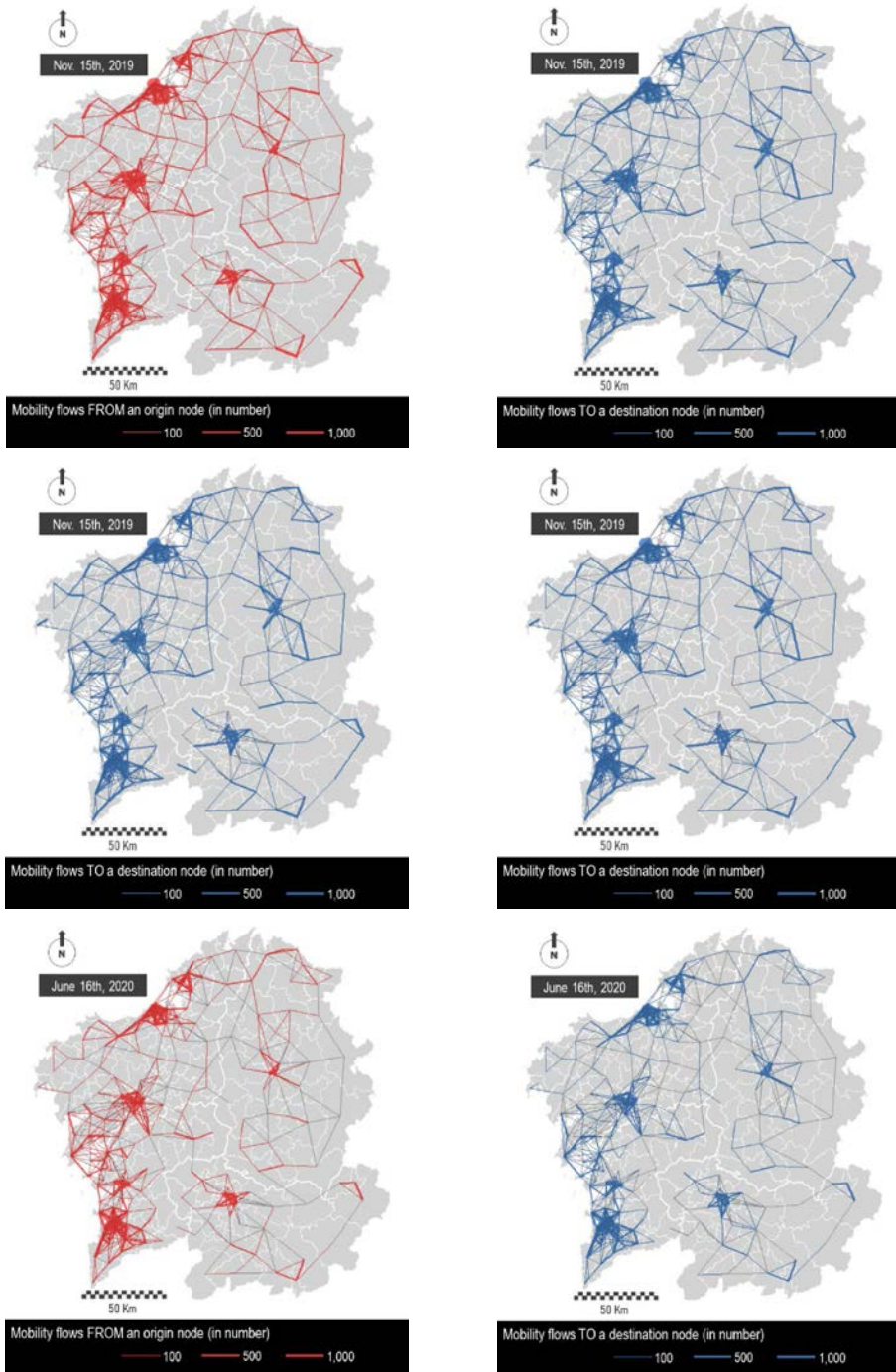


Figure 6. Mobility flows during the COVID-19 pandemic. In red, the flows are represented considering an area of origin mobility. In blue, the flows are represented considering a destination mobility area .  
Source: INE (2021)

In other words, in a normal situation, the reasons for movement increase, leading not only to more mobility, but also to a diversification of origins and destinations. Confinement, and the mobility restrictions that it brought with it, implied a simplification of main mobility patterns, which can be seen in the mapping presented here.

## Discussion

The emergence of the COVID-19 pandemic in 2020 required the forced adoption of non-pharmaceutical interventions and other measures by the national authorities. Similarly to other pandemics in the past, these mainly focused on social distancing and major constraints to human mobility. In this paper, we analyse the relationship between human mobility and the spread of COVID-19 during the first wave (March to June 2020) in the region of Galicia. For this purpose, we use detailed data on all reported infections and mobile phone data (Miramontes Carballada and Balsa-Barreiro 2021a).

The results show a clear correlation between the reduced mobility and the reduced transmission over time. On a larger scale, territorial complexity and regional specificities explain differences in virus transmission, but also uneven mobility rates across the region. Ideally, policy makers and health authorities should design interventions and responses to the current COVID-19 pandemic, or any other potential future infectious disease, according to the particularities and the geographical complexity of each region (Flandoli et al. 2021).

Mobility restrictions should be based on territorial characteristics and take into account the territorial heterogeneity at different scales. The authors would encourage a better communication between different levels of governments and authorities, as well as the free availability of detailed data that could help achieve the most optimal responses, which in turn would result in better management for society as a whole (Desjardins et al. 2020, Dong et al. 2020, De Cos Guerra et al. 2021). Future studies should focus on disentangling the correlation between human mobility and the spread of the virus at any spatial scale and attempt to resolve the territorial complexity and intrinsic mechanisms behind it.

## Conclusions

In mid-March 2020 in Spain, the national authorities declared a State of Alarm, a constitutional mechanism allowing for the concentration of powers in the executive, in order to take swift action to tackle the spread of the coronavirus. The State of Alarm was subsequently renewed periodically by the Congress of Deputies. On 14 March, a house lockdown with strict mobility restrictions was decreed. Work activity was reduced to very few essential activities related to human care and the purchase of



primary commodities. Between 30 March and 9 April, only essential workers were allowed to travel for work. Most businesses related to non-essential activities, as well as cultural and religious facilities, were closed.

As discussed in the previous chapter, Galicia was the first Spanish region to ease mobility restrictions and return to pseudo-normality. This was done in four different phases. On 4 May, some businesses and activities were authorised, mostly outdoors. Two weeks later, restaurants and some shops could be opened, but with some partial restrictions on capacity. Human mobility was limited in each province. On 15 June, the region began a "new normal" with no restrictions on mobility.

In this context, the first cases of the virus detected in Galicia were imported from other regions of Spain, especially Madrid, which was initially the main focus of infection. Transmission flows were determined by land transport routes and the radial design of infrastructures with Madrid (Balsa-Barreiro et al. 2019). The significant difference in the levels of virus incidence in the two eastern provinces, which have similar demographic structures, could be explained by this radial road design and the relationship of the provincial capitals with the Atlantic Urban Axis, being much more intense in the Ourense-Vigo axis.

As the virus circulates within the system, internal mobility flows and territorial structure are determinant for understanding the actual spread of the virus. The temporal analysis of human mobility allows us to verify the dynamic correlation between the virus and its territorial impact.

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