Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Introduction: Territorial analysis and reflexive mapping on the Covid-19 infection

Emanuela Casti

1 Context

On February 24, 2020, when the Italian media announced Italy’s entry into an epidemic phase from Covid-19, territorial analysts believed the matter did not concern them: The epidemic was a biomedical issue and researchers only involved doctors, virologists, or epidemiologists. However, evident territorial differences that the virus presented in its expansion and spread soon outlined a differentiated and anisotropic epidemic space, which attracted their attention. After a few weeks, when the region of Lombardy became the European epicenter of Covid-19, doubts vanished: Territorial analysts were to enter the field and provide their expertise to try to understand what was happening in their territory.

Faced with a new and unprecedented challenge, a group of researchers in Bergamo set up a study based on three features, namely, implementing a database on socio-territorial information and on the epidemic, with a view to mapping such information and obtaining spatialized data on which a set of initial hypotheses could be based; taking into account the spatiotemporal characteristics of the Covid-19 spread and interpreting them in light of geographical theories; and applying semiotic theories to the construction of a reflexive mapping for facilitating an interpretation of the phenomenon.

This introduction provides a brief account of how research progressed and traces our gradual realization that the epidemic was well beyond the purview of virology: Rather, it was a social event whose spatial implications expose the fragility and the most vulnerable sides of contemporary living.

2 Epidemiological data and the issue of sources

The first research obstacle was the reliability of data on the Covid-19 infection issued by the Italian Ministry of Health after being collected by regions and other territorial bodies (such as provinces, municipalities, and regional health services). As they were issued by territorial

*Contagion data used in this research come from the Presidency of the Council of Ministers-Department of Civil Protection (http://opendatadpc.maps.arcgis.com/apps/opsdashboard/index.html#/b0c68bce2cce478eaac82fe38d4138b1). However, some of these are provided by the Higher Health Institute (Istituto Superiore di Sanità) and were made machine readable thanks to OnData processing (see https://www.epicentro.iss.it/coronavirus/sars-cov-2-surveillance-data).
agencies whose main responsibilities did not include statistics, such data lent themselves to oversights and relied on a range of different survey methods. Although, as laid out by the Italian Constitution for states of emergency, antiepidemic measures were centralized and issued directly by the Council of Ministers, their applications were managed locally by the regions, with notable differences over testing and preventive or operational measures for disease containment. Processed at the local level by local health authorities (ASLs), data were sent to each region’s central department and from there to the Ministry of Health, which was in charge of disseminating them in an aggregate form at the national level. However, as the epidemic raged, difficulties in data transmission arose, that is, information was delayed, dispersed, or was simply incomplete. Moreover, it was interpreted in ways that differed from the diagnostics used. Furthermore, such data applied only to a particular and limited portion of the population, for they referred exclusively to people who were being hospitalized and thus to sick individuals who presented symptoms. Therefore, data were collected upon hospitalization, and the recorded data showed the evolution and outcomes of the disease (such as mortality, severity of intensive care, or otherwise.) Then, these data were assembled with diagnostic information on individuals confined to their homes with mild symptoms or on asymptomatic individuals. In the first months of the epidemic, data assessment occurred only at the hospital level. This meant that even plain cumulative data on daily infections were unreliable, since diagnostics were carried out only on a section of the population and varied in size depending on the swab testing that individual regions performed and on the results that they actually forwarded to the Ministry. This led some researchers to question the reliability of data: to cast doubt on the actual extent of infection and to challenge the legitimate use of such data for deriving exact infection indicators.

However, the objective pursued in our research, which is to investigate contagion in relation to territorial features and not as a virological phenomenon in its own right, places less importance on numerical data accuracy. Our aim was rather to sift such data for clues to outline trends that could be significant even despite epidemiological approximation.\(^b\)

Data dearth was partly compensated by a number of key secondary sources, such as scientific blogs, collective databases, shared online platforms, and qualitative data made public by large web operators. Initially, these sources made up for the lack of reports and studies on the epidemic, which various institutional bodies were still assembling. This made it possible to kick-start comparison and complementary information research.\(^c\) A noteworthy instance among the many in Europe is Medium, an online platform that enables users to publish

\(^b\)This goal was set after due consideration of opinions by biomedical experts, who first interpreted data, and by statisticians, who compensated for the lack or scarcity of data by building models derived from comparative data collected before the time of the epidemic.

\(^c\)Wikipedia or Google have also made available a series of reports on changes in people’s travel habits during the pandemic. See https://www.google.com/covid19/mobility/; in addition to institutional data by the Ministry of Health and the Higher Health Institute (2020), http://www.salute.gov.it/imgs/C_17_notizie_4766_0_file.pdf; the Office for National Statistics (ISTAT) and the Higher Health Institute (2020), https://www.epicentro.iss.it/coronavirus/pdf/Rapporto_Istat_ISS.pdf; the Higher Health Institute (2020), https://www.epicentro.iss.it/coronavirus/pdf/sars-cov-2-survey-rsa-report-3.pdf; and the National Environmental Protection Agency (ISPRA) (2018), https://www.isprambiente.gov.it/it/pubblicazioni/stato-dellambiente/xiv-rapporto-qualita-dell2019ambiente-urbano-Edizione-2018.
content also aimed at interdisciplinary scientific dissemination. Another example of communication along these lines is the Groupe d’Etudes Géopolitiques (GEG) founded by the École Normale Supérieure in Paris to advance interdisciplinary reflection on European geopolitics. GEG studies tap data from a range of disciplines (such as geography, philosophy, economics, sociology, and literature) in a transnational and multilingual perspective. They involve several universities and écoles, in particular, the École Polytechnique, Science Po and Paris IV, and the Sorbonne.

Our research also tapped a new technology, such as algorithm-driven processing of Big Data, which proved effective, even though it was mostly applied to a limited number of socio-territorial features, such as mobility or pollution.

Ultimately, the pandemic caught us unprepared with regard to sources of territory-based research and forced us to operate on an analytical basis, which has yet to gain firm grounding. While aware of the possible risks that such a procedure entails, we have deemed it prudent to include it in our analysis of the broader aspects of the contagion and of more circumstantial socio-territorial features. With regard to the former, we believed it was crucial to first address the space–time dimension.

3 Stages of virus propagation in relation to social and territorial factors

As we dwell on this feature of the Covid-19 infection, we will attempt to find investigative leads on the example of what happened in Italy. We should first underline the rapid onset of infection: Discovery of the first Covid patient at a specific location was followed within barely a few hours by reports of other Covid patients elsewhere. At first glance, the reported sites presented no evident similarities. However, they did seem to share at least one localization feature: They were part of peri-urban areas across the great Po Valley conurbation of Northern Italy. This is the most densely populated area in the country, the most economically vibrant, and the one boasting an advanced health-care, diagnostics, and hospitalization system. The territory is divided into regions (namely, Lombardy, Veneto, Emilia-Romagna, Piedmont, Val d’Aosta, and Liguria) administered by different political parties. These are complex features, which we will systematically address in this volume.

If we temporarily disregard the localization of outbreaks and instead focus on the spatial diffusion of infection, we are struck by the speed whereby the contagion spread.

---

\(d^{4}\)The platform, created in 2017, played an important role during the pandemic by bringing together European researchers and universities. See the Medium website, https://medium.com/. Institutions that use this platform include the Ecole Urbaine de Lyon (https://medium.com/@ecoleurbaindelyon), the University of Oxford (https://medium.com/@Oxford_University), and the MIT Technology Review (https://medium.com/mit-technology-review).

\(e^{4}\)In view of the current health emergency, the Medium Group set up the Observatoire Géopolitique du Covid-19, which publishes daily data updates on the evolution of the epidemic along with studies, maps, interviews, and reports related to the pandemic. See https://legrandcontinent.eu/fr/observatoire-coronavirus/.

\(f^{4}\)Data related to the insurgence of Covid-19 hotspots in Lombardy suggest a connection, if not an actual reticularity model, between outbreaks, as also attested by the sporting events that took place in the weeks before infection hotbeds were recorded. See Chapter 5 of this volume.
Unsurprisingly, therefore, infection speed will be a crucial factor in our analysis of the pandemic.\textsuperscript{8} Infection speed rate is a highly relevant variable for effective control of the epidemic, since, as epidemiologists remind us, Covid-19 is a respiratory infection that occurs by contact between individuals in urbanized and high-mobility environments, where viral propagation is notoriously swift. Therefore, the temporal aspect of the contagion was monitored within our research model by factoring speed in the spatial diffusion of infection in relation to measures being taken to contain it. Following WHO guidelines for identifying epidemic phases,\textsuperscript{h} we broke down the first phase of Covid-19 in Italy into three phases, namely, first, an onset phase, when first cases were reported and the existence of infection hotbeds or hotspots (i.e., tangible threats of epidemic spread to an entire community) was ascertained; second, an epidemic phase, when infection peaks were reached; and finally, an endemic phase, when the number of infected individuals decreased without disappearing (Fig. 1).

The duration of these phases and the speed of propagation differed as follows:

- The onset phase and the localization of hotbeds may be placed between February 24, 2020, when the first outbreak was ascertained, and the beginning of March, when the epidemic entered the epidemic phase.\textsuperscript{i} It should be stressed that since this first phase, contagion patterns outlined a subdivision of Italy into three distinct zones, with an epidemic epicenter located in the north, in the Po Valley, where it remained throughout the entire spring wave of Covid-19. Subsequently, the contagion spread to neighboring territories in the north, but the intensity and severity of infection recorded in this region did not extend to the rest of Italy.\textsuperscript{k}

\textsuperscript{8}It is precisely this ability to spread quickly across a large number of territories that led researchers to define the SARS-CoV-2 virus and the resulting Covid-19 infection in terms of pandemic. See Jackson (2020).

\textsuperscript{h}The World Health Organization (WHO) and the Center for Disease Control and Prevention of the United States (CDC) have codified epidemic phases in these terms: (1) emergence of a new microorganism dangerous to humans; (2) identification of contagion cases; (3) onset of a globally widespread infection; (4) acceleration of the pandemic wave, with an epidemiological curve pointing upward; (5) progressive and steady decrease of cases; and (6) end of the pandemic and at the same time beginning of the preparedness phase to further waves. See https://www.who.int/influenza/preparedness/en/ and https://apps.who.int/iris/bitstream/handle/10665/259893/WHO-WHE-IHM-GIP-2017.1-eng.pdf?sequence=1.

\textsuperscript{i}From a territorial point of view, a hotbed should be understood less in terms of the first recorded case of infection than as the site where a number of symptomatic individuals who may be traced back to one suspect case are found: These might spread the virus and threaten an entire community.

\textsuperscript{v}Virologists have estimated a duration of between 1 and 2 weeks for this coronavirus phase. In Italy, the phase occurred in sequential periods affecting Northern Italy between the end of February and the beginning of March and, subsequently, the entire peninsula, apart from a few internal regions and the islands, where the contagion emerged a few days later.

\textsuperscript{k}Only during the second wave, that is, the fall phase, did contagion spread relatively homogeneously throughout Italy, even though Lombardy held a sad record in that respect for most of the time. See the report published by the Office for National Statistics (ISTAT) and the Higher Health Institute (Istituto Superiore di Sanità) in December 2020, available at https://www.iss.it/documents/20126/0/Rapp_Istat_Iss_FINALE+2020_rev.pdf/b4c40cbb-9506-c3f6-5b69-4cbb5f015172? T = 1609328171264.
from the rest of the peninsula, also make it the most polluted region in Europe. Settlement issues would also have to be addressed, given that the Po Valley has a high population density and marked territorial connectivity, which are unique features in the national setup. High people mobility, especially the mobility of commuters whose reliance on collective public transport creates crowding and who remain at close contact indoors even for protracted periods, was an easy clue for explaining viral transmission.

- The fast and pervasive spread of the epidemic quickly revealed the severity of Covid-19 and its ability to undermine both health care and normal social and economic functions in Italy. A series of factors affected its progress, including the lack of social distancing among commuters, the difficulty hospitals faced in coping with a high number of patients, the inadequacy of the local health system – most notably in the region of Lombardy – and, finally, the inefficiency of the health-care system for the elderly, which caused a serious and forceful spread of infection in nursing homes and residential care facilities. In Italy, the epidemic phase began in the first half of March, whereas the peak of infection was recorded at the beginning of April and remained high till the end of the month. Even at this stage, the severity of infection recorded in Lombardy, especially in the province of Bergamo, was unmatched elsewhere in Italy.

FIG. 1 Stages of virus propagation at different speeds in relation to social and territorial factors.

On the issues of pollution and globalized living in the Po Valley, see contribution in the Chapter 4 of this volume.

Hospital system diversification across Italian regions and in nursing homes (such as the Nursing and Residential Care Facility—RSAs) is discussed at length in Chapter 5 of this volume.
• We finally get to the endemic or decrease phase, occurring at gradual speeds, and arguably traceable to social-distancing policies and other competing factors. A nationwide lockdown in Italy was decreed on March 9, 2020; its effects led to a slow and fluctuating decline in infection, which lasted until the end of June 2020\(^n\). At the time, containment strategies were adopted with a view to a progressive reopening by May 18 and without waiting for a complete disappearance of the virus, which virologists believed might be achieved solely by administering vaccines (Jackson 2020). In the meantime, however, the development of therapeutic protocols, the start of the summer season, and the organization and implementation of diagnostic tests favored a reduction in viral circulation and marked the end of emergency.

Overall, the first epidemic wave in Italy covered a period of 4 months (from February 24 to June 24, 2020) with markedly diversified outcomes across the Italian regions attributable to socio-territorial factors. We will dwell on such factors, after the range of empirical data discussed so far has been duly corroborated against a theoretical framework.

4 Theoretical grounding and spatial dimension of the virus

Scientists by now largely agree that in order to understand and interpret social phenomena, one must account for their spatialization: Where it is things happen is crucial to understanding how and why they happen. Although this spatial turn has undeniable interdisciplinary repercussions (Warf and Arias, 2009) for coming to terms with the complexity of social reality, for geographers it marks a unique opportunity for reassessing methodological priorities. The Covid-19 epidemic occurred at a time when this perspective had already been verified, and equipped with analytical methods to meet the challenges in the field of Geography.\(^o\) There, the spatial turn theory had not been considered exclusively as yet another recognition of the importance of localization in social phenomena, but rather as an acknowledgment of the relevance of geographical analysis itself, which has traditionally aimed to unveil territorial action as the foundation of territoriality, that is, of the ways in which a given society functions. In short, the configuration of territories was no longer assumed as a background canvas, but rather as one of the distinctive causes of the contagion, given that the contagion did vary in terms of propagation rate and intensity of the Covid-19 virus across different areas.\(^p\)

Having embraced territoriality as an analysis plan, we also took up the assumptions that living in the contemporary world is mobile and urbanized and that it unfolds in the intertwining nodes and connections outlined by the dynamic movement of inhabitants, as they endeavor

\(^n\)On this issue, see Chapter 6 of this volume.

\(^o\)The responsible pathogen, named SARS-CoV-2, was first reported in the Wuhan area of China in December 2019. It turned into a pandemic in <3 months. It led to lockdown measures, which affected half the world’s population, in attempts to limit viral spread and to ease pressure on health systems.

\(^p\)Marco Maggioli defines spatiality as a set of conditions and practices linked to the placement of individuals and groups relative to each other. Conversely, he defines territoriality as a process built on the forms, structures, and assets of a territory, which individuals themselves have helped shape (Maggioli, 2015, pp. 51–66).
to organize their daily lives not only solely in places where they live but also by interaction with global network systems (Lévy, 2008). Therefore, mobility is of great importance in the contemporary world. The dynamics triggered by a continuous flow of people and information amplify and accelerate the space–time cadence between days and nights, weeks and weekends, and the passing of seasons. In turn, altered cadences transform places where individuals live or connect, either in person or virtually. This pattern of living, defined as *urbanity*, is a conspicuous feature of contemporary living. As such, it entails a radical change in the analytical perspective because it shifts our attention from the materiality of territories to the action of their inhabitants (Djaiz, 2020).

It is worth noting that the notion of *urbanity* is not directly or merely related to that of *urban*. Rather, it defines a specific mode of living, not sedentary but mobile, expressed by inhabitants seen as *city users* who are simultaneously connected on multiple scales (Lussault, 2007, 2017). Along similar lines, cities should no longer be viewed in terms of a binary duality of center vs periphery, but rather as systems grounded on mobility, that is, as nodes of a mesh where the dynamics of local and global living intertwine (Hall and Pain, 2006; Soja, 2000). Therefore, the global space of urbanity appears as an extremely pervasive phenomenon, capable of materially integrating within one territory a wide range of systems, such as residential, productive, cultural, and service-related, which differ in terms of density and diversity. Ultimately, people’s new mode of inhabiting places takes shape in widespread *urbanization*. This certainly affects contagion, which is amplified by mobility and inevitable crowding in public spaces and becomes the visible expression of social dynamics, whereby a range of interests, services, and modes of experiencing urbanity (Lévy, 2020; Lussault, 2020) converge on a place.

In accordance with this approach, the territorial features involved in the contagion were not considered here individually, but in relation to each other. Hence, population density was analyzed in relation to mobility, pollution was related to morphological and climatic conditions, and health-care systems were viewed in connection with population, hospital types, and care management models. As we addressed such conditions, we also zeroed in on factors that may have favored the contagion, such as persistent pollution and impaired air quality, or on situations that involved crowding, which made isolation difficult: These features were defined as instances of “territorial fragility,” which research must adequately address in order to design new habitation models equipped to face epidemics. On the basis of this complex tangle of issues, we set out to interpret the devastating outcomes of the contagion in Lombardy.

From the start, it was clear that all the aspects mentioned above are in fact significantly present in Lombardy. Extensive population density in the metropolitan area of Milan spreads to the rest of the region across many medium or small towns. What ensues is a multidirectional and rhizome-like pattern of commutes, which creates ideal conditions for an intensification of infection. In short, urbanity enables us to take the dynamism of inhabitants and the complexity of urbanization as two sides of the same coin: a territorial system based on

---

4. Theoretical grounding and spatial dimension of the virus

---

4 See the Conclusion chapter of this volume.

5 To be sure, a thorough explanation of Lombardy’s very high mortality rate will have to await results of biomedical and epidemiological research still under way. As of now, however, it can be argued that a contributing cause for this outcome was the inadequacy of the health-care system in coping with the very high numbers of infected people and the management of some Nursing and Residential Care Facilities (RSAs).
mobility that amplifies the contagion in times of a pandemic because it promotes crowding in public spaces.

Taken separately, inhabitant mobility or population density may not be classified as factors facilitating the insurgence or the spread of the virus, as we were hastily led to suppose. They do become such, however, if taken in conjunction, when they in fact expose multiple systemic fragilities. Similarly, pollution not only depends exclusively on atmospheric emissions but also involves factors that may prevent pollutant dispersion, such as climatic and/or morphological features. Finally, with regard to the ability to tackle the epidemic and limit its most devastating outcomes, it would be misleading to label and blame health-care or assistance facilities as quantitatively deficient. In fact, it falls seriously short of considering the diverse range of health-care policies adopted by the regions, which in times of an epidemic did make a difference.

In short, adjusting our theoretical scheme to epidemic data for Lombardy enabled us to address the space–time dimension of Covid-19 spread as a key factor, and showed us how to interpret contagion data relative to Italy as a whole (Fig. 2).

5 Geographical implications of the contagion and Italian outcomes

Our analysis was developed along three main axioms, derived from the temporal and dimensional features of the contagion, namely, (i) outbreaks, (ii) diffusion, and (iii) intensity. As research continued, a fourth axiom was added, which was related to the severe manifestation of epidemic contagion in Lombardy (Fig. 3).

The typology and development of a contagion, in relation to both territories and peculiar features of infection, have outlined a space–time map. Such a map highlights the insurgence of the disease in the north and its persistence in the region for the entire duration of the epidemic wave, in ways that are substantially different from the rest of the country.
The initial outbreaks in Italy were of course identified in the regions of Veneto and Lombardy. However, while the Vo’ Euganeo outbreak in the Padua area was easily contained, the Lombard outbreaks of Codogno in the Lodi area and those of Alzano Lombardo-Nembro in the Bergamo area have urged us to reflect on the need for swift action, unhampered by other questions or financial concerns over the cost of localized closures, especially where a given geographical setup makes it possible to contain only the infected area.

Two diffusion dynamics were detected, namely, (1) by proximity, when the virus spreads in neighboring places and (2) by reticularity, where propagation occurs via people who live in different places and come into contact as they move. The Po plain outbreaks, monitored via sporting events, ultimately suggested that both dynamics were in fact present during the first epidemic wave and that they involved small towns more than large agglomerates.

Onset phase data were later cross-referenced to data on the next phase, or the epidemic phase. With an eye on the intensity and gravity of Lombardy’s case, we associated the contagion to population composition at the Italian level, thereby obtaining data on the most affected age groups. Of these, the most relevant was a division of the Italian nation into “Three...

---

*A small municipality of about 3000 residents based on cluster typology settlements (hamlets) and a secondary road network. The town was restricted and quarantined. Tests were periodically carried out to ascertain infection and study contagion trends, which led researchers to discover a possible viral transmission even via asymptomatic subjects.

†In an effort to understand viral spread, researches cataloged events (initially sporting events) that caused gatherings in the weeks immediately preceding the health emergency. See Chapter 5 in this volume.
Italies’ or zones, based on the intensity and severity of the contagion reported at the national level. This difference remained unchanged throughout the first epidemic wave, as shown in Fig. 4 and as discussed in detail in the relevant chapter. Italy’s three zones outline a geographical model that may not be explained virologically; rather, it depends on spatial differences connected to features such as pollution and rhizome-like commute patterns and to different degrees of urbanity, which call for further study.\textsuperscript{u}

In short, the distinctive socio-territorial factors of the Po Valley, not to be found in their complex configuration elsewhere in Italy, have corroborated our initial research hypothesis, namely that, territories influence speed of infection and viral intensity. To be sure, this conclusion does not come directly from knowledge of the virus and is derived from spatial factors of the affected regions. It may not solve the underlying questions or compensate for the lack of virological expertise. However, it does set out a research path that is hard to escape; this path leads us to postulate the incompatibility of contemporary living with pandemics and forces us to look for viable solutions.

At that point, all that remained for our research was to address the need to disclose and disseminate results and to publish the bulk of cartographic documents we had produced in order to reach them. Spatialization of epidemic data and cross-referencing with various socio-territorial features had been achieved via \textit{chorographic mapping}: a set of representations...
that functioned not merely as localization tools but as complex depictions that alluded to a cultural and social sense of territory, and could thus be effectively used to ground our research. All that remained was to make them widely available, along with a suitable set of directions for their interpretation. That would be done via online resources and representation toolsets of cybercartography.

6 From GIS to reflexive mapping

In the first months of the contagion, persistent but cursory references to cartography made by the media to communicate or explain the spread of the epidemic led us to envision maps that, setting aside trivial localization functions assigned to them by the media, would raise topography to the level of chorography: a reflexive mapping able to assemble both epidemic and social data based on constructive cues from cartographic semiosis (Casti, 2015).

This theory postulates that once the field has been cleared of neo-positivist assumptions whereby maps are objective and neutral tools, representations will play a crucial role not so much and not only as descriptors of the world but also as blueprints for modifying the world, thanks to the interpretative toolsets they provide. In other words, maps are given a mediating role between reality and representation, whereby reality itself can be actively shaped.

If we were to disregard this today and consider maps merely as one of the many modes of representations, which make up the image of the world, we would be grossly shortsighted. Representation obviously has its purpose, but its strength does not end in setting forth a sign system capable of conveying in an orderly manner what would otherwise appear too complex. Rather, what helps us to understand why representations are so essential in the relationship people establish with their world is the fact that the world actually takes shape through them. In short, a cognitive act is already a selection of attributes among possible others. However, this act is transformed and becomes interpretational when it is recognized as an instance of representation: a model that must necessarily rely on a sign system in order to express itself.

Therefore, as we enter the semiotic field to pursue this line of inquiry, what we need to stress is that every representation presupposes the adoption of a sign system capable of transmitting information. The next step is to become aware that not all representations must be placed on the same level with regard to their communicative effectiveness, or rather their ability to convey an orderly model of the world as the only one possible.

There is no doubt: Maps historically figure as the most effective instance of representation in this sense. Not only do they convey an orderly model but they also impose such a model by iconizing it, that is, to say, by setting it forth on the basis of an interpretative theory that varies according to the sign system on which a given map is built. In topography, for example, this

---

v The term “reflexive cartography” is meant to draw attention to the researcher/cartographer as a figure engaged in both the study and the solution of socially relevant issues, including the role played by GIS in empowerment or the potential cultural assimilation brought about by these tools.

w As Bourdieu convincingly argued, the effect of a representation is not based on its objectivity or its subjectivity, since both tend to establish what exists and what does not exist (Bourdieu, 1991).

x That sheds light on Dardel’s conviction that objectivity is not in itself a guarantee of final truth and ought not be accepted without reserve, since modern individuals draw objectivity from their subjectivity (Dardel, 1986).
theory consists in measurement: Objects must be scaled to reality, are located at a precise distance from each other, and respond to abstract symbolization criteria that refer to quantity. All this guarantees an objective and neutral topographical representation, which is as reliable or possibly more reliable than reality itself.

Furthermore, maps seem endowed with another powerful feature: They can generate discourse, that is, they can produce self-referential information not foreseen by the cartographer. Maps have been shown to function semiotically on several communicative levels, so much so that they do not merely invest things with meaning but produce meanings from scratch (Casti, 2000, 2015). This cartographic feature, defined as self-reference, is the actual engine of cartographic communication. Although it is activated by an interpreter, communication here refers to the self-referential working of maps. To use a theatrical metaphor, we may consider an interpreter as an actor on the “communicative scene”, which is directed by self-reference: It is the director who dictates the model whereby interpretation is to be achieved.

Thus, one conclusion seems inescapable: Interpretation cannot possibly be considered as a purely cognitive or, if you will, neutral operation. Rather, to interpret maps is to implement an instance of territorial action, to envisage phenomena that will take shape as they are read out on the map, and to become part and parcel of social knowledge. Think for instance of an interpreter acknowledging the existence of a phenomenon via a map: Such an interpreter simply accepts the map as a mediator and embraces the proposed form of the given phenomenon as the undisputed premise for his own actions. If a map charts a distribution of contagion based on a topographic metric, it records the phenomenon’s relevance based on the metric extension of regions rather than on the number of individuals who inhabit those regions. On the other hand, if we consider inhabitants as the relevant data on the map and distort the dimensions of those areas by expanding or contracting them, we will “humanize” the contagion and show its actual societal import.

In short, once a semiotic perspective is embraced against the strict requirements of accuracy and objectivity typical of topographic metrics, new horizons open up for interpretation. More importantly, new models become available for building maps capable of inducing mediatization, that is, a diffusion and amplification of complex phenomena to be represented, finally shown on the basis of criteria no longer strictly tied to metric dimensioning.

It goes without saying that if this possibility is in fact pursued and the map outcome is adjusted, manipulated, or tweaked while the map is constructed, ethical precautions must be taken with regard to interpreters. In the first place, choices, techniques, and aims must be explicitly stated and made transparent. It should be stated clearly that maps will be adjusted to reflect a specific goal, namely, not to provide an objective or neutral representation of the world, but to put forth a model of world phenomena grounded in their social relevance and complexity.

To avoid feeding false expectations, we should make it clear that what is presented here is not meant to fully address the radical (but also practical) question of laying out new principles or providing prescriptions on how to set up a new cartography. Rather, our aim is to provide an overall view of contemporary experimentation in the realm of cartography: a variegated and complex scenario, and a harbinger of new perspectives.

This book also proposes a cartography that alludes to the social sense of territory by distorting the topographic map base, implementing it, and treating it via choices and techniques, which are dictated by “other” metrics: for instance, “chorographic” metrics, aimed at representing the social relevance of territory. We bring out the communicative potential
of maps via specific tweaks or simple adjustments. In addition, we envision a long-term reflection on the potential adaptation of cartography to a societal view of the world. In short, as we inhibit topographic metrics and reclaim a topology of places, we set forth a model of chorographic metrics, achieved via digital technology, which allows for new interactions between cartographers and recipients and opens up new lines of study on the Covid-19 epidemic as well.

Familiarity with the constructive and communicative mechanisms at work in cartography makes it possible to have an effective recourse to digital and online tools for geographical information. However, the aim is less to use technology for a localized representation of phenomena and more to use their quantitative spatialization in order to convey the qualitative aspects of the contagion, namely, its propagation, intensity, and severity of infection in certain areas. Thus, we will be shifting communication from the depthless level of denotation to the highly meaningful level of connotation. The striking differences whereby contagion-affected regions may be investigated cartographically, via cross-referencing with differences that pertain to the physical, social and local environment. Accordingly, a contextualized framework on a local and national scale may be drawn. As it yields information about the relationship between contagion and socio-territorial systems, this data processing also brings to the surface the fragility of contemporary living that the pandemic has exposed. These are shortcomings tied to structural features that facilitate the contagion, such as pollution, or aspects related to our mobile and urbanized living, which favors contacts and crowding, for instance in commuting. They may also be flaws ascribable to the health-care system and lack of adequate local facilities. All these issues lay the ground for rethinking territorial policies both during and after the Covid-19 pandemic. Therefore, the role of digital mapping in this context is highly relevant, precisely because it implies reflexivity on what has happened and on what happens. Our understanding of the spread of contagion and of its local differences depends on that. Symbolic operator maps ultimately point out specific features that call for urgent intervention against pandemics. They also encourage wider reflection and an informed questioning of the western model, by now globalized, of inhabiting the earth.

All this is made possible by the far-reaching technical potential of GISs: the large amount of data GISs can manage and the unlimited number of attributes for each geographical phenomenon; the possibility of processing and reclaiming spatial relations otherwise hard to detect; the ability to integrate different datasets, at different scales and from a wide range of sources; and finally, on the basis of the same data, the ability to draw representations that differ each time, thanks to the distinction between an archival function, entrusted to the database, and an iconic function, achieved in the process output. There is no room for doubt: on account of their vast array of resources, GISs enable us to move away from topographic metrics in favor of a chorographic model.

Certainly, a quantum leap was achieved when GISs were integrated with online technology. The paradigm shift occurs because GISs online are no longer final products but developing constructs: dynamic cartographic models were never finalized or thoroughly

---

7 Maps may become *symbolic operators* when they are freed from their conventional role of mere recorders of reality and are seen instead as *media* of hypertextual communication, at once capable of describing and conceptualizing the world, of explaining how it functions on the basis of a theory, which also entails active intervention in territorial practices (Casti, 2015, pp. 17–19).
defined. Online GISs make it possible for anyone to make or unmake maps. There never is a
finished product. Instead there will be an ever-changeable model, which will have to be re-
thought less on the basis of technical requirements than on the needs of actual commu-
ication: a radically new tool that brings out the semiotic working of cartography while it sets
forth its own semiotic modeling.

That is where cybercartography comes in: chorographic dynamics that relies on multimedia
and shifting perspectives to represent a space–time dimension, which reclains the social
value of territory, in our specific case with regard to a viral contagion.\textsuperscript{z}

This marks a momentous objective, since WebGIS\textsuperscript{aa} applications exploit GIS software
analysis and use classic web-based functionalities to reach a wide audience of expert or
nonexpert users via multiple web platforms. When used competently, these online
geographic information tools may help disseminate both the relevance of the relationship
between socio-territorial aspects and pandemic contagion and the potential of new digital
mapping systems.\textsuperscript{ab}

7 Conclusions

The term “cybercartography,” in the sense laid out by Fraser Taylor (2006); Fraser Taylor et al. (2019), identifies digital maps aimed at reclaiming the social and cultural values of com-
munities, which are conveyed through the communicative and pragmatic potential of digital
cartography.\textsuperscript{ac}

In this context, however, and with an eye on cartographic semiosis, cybercartography is pro-
posed not only as an effective communication tool for representing spatial-temporal social
phenomena such as Covid-19 but also possibly as a symbolic operator, that is, an operational
tool for a social management of a contagion, which actively influences decision making.

\textsuperscript{z}An instance of digital mapping on the Covid-19 epidemic in Italy may be found at https://cst.unibg.it/it/
avvisi/mapping-the-epidemic-systemic-geography-of-covid-19-italy.

\textsuperscript{aa}WebGIS partake of online cartography or the set of electronic maps widely available online. This category
includes different types of representations both in terms of map processing and in terms of the resulting map
formats offered to final recipients (Casti, 2015, pp. 142–145).

\textsuperscript{ab}Covid-related cartography circulated at present arguably obfuscates the potential of digital cartographic
systems because computer scientists, who are neither mapping analysts nor experts on territory, tend to
entrust data representation entirely to computer algorithms, so that information is neither directly managed
nor made thoroughly intelligible. We do have one study conducted by a group of researchers in China, which
seems to pursue the cartographic processing outlined here: the use of logarithmic processing for
cross-referencing epidemic data to population data. See Zhou et al. (2020).

\textsuperscript{ac}Fraser Taylor introduced the concept of Cybercartography at the International Cartographic Conference in
Sweden in 1997. He convincingly argued that if cartography was to play a more incisive role in the information
age, a new paradigm was called for. Fraser’s studies evolved in the wake of “postmodern cartography” as
initiated by John B. Harley in 1989 and developed over the first decade of the 2000s by others. For a general
survey, see Azócar Fernández and Buchroithner (2014). This new cartographic model aimed at organizing and
communicating spatially related information on a wide variety of topics, which are relevant to society.
Cybercartography relies on an interactive and dynamic format based on multimedia and aims at
communicatively implementing a chorography model, which is meant to convey the social values of territory
and the cultural values of landscape (Casti, 2015).
On the basis of these theoretical assumptions, citizens may be involved in the process of producing a digital map of contagion, and that may in turn branch out to become a model of territorial governance, an instance of interactive democracy that envisions maps as symbolic operators affecting decision making.

Thus, our “deck of cards” has been laid out: we can set out our strategy for facing the pandemic challenge on sound intellectual grounds.

References

Azo´car Ferna´ndez, P.I., Buchroithner, M.F., 2014. Paradigms in Cartography: An Epistemological Review of the 20th and 21st Centuries. Springer, New York/Dordrecht/London.
Bourdieu, P., 1991. Language and Symbolic Power. Polity Press, Cambridge.
Casti, E., 2000. Reality as Representation. The Semiotics of Cartography and the Generation of Meaning. Bergamo University Press, Sestante, Bergamo.
Casti, E., 2015. Reflexive Cartography. A New Perspective on Mapping. Elsevier, Amsterdam.
Dardel, E., 1986. L’uomo e la terra, natura della realità geografica. Unicopli, Milan.
Djaiz, D., 2020. La mondialisation malade des ses crisis? In: Le Grand Continent. accessed December 2020 from https://legrandcontinent.eu/fr/2020/03/23/coronavirus-mondialisation-david-djaiz/.
Fraser Taylor, D.R., Lauriault, T. (Eds.), 2006. The theory and practice of cybercartography: an introduction. In: Fraser Taylor, D.R., Lauriault, T. (Eds.), Cybercartography, Theory and Practice. Elsevier, Amsterdam, pp. 1–13.
Fraser Taylor, D.R., Anonby, E., Murasugi, K. (Eds.), 2019. Further Developments in the Theory and Practice of Cybercartography. Elsevier, Amsterdam.
Hall, P., Pain, K., 2006. The Polycentric Metropolis. Learning From Mega-City Regions in Europe. Earthscan, London.
Jackson, M.O., 2020. Comment se diffuse un virus? In: Le Grand Continent. accessed December 2020 from https://legrandcontinent.eu/fr/observatoire-coronavirus/.
Lév y, J., 2008. Un événement géographique. In: Lévy, J. (Ed.), L’invention du monde. Une géographie de la mondialisation. Presses de Sciences Po, Paris, pp. 11–16.
Lévy, J., 2020. L’humanité habite le Covid-19. AOC. Analyse, Opinion, Critique. accessed December 2020 from https://aoc.media/analyse/2020/03/25/lhumanite-habite-le-covid-19/.
Lussault, M., 2007. L’Homme spatial. La construction sociale de l’espace humain. Seuil, Paris.
Lussault, M., 2017. Hyper-lieux. Les nouvelles géographies de la mondialisation. Seuil, Paris.
Lussault, M., 2020. Chroniques de géo’ virale. Ecole urbaine de Lyon/Editions deux-cent-cinq, Lyon.
Maggioli, M., 2015. Dentro lo Spatial Turn: luogo e località, spazio e territorio. Semestrale di Studi e Ricerche di Geografia XXVII (2), 51–66.
Soja, E., 2000. Postmetropolis: Critical Studies of Cities and Regions. Blackwell Publisher Ltd., Oxford.
Warf, B., Arias, S. (Eds.), 2009. The Spatial Turn. Interdisciplinary Perspectives. Routledge, New York.
Zhou, C., et al., 2020. COVID-19: challenges to GIS with big data. Geogr. Sustain. 1 (1), 77–87.