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7 Plague and the city

Methodological considerations in mapping disease in early modern Florence

John Henderson and Colin Rose

The places where the sickness was at its most severe were the extremities of the city, those which are inhabited by poor people. . . .

—Rondinelli, *Relazione del contagio stato in Firenze*¹

Early modern Europeans saw close associations among plague, poverty and the poorer areas of their cities. Historians have placed reactions to the plague within the wider context of developing policies towards the poor but have done less to study the relationship between disease and the physical environment. This chapter aims to bring these two together by exploring what methodologies might help examine the relationship among plague, the poor, and the physical environment in order to provide a more fine-tuned analysis of the impact of this disease on urban mortality. This type of examination can best be done at the local level, and we shall take the case of the impact of plague on Florence in 1630–31. This forms part of a forthcoming study by John Henderson that examines the impact of the epidemic on the city and on the developing policies of Grand Duke Ferdinando II de' Medici. The main themes include analysis of the relationship between public health and medical theory and the way in which this led to the implementation of a detailed survey of the city; the geographical spread of plague through Florence over the course of a year; the role of the *lazaretto* through the eyes of staff who worked in these isolation hospitals; the reactions and survival strategies of those at the lower end of society; and the relationship between the built environment and mortality.²

This chapter discusses methodological issues, leaving detailed results for the wider monograph. In the first section, John Henderson sets the context in plague studies generally and in his own long-standing research project as it developed from its beginnings in 1989 at the Centre for Metropolitan History at the University of London.³ He then outlines the main measures taken by public health authorities during the epidemic, with a focus on the mortality crisis within the parish of San Lorenzo in 1630–31. In the second section, Colin Rose describes how he used DECIMA in order to map the spread of the plague through San Lorenzo, explaining some of the problems he encountered and the methodologies he developed while working with Henderson's extensive database.

Plague and historians

The seventeenth century saw the end of the second pandemic of plague in much of Europe, which began with the so-called Black Death of 1347–52 and continued to afflict the population on a regular basis for some three hundred years. Subsequently it returned briefly twice more, in Marseille in 1720 and in Messina in 1743, before finally almost completely disappearing from Europe. The reasons for its disappearance have been debated for many years, and no really satisfactory explanation has been provided, although one of the most widely held ideas is a belief in the efficaciousness of public health measures and in particular the isolation and quarantine of plague victims and their contacts. This was done at the level of the house and household, with the sick being shut up in their homes or taken off to isolation hospitals called *lazaretti*. This relationship between levels of mortality and the social, economic, and topographical character of the city reflects the interests of today's demographic historians and also the concerns of contemporaries, such as Francesco Rondinelli, cited at the beginning of this essay. The imposition of cordons sanitaire between states has been hailed as particularly effective.⁴ In the case of early modern Italy, some indication of the effect of the quarantining of states emerges from a comparison of the geographical distribution of plague in the outbreak of 1629–33 and that of 1655–56. The first was confined to the north of the peninsula, while the second was limited to the south, except for Liguria.⁵

The study of plague in early modern Europe has, like plague itself, never quite disappeared, and interest has been rekindled within the past few years. This more recent revival of interest in plague has led to a series of new studies of Venice, Rome, Naples, Geneva, London, Barcelona, and Seville.⁶ These studies look at medical theory and plague tracts, government policies and plague hospitals, the impact on art, and reactions of the resident population.⁷ Much effort and many pages have also been expended on debates about whether 'historical plague' in the premodern period was in fact the same as bubonic plague in the postlaboratory era. DNA analysis of the dental pulp of those who died from historical plague epidemics has definitely shown the existence of *Yersinia Pestis* in medieval and early modern plague pits, although there do remain doubts about the applicability of these results across the whole period.⁸

One aspect that has tended to remain a minor theme until recently is the demographic impact of plague and its relationship to the urban environment. There are some exceptions. Robert Burr Litchfield's *Florence Ducal Capital, 1530–1630* provides a very useful general survey of the impact of the plague of 1630–31 on Florence.⁹ The innovative studies of Guido Alfani include an essay in which Samuel Cohn provides a detailed demographic analysis of the impact of plague on Normentola in northern Italy and a monograph, *Calamities and the Economy in Renaissance Italy*, that gives a more extensive study of the impact of the plague on the northern part of the peninsula within the wider context of war, famine, and the economy.¹⁰

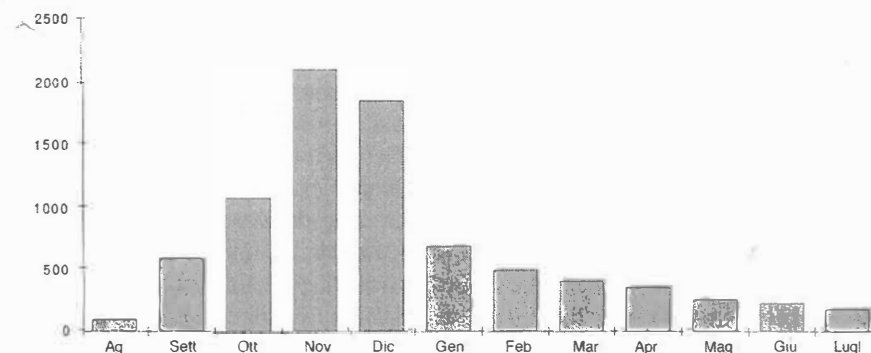
The current research project on the 1630–31 plague in Florence first emerged in 1989 as an effort to undertake a comparative demographic analysis of plague in relation to the socioeconomic and topographical character of two of the largest urban

centres in seventeenth-century Europe: London and Florence. It was envisaged as collaborative, with a joint methodology to be applied to both early modern cities. Within each city, areas were selected to provide a range of social and environmental conditions, from the more affluent to the very poor. Evidence for the incidence of plague and other deaths was studied in relation to surveys that revealed the character of the local communities. In the case of London, the main source examined was the Hearth Tax. Studying those parishes where complete tax records and parish registers survived allowed ambitious comparative socioeconomic analyses. This collaboration has generated numerous results, including Justin Champion's groundbreaking study of plague and its relationship to the built environment in early modern London, Graham Twigg's series of subsequent studies,¹¹ and a comprehensive project recently initiated at the London School of Economics to map changing mortality patterns in early modern London at the parish level.¹²

Plague in early modern Florence

The plague epidemic at the centre of this research project is that of 1629–33. It entered Italy in November 1629 during the Italian phase of the Thirty Years' War. Arriving on the tailcoats of both the French and the Imperial armies, it gradually travelled south until it arrived in Tuscany in summer 1630. It wreaked havoc on the way. For example, the two largest cities in the north, Milan and Venice, lost 46 and 33 per cent of their respective populations of 130,000 and 141,000. Smaller cities, such as Verona, were hit even more severely, with mortality rates reaching 57 per cent. By the time it reached central Italy in the spring of 1630, the epidemic had apparently lost some of its virulence, for Bologna suffered a slightly lower mortality rate of 24 per cent over the following months.¹³

This pattern continued as plague progressed further south. Florence itself only lost 12 per cent of its population of 75,000 between the late summer and the winter of 1630–31, although epidemic mortality did rise again briefly in 1633.¹⁴ The seasonality of the epidemic in Florence can be seen in Graph 7.1; the highest



Graph 7.1 Plague deaths in Florence, 1630–31.

mortality was in the autumn and early winter of 1630, and then it gradually tailed off over the following seven months until the disease disappeared altogether by late July 1631.¹⁵

As the epidemic took hold, authorities debated about the nature of the disease. While some of the medical advisers to the Health Board suggested that it was merely a 'pestilential fever', in the end there was a general agreement that plague had indeed entered the city, and all the normal crisis measures were put into practice.¹⁶ Debates about the cause of the disease were not uncommon in early modern European states at the beginning of epidemics, partly in order to avoid the panic and the inevitable commercial isolation of a state if plague was declared. In Florence, moreover, plague was not identified immediately since many assumed that it was a new occurrence of *patecchie* or typhus, which had broken out three times over the previous decade. Furthermore, the city had not actually experienced plague for about a century, although northern Italy had suffered from exceptionally virulent attacks in the 1570s.¹⁷

Once the Health Board had recognized the presence of plague, a series of routine measures were instituted to combat the 'invisible enemy'.¹⁸ These included digging special plague pits outside the city, setting up isolation hospitals outside the walls, establishing a Health Board to run the whole operation, and appointing voluntary and paid officials to implement all these measures. Voluntary employees included members of the confraternity of the Misericordia, who transported sick and dead bodies and anybody who had come into contact with the sick. Physicians and surgeons were employed to inspect and identify plague cases and gravediggers to bury the dead; police were appointed to investigate and arrest those who broke plague regulations, as were judges to try offenders.¹⁹

One feature of Florentine plague measures that differentiated the city's strategy from those of other cities was the close involvement of the court.²⁰ The twenty-two-year-old Grand Duke Ferdinand II had recently come to power and was bent on proving himself to be a Christian and beneficent ruler. Consequently, he decided to remain in the city during the epidemic and took an active interest in the day-to-day administration of the emergency. He also contributed to the major costs of the measures, which included feeding the thirty-five thousand citizens who remained shut up in their houses for forty days when quarantine was imposed on all residents. He provided an example to his courtiers and employed them to undertake surveys of the poor and needy to decide to whom food and alms should be provided.²¹

Among these surveys was one at the beginning of the epidemic to address unsanitary conditions that were regarded as creating the conditions that caused plague.²² 'Gentlemen of the Court' were appointed to identify which streets and households had leaking cesspits and defective water supplies that required mending, as well as which individuals slept in unsanitary conditions, either without a mattress or with a straw palliasse that was filthy and falling apart and needed replacing. Their survey contains the following accounts of the living conditions in

a medieval tower at the Canto alla Paglia that had four separate apartments, each with problems of its own:²³

On the first floor of the said tower: to the widow Monna Lisabetta a new straw mattress; climbing another staircase: to Monna Lisabetta, wife of Bartolommeo Porta, another mattress; to Monna Francesca on the said floor: mend a cesspit.

On the top floor: a mattress to Andrea the tailor; and instruct the landlord of the said [apartments], who is the above-mentioned Moscellaro, to have carried away all the rubbish in the said house because it causes a great stink.

The house which is built next door to the son of the widow the stretcher-bearer: a new straw mattress and empty the well; the landlord of it is called il Grazzini.

This short extract from the Gentlemen's survey enables us to determine both how contemporaries characterized 'the poor' and how they thought their living conditions determined that poverty. First, this group of a half-dozen people was living in rented accommodation in cramped rooms in or next to a medieval tower. They were obviously living in squalid conditions with a landlord who was normally too mean to have the rubbish cleared away. In this and the house next door there were also problems with either the supply of clean water or the system to deal with human waste. We know that two of these women were widows, presumably living in straitened circumstances. They were too poor to buy decent mattresses, and it must be remembered that mattresses were mentioned here because they were seen as harbouring the poison of plague. Finally, two of the men would also have been regarded as potentially suspect within the context of plague – Andrea the tailor because he dealt with cloth and the stretcher-bearer because he came into contact with the sick.

The surveyors believed that these unsanitary conditions created and increased the corrupt vapours that were seen as fomenting plague. As the grand-ducal librarian Francesco Rondinelli put it, 'filth is the mother of corruption'.²⁴ The exercise continued throughout the month, and towards the end of August the members of the commission noted an alarming growth of 'misery, necessity and sickness' among the poor.²⁵ They saw a direct relationship between the built environment and disease, with the former creating the conditions that led to and exacerbated the spread of an epidemic.

The importance of outlining the Florentine authorities' varied reactions to plague is to emphasize that each of these separate activities generated records, a surprising number of which have survived.²⁶ Henderson's forthcoming monograph uses these to explore in detail the demographic aspect of the project.²⁷ Like Justin Champion's study of London, it analyzes an area of the city as a case study. In Florence this was the parish of San Lorenzo, the largest in the city, located in the northwestern quadrant with boundaries virtually co-terminus with the quarter of San Giovanni. In this period it contained about 14 per cent of the city's population.²⁸

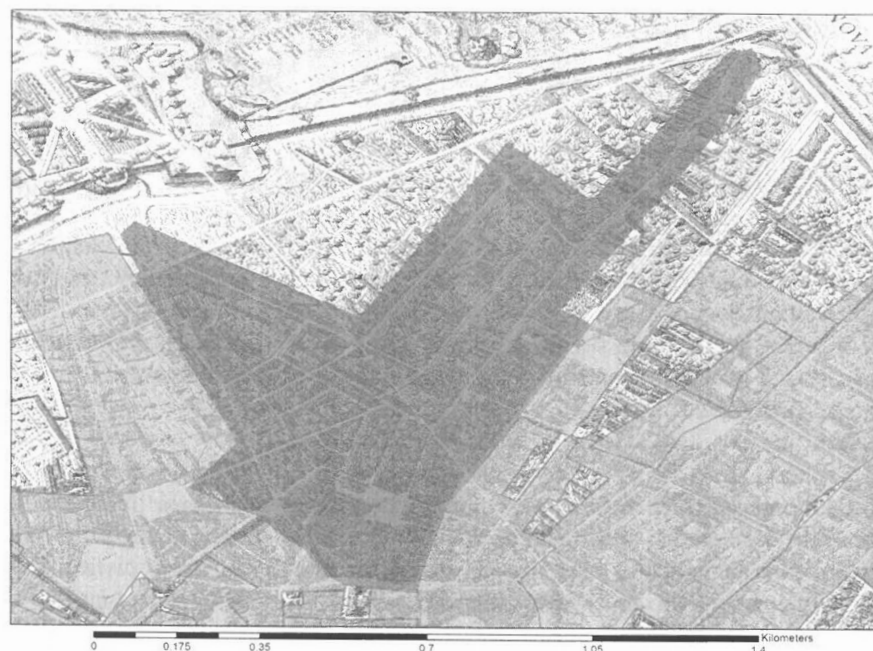


Figure 7.1 Buonsignori map of Florence showing the quarter of San Giovanni/parish of San Lorenzo.

San Lorenzo was chosen because of the survival of a rich cross section of records for both mortality and census-type information, which provide data on the socioeconomic and topographical character of the parish. Though best known for its close association with the Medici family, which had built their palace in San Lorenzo,²⁹ the parish had a very mixed social character. It contained a substantial concentration of artisan families, especially those working in the textile industries. It had streets dominated by patrician palaces, such as Via Ginori close to the centre, and others with a substantial number of large religious, monastic, and hospital buildings, such as Via S. Gallo, the arterial road leading to the northern city gate. Topographically, it was an area of contrasts, with substantial high-density housing mixed in with palaces and substantial ecclesiastical building complexes.

The initial aim in studying San Lorenzo was to examine the changing pattern of mortality and morbidity in the parish in relation to its social and physical character. A detailed database was compiled with the aim of mapping the results by linking them to a detailed reconstruction of housing types and density. This database is at the centre of the collaboration with the DECIMA project, as Colin Rose explains later in this chapter.

The broader comparative research study of which this forms a part has revealed significant differences between Florence and London. In England the vast majority of those who died from plague were buried in their parish. In major Italian

cities, plague victims were buried either in extramural plague pits or in cemeteries at the isolation hospitals or *lazaretti*. This meant, in theory at least, that Italian city parish registers would not have included those who had died of plague, although there were exceptions in the case of some of the more affluent victims.

Fortunately, in Florence a series of registers has survived that indicates the impact of the epidemic of 1630–31 on the city. The most complete consists of lists of households visited by the representatives of the public health authorities during the autumn of 1630, when the epidemic was at its height. These record individuals taken to the isolation hospitals between autumn 1630 and the official end of the plague, in late July 1631. Inevitably, there are differences in the completeness of each source, the periods covered, and the level of detail provided.³⁰ The most problematic in terms of consistent detail provided about individuals were the records of burials attributed to plague.³¹ The two most complete registers provide complementary information and together cover most of the period when plague was in the city. The first register covers a period of six weeks during the autumn of 1630, when mortality was at its height.³² This is a record of those sent to the *lazaretto* of San Miniato, with a record of those who were buried, the houses that were locked, and the names of some of those who remained inside and who were provided with food by the city authorities. Two entries provide some idea of what happened when somebody was suspected of having plague:³³

Francesco di Domenico Castrucci, aged 15 months, lives in [Via] Campaccio next to Maestro Giovanni, surgeon, and opposite the Nuns of S. Appollonia; sent the said day [15 October 1630] through the report of Morandini. House seized.

On 24 October 1630: Caterina di Francesco Porta, lives in Via di S. Zanobi next to Porta di S. Barbano, and her male child, are sent this day through the report of Morandini.

In the house there remains only one person, locked up, and it has been ordered to lock the main door on the street.

In both instances the names of the main suspect are provided: in the first case it is Francesco, an infant of fifteen months, and in the second it is Caterina di Francesco Porta and her male child. All were sent to the *lazaretto* of San Miniato. Each had been identified as sick by one of the surgeons appointed by the Sanità in the quarter of S. Giovanni. Fairly specific details were provided about where they lived; for example, the infant Francesco lived in a house identified by the street (Via Campaccio) as well as in relation to a neighbour, the surgeon Giovanni, and by location behind the convent of S. Apollonia. These details enabled the brothers of the confraternity of the Misericordia to find the sick person they were to transport to San Miniato.

The second register recorded all the houses that had been locked because one or more of the occupants had been diagnosed with plague and taken off to the *lazaretto*; some had died there. This register covered the western part of the quarter of San Giovanni. There is a two-week overlap between these two registers, but

the second one covers a much longer period, to the middle of September of the following year, six weeks beyond the official end of the plague epidemic. However, it provides much less specific information about those implicated. While the person who was taken to the *lazaretto* was identified, the co-residents who remained shut up in the house as members of the infected or suspected household were simply identified with a number:³⁴

25 November 1630: Via Romita at the Madonna, Dorotea di Bartolomeo cook for having gone to S. Miniato; five remaining.

27 November 1630: Via San Zanobi next to the Porta di Barbano for the death of Madonna Laura; ten remaining.

There is sufficient detail to trace the spread of the plague from street and sometimes even sections of the street. In the case of Madonna Laura, the house was close to the one in Via San Zanobi where Caterina di Francesco Porta had been identified in the previous register as sick and subsequently carried to S. Miniato.

The next stage of the study was to place the morbidity data within a wider socioeconomic context to help us understand the factors underlying the spread of plague. In addition to the methodology employed for the analysis of the Great Plague in London, a particularly detailed series of records helped characterize the parish. Unlike in London, where hearth tax records survive from before and after the plague, in Florence a complete census of the city has survived only from a point two years after the epidemic had ceased (1632). This census assessed how many people had died from plague.³⁵ It also provides detailed information of the resident population, with names of heads of household by street and trade, together with the numbers of male and females within each household below and above the age of fifteen years. This enables one to provide a general characterization of the socioeconomic character of the parish of San Lorenzo after the plague. Litchfield's study, written after research for the present project was completed, provides a wider context for the present study, for he examined the impact of plague on the whole city for November 1630. Identifying the quarter of S. Giovanni as among the areas of the city worst affected, he provided a general characterization of the socioeconomic background of plague victims and the probable impact of the epidemic on the city's population as reflected in the 1632 census.³⁶

One of the significant findings of the initial analysis is that the inhabitants of S. Lorenzo suffered more severely from the epidemic than did residents of the city overall.³⁷ During autumn 1630 a disproportionately high number of those admitted to the *lazaretti* (28 per cent) came from the parish, which contained about 14 per cent of the population of the city. This may very well be linked to the fact that the plague epidemic arrived from the north along the road to Bologna and first entered the city through the northern Porta San Gallo, from where it spread throughout the quarter of S. Giovanni. Slightly later the western part of the city also came to be infected, plague having been introduced through the Porta al

Prato. Although plague did break out in the other two quarters of the city, it was less severe in those areas.³⁸

Just as some parts of the city had higher infection rates, so some parts of the parish of S. Lorenzo were more affected than others. The central question that arises at this point is: how far did the socioeconomic and topographical character of each street contribute to its fate? The results of this analysis cannot be more than hinted at here, but again it is useful to outline the methodology that will, as in the case of the study of the plague in London, help us to arrive at some tentative conclusions. Having determined the morbidity rates from plague for each street in the parish of S. Lorenzo, we next constructed a picture of the topographical and socioeconomic character of each street. The physical character was best reconstructed through a comparison of Stefano Buonsignori's 1584 map of Florence with the first really detailed and accurate map of the city in 1832, associated with the cadastral survey of that year.³⁹ With these two maps it was possible to obtain approximate measurements of the streets and buildings and then to put them together with data from the 1632 census, linking, for example, the number of houses listed in the fiscal document with those represented on both the 1584 and 1832 maps. The 1632 census also provides a wealth of information about the resident population, which, even if it has to be interpreted with caution, can help to characterize each household resident in the parish of S. Lorenzo. The results of the analysis of three streets with different profiles – Via de'Ginori, Via S. Zanobi, and Via Romita – will be presented briefly before we turn to Colin Rose's discussion of the methodology associated with mapping the plague epidemic.

The three streets chosen for analysis each presented different characteristics and had different rates of morbidity. The first, Via de'Ginori, was situated in the city centre and had a frontage of some 434 metres, the total of the frontage of the houses on both sides. It was one of the grandest streets in the parish and contained a series of large patrician palaces. According to the 1632 census, the street possessed a high proportion of heads of household with surnames and larger than average numbers of servants. Overall the street suffered very little from the epidemic; only seven cases of plague were reported, or 0.7 per cent of the total number of 1,046 in the whole parish over the course of the year 1630–31. Indeed, contemporaries noted that few patricians died over this year, and most deaths recorded in their houses tended to be those of servants.⁴⁰ Lower patrician mortality can presumably be attributed the fact that the owners had either fled to their villas in the countryside or remained shut up in their city palaces and thus had less contact with the outside world than the poorer sort who had to travel round the city to buy food or work.

While low morbidity rates may have been expected in these palatial, stone-built constructions, few studies of plague have attempted to go beyond the straightforward dichotomy between the rich and the poor. With a closer comparison between the factors mentioned earlier, a more nuanced picture emerges. Via S. Zanobi, in the north of the parish, was identified by the Health Board as having been particularly badly affected, and indeed its morbidity rate was 15 per cent of the parish

total with 161 cases. Via S. Zanobi had a considerably longer street frontage than Via de' Ginori (810 versus 434 metres), but it had much greater housing density. The 1632 census recorded that Via de' Ginori contained 52 houses, whereas Via S. Zanobi had only 180. Occupational profile also differed: Via S. Zanobi was far from being patrician and had long been closely associated with textile production. In the 1562 and 1632 censuses, the majority of the heads of household were registered as employed to perform the more menial tasks of the wool and silk industries.⁴¹

The third street examined, Via Romita (today the top section of Via S. Antonino), is to the west of Via de' Ginori. Like Via S. Zanobi, it was long associated largely with the textile trade. Only sixty-six cases of suspected plague were reported (6.31 per cent of the parish total). Yet, because it was the shortest of the three examples, with a street frontage of only 183 metres, there were an average of two cases for each of its thirty-three houses, higher than in Via S. Zanobi with 1.12 cases for its 180 houses. One of the reasons for the difference was undoubtedly the density of the housing stock: Via Romita was the more crowded street; houses occupied narrow plots and contained, even after the plague, 7.6 people on average, while conditions in Via S. Zanobi were relatively more spacious, for houses contained on average 6.8 persons.

These correlations between the incidence of plague and the socioeconomic character of the streets represent only the first results of the analysis. Just as not all poorer areas within the city were equally affected, so not all the poorer streets had equivalent levels of morbidity even when contiguous. This question as to why this might have been the case will be explored in detail for the whole parish when an analysis of the socioeconomic profile of each street combined with its topographical character will provide a much more nuanced picture of the incidence of plague and its physical context.

Even during the initial stages of this comparative research project, it became increasingly clear how important it was to go beyond the graphic presentation of the data and represent it visually on a contemporary map. The aim then was to find a programme that could automatically link the database of plague mortality to the data from the census. In this way, we hoped, it would be possible to demonstrate clearly the chronological spread of plague and also to show clearly the relationship between patterns of mortality and morbidity and the socioeconomic and topographical profile of different streets within the parish. This was where the DECIMA project came in.

Mapping an epidemic's passage: change over time in the DECIMA HGIS

The plague of 1630–31 presented an excellent opportunity to test DECIMA's capacity for temporal mapping. This is possibly the most important aspect of HGIS for social historians, who are above all interested in process over event and in the effects of change on communities rather than individuals. The ability to analyze change over time is a major advance in historical cartography, which not

only allows historians to demonstrate visually their research but also prompts new questions about the relationship between time and space. John Henderson's data set on the impact of the 1630–31 plague is a rich trove of temporal data.⁴² Using the weekly totals of plague cases on a street-by-street basis and coupling these with analysis of street-level population density, DECIMA analyzes the impact of the plague with an eye to its movement from street to street. Mapping this data *over time* demonstrates that the plague of 1630–31 was fickle: some streets were hit extremely hard, while others were left relatively unscathed. This section describes the process of mapping an epidemic as a data set representing temporal change, the challenges encountered along the way, and the new forms of analysis and research questions that emerged.

The plague database covering the limited time frame of one year has provided the opportunity to develop DECIMA's capacity to map change over time. The complete data set required only minor modifications to become a time-enabled vector layer, with mensal plague morbidity attached to the street map of the parish of San Lorenzo, resulting in two layers in the DECIMA platform. One is a static data set that tracks the plague's weekly morbidity on a per-street basis and morbidity per capita, per metre of street frontage, and per household. This layer was comparatively simple to create and immediately lent a new dimension to the plague data, analyzing these significant variables in a single frame. The geographic dispersal of plague mortality at a given moment was made clear and led to the need for a layer that would demonstrate changes in mortality over time.

The second layer is the more dynamic of the two and organizes plague morbidity by monthly, rather than weekly, totals for simplicity's sake. It was created using a 'one-to-many join' operated through ArcMap's 'Make Query Table' tool. By arranging the plague data with time, rather than location, as the organizing principle, the HGIS researcher can use ArcMap not simply to show data at a given moment in time but also to demonstrate, visually, how those data change over time. This is a major advance in historical cartography. While projects such as *Mapping the Republic of Letters*, at Stanford University, the *Animated Atlas of African History*, from Brown University, and *The Atlas of Early Printing*, by the University of Iowa Libraries, all employ time lines and time-sliders to demonstrate, respectively, the progress of various 'Grand Tours', the development of colonial states in Africa, and the spread of print houses across Europe, DECIMA presents something distinctly different.⁴³ These projects maintain geography as their major spatial focus: time is used to show change over place, as travellers passed through Sicily, as colonial states were built and overthrown across the African continent, and as the printing press was developed in Strasbourg and rapidly picked up throughout Christendom. *Through, across, around*: geographical terms, shaping geographical thinking with the help of time. DECIMA's analysis of the 1630–31 plague reverses this and uses geography as an aid to temporal thinking: we show how streets and households suffered *during* the plague, how many sick people were taken away *throughout* its passage, and *when* the pestilence struck particular places and areas. John Henderson's data allow this, as they can use both geography and time to shape analysis.

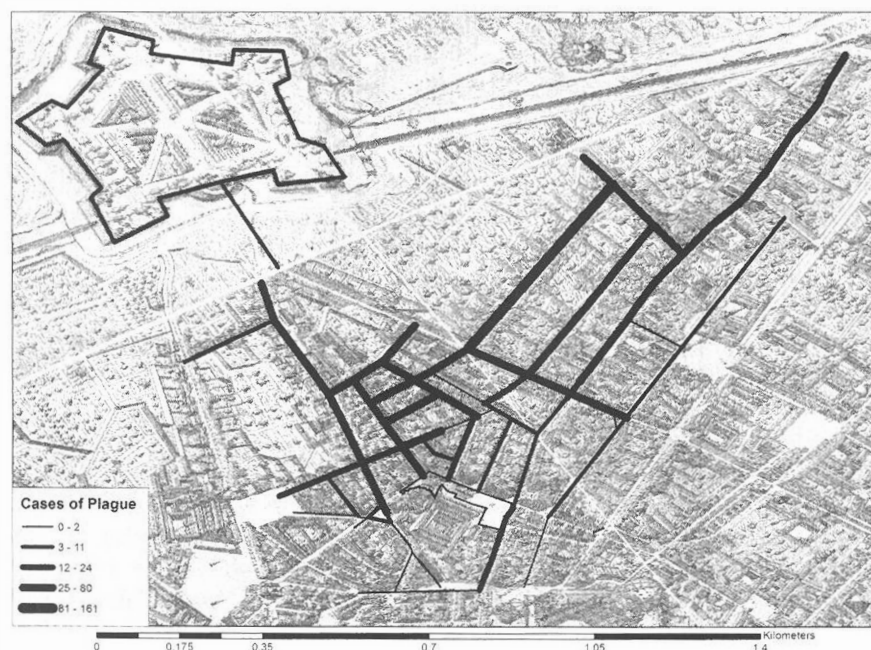


Figure 7.2 Total plague morbidity in San Lorenzo parish, 1630–31.

To my knowledge, DECIMA is the only HGIS project that employs street-level social data, organized by time, to map change over time for a social historical project.⁴⁴ That this type of approach is attracting interest can be seen from the ongoing research project of Neil Cummins, Morgan Kelly, and Cormac Ó Gráda on plague in early modern London, which has recently produced an animated map of the spread of plague by parish across the city during the epidemic (<http://neilcummins.com/PlagueinLondon.html>).⁴⁵

In the analysis of the Florence data, space does not move, but time does, and as it moves so does the plague. The map shows how the plague struck harder in particular months and seemed almost to disappear from the parish of San Lorenzo at others, how it flared up in different times in different places, and how it seemed not just to follow the major transit routes but spread erratically through the neighbourhood from autumn 1630 to early summer 1631.

The preparation for this temporal analysis was not straightforward. The data themselves have some spatial limitations. Temporal mapping significantly changes the way social historians should think about time and its relation to space: to understand change, we should prioritize the first and use the second as the supporting material.

Old parish, new map: limitations of the San Lorenzo plague data

John Henderson's database of plague mortality tracks the 1630–31 epidemic across forty-five streets in the parish of San Lorenzo. The DECIMA street map,

as it stood when Henderson first discussed his data, matched up to only twenty-four of those, a problem that diminished the scope and power of his database. The street map, built as it was from modern OpenStreetMap data, did not account for many of the small streets and *canti* (corners) in the parish, much less the Gomitolo del Oro or (between Borgo la Noce and Via S. Antonino) the vaguely named 'da S. Maria del Fiore'.⁴⁶ By continually refining the DECIMA street map, dividing modern streets into the pre modern segments, and working with visualizations of the parish provided by Nicholas Eckstein, I was able to identify another thirteen streets in San Lorenzo, bringing the total number of streets that I was able to match between the plague database and the street map to forty-three, a significant improvement that allows for a much more comprehensive analysis of the plague's impact over the course of 1630 and 1631.

The richer the data set appended to DECIMA through projects like the plague data, the greater its analytical powers become and the more widely useful it is to a broad range of social, economic, and demographic historians, among other researchers. The focus of the plague morbidity GIS is the number of plague victims. The database includes a great many more data, such as total plague morbidity in relation to the socioeconomic structure of each street after the plague as recorded in the 1632 census; topographical information, including housing density and structure; and the results of the environmental survey in August 1630. This is all analyzed easily in the static layer of the plague map but is more difficult to conceive of on a temporal basis. Knowing the monthly population numbers and the resulting impact of plague morbidity proportional to those population figures would allow for more advanced temporal mapping. The DECIMA continues to improve on these challenges, as an organic and growing Historical GIS project, which by its nature tends never to be truly 'finished'.

Temporalizing spatial data: from street by street to month by month

The data in the plague database presented an immediate cartographic challenge. In Henderson's Excel[®] spreadsheet, mortality data were organized by street on the y-axis and by weeks on the x-axis (i.e. moving right and left through the database demonstrated temporal data, and moving up or down demonstrated spatial data). ArcMap, for all its analytical capabilities, will do only *exactly what its operator tells it*. Among other things, the program has been told that time exists on a y-axis, and in order to operate time in its cartography, this must indeed be the case in all data.⁴⁷ The data needed to be transformed from their form of presentation in Table 7.1 into a database organized by time, as in Table 7.2.

The organizational differences should be immediately apparent: the original data contain one row for each street, and across the columns of that row are inserted the temporal data, organized by weeks (a,b,c,d) in months (1–12). The y-axis (rows) is a geographic description of place: the street name, where the x-axis (columns) tracks temporal data. In the modified database, time exists on the y-axis: all thirteen rows of the second table are data for Via Sant'Orsola, one of the parish's harder-hit streets during the early stages of the plague.

Table 7.1 Selection of John Henderson's original database

<i>Via Week</i>	<i>10c</i>	<i>10d</i>	<i>11a</i>	<i>11b</i>	<i>11c</i>	<i>11d</i>	<i>12a</i>	<i>12b</i>
Borgo la Noce		4	5	2	7	2	1	1
Borgo S. Lorenzo					2	1	1	5
Canto al Monteloro		1		2	2	1		
Canto alla Paglia						1		
Canto alle Macine	4			6	1	5	1	2
Canto del Giglio		2						
Canto di Bernadetto					1			
Canto di Puccino					1			
Da S. Maria del Fiore						1		

Table 7.2 Reorganized data prepared for temporal mapping

<i>Street</i>	<i>Date</i>	<i>Cases</i>
Via Sant'Orsola	1630/10/31	2
Via Sant'Orsola	1630/11/31	2
Via Sant'Orsola	1630/12/31	0
Via Sant'Orsola	1631/01/31	0
Via Sant'Orsola	1631/02/28	1
Via Sant'Orsola	1631/03/31	0
Via Sant'Orsola	1631/04/30	0
Via Sant'Orsola	1631/05/31	0
Via Sant'Orsola	1631/06/30	0
Via Sant'Orsola	1631/07/31	0
Via Sant'Orsola	1631/08/31	6
Via Sant'Orsola	1631/09/30	5
Via Sant'Orsola	1631/10/31	16

Moving down the y-axis, from 31 October 1630 to 31 October 1631, monthly totals of plague deaths are appended primarily to the date (the variable that changes) and secondarily to the street (which remains static on the y-axis, until one street has cycled through the full year; only then does the next street appear, with its thirteen rows, after which the name of the next street appears). In order for time to act as an analytical variable in GIS, it needs to be the operating y-axis, with geography (streets) secondary to time (months). This transformation took some consideration, but the end result is 408 entries that detail the progress of the plague over twelve months (plus a 'total' number, here faked by the date 31 October 1631) on forty-three streets.

Another of ArcMap's idiosyncratic programming characteristics is that geography must remain on the y-axis to be legible in the map as a 'shape'. This is a result of the nature of vector data. The street map of early modern Florence that

is the basis of the plague analysis counts each street as a *line segment*, part of a *polyline feature*. Each street occupies a row in the layer's *attribute table*, which tracks the street shapes running down the y-axis and appends data, such as the name of the road, its length, and its current road type, in fields along the x-axis. The attribute table for the street map looks like this:

Table 7.3 Selection from attribute table of the DECIMA layer *San Lorenzo Streets*, extracted from OpenStreetMap vector data

<i>OBJECTID</i>	<i>FME_TYPE</i>	<i>HIGHWAY</i>	<i>NAME</i>	<i>Shape_Length</i>
1	fme_line	tertiary	Via Larga	0.007257
2	fme_line	residential	Via S. Gallo	0.008052
3	fme_line	residential	Via dell'Amore	0.001091
4	fme_line	residential	Via Panicale	0.00212
5	fme_line	pedestrian	Borgo la Noce	0.001265
6	fme_line	residential	Via Mozza	0.004172
7	fme_line	service	Via Romita	0.001167
8	fme_line	residential	Via dell'Ariento	0.002246
9	fme_line	pedestrian	Canto alla Paglia	0.001612
10	fme_line	residential	Via Sant'Orsola	0.000983

Each row in Table 7.3 represents a *shape* read by ArcMap and converted to a *line* that is the cartographic representation of a *street* in Florence. This is the only way that ArcMap will read shapes, as rows descending the Y-axis, with their attributes appended on the X-axis. The same is true for the polygon shapes that represent the city's various administrative and social divisions and for the point shapes that represent the individual household entries in the *Decima ricerche*, geolocated onto the DECIMA HGIS. Having reorganized the database of plague morbidity, simplifying it as I went, to make time the operating principle of the resulting GIS layer, I was then faced with the challenge of exactly how to append the new plague data, in which each street appeared in thirteen consecutive rows, to the DECIMA street map, which gave each street only one.

Appending temporal street attributes to a single street shape

The process of transforming the plague mortality data into a time-oriented data table was necessary preparation work in order to tag the temporal data to the street map of the city. The operation necessary to do so is referred to in database management circles as a 'one-to-many join', that is, the attaching of one piece of data (in this case, the individual street in San Lorenzo) to many pieces of data (in this case, the twelve months plus total of plague morbidity data for each of those streets). Performing this operation allowed for the creation of a time-based and enabled layer that would animate the impact of the plague as it travelled through time. In this layer, geography does not change, but this animation does allow us

both to visualize the plague as a temporal phenomenon and also to analyze it as a process that was affected by the passage of time.

Creating the one-to-many join is relatively simple, but it requires a basic understanding of SQL querying (the expressions used to ask questions of a database). GIS software can be very finicky to use, and it is necessary to provide very exact instructions. The first join used for this project created the static map of plague data discussed earlier; this was a simple function of ArcMap's 'Join' command, which joined up as many street names as possible between the street map and the mortality data on a basic word-match: wherever the street map matched the plague database, the mortality data were appended to the street's attribute table. This can be done regardless of how the GIS is organized, as feature classes in a geodatabase or as shapefiles in a folder or series of folders. Once the two elements are layered in the GIS, the join is possible regardless of their location.

The one-to-many join requires that both elements be loaded in advance into the same *geodatabase* as a *feature class*, which must contain the *shape* of your desired layer, and as a *table*, which must contain the data for every iteration of the desired join. The first step in creating the time-dynamic plague map, then, was to load the street map and the plague table into a DECIMA geodatabase, where I had been previously working with the more flexible but less analytically robust shapefile formats. Once built, the geodatabase proved powerful enough that I migrated the entire DECIMA data set into it. Geodatabases are practical and effective ways to organize spatial-temporal data on a single machine or a local server, but they are difficult to employ in a WebGIS such as the DECIMA online portal. They provide significantly greater analytical capacities than shapefiles, such as the ability to create the one-to-many join necessary for temporally dynamic mapping.

With the DECIMA geodatabase operating, the next step was to create the one-to-many join. Using the ArcGIS toolbox, under 'Data Management Tools' and then under 'Table and Layer Views', I used the tool 'Make Query Table' to create this type of join. This tool allows one to query a feature of the geodatabase according to the characteristics of another database. To create the plague map, I input the time-organized mortality table and the street map feature class, selected all the fields from the plague data for output and only the 'shape' of the street map. The resulting table, which can be transformed quickly into a feature class layer, appends the shape of the street map to each instance of the street in the mortality table. It is organized by time and allows for the creation of a street map of the parish of San Lorenzo that can show both static representations of plague mortality in a given month and dynamic animations of the plague's impact over the course of a year. This chapter contains snapshots of that map; the dynamic version is accessible via the DECIMA Web portal.

Conclusion

The 1630 plague struck at a time when the ability of governments to record and archive information was rapidly growing, far outpacing the ability of governments to actually affect the course of a natural disaster of such magnitude. With a

significant bureaucratic and courtly apparatus, Grand Duke Ferdinand II resolved to face the plague head on. Before it arrived, he organized a citywide inspection program designed to ward off the conditions that, in Florentine thought, bred sickness; it is not coincidental that these very conditions were those of poverty and urban decay. When, despite all these efforts, plague struck the city, Ferdinand remained while other nobles fled, and he continued to direct a program that sought to limit the plague's destructiveness. In reality, perhaps the most tangible result was the creation of large sets of records about who became ill, where they lived, and how the city managed the mounting numbers of plague victims.

Because of the relationship, noted both by modern historians and by their early modern subjects, between the conditions of one's physical environment and the onset of the plague, the records of morbidity drawn from various areas of the city must be placed in the context of those areas' economic and demographic characteristics. DECIMA helps to visualize the results of that analysis in ways that are lost in spreadsheets and their explication. Spatializing the spread of plague over time, as Henderson and Rose have done, shows how the plague struck Florence dynamically, moving from one street to another and then back. It also shows how particular streets close to the walls and accessible to gates were much more susceptible to illness than others. The housing densities, average property values, and occupational structures of these streets can be mapped against their experience of the plague to test the link between poverty and plague.

Mapping change over time carries its own challenges, with some of them again being specific to early modernist concerns. The methods used to record an epidemic may change between one epidemic and the next; indeed, they may evolve over the course of one plague. Ensuring the compatibility of data sets from different periods is essential. Here, with a limited time frame and a limited documentary basis, we were able to successfully map the recorded experience of the 1630–31 plague over its entire passage. Mapping change over time significantly increases the utility of HGIS and other platforms to social historians, as the plague map of Florence demonstrates nicely.

Notes

- 1 F. Rondinelli, *Relazione del Contagio*, Florence, 1634, 36.
- 2 J. Henderson, *Death in Florence*, New Haven, CT: Yale University Press, forthcoming; I am grateful to Yale University Press for allowing me to publish the material in this article which forms part of the forthcoming monograph.
- 3 I am very grateful to Derek Keene for his invaluable advice on the mapping of this epidemic.
- 4 A.D. Cliff, M.R. Smallman-Raynor, and P.M. Stevens, 'Controlling the geographical spread of infectious disease: Plague in Italy, 1347–1851', *Acta Medico-Historica Adriatica* 7, 2009, 197–236.
- 5 L. Del Panta, *Le epidemie nella storia demografica italiana (secoli XIV–XIX)*, Turin: Loescher, 1980, 161–69.
- 6 J.L. Stevens Crawshaw, *Plague Hospitals: Public Health for the City in Early Modern Venice*, Farnham, UK: Ashgate, 2012; I. Fosi (ed.), *La Peste a Roma (1656–1657)*, *Roma Moderna e contemporanea* XIV, 2006; I. Fusco, *Peste, demografia e fiscalità*

- nel Regno di Napoli del XVII secolo, Milan: Franco Angeli, 2007; A.L. Moote and D.C. Moote, *The Great Plague. The Story of London's Most Deadly Year*, Baltimore, MD: Johns Hopkins University Press, 2006; J.S. Amerlang (trans. and ed.), *A Journal of the Plague Year: The Diary of a Barcelona Tanner Miquel Parets 1651*, Oxford, UK: Oxford University Press, 1991; K. Wilson Bowers, *Plague Public Health in Early Modern Seville*, Rochester, NY: Rochester University Press, 2013.
- 7 S.K. Cohn, *Cultures of Plague: Medical Thinking at the end of the Renaissance*, Oxford, UK: Oxford University Press, 2010; G.A. Bailey, P.M. Jones, F. Mormando, and T.W. Worcester, *Hope and Healing: Painting in Italy in a Time of Plague, 1500–1800*, Chicago, IL: University of Chicago Press, 2004.
 - 8 K.I. Bos, P. Stevens, K. Nieselt, H.N. Poinar, S.N. DeWitte, and J. Krause, 'A Draft Genome of *Yersinia Pestis* from the Victims of the Black Death', *Nature*, 478, October 2011, 506–10. For a recent discussion of the topic from both scientists and historians see: M. Green (ed.), 'Pandemic Disease in the Medieval World: Rethinking the Black Death', *The Medieval Globe* 1, 2014.
 - 9 R.B. Litchfield, *Florence Ducal Capital, 1530–1630*, New York, NY: ACLS Humanities E-Book, 2008. Online. Available <<http://quod.lib.umich.edu/cgi/t/text/text-id?c=acls;cc=acls;view=toc;idno=heb90034.0001.001>> (accessed 7 August 2015).
 - 10 G. Alfani, *Calamities and the Economy in Renaissance Italy: The Grand Tour of the Horsemen of the Apocalypse*, London, UK: Palgrave, 2013; G. Alfani and S.K. Cohn, 'Nonantola 1630: Anatomia di una pestilenza e meccanismi del contagio: Con riflessioni a partire dalle epidemie milanesi della prima età moderna', *Popolazione e Storia* 2, 2007, 99–138.
 - 11 J.A.I. Champion, *London's Dreaded Visitation. The Social Geography of the Great Plague in 1665*, Historical Geography Research Series, No. 31, London, 1995; J. Champion (ed.), *Epidemic Disease in London*, Centre for Metropolitan History Working Papers Series, No. 1, London, UK: Centre of Metropolitan History, 1992; G. Twigg, *Bubonic Plague: A Much Misunderstood Disease*, Ascot, UK: Derwent Press, 2013.
 - 12 N. Cummins, M. Kelly, and C.Ó. Gráda, 'Living Standards and Plague in London, 1560–1665', *Economic History Review*, 2015, 1–32.
 - 13 Del Pantà, *Le epidemie nella storia demografica italiana*, 160: table 24.
 - 14 J. Henderson, '"La schifezza, madre di corruzione": Peste e società a Firenze nella prima epoca moderna', *Medicina e Storia* 2, 2001, 23–56.
 - 15 The figures for this graph derives from a letter sent to Francesco Rondinelli, a copy of which is contained in the library of the late Carlo Cipolla. I am very grateful for permission to use the data here.
 - 16 Rondinelli, *Relazione del Contagio*, 26–27.
 - 17 See, for example, Preto, *Peste e società a Venezia*; Cohn, *Cultures of Plague*.
 - 18 On these measures in Florence in 1630–31 see: D. Lombardi, '1629–31: Crisi e peste a Firenze', *Archivio storico italiano* CXXXVII, 1979, 3–50; D. Sardi Bucci, 'La peste del 1630 a Firenze', *Ricerche storiche* X, 1980, 49–92; M.B. Ciofi, 'La peste del 1630 a Firenze con particolare riferimento ai provvedimenti igienico-sanitari e sociali', *Archivio storico italiano* CXLII, 1984, 47–75.
 - 19 See Calvi, *Histories of a Plague Year*.
 - 20 Cf. M.L. Leonard, 'Plague epidemics and public health in Mantua, 1463–1577', PhD thesis, University of Glasgow, 2014.
 - 21 Contemporaries wrote a series of encomia about him, praising him for his role during the plague: Rondinelli, *Relazione del Contagio*, 66–67; M. Guiducci, 'Panegirico', in Rondinelli, *Relazione del Contagio*, 109–39.
 - 22 Discussed in Henderson, *Death in Florence*, ch. 7; and see also: N.A. Eckstein, 'Florence on foot: An eye-level mapping of the early modern city in time of plague', *Renaissance Studies*, 2015.
 - 23 Archivio di Stato di Firenze (ASF), Compagnie Religiose Sopresse da Leopoldo (CRS), 1418.II, nos. 210–12. See N. Eckstein article in this volume.
 - 24 F. Rondinelli, *Relazione del contagio*, 24.
 - 25 ASF, CRS, 1418.II, 28.8.1630.
 - 26 J. Henderson, '"La schifezza, madre di corruzione"' ; J. Henderson, 'Epidemie, Miasmi e il corpo dei poveri a Firenze nella Prima Età Moderna', *Storia Urbana* 112, February 2007, 17–37; 'More Feared Than Death Itself? Isolation Hospitals and Plague in Seventeenth-century Florence', in: C. Bonfield, T. Huguet-Termes, and J. Reinartz (eds), *Hospitals and Communities, 1100–1960*, London, UK, and Bern, Switzerland: Peter Lang, 2013, 21–44.
 - 27 Henderson, *Death in Florence*.
 - 28 P. Pieraccini, 'Note di demografia fiorentina: La parrocchia di S.Lorenzo dal 1652 al 1751', *Archivio storico italiano* VII, 1925, 44–45, has 16 per cent over the whole period.
 - 29 D. Kent, *Cosimo de' Medici and the Florentine Renaissance: The Patron's Oeuvre*, New Haven, CT, and London, UK: Yale University Press, 2000.
 - 30 Litchfield, *Florence Ducal Capital*, 344–50.
 - 31 AFM, 259: 'Morti in tempo di contagio dal 1630 al 1633'. Litchfield and, before him, Deanna Sardi Bucci, 'La peste di 1630 a Firenze', have plotted these data for the whole of the city (though the former concentrated on the November data), providing a useful context for the present study.
 - 32 ASF, *Sanità*, 463.
 - 33 Ibid., ff. 1r, 31v.
 - 34 ASF, *Sanità*, 467, ff. 14r, 16r.
 - 35 Cf. Champion, *London's Dreaded Visitation*. For the 1632 Florentine census see: BNCF, Palatino EB XV.2 See also the surviving sections of the census of the city taken in January 1631: *Sanità*, 465: 'Sesto di S. Spirito; Carte Stroziane Serie I.XIX: Sesto di S. Croce.
 - 36 Litchfield, *Florence Ducal Capital*, 344–50, esp. 350: Table 7.1.
 - 37 Henderson, '"La schifezza, madre di corruzione"'.
 - 38 Litchfield, *Florence Ducal Capital*, 347–48.
 - 39 See G. Fanelli, *Firenze nel periodo della restaurazione (1814–1864): Una mappa delle trasformazioni edilizie*, Roma, Edizioni Kappa, 1989.
 - 40 Litchfield, *Florence Ducal Capital*, 346.
 - 41 Ibid.
 - 42 N. Eckstein, in this volume, uses geospatial data on the efforts of the Florentine *Magistrato della Sanità* to prevent a recurrence; here, Henderson tracks the plague itself, relying on the records of the sick and the dead to show its impact on a neighbourhood in Florence.
 - 43 P. Findlen et al., 'Case Study: Travelers on the Grand Tour', *Mapping the Republic of Letters*. Online. Available <<http://republicofletters.stanford.edu/casestudies/grandtour.html>> (accessed 21 June 2015); N. Jacobs and R. Peñate, *Animated Atlas of African History*. Online. Available <www.brown.edu/Research/AAAH/index.htm> (accessed 21 June 2015); G. Prickman et al., *The Atlas of Early Printing*. Online. Available <<http://atlas.lib.uiowa.edu/>> (accessed 21 June 2015).
 - 44 The *Republic of Letters* project is social historical, especially given its creator's interest in materiality and the relationships between things and the societies that produced them. Cf. P. Findlen (ed.), *Early Modern Things: Objects and Their Histories, 1500–1800*, London, UK: Routledge, 2013.
 - 45 N. Cummins et al., 'Living Standards and Plague in London, 1560–1665', 1–32.
 - 46 OpenStreetMap. Online. Available <www.openstreetmap.org/> (accessed 21 June 2015).
 - 47 I am grateful to Marcel Fortin, Head of the Map and Data Library, Robarts Library, University of Toronto, for his patience in helping me develop the techniques required for this aspect of DECIMA and the entire project. The platform would be much thinner were it not for him. Cf. J. Bonnell and M. Fortin (eds), *Historical GIS Research in Canada*, Calgary, Canada: University of Calgary Press, 2013.

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Part 3

Mapping motion, emotion, and sense

Using digital mapping to rethink categories and communication