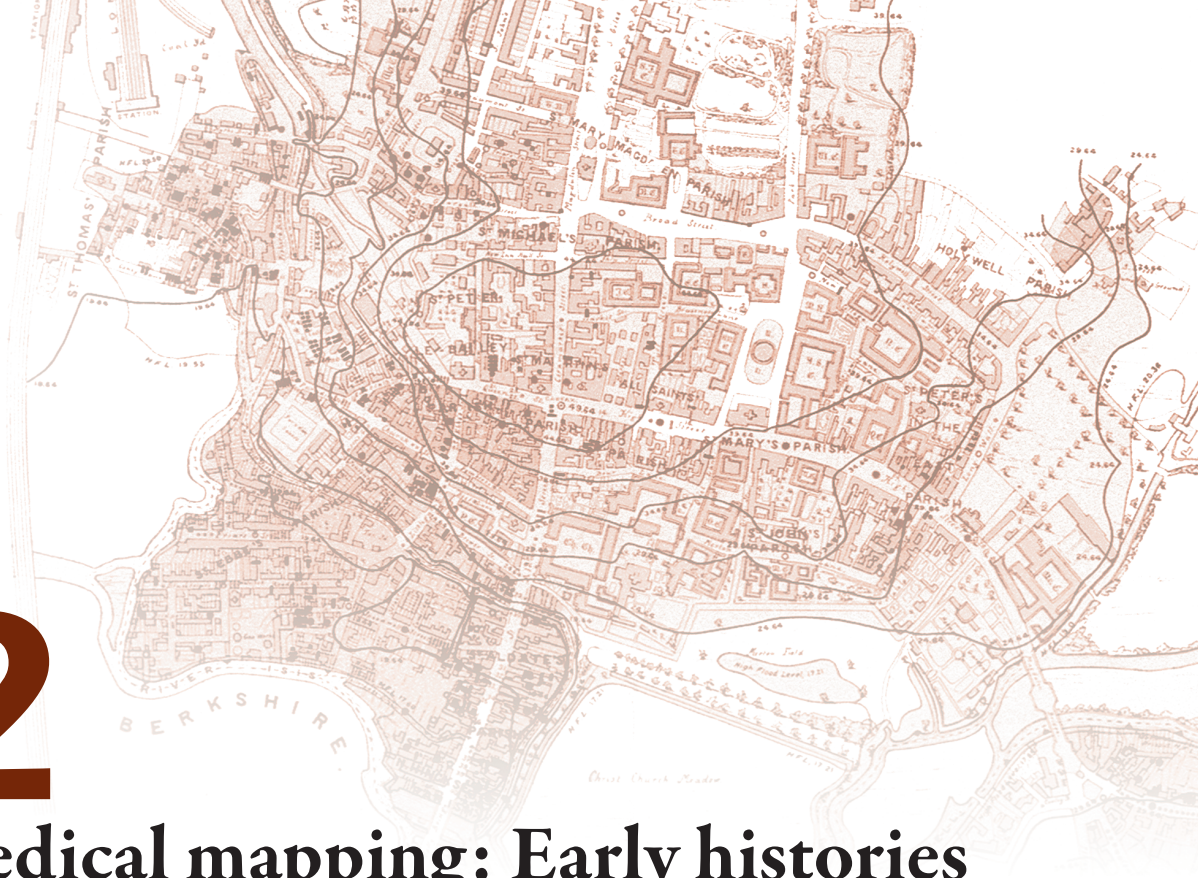

2
Medical mapping: Early histories

Epidemic disease

We are all double agents in the war against disease, encouraging its propagation while simultaneously fighting its spread. The communities we build, the technologies that enable them to function, and the commerce that sustains them assure environments favorable to the advance of our microbial friends and sometimes enemies. In a real way, medical science plays catch-up with the health problems we create in our evolving society; its advances are a response to the diseases we foster through economic, environmental, and social choices. It is no accident that medical mapping blossomed in the nineteenth century during a period of vastly increasing international trade and emigration, or that its renaissance began in the 1990s during a new era of globalization. In the early-to-mid-nineteenth and late twentieth centuries, similar elements coalesced to advance simultaneously a range of epidemic and chronic diseases as well as the mechanisms by which they might be understood. Medical mapping was a part of that process of understanding.

It is not simply that "multitudes of bacteria and viruses occupy our skin, our mucus membranes and our intestinal tracks, and we must learn to live with them in a 'truce' rather than victory" (Lederberg 2003, 20). That is true but insufficient. More centrally, new viruses and bacteria find our bodies

habitable because of the lives we lead in cultures whose conditions are favorable to their generation, development, and diffusion. "Rarely, if ever, do emerging infections appear without reason" (Morse 1999, 39). What Morse calls the "microbial traffic" by which infectious agents transmit disease from animals to humans, or disseminate it into new populations, is well understood (McNeill 1976). These include a population density sufficient to support their growth, travel vectors permitting the agent to move to new populations, and environmental factors in those population areas that create a hospitable home for microbial evolution.

"Travel and trade set the stage for mixing diverse genetic pools at rates and in combinations previously unknown" (Wilson 1999). In the late twentieth century, massive emigration and immigration fueled urbanization worldwide during a period of self-consciously intense globalization. Urbanization, in turn, fueled deforestation and the destruction of traditional habitats in which some microbes had long lived in a stable niche. Both goods and the people employed to create them traveled internationally at an ever-increasing rate, providing the means by which those dispossessed bacteria and viruses might find new lodgings. The result contributed to a context that encouraged the evolution of a range of diseases for which humans served as hospitable reservoirs.[1] It is no accident that "since the 1970s, there have been thirty-plus new diseases that have emerged. We also have old diseases that are reappearing where they've been eliminated, or appearing where they've never been before" (Dotto 2003, F7).

Something very similar occurred in the late eighteenth through the mid-nineteenth centuries. Massive migration by agricultural workers to the industrializing city and emigration from industrialized Europe (and later Asia) to the developing New World powered the emergence and diffusion of a range of infectious diseases: cholera, syphilis, tuberculosis, typhoid, yellow fever, and others. In what is today called the "Great Migration," more than five million people moved from Europe to the Americas (Guillet 1963). In 1832 alone, decades before the migration peaked, more than fifty thousand emigrants—the majority from Great Britain—crossed the Atlantic to Canada and the United States (Hansen 1961).

It was, in Robert Boyd's memorable title, *The Coming of the Spirit of Pestilence* (Boyd 1999), that expanded the range of then local diseases to a global field of exchange. It was not simply that some ships traveled with people infected with a disease before they left their homeport for another. That happened, and when it did the results for passengers on those vessels were disastrous. As important, however, is the fact that nineteenth-century ships sailed with a cohort of fellow travelers—rats and insects—agents of a host of bacterial and parasitic diseases. Rodents, insects, and mites all found a welcome environment in first the emigrant ships and later the cities where their ships would eventually dock.

Greater and greater numbers of minimally paid workers poured into ever-more densely settled cities to operate the machines and staff the myriad jobs that made the cities work. Emerging industrial centers typically bereft of even minimal standards of sanitation, protected water supplies, or adequate systems of sewage disposal, assured diseases that might otherwise have died for want of a hospitable setting would flourish. And because a health infrastructure was typically at best minimal, treatment was rarely begun

until the infected patient had transmitted his or her ailment to others. In this way, endemic diseases previously rooted in specific local communities became epidemic and sometimes pandemic.

The history of disease is one in which specific, environmental conditions give rise to reservoirs of evolving bacteria and viruses that diffuse along vectors of animal and human migration. Those reservoirs are typically urban, the unhealthy city where sufficient populations exist to permit a disease to first develop and from which it can then spread. This is an old story, one older than the maps in this volume, a tale as old as human settlement itself. Porter takes "the era of epidemics" back to 3000 B.C. and its populated cities (Babylon, for example) that rose in Mesopotamia and Egypt, in the Indus Valley, and in China in the valley of the Yangtze, the Yellow River. "Such settlements often maintained huge cattle herds, from which lethal pathogens, including smallpox, spread to humans, while originally zoognostic conditions—diptheria, influenza, chicken-pox, mumps—and other illnesses also had a devastating impact" (Porter, R. 1998, 22).

To take a single example, influenza is believed to have originated among domesticated fowl in China, mutating no later than 1600 B.C. into a strain that affected humans (Lewis 2004). The virus jumped

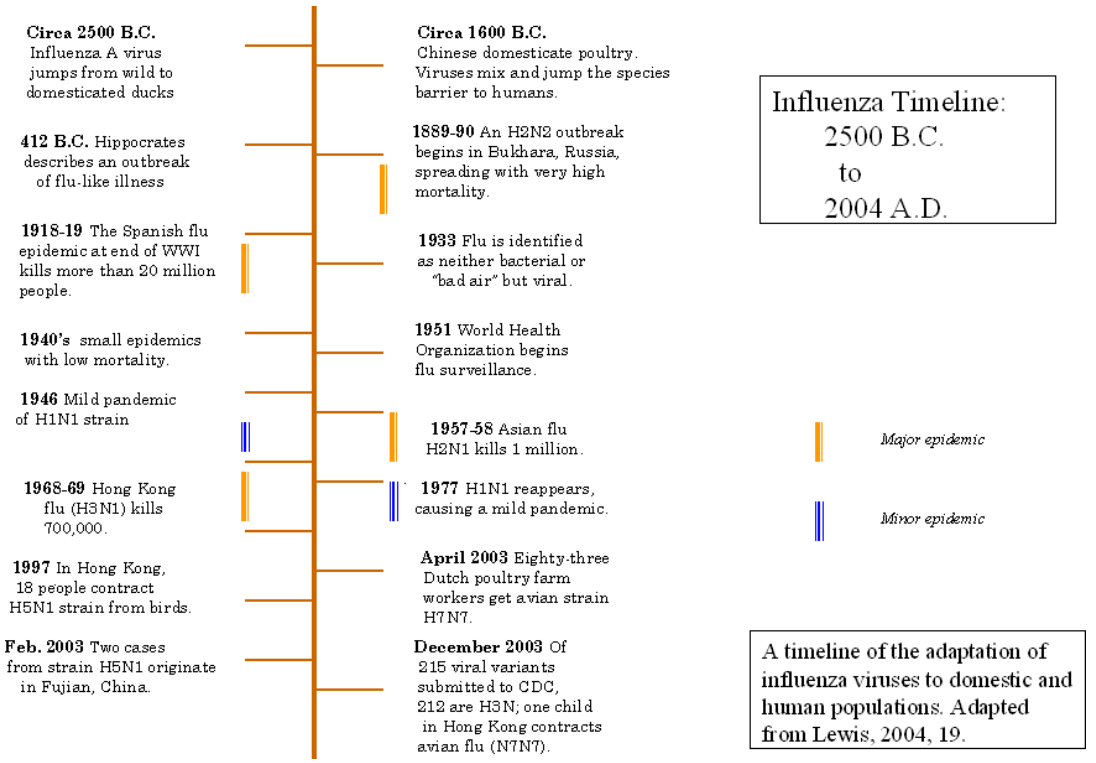

Figure 2.1 Influenza timeline. Source: Adapted from Lewis (2004, 19).

from poultry to humans living in cities—China was the most urbanized nation of that age—and spread from there throughout the world. By 412 B.C. the disease was in the Mediterranean where Hippocrates described an epidemic outbreak. Influenza then slowly diffused with travelers along trade routes to lodge in other cities and towns where the population was sufficient to sustain it as an endemic disease. Over time it has evolved as our civilizations have matured, adapting to the environments we create.

From the start, cities meant density—of humans and the commingled animal species that sustain us—and that density has been a primary requisite for the evolution of bacteria and viruses whose effect on humankind (and sometimes, animals, as well) can be disastrous. Human trade and travel—to the market, to the Crusades, or simply to another village—were the vectors by which the bacteria and viruses were transported to new populations. In the earliest histories, the diffusion of disease was limited by the paucity of reservoirs sufficiently large to serve as breeding grounds. As city sizes increased, and travel linked them, new opportunities for evolving microbial diseases emerged.

The rate of infection and reinfection for plague in the Middle Ages, for example, was directly proportional to the size of a village or town's population: "Plague could maintain itself in towns but not to any extent in villages unless they were large" (Twigg 1984, 187). The shift from village to town and town to city in the nineteenth century assured that diseases that earlier would have occurred only sporadically, or been locally endemic, became epidemic, and in some cases, pandemic. Trade and migration that tied together the commerce of nations, were the vehicles that carried diseases between communities either by sea in sailing ships or over land by horse and horse-drawn carriage.

Relationship between plague infection and population size in Indian communities

Mean population	% never infected	% infected once	% infected twice	% infected 3 times
92	80	20	0	0
257	51	32	17	0
352	50	33	14	0
603	31	32	32	5
784	21	39	35	5
1059	15	34	46	2
1465	7	25	61	7
2373	5	15	64	15

Figure 2.2 Relationship between plague infection and population in India. Rows do not all total 100 percent because figures exclude percentage of population infected four or more times. Source: Adapted from Twigg (1984, 186).

Plague: Bari, Naples, 1690–1692

It is appropriate that this history begins with a map of plague, a disease so pervasive and traumatic, so fearfully deadly that "it has transcended itself to become emblematic of something more invasive and apocalyptic than mere infection" (Marriott 2003, 10). In what is now thought of as its first pandemic, plague appeared first in China and then took almost a century to make its way through Asia and the Middle East to wreak havoc in the Mediterranean. The second pandemic occurred in the Middle Ages and may have appreciably hastened their conclusion. Again it was neither uniquely Asian nor European but pandemic, a global progression. The population of China was almost halved, dropping from 123 million people in 1200 to 65 million in 1239 (Marriott 2003, 10). In Europe the "Black Death," also called the "Oriental Plague" by some nineteenth-century medical researchers, was no less devastating. "Within a couple of years, plague killed around a quarter of Europe's population—and far more in some towns; the largest number of fatalities caused by a single epidemic disaster in the history of Europe. Thousands of villages were abandoned, and by 1427 Florence's population had plummeted by 60 percent from over 100,000 to about 38,000" (Porter, R. 1998, 123).

Plague returned in the 1600s when it repeatedly attacked much of Europe in a series of epidemics. While apparently endemic, with localized outbreaks in cities like London every few decades (Tomalin 2002, 167), the greater pandemic of the mid-1600s was ferocious. Its devastating effect can be read in "Bills of Mortality" compiled in England by clerks who recorded the names and parishes of plague victims. For a grave to be registered, a parish scribe had to list a cause of death and the name, by local parish, of the deceased. In this way, the clerks created what might be thought of as the first official databases of disease incidence aggregated to an administrative unit.

Nobody knew what caused the disease or sustained its diffusion. Sometimes an outbreak could be contained and sometimes, despite all efforts, the disease spread across provinces, countries, and continents. Some believed it a punishment on humankind for its multitude of sins; others insisted it resulted from the unfavorable conjunction of planets in the sky. Within the science of the day, steeped in the work of Hippocrates and Galen, there was a general assumption of a sickness in the air, a "pestitential atmosphere" arising from the effluvia of the city itself. Whatever plague was, what was known was that once it appeared it usually spread rapidly, decimating cities and towns, provinces and nations, almost beyond repair.

Two extraordinary maps of this period have survived in a single, book-length report on an outbreak of plague in the province of Bari in what was then the kingdom of Naples (Arrieta 1694). The author, Filippo Arrieta, was royal auditor for the province under the military governor of Bari and its neighboring provinces, Basilicata and Capitanata. Together the maps tell us much about the medicine and medical cartography of this period. They say a great deal as well about the assumptions and preconceptions of modern historians who have in recent years considered the mapping of this period.

Figure 2.3 Map of the plague in 1690–1692 in the province of Bari, 1694, by Filippo Arrieta. The map shows areas most affected and the boundaries of a military quarantine imposed to prevent its spread to neighboring towns and other provinces. Source: Arrieta (1694).

In a seminal article on disease mapping and the beginnings of medical cartography, for example, Saul Jarcho (1970, 131–142) considered the first map reproduced here as a predecessor of later and more rigorous disease maps. In it he identified two cordons, one forty-five miles in length and composed of 360 barracks enclosing the towns of Monopoli, Conversano, and Castellano where the infection was present and another, longer cordon (*circumvallation*) separating the province from its neighbors, Capitanata, Basilica, and Otranto. “Isolation was completed on the coastal side by feluccas, two of which are shown on the map” (Jarcho 1970, 132).

For Jarcho, the map was a curiosity, an “interesting and attractive” example of medical mapping more notable for its survival—most maps of the seventeenth century have perished—than its content. And certainly, the quaintness of the map’s symbolization made it easy (and perhaps too easy) to dismiss the artifact as intellectually trivial. This was especially true for those like Jarcho who assumed such maps were primitive representations rather than mapped distillations of complex and sophisticated thought processes. Thus, he sees the two feluccas as representations of specific coastal ships—“two of which are shown on the map”—rather than symbols of a naval blockade symbolized generically.

It is an understandable if unfortunate mistake. To a modern cartographer the map suggested a crude and undeveloped mapmaking technology distinguished by its quaintness. The symbols (churches, hospitals, trees, boats) were drawn in childish profile while the coastline and boundaries were rotated and oblique (Wood 1992a, 174–178). Towns and cities were symbolized by drawings of simplified buildings, churches (with a cross), or hospitals (without) where the ill were typically taken for treatment or burial. A "C" distinguished towns where the outbreak had occurred but had passed from those "B" towns where the infection was active. Between the towns, trees symbolized if not rural then non-urban areas in the province.[2]

Despite the crudeness of its symbology, the map was more involved—intellectually and graphically—than Jarcho realized. Within it can be seen a complex series of four levels of containment designed to prevent the spread of the plague. The coastal patrol symbolized by the feluccas (*feluca di guardio*) served both to contain the area of active disease and to prevent its exportation by ships carrying people and goods to other areas. They thus served both defensive and offensive containment protocols (Haggett,110–115). On land, a dark wall with the repeated letter "A" along a *linea di circonvallazione* separated the area of active plague from western neighbors (noted by a "C") where the plague had been active, and from southerly areas where it had yet to appear. On top of the wall are tents symbolizing the location of troops stationed at quarter-mile intervals to enforce the quarantine.

Within the district of active plague was a third containment level that was ten miles in circumference, marked with a "B," and described in the legend but not symbolized in the map. These individual districts separated towns free of plague but susceptible to it (Mola, Polignano, Fasno, etc.) from others in the district where plague was active or had recently been active. These inner cordons were enforced by the deployment of 250 soldiers from fifty barracks, troops living in the town and charged with their protection. Finally, the map included a general, provincial cordon "D" separating Bari province from its neighbors. Here, too, the quarantine was enforced by troops whose tents are used to symbolize their presence. The military cost of deploying 1,750 troops stationed at 350 barracks was considerable, as Arrieta's text makes clear.

The map distills the details of a major military operation designed to halt or at least slow the spread of plague, one that reflects a real understanding of the disease's typical pattern of diffusion. Levels of containment separated the province from its neighbors ("D"), districts where plague had been ("C") from those where outbreaks were active, and insulated individual towns still plague-free from those where it was evident ("B"). The map reflects a surprisingly modern approach to disease containment.

This modern approach is clearer in a second map (figure 2.4), one not discussed by Jarcho (1970). In this second map there are two walled areas, one around the north central area of the province where the plague was active ("D"), and a second ("C") around Bari and nearby towns where the disease had earlier appeared. The broader containment area ("E") is province wide, one separating Bari from its provincial neighbors. In modern terms (Haggett 2000, 98–103), the whole map describes an interlocking

series of quarantine buffers designed to separate areas of infection and thus slow the rate of plague's progression. Inherent in the map is a theory of the disease, one based on its past activity, contemporary pattern of occurrence, and known potential for diffusion.

In 1694, medicine in the Hippocratic tradition was about observing nature, not probing for its secrets (Barry 2004, 16). Plague (like other diseases) just was, its periodic outbreaks a fearsome given whose cause was acceptably unknown. The science of the day was capable of various explanations of its nature but incapable of a means either to effectively treat or to prevent its occurrence. What health and administrative officials had was a knowledge of past outbreaks—where they had occurred, the pattern of their diffusion, and the damage they had caused—and a conviction that containment might halt or at least slow plague's progression through the province and kingdom. Embedded in the map is a tight argument linking the history of plague's previous occurrences (the basis for containment), the limits of medical science (no treatment but a general etiology), and the social structure of the greater community (civil, military, medical, and religious). Containment strategies were conceived and carried out with attention to all.

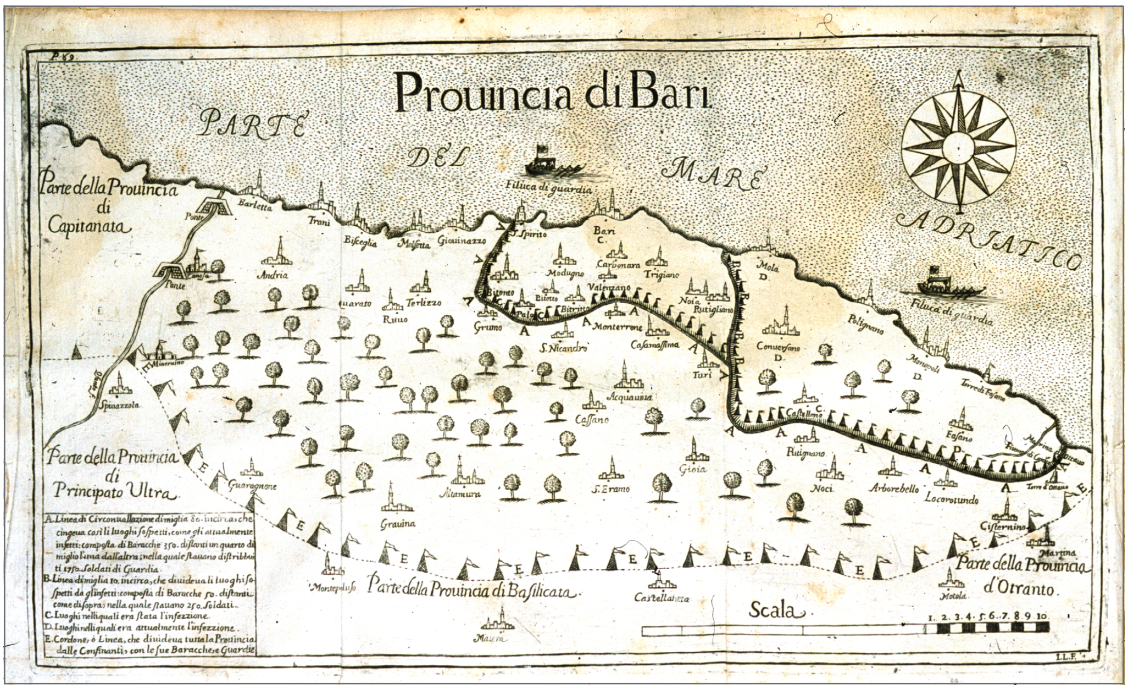

Figure 2.4 Map of plague containment zones in 1690–1692 in the province of Bari, Italy, 1694. Tents represent troop deployments on provincial borders, zones of active plague, and those where plague had already occurred. Source: Arrieta (1694).