Mapping Society

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Disease, health and housing

A double row of five-story tenements, back to back under a common roof, extending back from the street two hundred and thirty-four feet, with barred openings in the dividing wall, so that the tenants may see but cannot get at each other from the stairs, makes the ‘court’. Alleys — one wider by a couple of feet than the other . . . skirt the barracks on either side. Such, briefly, is the tenement that has challenged public attention more than any other in the whole city and tested the power of sanitary law and rule for forty years . . . in the public records it holds an unenviable place. It was here the mortality rose during the last great cholera epidemic to the unprecedented rate of 195 in 1,000 inhabitants.¹

The city as organism

Historical cartographers claim that the earliest use of maps to trace the spread of disease was in the United States in the 1790s, where they were used to record the location of infected households (see Figure 2.1), although for many centuries travellers have used maps to record the spread of exotic diseases amongst so-called native populations. In fact, some historians cite Aristotle’s De Aere, Aquis et Locis (‘On Airs, Waters, and Places’, written c.400 BCE) as the first to assess climatic, topographical and geographical conditions to seek patterns of disease in local populations.²

Later examples include quarantine maps, such as that used to record the path of the plague of 1347–8. The resulting map was shown to correspond to trade routes, leading the government of Venice to halt all trade in its port for 40 days.³ In later periods cordons sanitaires around diseased areas were determined by mapping the extent of a plague-ridden area in order to isolate it from areas that were disease free.⁴ By the
nineteenth century doctors were seeking to improve their practice by searching for environmental regularities in socio-medical phenomena by plotting them on maps. Such maps were used by doctors to look for causal relationships with environmental factors that may have caused disease. By plotting disease on the map, they were considering both spatial location and interrelationships, whether connections between data points or connections between the data and external factors, such as spatial location, social conditions, exposure to pathogens and so on.\(^5\)

The metaphor of the city as organism can be dated back to the early nineteenth century, when the city was seen to be akin to the human body, wherein the circulation of water and air and the removal of waste created a healthy bodily state. Sanitary reformers took this further, wishing to use the mapping of disease as a method for identifying the causes of that disease. Taking a step beyond a medical topography, the mapping of disease sought to diagnose the city’s disorder, a form of ‘anatomical diagnosis of urban circulation and homeostasis’.\(^6\) It is unlikely to be a coincidence that the earliest maps of urban social ills were those of disease, given that in the early days of medical geography the city itself was seen to be part of the problem of disease. Looking at one of the earliest examples (see Figure 2.1), in his inquiry into the cause of the prevalence of yellow fever in New York, the physician Valentine Seaman mapped the addresses of recent yellow fever fatalities in New York, 1797, observing ‘that no Yellow Fever can spread, but by the influence of putrid effluvia’, namely the accumulation of stagnant water and the close proximity of a sewer drain, which were viewed by Seaman as a likely source of the disease.\(^7\) This sort of association of the disorder of the city with cases of disease was to continue for many decades further, until the first scientific diagnosis of contagion.

The use of maps to record disease was particularly common in early medical science, when, prior to Pasteur’s work in the 1850s – which was to find the biological causes of disease – environmental causes were the focus for investigating disease.\(^8\) One study has found that as many as 53 cholera maps had been published by 1832.\(^9\) Yet the use of cartography remained limited to making visual correlations, instead of analysing the possible underlying factors, such as the physical (water quality or climate) or human (which would encompass man–environment relationships, as well as population size and composition).

In the United Kingdom, public concerns about outbreaks of the highly contagious disease of cholera in 1831, and subsequently 1848, 1854 and 1866, led to a series of reports which used maps to show the spread of
disease. These included a report from 1849 by Shapter, which contained a lithograph map that used three different red symbols to identify deaths from the disease in 1832, 1833 and 1834. The map also showed the city’s response to the epidemic, such as locations where contaminated clothes were burned and buried, convalescent homes, druggists, burying grounds and soup kitchens. The notes on the map mention that Shapter believed cholera to be more prevalent in ‘low-lying areas of dense habitation, near the river, where drainage was poor and waste and refuse accumulated – in other words, the disease was
miasmatic’ (namely, came from bad air). A later map by Acland used black contour lines to mark altitude, to analyse the association between the prevalence of cholera and low-lying lands. Acland observed how the map of Oxford shows the infection to be ‘concentrated in the undrained parts’. Somewhat anticipating the later work by John Snow in London, Acland also noted the significance of wells being contaminated ‘by the sewage of the Town’.

In the United States similar developments in medical cartography led to a study of cholera in 1850s Boston, where an outbreak of cholera led the city’s leaders to commission a report that located all known hospital admissions from the disease in the city. The analysis also noted places of origin, age and meteorological reports against each case, while the map itself allowed its authors to take account of both the natural and human environment.

We can see an early example of medical cartography in Edwin Chadwick’s 457-page Report on the Sanitary Conditions of the Labouring Population of Great Britain from 1842. The report’s maps of Leeds (see Figure 2.2) and Bethnal Green in East London are an interesting development in social cartography, in that they bring together three sorts of graphics: data on individual cases of disease (with cholera in red dots and respiratory disease in black) plotted on the maps; data on poverty levels, presented in three shades of block infill, with darkness increasing with poverty; and marking on the map (in a wash of brown colour) the areas containing streets lacking in ‘cleansing’. Notably, disease is presented here as being associated with dirt (and the choice of the colour brown is unlikely to be a coincidence). The graphic sophistication of these maps was insufficient to take the analysis much farther than associating dirt with disease, though the report to the Leeds Board of Health following the cholera epidemic of 1832 had attributed a lack of drainage, sewerage and paving as likely causes of the disease.

By the mid-nineteenth century, Leeds had become a centre for the manufacturing industry, with engineering and textiles the most dominant sectors. The city’s natural resources, transport connections and regional location helped encourage rapid industrialisation. In his map of cholera in Leeds, Chadwick identifies two groups of dwellings: houses of the working class and ‘shops, workhouses, and houses of tradespeople’.

By the inspection of a map of Leeds, which Mr. Baker has prepared at my request, to show the localities of epidemic diseases, it will
Figure 2.2  Sanitary Map of the Town of Leeds, 1842.

Copyright Cornell University – PJ Mode Collection of Persuasive Cartography.
be perceived that they similarly fall on the uncleansed and close [sic] streets and wards occupied by the labouring classes; and that the track of the cholera is nearly identical with the track of fever. It will also be observed that in the badly cleansed and badly drained wards to the right of the map, the proportional mortality is nearly double that which prevails in the better conditioned districts to the left.17

Dots (blue for cholera and orange for other contagious diseases) proliferate in the working-class areas. These are not contiguous regions but are sprinkled around the map. The map shows the importance of the river in shaping the land use pattern of the city, with residential areas dominating the area to its north and industries dominating the area south of the river. In fact, many of the city’s industries utilised the river as a source of energy and transportation. The area north of the river and around the Leylands (the principal area of Jewish settlement in 1881) was primarily residential, but also contained smaller-scale industry such as leather works, shoe manufacturing workshops and small-scale brick factories.

Given the clear coincidence between disease and poverty, housing conditions were one of the most central concerns of the report, whose conclusions emphasised the need to improve the layout of working-class housing. While theories regarding the transmission of cholera through contaminated water were not then widely known, the relationship was becoming increasingly obvious to those who studied the map data closely:

... the public loss from the premature deaths of the heads of families is greater than can be represented by an enumeration of the pecuniary burdens consequent upon their sickness or death... The primary and most important measures [for improving health], and at the same time the most practicable, and within the recognized province of public administration, are drainage, the removal of all refuse of habitations, streets, and roads, and the improvement of the supplies of water.18

Space syntax analysis of the historical pattern of accessibility across Leeds’s street network has found that the city’s most accessible streets were situated north of the river and railway lines. Nevertheless, the sanitary map of Leeds (see section of the map in Figure 2.3), reflects the spatial conditions of the district, so although the Kirkgate area highlighted
here was quite close to the heart of the city, its northern part, known as Leylands, suffered from being inaccessible, with the main streets of the area skirting the district but generally not penetrating it.  

The records show that the Leylands was a very poor district with mostly back-to-back houses (see Figure 2.4) in cobbled streets and many tumbledown yards. A report from *The Lancet* from as late as 1888 found that many of the houses in the Leylands had no backyards or rear windows, and the housing density in the area was very high. Aside from the cemetery, there was no open ground in the area and only in 1888 was the first recreation ground established in the district. In later years the area south of Roundhay Road had better housing, having benefitted from a bye-law of 1866 that required blocks of no more than eight
terraces, with privies in between each block. Yet this housing was still of miserable quality and improved only in the 1890s, when several slum clearance programmes were implemented.

On the other hand, despite its accessibility, the southern area contained the worst housing in the district, ranging from back-to-back housing (with consequent seriously reduced ventilation and poor sanitation) to more orderly housing in the Regent Street and York Road areas, following the ‘graph paper’ terrace model.21

Elsewhere mapping of cholera was undertaken in Hamburg, Germany, by Dr Rothenburg, using the choropleth method to create hand-coloured gradations of red to display the relative aggregate incidence of the disease in 1832.22 This map was reprinted in an 1850 British parliamentary report on cholera, helping to reinforce how widespread cholera was as a problem. Dr Hellis’ map of cholera in Rouen, also in 1832 (see Figure 2.5 and Figure 2.6) was similarly influential. Published in his 1833 book, the map plotted each cholera case as a red dot on a highly detailed map, allowing for a visual inspection of the relationship between the location of shipping crew and clusters of disease.23 Red lines were also used to
outline establishments such as the prison or army barracks. The report also records the ports of origin of the ships. His multiple observations led Hellis to the conclusion that cholera dispersed along the banks of the river and into particularly impoverished and run-down dwellings, so starting, at least in principle, to favour a contagion theory.

A recent study assessed the Hellis map by modelling the two main factors assumed to be responsible for propagating cholera: the presence of an aquatic environment (river and wells) and the density and level of income (measured by charitable expenditure). The computer simulation found a close association between health risk according to these spatial and social determinants and the clusters of high rates of cholera. This study shows that with sophisticated analysis it is possible to consider socio-spatial relationships in great detail. In this instance, the authors provide evidence that places of exchange (such as markets), the quality of the housing, poverty and—importantly—water supply, were all likely to

Figure 2.5 Cholera in Rouen, 1832.
have contributed to the spread of the disease over and above the fact that its original source may have been seafarers coming into the city.

By the time of the cholera outbreaks in 1830s and 1840s London, the streets of its district of Soho had become a crowded slum that had gone down in the world. It was a place that Dickens’ Nicholas Nickleby found had

... pieces of unreclaimed land, with the withered vegetation of the original brick-field. No man thinks of walking in this desolate place, or of turning it to any account. A few hampers, half-a-dozen broken bottles, and such-like rubbish, may be thrown there, when the tenant first moves in, but nothing more; and there they remain until he goes away again: the damp straw taking just as long to moulder as it thinks proper: and mingling with the scanty box, and stunted everbrowns, and broken flower-pots, that are scattered mournfully about – a prey to “blacks” and dirt. 25

Figure 2.6 Detail of Cholera in Rouen, 1832. Eugène-Clément Hellis. Reproduction courtesy of Emmanuel Eliot and the Geoconfluences project.
In fact, space syntax analysis of the built form shape and configuration of the district of Soho in the latter part of the nineteenth century has found that the area was significantly more spatially segregated than its surrounding streets. This can be seen in Figure 2.7, which shows a section of the space syntax analysis for the Soho area c.1890 overlaid on the Ordnance Survey map of the area from the same period. Oxford Street, running south-west to north-west, appears in the warmest colour, signifying its wide-scale accessibility, while the area south of that street is markedly more segregated (note cooler shades of blue and turquoise surrounding Soho Square, south-east on the map).

Further analysis found that a combination of shorter blocks and a complex morphology, with narrow visual fields from the main streets surrounding the area into its interstices, meant that flows of movement into the area would have been restricted. The result was that the Soho district became socially separated from its prosperous surroundings,

**Figure 2.7** Space syntax analysis of the Soho area c.1890 showing local accessibility (axial radius 3) (inset) and Ordnance Survey map of London of the same period.

Image by the author.
attracting itinerant migrant workers, such as the seasonal Italian ice-cream sellers of the nineteenth century, radical revolutionaries at the turn of the twentieth century, or fashion sub-cultures in the twentieth and twenty-first centuries.\textsuperscript{26}

At the same time, Dr Perry, Senior Physician to the Glasgow Royal Infirmary, was one of many physicians contributing to the plethora of medical reports on disease and housing conditions. In a study into the extent of the typhus epidemic in Glasgow of 1843 he pinpointed individual households affected by the fever. Using reports collected from the local surgeons he had a team colour up a map of the city, shaded darker where the epidemic was most prevalent. His analysis showed six-fold differences between parts of Glasgow when calculating fever cases as a proportion of the population, with a clear association between overcrowding and disease – but also vice.

\ldots those places most densely inhabited, by the poorest of the people, have suffered most severely. The epidemic, having once got into a densely crowded land or close, never ceased until it had visited every house, and in many of the houses every inmate \ldots The houses in most cases were too crowded; some small apartments containing two, three, and occasionally four families! In others numerous lodgers, men, women, youths, and children, were huddled indiscriminately together on a cargo of straw upon an earthen floor \ldots a fruitful source of vice, pollution, and disease.\textsuperscript{27}

**Medical mapping as statistical method**

It was not until John Snow published the second edition of his essay ‘On the Mode and Communication of cholera’, showing the association between the incidence of deaths from cholera and the location of pumps in the Soho district of London, that mapped statistics were used scientifically (see Figures 2.8 and 2.9).\textsuperscript{28} London was among many large cities that had been suffering from periodic cholera epidemics since the 1830s. Snow hypothesised that cholera was caused by a germ spread through contaminated water, in contrast with the prevalent miasma theory of contagion through bad air. The two theories were debated vigorously, but Snow’s ground-breaking studies of the 1853–5 epidemic resulted in his being considered the father of epidemiology, due not only to his well-reasoned statistics but to his maps, which illustrated to
Figure 2.8  J. Snow, Street Map of Soho, around Golden Square, Illustrating Incidences of Cholera Deaths during the Period of the Cholera Epidemic, 1853.

Figure 2.9  Detail of Fig. 2.8, J. Snow, Street Map of Soho, 1853.
a lay audience the evidence of a cluster of cholera cases amongst people living close to a single water pump on Broad Street and, hence, that contaminated water was the source of the disease (see Figures 2.8 and 2.9 showing John Snow’s Broad Street map).

Notably, instead of using his map as a source of evidence, Snow used it to communicate that evidence. While some critique the mythology that surrounds the Snow story (which states that, following his testimony, the handle of the pump believed to be the source of the disease was removed), Snow’s central role in the history of social mapping is significant. His importance lies first in his establishment of a clear spatial relationship between contaminated water and the disease, and second in his use of disease mapping to observe, communicate and analyse statistics. By using statistics to disprove the air theory, he pinned down the causation in such a way that his argument became incontrovertible. In order to understand the results of his study in their full complexity the reader had to take in a mass of statistical tables, which, once read alongside the maps, became clear; at the same time the clarity of the maps made them devices for communicating a simpler form of the argument to the general public.

Snow allowed the viewer of the map to – as Gilbert puts it – ‘. . . conceptualise [the causal relationships] in a whole new way, having to do with the actions of humans in relation to the environment’.

While the stories around Snow project a picture of a single pump affecting a single group of people, in fact his analysis demonstrated that people’s pattern of illness was (unsurprisingly) much more complex, with some of the deaths close to the pump being due to contagion having taken place elsewhere; other deaths were recorded outside of the area, even though the people had been infected by contaminated water taken from the pump. Gilbert also points out that Snow’s second map, which shows the coverage of the various water companies supplying the wider London area, emphasises this reading of a community as having a much wider spatial scale than the Broad Street map would suggest. While Dorling and Shaw argue that Snow’s dot-mapping method is a problematic precedent, in that it is easily misread if it is not normalised for the size of the population; indeed, by centring the map on Broad Street, it emphasises the individual pump’s culpability, when in fact there is evidence that while there were higher rates of cholera elsewhere in London at the time, cases were lessening overall due to the work of the local boards of health to clean up water supplies following the passage of the 1848 Public Health Act.

Although he is less well known today, the importance of the work of William Farr in compiling the statistics on cholera mortality used by Snow
has been highlighted by Tessa Cicak and Nicola Tynan. In their study, they used a Geographic Information System to map London’s water company boundaries at that time. They then tested Snow’s data: first by correlating them with figures on ground elevation above the level of the River Thames and then by correlating them with the water company supply areas. Their results substantiate Farr’s proof of the ‘influence of water as a medium for the diffusion of the disease in its fatal forms’. Farr had initially believed that elevation was the strongest correlate with cholera mortality, but by 1853–4 he was persuaded by the statistically significant differences in mortality rates between different water companies, after which he switched allegiance to Snow’s theory.

Snow’s work remained influential for a considerable time onwards. While the waterborne theory of cholera became more commonly accepted, his map was viewed as a way to explain the impact of ‘microorganisms invisible to the human eye’, as Steven Johnson has put it. Snow’s longer-term impact was two-fold: in starting a tradition of medical mapping that continues to this day, but also in pushing for more accurate, large-scale maps of cities. His study also helped establish a standard cure for the spread of the disease, namely direct intervention in the environment, whether through sanitary improvements or wholesale redevelopment of the slums. These environmental solutions are part of a step-change that took place in this period, whereby medical and public health practitioners were able to construct a ‘fine-grained, spatially precise argument’, based on street-by-street data, namely data that corresponded to the environment within which the victims of the disease were living at the time. Snow’s map also serves as an exemplary research instrument, to ‘illustrate an inferential process of deduction [to be employed] in considering the logical relationship between spatially grounded data on disease incidence and environmental [in this case] principally water-borne, sites of suspected contagion’. In effect this practice continues to this day in epidemiology, which regularly uses maps to analyse spatial correlates of disease, of which more in the last section in this chapter.

On housing and health

By the mid-nineteenth century, massive growth in industrial towns, in the absence of stringent regulation of house building, road laying, water supply, and sewage removal, had led to increasing public concerns in Britain. The quality of housing, unmade roads and overcrowding became the focus of debate. Edwin Chadwick’s 1838 report on living conditions
in east London, as well as the report on the *Sanitary Conditions of the Labouring Population of Great Britain* in 1842, led to recommendations to build drains, remove sewage via sealed pipes, improve water supplies and build cemeteries on the edges of towns. Yet it was only with the passage of the 1848 Public Health Act (due partly to proof from William Farr that linked disease with squalor and to Chadwick’s argument about the cost of death and illness for the nation’s productivity) that improvements to the quality of housing and urban layouts started to take shape. Following Snow, the focus of public health efforts led to the appointment of John Simon as first Medical Officer of Health from 1858, who pushed prevention as well as curative methods. The Public Health Act of 1875 subsequently required local government bodies to improve water sanitation and to appoint inspectors responsible for housing standards, quality of waterways and so on.

As Pamela Gilbert has shown, the cholera epidemics that plagued London in the nineteenth century were a turning point in the science of epidemiology and public health, and the use of maps to pinpoint the source of the disease initiated an explosion in medical and social mapping not only in London but throughout the British Empire as well. She writes that ‘medical mapping . . . is essentially a statistical argument presented visually . . . it also comes into being because of the spatialized understanding of social problems’. Gilbert goes on to explore an anatomical metaphor for the way in which Booth coloured his maps, demonstrating a form of visual rhetoric in the way in which the map is coloured:

\[\ldots\] the west appears to be a healthy, bright orange-red with pockets of darkness. The east . . . and to some extent the south, range from a pallidly under-oxygenated pinkish-lavender to a chilling pale blue, with threateningly concentrated blotches of dark blue and black. Given the ethnic distribution of the London population, this darkness may have taken on racial overtones as well.

Claiming that Booth’s understanding of poverty was ‘informed by nineteenth-century sanitary and medical understanding of both public and individual health’, Gilbert sees Booth’s dislike of dark, airless spaces as coming from a medical understanding of sanitation: ‘\ldots we see again the notion of circulation which is encoded in the anatomical representation of London’s body’. Interestingly, this could be said equally to apply to the way in which Booth himself viewed the city, whose severing by railways could cut off the life-blood of its inhabitants: ‘In Battersea
poverty is caught and held in successive railway loops south of the Battersea Park Road. . . This is one of the best object-lessons in “poverty-traps” in London.” 38 See the reference to gangrene by Harold Dyos:

A . . . careful reading of Booth’s maps would show how some additions to the street plan – a dock, say, or a canal, a railway line or a new street – frequently reinforced these tendencies. What often made them more emphatic still was the incense of some foul factory, a gas-works, the debris of a street market, or an open sewer. They all acted like tourniquets applied too long, and below them a gangrene almost invariably set in. The actual age of houses seldom had much to do with it and it was sometimes possible to run through the complete declension from meadow to slum in a single generation, or even less. 39

After the publication of Booth’s maps there was increasing public pressure to clear out the poor areas and tidy up the existing intricate and enmeshed networks of streets. As we saw in the previous chapter, the city’s morphology – its physical form and layout – was itself viewed by the general public as a source of the immoral behaviour of its inhabitants, and a significant obstacle to policing. We will see more on the importance of Booth’s study in influencing housing and urban legislation in Chapter 3.

In the United States the housing tenements of densely occupied cities such as New York attracted a series of housing commissions and enquiries whose impact was limited until the turn of the twentieth century. Population growth in New York in the latter half of the nineteenth century had led to a rapid increase in population densities – a particularly acute problem on Manhattan island, especially within the constraints of the standard lot size of 25 by 100 feet. With this increase in population, the tenement building emerged as a response to the demand for low-cost housing design. Yet, without building regulation, buildings were constructed with a severe lack of light and ventilation. Up to 90 per cent of a lot was permitted to be built upon, producing a sequential layout akin to a railroad carriage (hence their being called ‘railroad flats’). The 1867 and 1879 Tenement Acts sought to introduce legislation to improve housing and led to a new housing form, the ‘dumb-bell’ (so called because of its shape in plan – see Figure 2.10), which was an improvement, but did not yet achieve the desired outcome of improvements in light and ventilation. It still permitted up to 65 per cent coverage of each lot.
The Tenement House Committee was created by the New York State legislature to enquire into New York’s housing problem. Its report, and maps, were presented on 17 January 1895 and sparked much public interest after they were published in *Harper’s Weekly*, a widely read publication that had frequently written on poverty and housing problems. The maps ‘represented an important milestone in the use of new forms of graphic representation by reformers’.  

Of the two maps, the upper shows population density, with the highest densities located in the Lower East Side, an area of high immigrant settlement (see photograph of New York tenement in Figure 2.11 and maps in Figure 2.12). The lower map was adapted from a colour version that was shown to the committee, and that, interestingly, anticipated Jacob Riis’ conception of the city’s various nationalities, which (as we saw in the Chapter 1),

would show more stripes than on the skin of a zebra, and more colours than any rainbow. The city on such a map would fall into two...
great halves, green for Irish prevailing in the West Side tenements and blue for Germans on the East Side. But intermingled with these grand colours would be an odd variety of tints that would give the whole the appearance of an extraordinary crazy quilt.\(^{42}\)

Although they were never interpreted in detail, the maps were a powerful representation of two coinciding urban characteristics: on the one hand, the cluster of extremely high population density in one corner of lower Manhattan and on the other, this being the heart of the highly diverse immigrant quarter.

The Tenement House Committee’s maps appeared almost simultaneously with several reports, which collectively helped speed along the programme to cut out the diseased areas of the city from its body. In one example, a ground-plan of a ‘Lung-Block’, a single block in New York that was riddled with cases of tuberculosis, was published in a report by Dr John Bessner Huber (Figure 2.13).\(^{44}\) His report is full of graphic descriptions of the conditions in this single block of dwellings, whose
Figure 2.12  The Tenement House Committee maps, 1894.

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appalling physical conditions he blamed for the block’s extremely high rates of consumption (tuberculosis), such that,

Infection comes not only from the room, but as well from halls and stairways. An old Italian, a hopeless victim, sits out on the steps in front all day long in the sun, while the children play around him, and all through the evening, with men and women beside him. His cough never stops. The halls behind and above are grimy, offensive, lying heavy with cobwebs, and these cobwebs are always black. The stairways in the rear house are low and narrow, uneven, and thick . . .

Alongside various disease maps of this time, about which further discussion is presented below, the impact of this map led to reforms in housing and ultimately to the Tenement House Act of 1901, which followed many of the prescriptions of the Committee’s report.

The graphic impact of Huber’s ground-plan was widespread. It featured in The Brooklyn Daily Eagle newspaper in 1903, along with a long article discussing the appalling situation in blocks such as this. The powerful image of the ground-plan, with its patches of shading to indicate the miniscule amount of open space in its interior, marked with the many
cases of disease, crossed the continent: just a couple of weeks later the *Los Angeles Herald* described the building as ‘supplied with tuberculosis germs on its walls and its ceilings, in its hallways, on all the furniture and in the dirt-filled cracks in the floors’. The article goes on to blame the city for the fact that such buildings are permitted to stand, but notes also that a new ordinance – evidently the Tenement Act of 1901 – will hopefully eliminate such disease-breeding buildings. Indeed, soon after this date housing reform took shape in the form of localised slum clearance, which then became more widespread with a systematic programme of slum clearance and public housing construction. Only a few years later another doctor, this time in Chicago, made a comprehensive study of the incidence of tuberculosis in the Near West Side of Chicago. His report’s striking graphics, which show building morphology and land use alongside mortality cases, were another step forward in using maps to test hypotheses regarding the causes of contagious disease (Figure 2.14 and detail in Figure 2.15).

The spatial solution for disease in the ‘body’ of the city shifted over time. By the end of the nineteenth century, Charles Booth was advocating suburbanisation as the best solution to ‘the evils of over-crowding’, proposing a system of tramlines to provide easy commuting routes that would allow London to be broken up into suburban centres. These went on to be constructed alongside a programme of widening thoroughfares, and courts were opened up to allow for a battle to be fought against ‘the war with dirt, disease, and premature death’. At the same time in the United States, following the New York State Commission, other states picked up the issue of overcrowding, not only at building scale, but also at the scale of the lot or the block (in something of a recollection of the early Housing Acts of the city). In one example, a map of a Blind Alley in Washington and its associated report was explicitly attributing the lack of through passage as one of the causes of disease and crime in the city (see Figure 2.16).

The Blind Alley map was published in a ‘Directory of Inhabited Alleys in Washington’ from 1912, which was drawn up to allow for easy inspection of these alleys. The directory cites the death rate in alleys as exceeding that in streets by a considerable degree, with the most prevalent diseases being pneumonia and tuberculosis. The solution is also outlined in the directory; it cites the relevant District Codes which will allow the alleys and minor streets to be extended, widened or straightened for purposes of improving health. The poor health of the alley’s inhabitants was attributed by the directory’s authors to their living conditions – yet the
Figure 2.14  Tuberculosis in a Congested District in Chicago, Jan. 1st, 1906, to Jan. 1st, 1908, including the district represented in chart 1, population chiefly Jewish.

Theodore B. Sachs. Image credit: University of Chicago Map Collection.
analysis of *Alley Life in Washington* by James Borchert refutes this argument, describing how the Black American migrants from the Southern states had made the most of the layout of street layouts such as these to reinforce internal communal ties, creating a reciprocal relationship of support.\(^\text{52}\)
By the end of the nineteenth century major advances in bacteriology meant that a concern with the biological causes of illness – a long list of which includes tuberculosis, tetanus, dysentery and the old enemy cholera – shifted the focus from mapping disease to the new urban problem of the era: mass immigration. Not only was this seen to be intensifying poverty in urban areas, it was also coupled in the public mind with contagious disease, a concern reaching its peak when outbreaks of yellow fever became associated with Chinese migration to major cities in Australia, the US and the UK. One striking example of how fear of contagion led to a racialised mapping of San Francisco’s Chinese quarter will be looked at in Chapter 5.

Following a decline in the use of disease maps in the latter part of the nineteenth century (to be supplanted by maps of ethnicity and poverty), a resurgence came in the twentieth century, when social planners and
so-called ‘hygienists’ started to conduct surveys and then map cultural traits, such as language, dialect and custom. This chapter’s last section demonstrates that disease maps are increasingly being used in contemporary public health research as tools both for diagnosing disease and for testing out cures for it. A wide variety of medical disciplines use disease mapping nowadays to analyse disease incidence and spatial distribution, frequently working in a multidisciplinary (and sometimes interdisciplinary) team that could include forms of expertise as varied as anthropology, transport and geography, although for the medical sciences the main practitioners come from epidemiology and public health.

**Contemporary mapping of disease: a story of spatial inequality**

While contemporary use of medical cartography continues the historical tradition of mapping disease spatially, medical mapping has shifted its focus in modern times to look mostly at non-contagious disease. Health cartography typically captures possible environmental factors, for etiological research (the study of the causes or origins of disease), as well as more complicated mapping of health (or wellbeing) and disease in relation to other factors, such as studies of social equity.

A classic example of etiological research is a study of the prevalence of Burkitt’s lymphoma in the 1960s. Disease maps showed a wide variation in the number of cases, which seemed to correspond with climate: incidence was high in the damp, hot climatic conditions of the lowland areas of Uganda and the coastal regions of Kenya and Tanzania, and low in the highlands of south and west Uganda, central Kenya and northern Tanzania. Analysis of the maps and further research led to the conclusion that Burkitt’s tumour is related to the presence of malaria (which is more prevalent in moist, hot regions).  

A western-centred review should also mention the continuing problem with contagious disease around the world, with cholera rearing its ugly head again in war-ridden Yemen at the time of writing this book. Indeed, just a few years ago, it took careful spatio-temporal analysis by a group of physicians to unpick the causes of an outbreak of the disease in Haiti, which proved to have been brought by United Nations peacekeeping troops from Nepal who came to the rescue of earthquake victims on the island. The lack of access to clean water and decent sanitation meant that once the disease had been introduced, it spread rapidly.
Dr Snow’s dot maps continue to be used to identify clusters of diseases such as cancer, as a way in which to identify possible local environmental causes. It is essential, however, to go beyond simply identifying problems by eye and embrace more sophisticated mapping and mapping analysis to avoid misattribution of cause and effect, as well as to avoid missing other causes that are not easily identifiable at first glance.55

In the context of this book, it is interesting to cast the gaze back to the so-called developed world,56 to see how contemporary mapping methods allow us to understand the much more complex interplay between disease, poverty and urban space, what might be termed as spatial inequality.57 In Britain, for example, premature death rates at all ages are two to three times higher among disadvantaged social groups than their more affluent counterparts. Contributory factors include the quality of housing, working conditions and pollution; economic and social influences, such as income and wealth; level of unemployment; quality of social relationships and social support; and access to effective health and social services.58 The impact of the physical environment itself has been the subject of a recent review and continues to be researched widely, including its impact on levels of obesity due to poor access to healthy food or due to the quality of a person’s local environment in encouraging walking and cycling.59 There are still many unanswered questions regarding the relationship between health and space.

An early example of contemporary analysis of spatial inequalities is the work of the radical geographer William Bunge, whose Nuclear War Atlas from 1988 highlighted the disproportionate rates of injury amongst inhabitants of a slum area of Detroit (see Figure 2.17). Bunge mapped data on rates of injury from automobile accidents that he had collected in the 1960s, showing how they occurred on parts of the historical street network that were being used by commuters as a cut-through. The conflict between automobiles and pedestrians walking to school was, he argued, an entirely predictable pattern, one that was therefore not accidental at all. An earlier version of the map was more bluntly entitled Where Commuters Run over Black Children on the Pointes-Downtown Track.60

Bunge’s blaming of the geography of Detroit’s streets, namely the inner-city gridiron pattern, was a common critique of older ‘small lot’ cities, which in the past had been shaped for a scale of distance that could be travelled by horse and buggy. This supposedly anachronistic planning scale was one of several reasons given for the building of clean, safe
suburbs as a solution to inner-city problems. Putting aside the lack of evidence that through streets were more prone to pedestrian injuries from cars, Bunge’s analysis highlights a much more complex situation: in impoverished neighbourhoods, which would at this time have had a disproportionately high African-American population, a wide variety of factors contributed to the accident rate, including a lack of investment in safe crossing or traffic calming measures. Even if dispersal to the suburbs was the correct solution, many inner-city residents would have been excluded from moving there, whether for reasons of affordability, prejudice or both (see section on redlining in Chapter 5).

Another more recent study from the US concerning spatial inequalities has suggested a multivariate connection between spatial morphology, housing quality and race. In a study of excess mortality amongst the residents of a pair of neighbourhoods in Chicago, 1995, Eric Klinenberg found a stark difference between survival rates in two adjacent neighbourhoods, North Lawndale and Little Village. The two had ostensibly similar demographics, with large elderly populations living on their own, but North Lawndale had a death rate 10 times that of its neighbour. His analysis considered (amongst many factors) whether a
variety of economic and social transformations had resulted in a sharp difference in the social ecology of the two areas. While North Lawndale was full of empty lots and abandoned buildings, Little Village had a dense concentration of buildings fronting the street, generating a network of social ties between business owners, customers and passers-by. This neighbourhood had a much higher residential population, with deeper kinship networks than North Lawndale. In contrast, North Lawndale had a low population density, and few social ties within or outside of the neighbourhood. This meant that when a heatwave struck, given the widespread lack of home air conditioning (and the expense of running it where it was present), North Lawndale residents did not seek refuge in local shops and businesses or amongst neighbours, and remained trapped in their overheated apartments: meanwhile ‘the collective life of the area, the material substratum of busy streets, dense residential concentration, proximate family habitation, and booming commerce in Little Village fosters public activity and informal social support amongst the residents’. Klinenberg points out that other factors influenced the death rate overall, such as power outages and a shortage of ambulances. However, these do not explain the local differences in mortality. David Seamon has pointed out that Klinenberg’s analysis is akin to the view famously put forward by Jane Jacobs on how the urban layout is vital in shaping social interaction. She argued that simple devices, such as street-facing buildings in a dense mesh of mixed uses, create opportunities for informal social interaction to take place and, over time, for casual acquaintanceship to develop. In effect, Seamon argues, the differences between the two adjacent neighbourhoods’ survival rate had a fundamental environmental explanation.

A similar pattern of spatial inequalities can be observed in the rates of excess mortality during the 2003 heatwaves in Paris (with a total of 15,000 deaths in three weeks). One study has found a disproportionate number of heat-related deaths amongst older people was due to high mean minimum nocturnal temperatures (namely, not enough of a relief from the heat at night) that correlated with spatial and environmental factors such as surface temperature, vegetation and building materials. Interestingly, in a different study, Richard Keller has found that the Parisian cholera epidemic of 1849 and the pattern of deaths during the 2003 Paris heatwave are closely associated spatially. Vulnerabilities, he writes, can build up over decades, the outcome of urban planning along with a political culture and social structure. In this instance, the large
numbers of elderly women who died in the heatwave can be associated with the fraying of social networks for people living alone. Here, social isolation was concentrated in a number of inner-city districts in which there is a concentration of buildings dating back to Hausmann’s reconfiguring of the Paris streetscape in the mid-nineteenth century. The city’s existing network of narrow streets was said to inhibit circulation as well as contributing to miasmatic conditions (Figure 2.18). Haussmann’s vast planning project, which continued for almost two decades from 1852, included the demolition of many of the narrowest streets in the city, creating a network of wide boulevards which cut through some of the city’s poorest districts. The result was a relocation of many of the city’s poor to its periphery, while those that remained found themselves situated in overcrowded districts with boundaries hardened by the grand boulevards. Keller’s analysis of the 2003 heatwave found that the districts which Villermé had found in 1849 to be disproportionately poor, and suffering from excess deaths, matched the districts which had the greatest excess mortality in 2003.67

In addition to urban spatial conditions, Keller’s analysis found that the architectural characteristics of the buildings dating back to Haussmann’s times, which had tiny chambres de bonne (maids’ quarters) at the top of the buildings, were disproportionately occupied by the city’s elderly. Poorly ventilated, situated at the top of steep staircases, these were the least ideal locations for the frailest population of the district (see Figure 2.19). In essence, a form of vertical segregation had brought social exclusion down to the scale of buildings.

Just as in Paris, London has also shown signs of long-term persistence in spatial inequalities. In a recent study Danny Dorling, Scott Orford and colleagues looked at patterns of mortality from poverty-related illness, using data from the Charles Booth maps of poverty 1889 to compare the geography of poverty in the late nineteenth century with that of the late twentieth century. They concluded that the spatial persistence of poverty over time was extremely robust, despite a century of urban change having taken place since Booth’s time.68 Importantly, the mapping process aimed to go beyond the simple pursuit of visible patterns on the map – the authors tested for underlying spatial explanations for the measurable differences in health outcomes in different areas of a city.69

Another aspect of spatial inequality is the relationship between the location of pollution and respiratory disease. Alan Penn, Ben Croxford and
colleagues have used space syntax methods to analyse the street grid configuration of an area of London to compare the predicted rates of vehicular flows and average and extreme CO concentrations, finding a strong relationship between the two, meaning that planners can take account of potential problems with pollution at the finest resolution of
single streets (whereas typically pollution monitoring will take account of average data covering a relatively large area, and without consideration of the street layout). More recent research that builds in the prevailing wind direction may also bear fruit in the future, while the increasing availability of cheap pollution monitors means that local communities are getting involved with citizen science projects to monitor, and provide evidence for, local pollution problems.  

The geography of health in relation to obesity (and the diseases associated with it, such as diabetes and heart disease) is one of the dominant topics in public health research in developed countries today, due to its prevalence as an issue of concern. A variety of indices that aim to model how much an environment encourages physical activity are used by health researchers to predict patterns of walking and/or cycling. A typical walkability index will be a combined model of residential and commercial density, land use mix and junction density. By quantifying how walkable an urban landscape is, health researchers can test whether environments have measurable effects on people’s walking activity or on health outcomes (such as weight or blood pressure). One such index

Figure 2.19  Rooftop chambres de bonne in Paris, 2008. Photograph by Rafael Garcia-Suarez via Wikimedia Commons.
developed for the United Kingdom incorporates space syntax measures to predict walking in London.¹²

In general, disease mapping today is both graphic and statistical: first describing the nature of the disease spatially, then attempting to determine its cause by hypothesising cause and effect. The map is only the starting point in the process of research investigation. Despite the fact that the field of research has advanced enormously since the first maps of yellow fever were plotted over two centuries ago, a lot still remains to be understood about the role of the built environment in health outcomes. While contemporary maps continue to advance in their sophistication, it is clear that further work needs to be done to understand this complex interrelationship. We know, for example, that health declines with poverty, and that poverty corresponds to certain types of spatial settings, but how these factors interrelate is not yet clear. The next chapter picks up the subject of poverty, taking us back to 1850s Liverpool.

Notes
3. This is one of the earliest uses of the term quarantine. It relates to the Venetian dialect word for a unit of 40, quararentena, here denoting a period of 40 days. It is originally meant to relate to the period of Lent, though various other origins are given in the Oxford English Dictionary. In fact, the concept of spatially isolating disease dates to biblical times; e.g. ‘All the days the lesion is upon him, he shall remain unclean . . . his dwelling shall be outside the camp’; Leviticus 13:46.
5. For more on this conception of mapping as opposed to map-making, see Chapter 1 of T. Koch, Cartographies of Disease: Maps, Mapping, and Medicine (Redlands: California ESRI Press, 2017).
8. Cosgrove, Geography and Vision.
10. The map notes can be found in Princeton University Library, ‘Medicine,’ in First X, Then Y, Now Z: Landmark Thematic Maps, Princeton University Library Historic Maps Collection (2012), http://libweb5.princeton.edu/visual_materials/maps/websites/thematic-maps/quantitative/medicine/medicine.html (accessed 11 April 2018). Although he misattributed the cause of the disease, it is important to note his use of dots to record the locations of disease, some six years before John Snow.


15. The map's legend states that ‘less cleansed districts are marked in dark brown’. Chadwick's report mentions house owners being brought before a magistrate for neglecting to cleanse and whitewash their property between tenants, this being especially bad in the poorer districts. ‘Even the best streets are very badly cleansed, but in the poorer streets of the city the cleansing is very bad indeed — horribly bad. Take Duke's Place, for example; you will see cabbage-stalks and rotten oranges that have been thrown away, and they often remain there for several days. We do not get our streets swept oftener than once a-week.’ E. Chadwick, ‘Report on the Sanitary Conditions of the Labouring Population of Great Britain,’ in Report to Her Majesty's Principal Secretary of State for the Home Department, from the Poor Law Commissioners, on an Inquiry into the Sanitary Condition of the Labouring Population of Great Britain (London: W. Clowes and Sons, 1842), p. 225.


17. Chadwick, *Report*, p. 160. Mr Baker was a poor-law surgeon in Leeds, namely, he had responsibility under the terms of the Poor Law for examining and certifying the conditions of workhouse inmates and the poor of the district. His report from 1833 was the source cited by Chadwick in his report.


19. The original analysis of Leeds was published in L. Vaughan and A. Penn, ‘Jewish Immigrant Settlement Patterns in Manchester and Leeds 1881,’ *Urban Studies* 43, no. 3 (2006), and is re-examined here.


21. The area also contained Kirkgate Market, which is where Mr Marks (subsequently of Marks and Spencer) opened his first ‘penny bazaar’.


27. R. Perry, *Facts and Observations on the Sanitory State of Glasgow During the Last Year: With Statistical Tables of the Late Epidemic, Shewing the Connection Existing between Poverty, Disease, and Crime* (Glasgow: Glasgow Royal Asylum for Lunatics, printed at the institution, 1844), p. 9, p. 22.


34. Koch and Denike, 'Essential, Illustrative, or . . . Just Propaganda?', p. 28.


42. Riis, *How the Other Half Lives*, p. 25. The Tenement House Committee maps of nationalities and population density from 1895 are coincidentally an important record of what Riis is describing.


44. J.B. Huber, *Consumption, Its Relation to Man and His Civilization, Its Prevention and Cure* (Philadelphia: Lippincott, 1906). The plan appeared on page 147. The publication date is only an estimate. It seems likely that it was published around the time it first appeared in the press in 1903.

45. Map image from Huber, *Consumption*.

46. Jacob Riis also describes buildings such as this, with their ‘dirt and desolation’ reigning in a tenement leading to ‘a dark and nameless alley, shut in by high brick walls’. Riis, *How the Other Half Lives*, Chapter IV: ‘The Down Town Back-Alleys’, p. 149.


48. *Los Angeles Herald*, Number 1, 2 October 1903.

(General) William Booth, founder of the Salvation Army, advocating moving the poor from the filth and squalor of the slums to ‘a neat little cottage in the pure air of the country’.


T.J. Jones, Directory, p. 6.


See historical review in B. Clarke, ‘Mapping the Methodologies of Burkitt Lymphoma,’ Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 48 (2014).


See review in Barford and Dorling, ‘Mapping Disease Patterns’, of the pitfalls in mapping the geography of disease.

Access to clean water is not necessarily a given even in the developed world today, as has been seen by the scandal of lead-contaminated water in Flint, Michigan. The location of Flint homes with >15 ppb of lead as of 1 February 2016 was published in the Detroit Free Press; see R. Allen, ‘Flint Map: Where Lead Levels in Water Remain Too High,’ Detroit Free Press, 2 February 2016, http://www.freep.com/story/news/local/michigan/flint-water-crisis/2016/02/02/flint-lead-map/79686158/. Here also the affected population is disproportionately from impoverished areas of the city.


Social interaction and urban design research dates back to the influential early work of Appleyard and Lintel, who found that the amount of vehicular traffic on streets had an impact on the ability of people living on them to form friendship ties. It has been revised recently by Jennifer Mindell and colleagues, who have looked at the impact of community severance – namely the effect of busy roads on people’s access to goods and services and the consequent impact this has on health (whether people’s willingness to walk, or their ability to be socially engaged: a lack of social engagement in itself can have a negative impact on health).


Information on the map is from the ‘Collector’s Notes’ on the map on the Cornell University website, https://digital.library.cornell.edu/catalog/ss:19343514. A sister map to this one shows the point location of ‘Region of Rat-Bitten Babies’ in the same district and aims to demonstrate that virtually all ‘frequent rat sightings’ in Detroit – and every one of the ‘Confirmed rat bites, 1967, 1969 and 1970’ – occurred in the inner-city Fitzgerald ‘slum ghetto’. See notes on this map at the Cornell University website https://digital.library.cornell.edu/catalog/ss:19343517.


excess mortality (namely where the number of deaths exceeds what would be expected within a population) across the city to see if there is a relationship between spatial location and excess mortality, taking account of factors such as socioeconomic status and population age in each neighbourhood.


69. The Booth map has also been used to compare data on diabetes in an area of East London to see if there are associations with poverty pockets persisting from the past. See D. Noble et al., ‘Feasibility Study of Geospatial Mapping of Chronic Disease Risk to Inform Public Health Commissioning,’ BMJ Open 2, no. 1 (2012), and their images at http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/12345.pdf.


Recent citizen science projects of this nature have been carried out by a London-based social enterprise, Mapping for Change.

71. For example M.P. Buman et al., ‘Objective Light-Intensity Physical Activity Associations with Rated Health in Older Adults,’ American Journal of Epidemiology 172, no. 10 (2010).