



PERGAMON

Social Science & Medicine 50 (2000) 923–935

SOCIAL
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MEDICINE

www.elsevier.com/locate/socscimed

Our sense of Snow: the myth of John Snow in medical geography

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Abstract

In 1854, Dr. John Snow identified the Broad Street pump as the source of an intense cholera outbreak by plotting the location of cholera deaths on a dot-map. He had the pump handle removed and the outbreak ended...or so one version of the story goes. In medical geography, the story of Snow and the Broad Street cholera outbreak is a common example of the discipline in action. While authors in other health-related disciplines focus on Snow's "shoe-leather epidemiology", his development of a water-borne theory of cholera transmission, and/or his pioneering role in anaesthesia, it is the dot-map that makes him a hero in medical geography. The story forms part of our disciplinary identity. Geographers have helped to shape the Snow narrative: the map has become part of the myth. Many of the published accounts of Snow are accompanied by versions of the map, but which map did Snow use? What happens to the meaning of our story when the determinative use of the map is challenged? In his book *On the Mode of Communication of Cholera* (2nd ed., John Churchill, London, 1855), Snow did not write that he used a map to identify the source of the outbreak. The map that accompanies his text shows cholera deaths in Golden Square (the subdistrict of London's Soho district where the outbreak occurred) from August 19 to September 30, a period much longer than the intense outbreak. What happens to the meaning of the myth when the causal connection between the pump's disengagement and the end of the outbreak is examined? Snow's data and text do not support this link but show that the number of cholera deaths was abating before the handle was removed. With the drama of the pump handle being questioned and the map, our artifact, occupying a more illustrative than central role, what is our sense of Snow? © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: John Snow; Broad Street cholera outbreak; Medical geography; Myth; Disease mapping; Disciplinary identity; Memorialization

Introduction

The story of John Snow and the 1854 Broad Street cholera outbreak is common in disciplines with a health-related focus. It is an appealing tale because it

is short, dramatic, and heroic. For medical geographers the story is all the more attractive because it puts a geographic research tool into the spotlight. The story is a myth in the sense that it recounts events that may or may not be true: it is a way for us to make sense of something that is not truly knowable or understandable. There are many variations of the myth, but many of them — particularly in medical geography — resemble this pattern:

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During a ten-day period at the end of the summer in 1854 there was an intense cholera outbreak in Soho, London during which five hundred people died. Dr. John Snow used a dot-map showing the location of cholera deaths to identify the source of the outbreak as the Broad Street water pump. He convinced the Board of Guardians that the pump should be deactivated, they removed the handle, and the number of deaths dropped immediately. (Some versions of the story have Snow removing the handle himself.) With his work on the Broad Street outbreak and with the results of his study in the South London districts that same summer and autumn, Snow proved that cholera was transmitted by contaminated drinking water. His research helped to change his contemporaries' theory of disease transmission.

John Snow was a physician in the Soho District of London during the mid-nineteenth century who had an interest in cholera and in anaesthesia. Comprehensively establishing the details of his life is difficult because the only known personal documents written by Snow are his Case Books on his experimentation with and administration of anaesthesia, a letter, and a testimonial, all of which are held at the Royal College of Physicians (Ellis, 1994). These documents are augmented by the University of British Columbia's Clover/Snow Collection which includes personal correspondence to and about Snow (Thomas, 1992). Shortly after Snow's death, his close friend B.W. Richardson wrote a biographical essay and had it published with Snow's *On chloroform and other anaesthetics* (Ellis, 1994). A second, less informative, and much shorter version was published in 1887 and reprinted in Frost's edition of Snow's *On the Mode of Communication of Cholera* (Frost, 1936). Unfortunately, the accuracy of Richardson's account is questionable. "His *Memoir* of Snow was written, with Victorian prolixity, at a time when he was only twenty-nine years old and still mourning the sudden loss of his friend and colleague. Accordingly, careful historical judgement needs to be exercised when assessing some parts" (Ellis, 1994, p. xi).

Despite these difficulties, it is possible to construct a brief biography of Snow by supplementing Richardson's essay with research by Ellis (1994, 1991) and Brunskill (1992). John Snow was born in York, England on March 15, 1813, and his father was a labourer. Snow received his preliminary medical training as an apprentice and later attended the Hunterian School of Medicine in Soho, London. His first encounter with cholera was in Newcastle during the 1831–1832 epidemic. Snow was involved in the scientific medical community, presented papers to medical societies, and published in medical journals, the first

being the *Medical Gazette* in 1841. In 1849 he set out his theory of cholera transmission in a pamphlet called "On the mode of communication of cholera" and expanded it with more evidence in a book by the same name in 1855. The latter contained the results of Snow's examination of the water supply in the South London districts where he found that people living in houses with water supplied by the Lambeth Company were $8\frac{1}{2}$ times less likely to die from cholera during the first seven weeks of the epidemic, and 5 times less likely over the next seven weeks, than people in houses with water from the Southwark and Vauxhall Company. Lambeth had moved its source upstream on the Thames in adherence to the 1852 Metropolis Water Act (Luckin, 1986). In this book Snow also detailed the results of his investigation of the cholera outbreak in Golden Square (the subdistrict of Soho in which Broad Street is located) and included a map of the location of cholera deaths (Fig. 1). The dimensions of the map are $14\frac{1}{2}$ by $15\frac{1}{2}$ inches with a half-inch border and the scale is 30 inches to one mile. Concurrent with his research on cholera, Snow had a scientific interest in anaesthetics. In 1846 he began experimenting with ether and then moved to chloroform. By 1850, his reputation as an anaesthetist was well-established, and he was asked to administer chloroform to Queen Victoria during the birth of Prince Arthur if she requested it. Although his services were not used during that confinement, he administered the anaesthetic to her during the births of Prince Leopold in 1853 and of Princess Beatrice in 1857. Snow was in the process of writing a book on his experiments with anaesthetics when he died on June 16, 1858, probably of a stroke.

Variations of the Snow and Broad Street myth exist in public health, epidemiology, history of medicine, geography, and cartography. For the moment, if we accept as true the version of the story presented at the beginning of this paper, John Snow is a hero for four reasons. The first three of are not necessarily confined to a disciplinary context while the last is more characteristic of geography. First, John Snow showed how a disease is transmitted — clearly something laudable in science and medicine. Through his investigations he demonstrated that cholera was not transmitted in miasmata (bad air), the dominant scientific theory at the time, but in contaminated drinking water and through human contact. Second, his ideas affected public health and health policy decisions, at least at the local level. Snow convinced someone, or some group, to remove the handle from the Broad Street pump. Third, he provided definitive proof of a hypothesis, and as a result of the power of his evidence and his argument he changed scientific opinion to fact. Finally, John Snow used the quintessential geographic artifact as a spatial-analysis device to show that the

pump was the source of the local epidemic. The map demonstrated the relative space of death-events arranged around a locationally fixed point. It also confirmed his theory that cholera was transmitted through polluted drinking water.

A timely re-examination

For geographers in general and medical geographers and cartographers specifically, the map is of central importance in the story. However, there are many variations of the map in the geography literature, and it is not clear which map Snow would have used to identify the source of the outbreak. This ambiguity leads to questions about whether Snow drew the map (or had the data compiled and displayed on the map by someone else) to determine the source of the outbreak or as an illustration of his argument. The meaning of Snow's map for medical geography illustrates the power of cartography. Maps are not just analytical tools. They are visual arguments that contain and convey political statements, meaning, and power (Harley, 1989; Monmonier, 1991; Muchrcke, 1996; Tufte, 1997). Thrower describes Snow's cholera dot-map as achieving "the highest use of cartography: to find out by mapping that which cannot be discovered by other means or, at least, not with as much precision" (Thrower, 1996, p. 150). May wrote that "many secrets of nature" would have been revealed had humans accurately mapped disease throughout history (May, 1958, p. 25). However, despite mapping's meaningful place in medical geography, Pyle notes that it is also controversial (1979). Can disease maps show causation? Do they *prove* anything? Do medical cartographers actually state that causation and proof exist in their maps, or do the map interpreters project those expectations?

Recent questions about the presentation of the story of Broad Street outbreak in the medical geography literature (McLeod 1998a,b; Rip et al., 1998) also fit into the debate on the nature of the discipline (see Bennett, 1991; Mayer, 1992; Kearns and Joseph, 1993; Dorn and Laws, 1994; Kearns, 1994; Mayer and Meade, 1994; Del Casino and Dorn, 1998 for some examples). Some authors have argued that the traditional concerns of medical geography — the geographic study of disease and of accessibility, utilization, and provision of health care — are rooted in spatial theory, and as such miss the complexity of human experiences with health, illness and healing by hiding behind the simplicity of quantitative explanation. Authors have also critiqued the biomedical model of disease as the basis for our understanding both definitions and processes of disease and methods and expectations of treatment for four reasons. It presents disease as a deviation from a

defined 'normal', proposes that each disease has a single cause with a distinct "pathogen agent, micro-organism or disease vector" (Curtis and Taket, 1996, p. 27), assumes that the manifestations of diseases are generic in all individuals, and portrays science and medicine as objective, rational, and neutral. Alongside these criticisms have come calls for alternative understandings of experiences of illness and wellness informed by: social theories (from Marxism and humanism to postmodernism and poststructuralism), space and place as defined and mediated through human activity and the construction of meaning (rather than as a geometric absolute measurement), and views of illness as socially constructed (rather than biomedically defined). Proponents of these changes also call for the adoption of qualitative and textual analysis methodologies, either in addition to or exclusive of quantitative methods.

This is an appropriate time to re-examine John Snow — medical geography's hero — because during this latest period of looking forward to what the discipline should be about, we should also look at what we believe the discipline is and has been. Determining how Snow used his dot-map of cholera deaths to study the outbreak speaks to how we as medical geographers view the importance, place, and meaning of mapping in the study of disease. By re-examining the details of the story, this paper challenges what we value in the Broad Street myth: that Snow used a dot-map to determine the source of the outbreak, successfully argued for public action to disengage that source, and stopped the outbreak. This paper is divided into four sections. The first will show how disciplines other than geography present Snow in ways that represent their disciplinary identities. The second will examine medical geography's focus on the map in the story of Broad Street. The myth forms part of the identity of our discipline — whether we call it medical geography, 'post'-medical geography, the geography of health and health care, or health geography (Barrett, 1992; Kearns, 1996). The third section will draw on archival evidence collected in London, England in the winter of 1997 to retell some of the details of the Snow myth. The process of challenging the story will raise the question, "What is our sense of Snow?" The final section will present some of the many themes opened up by a more critical and complex understanding of Snow and the 1854 Broad Street cholera outbreak.

Snow from other disciplines

Any investigation of the portrayal of John Snow in the medical geography literature inevitably leads to references in epidemiology, public health and the history of medicine. These literatures also contain mythi-

cal representations of Snow and the Broad Street outbreak; however, a few authors have revisited the myth and both related the details of Snow's life in a more historically accurate way and/or examined the meaning of the Snow myth (Pelling, 1978; Vandenbrouke et al., 1991; Ellis, 1994; Lock, 1994; Winkelstein, 1995). To examine how Snow is portrayed in different disciplines, I conducted a broad survey of the literature by collecting Snow anecdotes and references from textbooks, books, papers, and the Internet, and organized them within three disciplinary contexts: public health and epidemiology, history of medicine, and medical geography. I collected the literature in stages, starting with searches of the library databases at Carleton University and the University of Ottawa including their Current Contents database for journal articles published during the last five years. I then used the references cited in these sources to expand the survey. These searches were augmented by Snow references sent to me by people, mostly professors, interested in my research. The earliest references found were from the mid-1930s, which is consistent with the results of similar work done by Vandenbrouke et al. (1991). Categorizing each source under one of three disciplinary headings was not always straightforward, especially for references on the history of health-related disciplines in practical textbooks, but I classified each one in terms of the context of the source document.

This content analysis revealed that Snow's reputation is well-established in public health, epidemiology, and history of medicine, but in ways that are significantly different from his reputation in medical geography as an early medical cartographer. The disciplinary portraits presented in this paper are necessarily brief summaries of the multiple versions of the Snow myth I uncovered in the literature, which is understandably problematic for the task of unpacking representations of myth. Nevertheless, the purpose here is to introduce the ways in which authors have created Snow as an heroic figure and to provide insight into how the Broad Street story helps to define disciplinary identities. In this section I will treat epidemiology and public health together, recognizing that their histories, intents, literatures, and functions are not interchangeable. The history of medicine is a catch-all phrase to describe literatures from the history of disease, the history of medicine, and other historical literatures (such as social histories of Victorian England) that mention John Snow.

Epidemiology, public health, and engineering for public health present Dr. John Snow as a pioneer epidemiologist. He is, after all, "the father of shoe-leather epidemiology" — a title originating from his house-to-house survey in the South London districts (see Frost, 1936; Holland et al., 1978; Barker and Rose, 1979; Hennekens and Buring, 1987; Last, 1987; Levine and

Lilienfeld, 1987; Vandenbrouke et al., 1991; Dadswell, 1992; Stolley and Lasky, 1995; Winkelstein, 1995 for some of the many accounts). The literature not only describes Snow's role in the Broad Street cholera outbreak, but also recounts his development of a water-borne theory of cholera transmission and his study of the water supply in the South London districts. In this investigation he used data from the Registrar-General's office, a house-to-house inquiry, and a chemical test of water purity, and showed that houses supplied by the Southwark and Vauxhall water company had a higher cholera mortality rate than those dwellings supplied by the Lambeth company (Hennekens and Buring, 1987; Levine and Lilienfeld, 1987; Stolley and Lasky, 1995). Snow is a revered figure in the disciplinary history because he "showed that cholera was transmitted by drinking water polluted by sewage. His findings led to the elimination of cholera by the provision of pure water supplies many decades before the isolation of the causal organism" (Farmer et al., 1996, p. 13).

These disciplines do not focus on the dot-map in their stories of the Broad Street cholera outbreak, although Stolley and Lasky provide detail of a map with a side-bar that reads: "John Snow mapped the occurrence of cholera cases in these streets of London. ... He also marked the positions of the local water pumps. Snow deduced that water from the Broad Street pump was the source of cholera" (1995, p. 35). Instead of the map, the discipline commemorates Snow for his logic in developing his water-borne theory of cholera transmission, his methodology, and his success in effecting a public health action that saved many lives. According to Calkins (1987) and Winkelstein (1995), the Board of Guardians of the parish of St. James removed the handle from the Broad Street pump on the advice of Snow. A number of other authors describe Snow's failure to convince the Board and his removal of the handle himself (Charles, 1961; Sterritt and Lester, 1988; Acheson, 1992; Dadswell, 1992; Godlee and Walker, 1992).

The nature, purpose and intent of epidemiology, public health, and engineering for public health are evident in the representations of Snow in the literature. Epidemiology is the scientific study of disease origin, pathology, transmission patterns, and prevention measures at a population scale. As "the basic discipline of public health" (Holland, 1977, p. 12), the knowledge it produces is translated into policies for promoting health in a population. One of the roles of engineering for public health is the provision of safe drinking water for populations. Snow and his work on cholera provide a focal point that illustrates disciplinary identity for each of these fields of study.

Snow is also a character in the history of medicine. There is an impressive breadth of information on

Snow in the literature, but he does not occupy as prominent or specific a place in the discipline as in medical geography, public health, or epidemiology. There are two possible reasons for this. First, Snow's contribution to medicine has been less significant than the work of the Hippocratic tradition, Galen, Harvey, Jenner, Lister, Koch and Pasteur. Second, Snow is portrayed as a pioneer in both epidemiology and anaesthesia (see Scott, 1934; Rosenberg, 1962, 1992; Pelling, 1978; Smith, 1979b; Magner, 1992; Bynum, 1994; Ellis, 1994; Lock, 1994 for some of the accounts). Depending on their purpose, authors can discuss Snow's theory of cholera transmission in its historical context (Smith, 1979b; Rosenberg, 1992; Lock, 1994) including his work in Broad Street and in the South London districts. They can describe his early

work with ether and chloroform as anaesthetics culminating in his administering the latter as an analgesic to Queen Victoria during the births of her last two children (Magner, 1992; Ellis, 1994). Or, they can combine both representations.

Two sources in the history of medicine literature contain reproductions of Snow's dot-map (Longmate, 1966, p. 205; Bynum, 1994, p. 80), but it is only one of three explanations given for how he identified the source of the outbreak. Lock (1994) describes how Snow used both death records from the General Register Office [*sic*] and his own personal investigation during the beginning of the outbreak to determine that the 89 recorded deaths in the parish were located near the Broad Street pump and that 69 of these people were known to have drunk water from the pump.

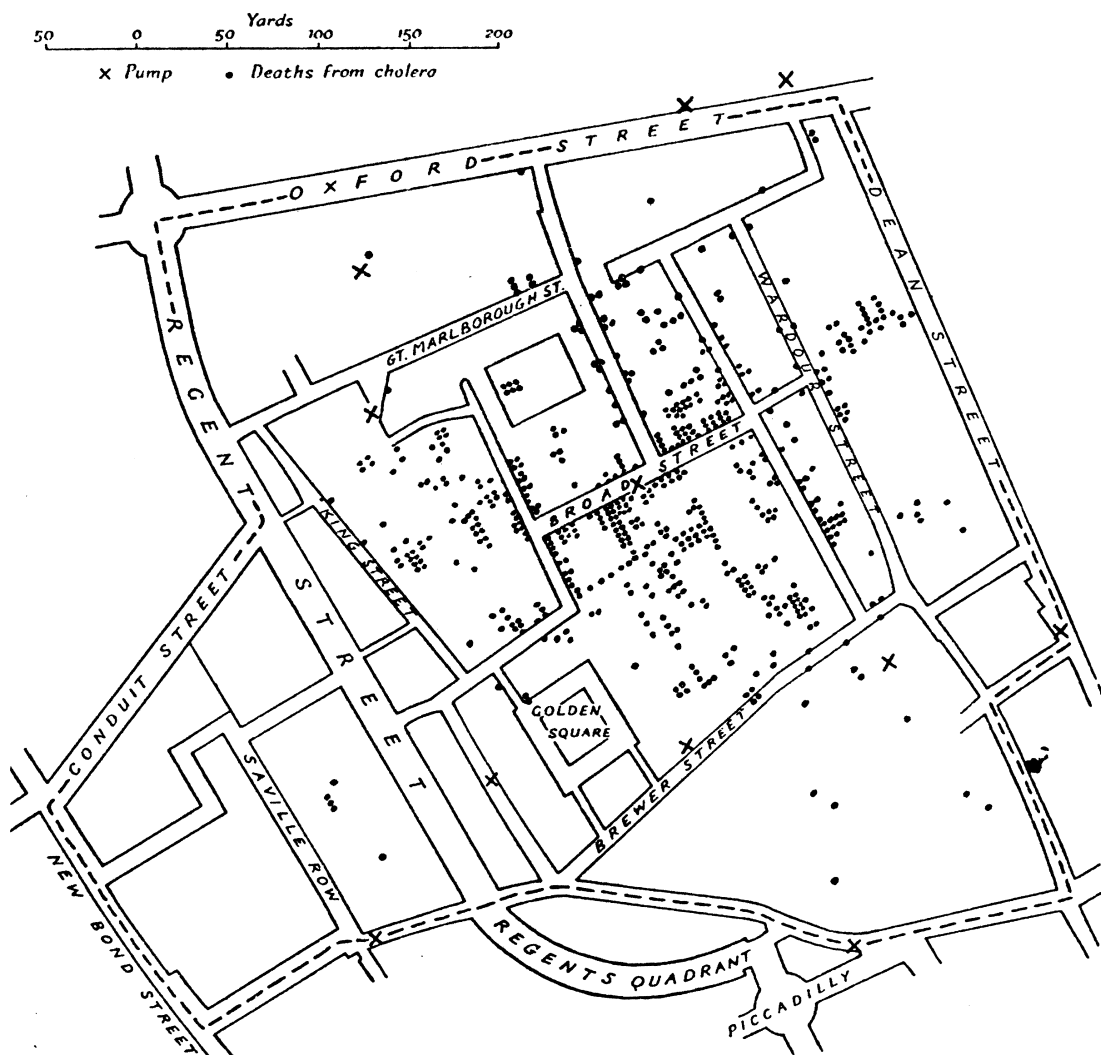


Fig. 2. Gilbert's recreation of Snow's dot-map (Gilbert, 1958, p. 174).

Three authors (Chave, 1958; Morris, 1976; Lock, 1994) explain that Snow's investigations were only possible with the help of Henry Whitehead, a local curate. In the literature, much of the discussion on Snow, his theory, and his 1854 investigations concerns their impact on Snow's contemporaries, on the predominant miasmatic theory of disease, and on public health policy (see Luckin, 1986; Riley, 1987; McKeown, 1988; Kudlick, 1996 as well as some of the aforementioned sources).

Snow is remembered in the history of medicine literature for his dual role as a pioneer in epidemiology and anaesthesia. Of all the literature surveyed for this project, the history of medicine literature provides the most detailed biographical information on Snow. These authors are the most consistent in placing Snow's work in its historical context and for examining its contemporary effects, which is not to imply that some of the details in these disciplinary accounts are not questionable. Instead, I am suggesting that a comparison of the disciplinary accounts of Snow and the Broad Street outbreak with the archival evidence does not challenge Snow's place in the disciplinary identity of the history of medicine in the same way that it does in the disciplinary identities of epidemiology and public health or medical geography.

Medical geography and the map

Monmonier recently wrote, "When asked about disease maps, most epidemiologists and geographers think of John Snow's 1854 map of cholera deaths and the Broad Street pump" (Monmonier, 1997, p. 263). The story of Snow and Broad Street is popular in the medical geography literature and can also be found in general geography and cartography literature (see May, 1958; Gould, 1985; Adesina, 1991; Thomas, 1992; Curtis and Taket, 1996, plus the map sources referred to below for some of the many descriptions). Many of these accounts follow the format of the story presented at the beginning of this paper, with Snow using the map to determine the source of the outbreak. Medical geography — and geography and cartography more generally — memorializes Snow's use of a dot-map to identify the source of the Broad Street cholera outbreak by reproducing the map in the literature. He is known as a pioneer medical cartographer who produced "a very significant document in the history of medical geography" (Gilbert, 1958, p. 175).

Reproductions and re-creations of the map have been printed in journal articles (Gilbert, 1958; Smith, 1993), books and textbooks (Stamp, 1964a,b; de Blij, 1977, 1993; Jones and Eyles, 1977; Howe, 1972; Smith, 1979a; Eyles and Woods, 1983; Cliff and Haggett, 1988; Learmonth, 1988; Meade et al., 1988; Jones,

1990; Monmonier, 1991), and on the Internet (see "Just Another Medical Geography Page" at http://members.xoom.com/mgdigest/medical_geography.html). Snow's map is also a common example in geography and cartography courses. However, a close look at the maps begs the question, "Which map is Snow's map?", because their appearance and content are inconsistent (Tufte, 1997; McLeod, 1998a).

Stylistic and substantive differences in the reproductions (or re-creations) of Snow's map become evident when we compare two versions printed in the geography literature. I have chosen to use an early version of the map (Gilbert, 1958, p. 174 — Fig. 2) and a more recent one (Monmonier, 1991, p. 142 — Fig. 3) as illustrations of these differences and as contrasts to Snow's original map (Fig. 1). Neither reproduction contains a north arrow, nor does the original for that matter. Both maps symbolize the location of cholera deaths with dots, but Gilbert notes that deaths were marked with black rectangles on Snow's original map. He does not explain the cartographic change. Gilbert's map shows the locations of the pumps with small Xs; whereas, Monmonier's represents them with large dark Os. More discrepancies become evident upon closer examination. Gilbert includes a delimited study-area, a bar scale, and several street names, elements omitted by Monmonier who uses only a labeled arrow to identify the Broad Street pump. The streets on Gilbert's map are open-ended and have different widths. Monmonier's streets are closed at the ends and are more uniform in width with smoother lines (see the area on both maps near the pump towards the bottom of Dean Street for comparison). It seems likely that

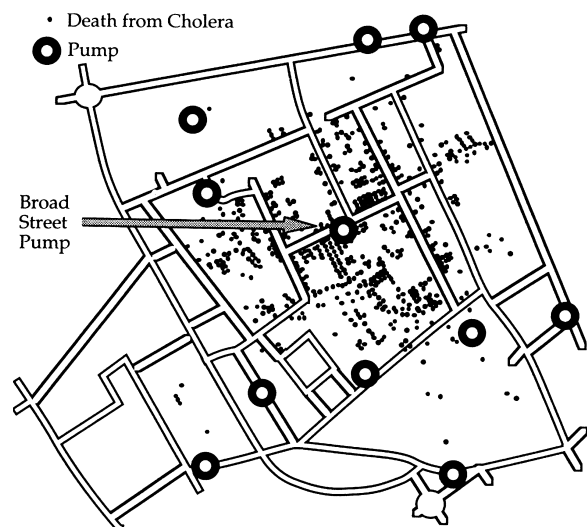


Fig. 3. Monmonier's recreation of Snow's dot-map (Monmonier, 1991, p. 142).

streets have been omitted from both maps because their respective patterns of dots between Broad Street and Brewer Street suggest the existence of streets. As the Snow map has been reproduced and re-created, the cartography symbolizing the location of deaths has become messier (Tufte, 1997; McLeod, 1998a), resulting in concrete differences. For example, at a residence near the pump (below and to the left) there are sixteen dots on Gilbert's map and twenty on Monmonier's. There are eighteen at this location on Snow's map. Finally, Gilbert cites Snow's map as his source and documents the differences between his re-creation and the original; Monmonier does not provide a source for his version.

Although the story of the role of Snow's map in the Broad Street cholera outbreak is common in the literature, it has not been uncritically accepted by all authors, nor is it the only aspect of Snow's cholera research to be examined. Learmonth questions whether Snow used the map "as an actual tool of research" to locate the source of the outbreak (1988, p. 148). Jones and Moon (1987) do not mention Broad Street in their portrayal of Snow. Instead, they use his study of the water supply in the South London districts as an example of a natural experiment.

Taking a close look at the re-creations and reproductions of the Snow map challenges the prominent place of the dot-map in medical geography's myth of the Broad Street cholera outbreak. Questions about the role of the map in Snow's investigation arise from the variations between the maps. Snow's map is our icon — our cultural artifact, but we have not presented a consistent image of it. The myth of John Snow in the geographic literature is as much a myth of the map as it is of anything else, and the story helps to define what some medical geographers want the discipline to be about: one of the contributing sciences to the study of disease.

Part of the story retold

The process of critically examining the cartographic representations of Snow's map in the literature provokes questions regarding the details of the Broad Street story and the accuracy of Snow's reputation within various disciplines. In this section I will use sources collected in London, England in 1997 to challenge the story presented at the beginning of this paper. I will address only two details of the myth and disregard the others and their implications for how disciplines represent Snow. First, did Snow use a dot-map to determine that the Broad Street pump was the source of the cholera outbreak? Second, what effect did the removal of the handle have? I will not discuss the fact that there is no evidence to suggest that

Snow's work on cholera directly led to the provision of safe drinking water in London or to support the assertion that his evidence and argument immediately changed the predominant theory of disease transmission.

Snow produced his Broad Street findings in two publications: the second edition of his work *On the Mode of Communication of Cholera* (Snow, 1855a¹) and the *Report on the Cholera Outbreak in the Parish of St. James's, Westminster, During the Autumn of 1854* (Snow, 1855b, pp. 97–120). His own description provides the most effective source for examining how he decided that the Broad Street pump was the focus of the local outbreak (Snow, 1855a, pp. 38–40). He writes that he suspected that contaminated water from the pump was spreading cholera in the area, but that samples did not reveal the water to be particularly dirty. After it sat on his counter for a couple of days however, he noticed white flakes had formed in the water. He then obtained a list of deaths in the area from the Registrar-General's Office for the week ending September 2 and determined the addresses of the 83 cholera victims on the list. He proceeded to the corner of Cambridge and Broad Streets where the Broad Street pump was situated. Standing there, he realized that all but 10 of the deaths were located closer to that pump than any other public water pump. He confirmed his suspicions by talking to five affected families who acknowledged that they always fetched their water from the Broad Street pump. In relating these events, Snow does not discuss using a map.

Snow's text about the map is mostly descriptive (Snow, 1855a, pp. 45–47, 1855b, pp. 107–110), refer to the text below. In terms of this paper, the most important point in his account is that the map shows cholera deaths from the 19th of August until the 30th of September. The dates of the outbreak are usually accepted as August 31st to September 9th or 10th, and Snow recorded that the pump handle was removed on September 8th (Snow, 1855a, p. 40, 1855b, p. 102).

All deaths from Cholera which were restored in the six weeks from 19th August to 30th September within this locality... are shown by black lines in the situation of the house in which it occurred or in which the fatal attack was contracted.

...it will be observed that the deaths either very much diminished, or ceased altogether, at every point where it becomes decidedly nearer to send to another pump than to the one in Broad Street. It

¹ Both books of Snow as well as the report to the Cholera Inquiry Committee have been used as primary sources.

may be noticed that the deaths are most numerous near to the pump, where the water could be more readily obtained. The wide open street in which the pump is situated suffered most, and next the streets branching from it, and especially those parts of them which are nearest to Broad Street. If there have been fewer deaths in the south half of Poland Street than in some other streets leading from Broad Street, it is no doubt because this street is less densely inhabited (Snow, 1855a, p. 47).

It is possible that Snow used a sketch map when he stood on Broad Street and realized that all but 10 of the 83 deaths in the neighbourhood were closer to the Broad Street pump than any other pump. However, his publications provide detailed accounts of the methodology he used for his numerous cholera investigations, so it seems unlikely that he would not have mentioned it. Deaths were reported by the Registrar-General's Office on a weekly basis. If we accept that the handle was removed from the pump on September 8th, Snow's map data would have only included deaths recorded as of September 2nd because the next weekly return would not have come out until September 9th. In other words, even if he had used a map to help identify the source of the outbreak, it would have only showed the location of 83 deaths instead of the 616 deaths Snow accounted for between August 19th and September 30th on his published map (Fig. 1).

Some of the Snow stories draw a direct causal link between the removal of the pump handle and an immediate decrease in the number of cholera deaths in St. James's parish. Snow did not make this claim:

There is no doubt that the mortality was much diminished, as I said before, by the flight of the

population, which commenced soon after the outbreak; but the attacks had so far diminished before the use of the water was stopped (Table 1), that it is impossible to decide whether the well still contained the cholera poison in an active state, or whether, from some cause, the water had become free from it (Snow, 1855a, pp. 51–52). [Note that the data in Table 1 was finalized after the outbreak which may explain why the data does not correspond to the 83 deaths reported on September 2 that Snow used to identify the pump as the source of the outbreak.

The drop in fatal attacks from September 1st to 3rd and the drop in deaths from September 2nd to 4th is much more dramatic than the drop in either during the days following September 8th, the day the handle was reportedly removed. Snow thought that after September 10th or 11th all new cholera cases “must have been occasioned in the usual manner, and not through the medium of water” (Snow, 1855b, pp. 118–19). By this he meant that the cholera “poison” was ingested after direct contact with a victim, not directly from a local water source. What we now recognize as the self-limiting nature of cholera is suggested by the data, and the process had already occurred before the pump handle had been removed (an event for which circumstantial evidence exists but for which there is no corroborating archival evidence in the form of Minutes for the Vestry or Board of Guardians). With the determinative nature of the map and much of the mythical drama of the story in doubt, what is our sense of Snow?

Our sense of Snow

The original intent of this re-examination of Snow was not to remove him from his place in our mythology. The ‘full’ story is much more detailed and thought-provoking than the caricature presented at the start of this paper and in much of the literature. A more critical look at the story of John Snow, his dot-map, and the 1854 Broad Street cholera outbreak provides a number of themes for discussion and research.

As mentioned in the last section, Snow published the results of his research on the Broad Street outbreak in two places, his book (Snow, 1855a) and a report to the Cholera Inquiry Committee (1855) which investigated the outbreak for the Parish of St. James's, Westminster (Snow, 1855b). This report contained a dot-map that was almost the same as the one in Snow's book, but this version included a line of equidistance between the Broad Street pump and all neighbouring pumps (Snow, 1855b, pp. 106–107). Snow clearly thought about the purpose of this line because

Table 1
Cholera deaths in Golden Square, Soho from August 31 to September 11, 1854 (adapted from Snow, 1855a, p. 49)

Date	No. of fatal attacks	Deaths
August 31	56	3
September 1	143	70
September 2	116	127
September 3	54	76
September 4	46	71
September 5	36	45
September 6	20	37
September 7	28	32
September 8	12	30
September 9	11	24
September 10	5	18
September 11	5	15

he measured street-pattern distances, not the straight-line or Euclidean distance. This line is significant because it is an early example of a network Voronoi-area diagram, and it predates similar uses of this application by at least 120 years (Boots, 1997). Voronoi diagrams can be explained like this: “Given a finite set of distinct, isolated points in a continuous space, we associate all locations in that space with the closest member of the point set” (Okabe et al., 1992, p. 1). Paraphrased using the example of Snow’s map, this statement reads: “Given a finite set of distinct, isolated pumps in the neighbourhood (as represented on the map), we associate all cholera deaths with the closest pump”. The purpose of Snow’s map was not to argue that deaths located outside the line were associated with other pumps. Rather the purpose was to illustrate how few deaths occurred outside the line and how the deaths inside the line clustered even more strongly around the Broad Street pump.

Snow, or whoever drew the map (and we must question whose idea it was to draw the map as well as who the cartographer was), presented a clear and logical spatial argument in his illustration of the distribution of the Broad Street outbreak. The map provided strong visual evidence to support his argument that the Broad Street pump had been the source of the outbreak in late August and early September, 1854. Geographers and cartographers, whether medical or not, can use the Snow story as an example of the early use of the Voronoi diagram. They can also use the image of Snow standing at the corner of Broad and Cambridge Streets to discuss spatial intuition and reasoning.

The Broad Street story also allows for discussion about the decision-making process in public policy and about the power of policy decisions. How are decisions made, how does reputation positively or adversely affect an argument, and what kind of and how much evidence is needed to convince people to take action? Snow convinced the Board of Guardians to remove the handle from the pump, or so the story goes. McKeown (1988) noted that the evidence Snow presented in 1854 would not be enough to provoke action or constitute proof today. How panicked was the Board during the outbreak, and how did this play into its decision to disengage the pump handle? Did Snow’s reputation as a local physician affect the Board’s decision? Did Snow “convince” the Board that cholera was transmitted in contaminated drinking water? Does it matter whether or not they believed that? The idea that the removal of the pump handle led to the end of the epidemic is a powerful image of the impact of a policy action that has a certain popular cachet. A *New York Times* journalist recently likened the causation in the Snow story to the possible impact of gun control

in the United States in the wake of the massacre at a high school in Littleton, CO (Stolberg, 1999):

There is a well-known story about the London doctor John Snow, who traced an outbreak of cholera to one pump spouting tainted water. He removed the pump handle. It didn’t clean up the water, but it ended the epidemic. In the same way, said Dr. Alfred Blumstein, director of the National Consortium on Violence Research at Carnegie Mellon University in Pittsburgh, there is a simple way to address school shootings: eliminate access to guns. “Guns,” he said, “transform what is widespread teen-age behavior into disasters”.

An underlying theme of the various representations of Snow is history as memory and memorialization (Hutton, 1993; Warner, 1998). How do we remember Snow, and what artifacts are used as memory cues? A few Snow memorials can be found in Soho, London. On Broadwick Street (the current name for Broad Street) there is a replica of the handle-less pump standing kitty-corner to the pump’s original location. Affixed to the side of a newer building on Frith Street, located where his first practice stood, there is a plaque that commemorates Snow as a pioneer in epidemiology and anaesthesia. A curious memorial to this pioneer is a pub at the corner of Broadwick and Lexington Streets (the location of the original pump) called “The John Snow”. It is curious because Snow was a teetotaler for most of his life. You can buy a t-shirt at this pub with an image of Snow printed on the front and a version of the story of the Broad Street outbreak on the back. Snow memorials are not exclusive to London: reproductions of the dot-map are memorials to Snow that can be found in textbooks, papers, classroom lectures, and on the Internet (see the CDC’s web-site at <http://www.cdc.gov/ncidod/dbmd/snowinfo.htm> and the page referred to earlier). There has been a progressive loss of information as the original events are mythologized and the myth is then memorialized by artifacts. The pump replica, the plaque, the pub, the t-shirt, and the maps are representations of the Snow myth, and the variations of the myth are representations of the original course of events.

At the heart of this critical re-examination of the Broad Street myth is not so much what Snow did or did not do, but what we *say* he did. It is doubtful that the Snow story is unique in its variations within disciplinary contexts. Rather, it is evidence of a need for disciplines to have myths and for authors to memorialize disciplinary heroes in ways that reflect or help to create disciplinary identity. By analyzing how various disciplines have written about Snow, we can examine how myth is constructed through the practice of historiography. In his paper

on John Snow, Birkenhead wrote that “though history may not repeat itself, the writers of historical texts often do” (Birkenhead, 1969, p. 106). How often do we as academic writers throw in a tried-and-true anecdote that brilliantly illustrates a point without going back to the source? The unquestioning repetition of the Snow story has led to an unscholarly — though not unusual — “taken-for-grantedness” of its details and meaning. The Snow myth is not constructed and perpetuated simply through writing however. The most common place where students learn about Snow and the Broad Street cholera outbreak is in the classroom: the “history of oral teaching” perpetuates the variations of the myth (Vandenbrouke et al., 1991, p. 967).

For medical geographers, there is a tactical reason for the central place of the map, our cultural artifact, in the Snow myth. The image of Snow using a dot-map to identify the source of the Broad Street outbreak is a powerful one both inside and outside the discipline. Geographers can and do use Snow’s map, and mapping and general, as leverage when they argue for a place in health and healthcare research. Snow links the expertise of geographers with that of disciplines like epidemiology, public health, and medicine. In light of the many debates on epistemology and practice in medical geography over the past decade, the discipline might need its hero(es) now more than ever. Geographers have a claim on Snow because the story gives pride of place to the map. Without that we would probably let other disciplines claim him, but the map makes him ours. Snow matters to us because we ‘own’ the map. He “is now recognized as a formative figure in both the development of medical cartography and in the understanding of disease transmission” (Smith, 1993, p. 43).

These are some of the points opened for discussion by a critical re-examination of the Snow myth. The belief that Snow used the dot-map to determine the source of the intense cholera outbreak in Soho in 1854 is not supported by archival evidence, nor is the causal connection many authors make between the removal of the pump handle and the end of the outbreak. The meaning of the myth is thus challenged for medical geography as well as for the other disciplines reviewed here. However, using archival evidence to retell the story yields a much richer version than the one in much of the literature, and interpreting the disciplines’ variations of the story in light of a more historically accurate rendition encourages us to examine the importance of myth in disciplinary identity. Dr. John Snow deserves a prominent place in the histories of geography, public health, epidemiology and medicine, as reflected by a more accurate version of the Broad Street story than has traditionally been presented.

Acknowledgements

I would like to thank Professor David Bennett for his suggestions and guidance, the Faculty of Graduate Studies and the Department of Geography and Environmental Studies at Carleton University for research and travel funding, and Chris McKerley for his editorial guidance. I am also grateful for the comments of both anonymous reviewers.

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