

# History, maps and the internet: UCLA's John Snow site

Ralph R. Frerichs

*John Snow is closely linked to the history of cholera, but even more so to epidemiology, medical geography and cartography. Yet in most contemporary textbooks the description of his work tends to be cursory, leaving out rich details of his existence. To present a wider view of John Snow and his accomplishments, a website was created at the UCLA Department of Epidemiology. In addition to Snow's life and achievements, the site presents a geographic information system of London in 1859, a contour map of London's water purveyors in 1856, and two maps featured by John Snow in his 1855 book.*

## Introduction: cholera, fame and the internet

When Asiatic cholera visited London in 1853-54, death greeted many in the population. Vomiting and diarrhea quickly ended life, and no one knew why or what caused such devastation. There were many theories. Some thought the killer was airborne, coming from gases emitted from swamps or decayed organic matter. Others thought it arose from microbes, too small to see but existing nevertheless. Although the Italian scientist and microscopist Filippo Pacini (1812-83) first discovered the cholera organism in 1854, it was not until Robert Koch's widely publicized re-discovery in 1883 that *Vibrio cholerae* was finally accepted as causative agent (Bentivoglio, 1995). While Koch's findings eventually explained the etiology of the disease, they were not essential for Londoners to develop control measures. Such actions came years earlier, arising from the scientific studies of John Snow, as described in his seminal book, *On the Mode of Communication of Cholera* (Snow, 1855).

John Snow (1813-58) was a London medical practitioner of modest origin from a laboring family in York. He was the oldest of nine children. Following three apprenticeships with medical practitioners, Snow came to London at age 23 for further education, culminating with the MD degree from the University of London in 1844. He was known for his work with anesthetic agents, and achieved prominence for having administered chloroform to Queen Victoria in 1853 during the birth of Prince Leopold. Later in 1857 he would repeat the service during the birth of Princess Beatrice. Yet his most lasting fame arose in epidemiology as a skilled medical detective and innovative user of illustrative maps (Gordis, 2000). When deadly cholera appeared in his city in 1853-54, he used his formidable intellectual skills to investigate and then identify the likely cause. He argued forcefully for the germ theory, feeling that cholera was caused by an infectious microbe rather than *miasmata*, or polluted gases. While many doubted him, others agreed and gradually over time, effective control strategies were accepted.

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*Ralph Frerichs is Professor and Chair of the Department of Epidemiology at the University of California, Los Angeles (UCLA). This material was first presented at the Cartography 200 Conference, Oxford, England, September 7, 2000.*

*Contact: Professor Ralph R. Frerichs, UCLA Department of Epidemiology, Los Angeles, CA 90095-1772 USA. Email: frerichs@ucla.edu*

History has always been a selective field, recognizing some but forgetting others. Although the accomplishments of John Snow have been cited for decades in introductory epidemiology books (Mausner & Bahn, 1974; Gordis, 2000), the descriptions tend to be limited, offering a taste but not a meal. The internet offers a new opportunity to delve more deeply into the life and times of John Snow, using text, graphics, sound and linkages to promote understanding of his accomplishments. While a book might have attempted the same, the print medium is less interactive and the size of audience more limited. A worldwide website to focus on John Snow was established in late 1999 at the University of California, Los Angeles (UCLA) Department of Epidemiology (Frerichs, 1999). Over time the site has increased in size, scope and mission, as will be described. It features historical London maps of 1856 and 1859, and area maps of John Snow's cholera investigations.

In this article I will briefly describe Snow's two most famous investigations, the Grand Experiment and the Broad Street Pump outbreak, both using maps. Next I will comment about geographic information systems and maps of health conditions, with examples from the John Snow site. Finally, I will conclude with details of the John Snow site, showing how the internet brings rare maps and historical images to a much wider audience.

## John Snow's Investigations

In his *Grand Experiment*, Snow took advantage of a change in water supply that took place in London between two cholera epidemics. The source of water for many was the River Thames which flowed with fresh water towards London, but was both polluted and tidal once within London. One of the London water companies acknowledged the problem and moved to a cleaner site. Snow wrote, "London was without cholera from the latter part of 1849 to August 1853. During this interval an important change had taken place in the water supply of several of the south districts of London. The *Lambeth Company* removed their water works, in 1852, from opposite Hungerford Market [in the heart of London] to Thames Ditton [upriver where the water was much cleaner]; thus obtaining a supply of water quite free from the sewage of London" (Snow, 1855). He went on, "The districts supplied by the *Lambeth Company* are, however, also supplied, to a certain extent, by the *Southwark and Vauxhall Company*, the pipes of both companies going down every street, in the places where the supply is mixed."

In 1849 when cholera was last present in London, mortality due to cholera was similar among persons supplied by the *Lambeth Company* and the *Southwark and Vauxhall Company*. With the change in water inlet for the *Lambeth Company*, what would happen to the rate of cholera in the served population? John Snow attempted to address this question when cholera reappeared in July 1854. He recognized the potential occurrence of a natural experiment. Snow wrote “The experiment ... was on the grandest scale. No fewer than three hundred thousand people of both sexes, of every age and occupation, and of every rank and station, from gentlefolks down to the very poor, were divided into two groups without their choice, and, in most cases, without their knowledge; one group being supplied with water containing the sewage of London [i.e., the *Southwark and Vauxhall Company*], and ... the other group having water quite free from such impurity [i.e., the *Lambeth Company*]” (Snow, 1855). To avoid exposure classification errors, Snow devised a simple test that measured salt to determine if the source of the drinking water was up- or down-river. Hence he was able to determine both exposure and mortality for households in the areas where both companies supplied water to the local residents. His findings seven weeks after the start of the epidemic in July 1854 are shown in Table 1. Those households supplied with the cleaner water of the *Lambeth Company* experience much lower mortality than those supplied by the contaminated *Southwark and Vauxhall Company*.

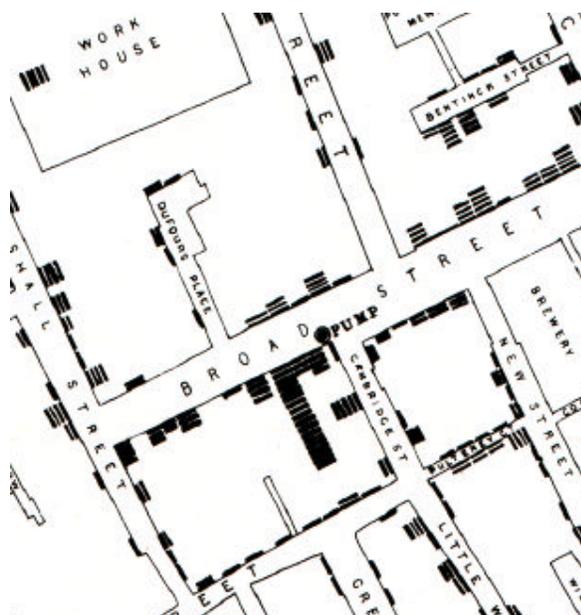
**Table 1: Cholera deaths in 1854 in Snow’s Grand Experiment**

<i>Water Company</i>	Number of households	Cholera deaths	Deaths per 10,000 households
Southwark and Vauxhall Company <i>(inlet remained in London section of river)</i>	40,046	1,263	315
Lambeth Company <i>(had moved inlet to cleaner upriver location)</i>	26,107	98	37
<i>Rest of London</i>	256,423	1,422	59

John Snow’s most famous investigation occurred nearly the same time in the Soho region of London near the Broad Street pump. To Snow, this area was home, first during his student years and then at two locations in his professional life. Snow wrote in late 1854, “The most terrible outbreak of cholera which ever occurred in this kingdom is probably that which took place in Broad Street, Golden Square, and the adjoining streets a few weeks ago. With two hundred and fifty yards of the spot where Cam-

bridge Street joins Broad Street, there were upwards of five hundred fatal attacks of cholera in ten days.” He went on to write, “The mortality in this limited area probably equals any that was ever caused in country, even by the plague, and it was more sudden, as the greater number of cases terminated in a few hours.”

**Fig. 1. John Snow’s cholera map, 1854**



The outbreak started in late August 1854, with deaths reaching a peak on September 2. Snow noted that many of the cases occurred near the Broad Street pump, or among those who had traveled to the area to obtain water from the pump. He also noted that rates of cholera were much lower in the neighborhood workhouse, where residents drank from their own pump, and employees of a local brewery where many did not drink water at all. Being convinced that water from the Broad Street pump was at fault, Dr. Snow spoke on September 7 to the Board of Guardians, the political group responsible for maintain the safety and welfare of the area. They listened to his concerns, noted his findings, and on September 8 authorized the removal of the pump handle.

In hindsight, it was evident that the outbreak had peaked the week before, likely due to fleeing of persons from the area. Thus it is not clear that Snow’s recommendation had an actual effect in controlling the epidemic. Nevertheless it took political courage and a commitment to action for him to address the Board of Guardians, and for these characteristics Snow was valued.

In his book of 1855, Snow used a map of the Broad Street area of London (now Broadwick Street) that was produced in 1854 by C. F. Cheffins of Southampton Building, London. As shown in Figure 1, Snow tallied the address of cholera fatalities and presented them as short lines. With this map he was able to show that cholera deaths had clustered around the Broad Street pump, supporting his earlier

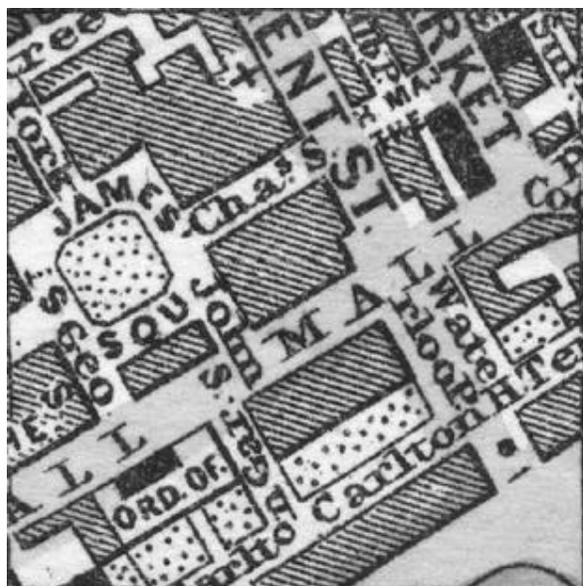
hypothesis that the organism (not yet detected) was transmitted by water. Snow did not use the map to derive his hypothesis, but rather to illustrate his findings in support of his hypothesis (Brody, 2000).

### Disease Maps and Geographic Information Systems

Besides describing interesting investigations, the John Snow website presents how maps and a geographic information system (GIS) can be used to enlighten and inform epidemiologists, historians and cartographers. Medical geography and cartography have a rich history, bringing together divergent fields that feature spatial patterns and population-based measures of biological conditions and abnormalities (Learmonth, 1978; Meade, 2000). While epidemiological outbreaks are often describe as new cases per time, the process is much easier to understand if described in space and time. John Snow appreciated spatial and temporal dimensions. His book featured two maps by C. F. Cheffins. A section of the first was shown in Figure 1. Map 2 accompanied his presentation of the *Great Experiment* and shows the regions of south London that were supplied by the *Southwark and Vauxhall* and *Lambeth* water companies. Both maps can be seen in detail at the John Snow website (Frerichs, 1999).

Cholera did not happen in London by chance. Instead the mid-nineteenth century epidemic was part of a larger pandemic of 1846-63 that arrived in London in 1849. This followed the earlier cholera pandemic of 1826-37 which arrived in the United Kingdom in 1831 (Howe, 1972). Maps that show the spatial and temporal patterns of cholera pandemics during the lifetime of John Snow (1813-58) are included at the website.

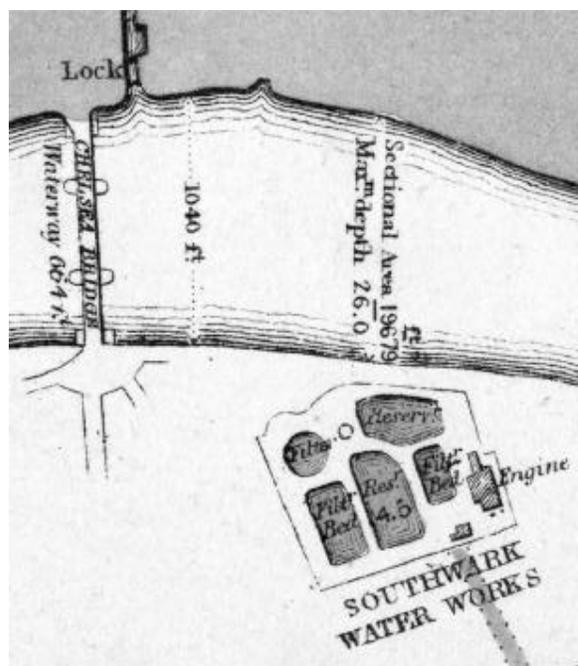
Fig. 2. Reynolds's London Map of 1859



The most popular item on the John Snow site is the *Map of John Snow's London in 1859*. The map was originally engraved and colored in 1857 and then updated to 1859. It is comprised of 711 quarter-mile squares and one title square in a setting that is 29.5 inches wide and 19.5 inches high. The map was scanned into the computer, section by section. Because of resolution and transmission limitations with the internet, the map was divided into layers starting with a low resolution overview, then six sections, followed by four regions per section, and four sub-regions per region. At the lowest level, are nine cells per subregion. The cell level has the greatest resolution and provides considerable detail on streets and names. An example of a cell is shown in Figure 2, presenting the St. James Square region of London.

While the extensive detail of Reynolds's map is visually interesting, another feature is perhaps more useful. The map is actually a geographic information system (GIS) in the guise of a historical document (Clarke, 2001). That is, the map presents various forms of data arranged in a spatial format and linked to 711 quarter-mile cells. The 1859 map has two indices, one focusing on events in John Snow's life and writings and the other on London between 1813 and 1858 as a unique social, cultural and institutional setting. Many quarter mile cells have a brief narration describing what look place of epidemiological or historical importance. Also included as data are additional maps showing the location at different times during the nineteenth century; images of buildings, street scenes or people such as Charles Dickens who were connected to the cell; and text of creative or scholarly writings on topics connected to the cell. In the future, the cells will have sound files with music of the times, and short video presentations of a descriptive, dramatic or artistic nature.

Fig. 3. Mylne's Waterworks Map of 1856



Another map prominently displayed at the website is a contour map of London that shows the districts and areas supplied by various metropolitan water companies in the mid-1800s (Mylne, 1856). Robert Mylne in 1847 created a contoured map of London from existing surveys and documents. He added to his map details from the Ordnance skeleton Plans of 1850, and from surveys made for the Thames Navigational Commissioners in 1852. The final version of his map, appearing on the John Snow website as *Map of London Water Works, 1856*, was published in 18 linked panels, each measuring 10.5 inches wide by 15.75 inches high, bound with linen, and folded into a hardcover with an introduction on one side. The map covers an area of 176 square miles with a scale of 17,032:1. Rather than divided into cells as is the 1859 map, the water works map is presented as 18 panels, with close-ups of interesting sites a click away. An example of a close-up for the *Southwark and Vauxhall Water Company* is seen in Figure 3. Notice that even though the company changed its name in 1845 from Southwark Water Company to *Southwark and Vauxhall Water Company*, the Mylne map of 1856 mistakenly used the earlier designation. Different from the 1859 map, the *Map of London Water Works, 1856* is not a geographic information system since there is no other information at the lowest level, other than the map image.

### Intentions of the John Snow Site

The John Snow site at UCLA has several intentions. The first is to bring prominence to a historical figure who means much to the fields of public health in general and epidemiology in specific. While John Snow is routinely mentioned in introductory epidemiology books, the passages tend to be cursory in nature. The John Snow website, being constantly updated, allows for more extensive description. The second intention is to present the link between cartography and epidemiology, showing the contributions that both fields make to presenting disease patterns and unraveling etiology. The third is to explore the interaction between agent, host and the broader social and cultural environment that accounts for urban epidemics such as cholera. While the epidemiology of cholera in Snow's time is not presented as a single thread, the mosaic elements are available at the website. Facts can be assembled and understood using the logic, as John Snow did before modern laboratories and computers were available. Finally, the site is intended to focus attention on epidemiology at UCLA for those considering further education in the field.

Has the site succeeded? The answer relies on counts. Tallying programs determine the number of persons who visit a site and where in the site they visit. During the month of January 2001, the Department of Epidemiology had 7,506 unique daily visitors coming from different individual computers (listed as site numbers) around the world, most of which had humans attached. But is this number high or low for an academic unit at UCLA? The UCLA Department of Health Services provides a good comparison since it has an active website, similar professional reputation, and is nearly identical in size. Its website during a

typical month received 530 unique daily visitors, or about seven percent of those coming to the Department of Epidemiology. Thus the Epidemiology site seems to be reasonably popular, at least when view as an academic undertaking.

While tallying visitors each day is a usual practice, perhaps better is counting unique visitors per month, or those computers that visit a site one or more times during a month. These figures are presented in Table 2 for the month of January, 2001. There were 7,506 unique daily visitors and 5,095 unique monthly visitors, indicating that 7,506 minus 5,095 or 2,411 visitors toured the site on more than one day in January 2001. Based on a more detailed analysis, we found that each monthly visitor clicked on an average of 32 different sites within the Department of Epidemiology website.

The John Snow site has several locations of special interest to cartographers. The first is the *Map of John Snow's London in 1859*, the second is the *Map of London Water Works, 1856*, and the third is a recent article from *The Lancet* on a prominent myth surrounding John Snow regarding his use of maps to unravel the etiology of cholera. As observed in Table 2, nearly two-thirds of those who visited the Department of Epidemiology website had gone to the John Snow site. Among the latter, slightly more than half visited *Map of John Snow's London in 1859*. A much smaller group – about one in ten – visited the *Map of London Water Works, 1856*. Finally, very few clicked on the informative journal publication which is presented in its entirety. Thus the main attraction is clearly the London map of 1859.

**Table 2: Unique visitors\* during January, 2001 to the UCLA Dept. of Epidemiology website and the John Snow website.**

<i>Directory in UCLA server</i>	Number of unique visitors	As % of Epi	As % of Epi/Snow
Epidemiology Department	5,095	100.0	- -
Epi/Snow site	3,334	65.4	100.0
Epi/Snow/1859 map	1,800	- -	54.0
Epi/Snow/Watermap 1856	354	- -	10.6
Epi/Snow/Mapmyth	121	- -	3.6

\* computers that visited site one or more times per month

To come to a website, persons must first know about it. In mid-2000, I contacted most departments of epidemiology in the United States, and many in Europe and Asia, to tell them of the John Snow site. I also contacted geography and cartography departments, history departments, and on-line newspapers and media outlet. Perhaps the most important referral is by search engines. Over time, as more

educators and health professionals learned of the site, the search engines gave the site more prominence, which brought even more people. In mid-January 2001, I entered “John Snow” into ten prominent search engines in the United States. The UCLA site was selected first by six and second by two (see Table 3).

**Table 3: Ranking of UCLA’s site with “John Snow” search, January, 2001**

Search engine	Ranking
hotbot.lycos.com	4
ixquick.com	1
search.aol.com	1
search.excite.com	1
search.go.com	2
search.msn.com	9
search.yahoo.com	1
www.altavista.com	2
www.google.com	1
www.northernlight.com	1

Perhaps equally useful is a comparison of usage at the website versus in a library. Mylne’s *Map of London Water Works, 1856* belongs to the UCLA library. The three-volume set is located in an oversized book section, on a back shelf in the research library, available with no restrictions for any student, faculty, staff or associate to take out and read. In the past 27 years, only three persons had done so. As seen previously in Table 2, in one month at least 354 persons had visited the water works map, more than a hundred times the number that did so in the prior 27 years. Clearly the map is reaching a larger audience now that it is on the web.

## Conclusion

The John Snow site is an evolving project that presents information on an important figure in the history of epidemiology, anesthesiology and medical cartography. It reaches a worldwide audience that is not large in a commercial sense, but is sizeable for an academic unit. At the site, visitors can learn about epidemiology, cholera, and historical London. Above all, they can experience the joy of studying a map and sensing the location in space and time of an important person, place, institution or event in the history of London.

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