Substantiating the impact of John Snow’s contributions using data deleted during the 1936 reprinting of his original essay *On the Mode of Communication of Cholera*

Samantha Hajna,* David L Buckeridge and James A Hanley

Department of Epidemiology, Biostatistics and Occupational Health, McGill University, Montréal, QC, Canada

*Corresponding author. Department of Epidemiology, Biostatistics and Occupational Health, McGill University, 1020 Pine Avenue West, Montréal, QC, H3A 1A2, Canada. E-mail: samantha.hajna@mail.mcgill.ca

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Introduction

John Snow is considered a founder of modern epidemiology and his contributions to the field are highlighted in many introductory courses in medicine.1 Whereas all epidemiologists are familiar with the account of the Broad Street pump,2 fewer are familiar with the much larger and more compelling Grand Experiment that Snow exploited in South London.3–5 In his well-known essay *On the Mode of Communication of Cholera*,6 Snow devoted 25 pages to listing the details surrounding the deaths of 334 people who died during the first 4 weeks of the 1854 epidemic. John Snow, along with his assistant Mr John Joseph Whiting, visited the dwellings of every person who died from cholera in South London during this period. With utmost attention to detail and at great risk to their own personal health, Snow and Whiting recorded important details surrounding the deaths of these individuals. These data provided undeniable evidence that cholera was spread through the ingestion of contaminated water and, as noted by Sir Austin Bradford Hill, are one of the reasons why England and the rest of the developed world have been free from epidemic cholera since the late 1800s.7

In 1855, John Snow printed 300 copies of his original essay *On the Mode of Communication of Cholera* at a personal cost of more than £200.6 He sold only 56 copies.7 In 1936 Wade Hampton Frost, a professor of epidemiology at the Johns Hopkins School of Hygiene and Public Health, reprinted Snow’s original essay; but he deleted the South London data that Snow collected at such a great personal cost and that were of such great epidemiological value.8 Frost only listed the first 23 of the 334 entries that John Snow recorded in his original essay, and followed this truncated list with the words: “In the original publication the list of deaths is continued in this form for a total of twenty-five pages (p. 139).”8 In contrast to the small number of copies that John Snow sold, thousands of copies of the 1936 reprint were published and widely disseminated. Unfortunately the wide availability of this reprint has perpetuated the omission of these data and undermines the role that they played in identifying the mode of communication of cholera.

To commemorate the 160th anniversary of the publication of Snow’s second edition of *On the Mode of Communication of Cholera*6 and to redress this epidemiological slight, we highlight John Snow’s important work in South London, unearth the original data that Snow collected at great risk to his own personal health and present a first-time mapping of these data in time and space. We trust that this piece will foster a deeper appreciation for John Snow’s contribution to epidemiology and increase respect for small yet valuable epidemiological data.
The Grand Experiment

In 1854 two water companies, the Southwark and Vauxhall Waterworks Company and the Lambeth Waterworks Company, supplied water to South London. The intake of Southwark and Vauxhall was located next to Battersea Park. Because of its close proximity to downtown, the intake drew water contaminated with sewage that had emptied into the River Thames. In his book Microscopic Examination of the Water Supplied to the Inhabitants of London and the Suburban Districts, Arthur Hill Hassall, a British physician, stated that ‘This water was the most disgusting which I have ever examined: when I first saw the water of the Southwark Company, I thought it as bad as it could be, but this far exceeded it in the peculiarly repulsive character of living contents’. The intake of the Lambeth Company was upstream of central London at Thames Ditton, and thus provided a much cleaner water source.

To exploit the Grand Experiment, Snow and his assistant, Mr John Joseph Whiting, visited the addresses where each of the cholera deaths occurred and recorded the details surrounding each death. Snow placed Mr Whiting in charge of visiting the addresses that lay in districts where water was supplied only by the Southwark and Vauxhall Waterworks Company. Mr Whiting’s task was to make an enquiry at each house to determine if the water was indeed supplied by the Southwark and Vauxhall Waterworks Company or if the residents drew their water from another source, such as the ditch, drain or river.

John Snow took the more difficult task of visiting the districts in South London that were supplied by both the Southwark and Vauxhall Waterworks Company and the Lambeth Waterworks Company. Snow asked residents at each address to identify their water supplier. If unknown, Snow asked them to look at their water payment receipts. If the water company still could not be identified, Snow employed a chemical test by which he was able to identify the company based on the salt content of the water.

The test I employed was founded on the great difference in the quantity of chloride of sodium contained in the two kinds of water at the time I made the inquiry. On adding solution of nitrate of silver to a gallon of the water of the Lambeth Company, obtained at Thames Ditton, beyond the reach of the sewage of London, only 2.28 grains of chloride of silver were obtained, indicating the presence of 0.95 grains of chloride of sodium in the water. On treating the water of the Southwark and Vauxhall Company in the same manner, 91 grains of chloride of silver were obtained, showing the presence of 37.9 grains of common salt per gallon. Indeed, the difference in appearance on adding nitrate of silver to the two kinds of water was so great, that they could be at once distinguished without any further trouble.

To verify that the information provided by the residents and the results of his chemical tests were correct, Snow ascertained that the time that the main supplies were turned on by the water companies corresponded to the time that the water appeared in the home.

Based on listings provided by the Registrar General’s Office, Snow and Whiting visited the homes of 334 people who had died of cholera between 8 July and 5 August 1854. Of these, 286 received their water from the Southwark and Vauxhall Waterworks Company and 14 received their water from the Lambeth Waterworks Company. The remaining 34 received water from other sources (e.g., directly from the River Thames, from pumps or from ditches). Based on this and the reported number of houses that the companies supplied water to (Southwark and Vauxhall Waterworks Company: 40,046; Lambeth Waterworks Company: 26,107), Snow estimated that the incidence of fatal cholera was 14 times higher in households supplied by the Southwark and Vauxhall Waterworks Company. (Note: The incidence of fatal cholera is 13.3 times higher in household supplied by the Southwark and Vauxhall Waterworks Company. When John Snow calculated the incidence he calculated the proportion of deaths for every 10,000 households and rounded the numerators and denominators to the nearest 10 before dividing (i.e., 71/5), giving him an incidence ratio of 14.)

The majority of districts in which the 334 deaths occurred were supplied with water from both the Southwark and Vauxhall Waterworks Company and the Lambeth Waterworks Company. This provided near perfect randomization of people to one or the other water source and added weight to John Snow’s theory that cholera was transmitted through the ingestion of contaminated water. According to Snow:

The mixing of the supply is of the most intimate kind… each Company supplies both rich and poor, both large houses and small; there is no difference either in the condition or occupation of the persons receiving the water of the different Companies [(pp. 74–75)]… [and this intermixing provided]… incontrovertible proof on one side or the other (p. 74) [for the mode of communication of cholera].

John Snow’s investigation into the mode of communication of cholera did not come without criticism. One notable critic of Snow’s work was Edmund Alexander Parkes, a proponent of the miasma theory. In 1855 Parkes published a critical review of Snow’s major essay published earlier in the same year. Although Parkes underestimated the strength of Snow’s evidence, he was...
not amiss in pointing out that Snow’s work was not perfect. John Snow’s work in South London had one important limitation. Snow did not know how many homes the two water companies supplied water to in the districts that were served by both water companies. As a result, he was only able to compare the absolute number of deaths that occurred among customers supplied by the two water companies, not the rates of death. Snow recognized this as a limitation, stating in an article that he published shortly after his enquiry in South London that:

I hope shortly to learn the number of houses in each sub-district supplied by each of the Water Companies respectively, when the effect of the impure water in propagating cholera will be shown in a very striking manner, and with great detail (p. 365).14

Shortly thereafter, the General Board of Health released statistics relating to the number of households that were supplied by both of the water companies in each district and sub-district. In October of 1856 Snow published a paper in which he demonstrated that in the sub-districts supplied by both water companies, the death rate from cholera was the highest among people supplied by the Southwark and Vauxhall Water Company.7,15 Snow’s work using both absolute numbers and rates provided compelling evidence in support of his theory that cholera was spread largely through the ingestion of contaminated water. Sir Bradford Hill acknowledged the value of Snow’s analyses using both absolute numbers and rates, stating ‘Snow must have bitterly regretted that he could not do it in his major work. However that may be, the contrast, whether in absolute numbers of deaths or in total districts, was so great as not to be mistaken (p. 50).’7

Mapping the South London deaths

In an appendix to the second edition of his 1855 essay, John Snow provided a detailed record of the 334 deaths from cholera that occurred in South London between 8 July and 5 August 1854. According to Snow, this information was included in the second edition of his essay ‘as a guarantee that the water supply was inquired into, and to afford any person who wishes it an opportunity of verifying the results (p. 80)’.6 The information that John Snow recorded included the address at which each cholera-related death occurred, the date of death, the occupation and the age of the deceased, the duration of symptoms before death and the water source (Figure 1).

We mapped the locations of the cholera deaths that occurred in South London on Reynolds’ Shilling Coloured Map of London,16 using the Create Features/Point Construction Tool in ArcMap 10.1 (ESRI; Redlands, CA). The location of each address was identified using Reynolds’ Index of streets,16 Lockie’s Topography of London,17 Large’s Way about London18 or the Map of London 1868 by Edward Weller.19 Unless the precise location of the address was visualized, the addresses were mapped in the centre of the street segment. The cholera deaths were animated by time using the Animation Manager (ArcMap 10.1).

Findings

We identified the locations of 286 of the 334 cholera deaths that occurred between 8 July and 5 August 1854 in South London (85.6%). Of these, 14 were supplied by the Lambeth Waterworks Company and 272 were supplied by the Southwark and Vauxhall Waterworks Company. The locations of the cholera deaths were mapped (Figure 2)
Figure 2. Locations of the cholera deaths occurring in South London between 8 July and 5 August 1854.
and animated by the date of death (Supplementary Video 1). We encourage researchers interested in completing the mapping of the South London outbreak to identify the locations of the 48 addresses that we were unable to find (Supplementary File 1, available as Supplementary data at IJE online).

No temporal trend in cholera deaths was observed. This was expected, given that cholera was spread largely by the water supplied by the Southwark and Vauxhall Company and less from person-to-person contact. Most of the cholera deaths that occurred between 8 July and 5 August clustered around the northern part of South London. This was also expected as this was the area with the highest population density.

Discussion

Since Snow published his well-known essay On the Mode of Communication of Cholera, 160 years have passed. Sir Austin Bradford Hill, in his piece commemorating the 100-year anniversary of the publication of this essay, acknowledged the impact of John Snow’s work, stating:

For close upon 100 years we have been free in this country from epidemiologic cholera, and it is a freedom which, basically, we owe to the logical thinking, acute observations and simple sums of Dr. John Snow (p. 50).7

Since then many others have also highlighted John Snow’s contribution to the field of epidemiology.11,20–24 What makes Snow’s work surrounding the Grand Experiment extraordinary was his attention to detail, the painstaking effort that he expended and the personal risk that he took upon himself to collect these data. From visiting each residence where a cholera death occurred, to conducting chemical tests to determine the water source, to investigating water bills, to ascertaining the time at which the water supplies were turned on, to describing the need to balance comparator groups, John Snow provided incontrovertible evidence that cholera was spread largely through the ingestion of contaminated water. Unfortunately these data, that he so painstakingly collected at great personal risk, were unceremoniously deleted from the 1936 reprinting of his essay. To commemorate the 160th anniversary of the publication of John Snow’s second edition of On the Mode of Communication of Cholera,6 we have presented a first-time mapping in space and time of these data. Albeit small, these data demonstrate the value of well-conducted shoe-leather epidemiology and should be credited alongside the rest of John Snow’s work.

Supplementary Data

Supplementary data are available at IJE online.

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