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Commentary: Sutherland, Snow and water: the transmission of cholera in the nineteenth century

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Figure 1 'The first victim to die of cholera in Sunderland'. Reproduced by kind permission of the Wellcome Institute Library, London

Cholera

The first confirmed case of cholera in Britain occurred in September 1831 when William Sproat of Sunderland contracted the disease. Over the next 30 years or so, Britain was invaded by four of the pandemics of cholera that had spread from Bengal since the early 19th century and suffered epidemics in 1831–1832, 1848–1849, 1853–1854 and 1866. Cholera was not as persistent or as frequent in its attacks as other infectious diseases but was remarkable for its high mortality rate and the speed at which it could kill. In terms of overall number of deaths for example, cholera claimed only 6% of the total for 1832. This put it no higher than third in the table of leading causes of death—behind consumption and convulsions and not far ahead of typhus, pneumonia, smallpox and dropsy.[1] By 1831, Britain had known for some time that cholera was moving towards its national boundaries. Both the public and medical practitioners reacted to the arrival of cholera with sheer panic. *The Lancet* set a tone of alarm through its editorials which spoke of cholera raging with 'unabated virulence', and the same sentiments reverberated through the popular press.[2] It was common knowledge that medicine could offer no cure for cholera and medical society debates highlighted the disagreement over the nature of the disease and its transmission.[3] It is no surprise that this 'new' disease, which had no antidote and which could kill its victims in 12 hours, created ripples of fear throughout Britain.

The second major epidemic of cholera began in Scotland in October 1848 but did not establish itself in London until February 1849.[4] In relation to the number of fatalities, this was the most serious of all 19th-century epidemics and around 53 000 deaths were registered for England and Wales compared to around 20 000 for the 1831–1832 epidemic.[5] Between 1845 and 1856 over 700 individual works were published in London

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on the subject of cholera.[6] The majority were concerned with explaining both the course of the disease and, most importantly, the way in which it spread through a population.

By the 1840s debates on the causes and transmission of epidemic diseases were complex and numerous. The miasmatic theory of disease—the understanding that disease originated from 'bad air': air infected with rotting organic matter such as sewage and rotting corpses—was the central tenet of Edwin Chadwick and other sanitarians. Chadwick's infamous comment to the parliamentary commission in 1846 that all smell is disease provided the focus for the environmental sanitary reforms of the mid-19th century.[7] The provision of clean streets, well-ventilated housing, and effective sewage systems were the key to a healthy population. The miasmatic theory was very popular among medical men and the public alike. Part of its acceptability can be understood through its apparent clarity. Offensive smells could be experienced by all individuals with unanimous agreement on their unpleasantness. So it seemed possible to suppose that long-term exposure to such experiences could have a physical effect upon the human body. For Chadwick and his supporters, therefore, preventive measures for diseases such as cholera centred on overall sanitary improvements. There were considerable political advantages stemming from this viewpoint as well. If cholera was accepted as being contagious, then measures such as the quarantine of incoming ships to British ports were necessary and this was a very unpopular measure.[8]

Sutherland and the Board of Health

John Sutherland (1808–1891), a graduate of Edinburgh University, was appointed inspector to the General Board of Health in 1848, joining well-known figures such as Chadwick and Southward Smith.[9] The Board's Report on the 1848–1849 cholera outbreak served to emphasize the fact that the cholera epidemic had brought to light no new information which would help contain the disease.[10] The Board wanted to affirm that the best measures to be taken against such epidemics were general sanitary improvements such as cleaning up the physical environment, removing dirt, purifying the air, improving waste disposal and refuse services. It was a necessary political strategy because quarantine had been tried again as a preventive measure and had failed particularly badly during this second epidemic.

Sutherland's report, whilst affirming the core response of the Board, stands as an important marker in the shift towards the gradual acknowledgement of water as the main vehicle of transmission of cholera. Using the outbreak of cholera in Hope Street, Salford, Sutherland provides statistical evidence to show that during the epidemic, cholera cases only occurred in houses using the contaminated pump. He also notes that 'deficient and poisonous water' was involved in the Bristol epidemic.[11] Sutherland therefore identifies water as a very important causal factor in relation to cholera epidemics, although he tags it as a predisposing rather than a primary cause. The idea of predisposing factors, such as contaminated water or bad air, which played an integral part in the causation and development of disease, was a widely accepted notion.[12] One individual, however, stands out during these years for his conviction and singular belief that contaminated water was the main means of the spread of cholera.

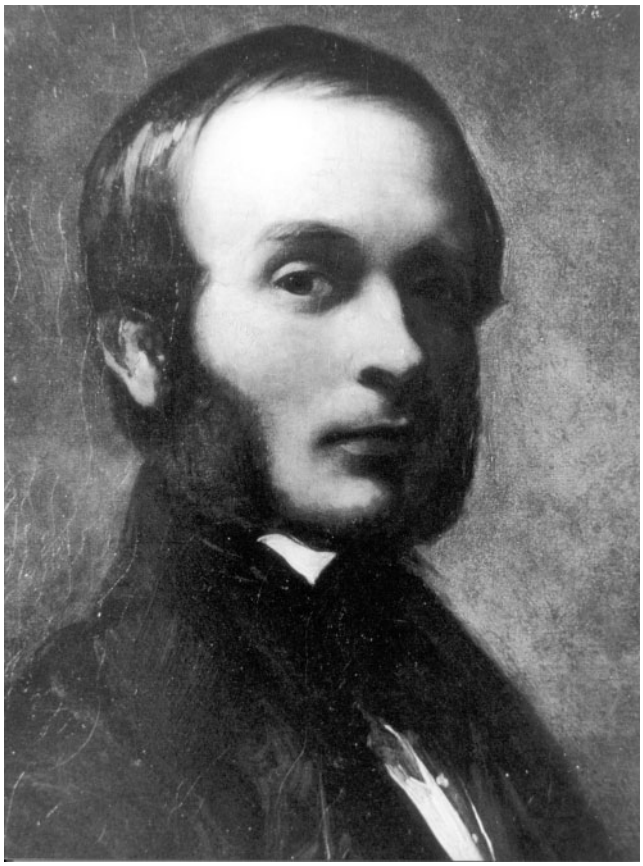

Figure 2 John Snow MD (1813–1858), oil portrait

John Snow and cholera

John Snow (1813–1858), had practised in London since the 1830s having served his medical apprenticeship in Newcastle upon Tyne during the years of the first cholera epidemic.[13] Snow published his cholera theory in a pamphlet in August 1849.[14] He began by drawing clinical observations from the cholera cases he had seen and heard about. The first part of his theory related to the pathology of cholera. He argued that cholera was, in the first instance, a local infection of the alimentary canal. He suggested that the cholera poison was introduced into the alimentary canal through the accidental swallowing of the cholera poison (found in the diarrhoea of cholera patients) which then multiplied itself in the stomach and bowels.

Snow extended his arguments to public water supplies suggesting that cholera faeces contaminated the public water supply 'either by permeating the ground and getting into wells, or by running along channels and sewers into the rivers'.[15] His preventive measures concentrated on scrupulous personal hygiene—he drew attention to the fact that doctors rarely caught cholera from their patients—and measures such as improving the conditions of working groups such as the miners in order to limit the potential for faecal-oral transmission. Here his thinking is very much at one with the Chadwickian sense of controlling disease through its environment.

Snow had to wait until the next cholera epidemic in 1854 before he obtained the substantive proof he had been waiting for. He published the second edition of *On the Mode of Communication*

of Cholera in 1855. It contains the two classic epidemiological studies, the first on the cholera outbreak in Broad (now Broadwick) Street, close to where Snow lived, and the second on the supply of water to south London.

In 1854, Snow was living in Sackville Street, Piccadilly, about 10 minutes walking distance from Broad Street, Golden Square and Berwick Street. A few cases of cholera occurred in the last part of August but the main epidemic started during the night of 31 August. He described it as 'the most terrible outbreak of cholera which ever occurred in this kingdom'. It was an outbreak that claimed over 500 lives in 10 days, and he believed there would have been more fatalities had the population not left the area so quickly. As soon as he became aware of the outbreak he considered water supplies and became suspicious that there was 'some contamination of the much-frequented street pump in Broad Street'. On 3 September he collected some samples of water from the pump for analysis. It showed, however, so little impurity that he hesitated to come to a conclusion. Over the next couple of days he did identify some 'small white flocculent particles' and decided to investigate the situation thoroughly (Table 1). This investigation comprised taking a list from the Registrar General's Office of the deaths from cholera which had been listed during the week ending 2 September. He then undertook detailed enquiries into the circumstances of each death in the area to ascertain where the deceased had obtained their drinking water. In 83% of the cases he found that the dead had been in the habit of drinking the water from the Broad Street pump. Once he was convinced that he had found the source of the contaminated water which had led to the outbreak, he attended a meeting of the Board of Guardians of St James's parish on 7 September and he recorded that 'in consequence of what I said, the handle of the pump was removed on the following day'.[16]

Following the outbreak, the General Board of Health carried out a local enquiry. Snow's evidence, in particular, held no sway for officials. They dismissed contagion or contaminated water as possible causes of the outbreak and recorded that the outbreak of cholera could not be attributed to 'any communication of the disease from person to person either by infection or by contamination of the water with the excretions of the sick'.[17]

In 1849, the *London Medical Gazette* had suggested that in regard to Snow's theory, the *experimentum crucis* would be that the water conveyed to a distant locality where cholera had been hitherto unknown produced the disease in all who used it.[18] One of the cholera victims Snow had traced through his Broad Street investigation was a widow who lived in Hampstead. She had a regular delivery of water from the Broad Street pump as she preferred its taste. Her last delivery was made on 31 August and by 2 September, having drunk the water, she had died from cholera. Snow regarded this as 'the most conclusive' of circumstances in proving the connection between the water pump and the cholera outbreak.[19] Despite all this evidence it still looked as though Snow's theory was to receive no further support. It would have remained so had it not been for the action of Edwin Lankester, a fellow member of the Medical Society of London and vestryman at St Luke's. Lankester established a Cholera Inquiry Committee to look into the recent outbreak and produced a final report with sections written by Snow and the Reverend Henry Whitehead, a local curate.[20] Whitehead was also responsible for tracing the original source of contamination of the water-pump at the commencement of the outbreak. He noticed a return for the death of an infant suffering from diarrhoea on 2 September—a significant finding because the child's house was closest to the pump. It was revealed by the child's mother that she had emptied water from soiled napkins into the cesspool at the front of the house. The well was inspected in June 1855, and this revealed beyond all doubt that the faecal matter had seeped through the decayed brickwork of the cesspool into the well which was less than 3 feet away. The Committee therefore reached the conclusion that the outbreak was in some manner attributable to the use of impure water from the well in Broad Street.[21]

Table 1 Snow's investigations into the Broad Street 1864 outbreak

Date	Activity
31 Aug/1 Sept	Cholera outbreak overnight
3 Sept	Collected water from Broad St pump
4 Sept	Analysed water samples
5 Sept	Collected from Registrar-General's office a list of deaths from cholera for week ending 2 Sept
6 Sept	Investigated where deceased obtained water from
7 Sept	Attended vestry meeting
8 Sept	Pump handle was removed

Source: Snow J. *On the Mode of Communication of Cholera*, pp. 39–40.

The second of Snow's investigations began during 1849 when he considered the water supplies to London houses. Although many London households still depended on drawing water from public wells like the one in Broad Street, an increasing number of them had bought mains water supplied by private, profit-making water companies. Snow had noticed that the cholera fatality rates in 1849 were particularly high in the areas supplied by the Lambeth and the Southward and Vauxhall water companies. At this stage, both companies obtained their water from a point in the Thames that was heavily polluted with sewage. In 1852, the Lambeth water company moved its waterworks to Thames Ditton, thus obtaining a supply of water quite free from the sewage of London, whilst the Vauxhall company continued to draw its water from the sewage-laden Thames at Battersea Fields. By 1854 these two companies supplied around two-thirds of the population of south London. Snow undertook an investigation to calculate the number of deaths from cholera per 10 000 houses during the first 7 weeks of the 1854 epidemic. He began his enquiry in the middle of August 1854 and having found that 38 houses out of the 44 where deaths from cholera had occurred were supplied with water from the Southwark and Vauxhall water company, he communicated these facts to William Farr, the Registrar General. Farr was as struck with the result as Snow and so he ordered the registrars of all southern districts of London to make a return of the water supply of the house in which the attack took place in all cases of death from cholera. As a result of the researches Snow concluded that the mortality rate for the houses supplied by the Southwark and Vauxhall water company was between eight and nine times greater than houses supplied by the Lambeth company (Table 2).

Snow and Sutherland

There are notable consistencies between Sutherland's analysis of the role of water in cholera outbreaks and Snow's work

Table 2 Deaths by water company

Water company	No. houses	No. cholera deaths	Deaths per 10 000 houses
Southward & Vauxhall	40 046	1263	315
Lambeth	26 107	98	37
Rest of London	256 423	1422	59

Source: Snow J. *On the Mode of Communication of Cholera*, p. 86.

on the topic. Both used the microscope in the first instance to identify organic matter in the contaminated water. They then proceeded to analyse the outbreaks statistically, gathering information on matters such as water supply and mortality. The key difference arises in their interpretation and response to the results.

Sutherland's analysis of the Manchester outbreak is used by Snow as yet another clear proof of the way in which water transmits cholera.[22] Snow did not accept that the progress of a disease could be swayed by predisposing factors such as bad air or contaminated water. However, he was pragmatic enough to accept that, in terms of encouraging the necessary public health reform, the views of individuals such as Sutherland served a purpose:

> 'They [medical men] look upon the bad water as only a predisposing cause, making the disease more prevalent amongst those who use it—a view which, in a hygienic sense, is calculated to be to some extent as useful as the admission of what I believed to be the real truth, but which, I think, will be found to be untenable, when the circumstances are closely examined. If the bad water merely predisposed persons to be acted on by some occult cause of cholera to which it is supposed that all are exposed, those using such water ought to become more subject to the disease from the time it enters a town or neighbourhood; instead of which it has been shown in many of the above instances that no particular effect was observed amongst those using the water, until by the occurrence of a case or two of cholera, the evacuations entered the water, when, after a short period of incubation, there were several persons attacked nearly together.'[23]

Sutherland, having once acknowledged that water played a primary role in cholera outbreaks, took a far more simplistic approach. He was content to accept the finding that clean water was an essential corollary of public health rather than push forward his thinking into the specifics of disease transmission.[24] In this he was very much at one with his contemporaries. Snow remained steadfast to his conviction that outbreaks of cholera would continue to occur until it was accepted and understood that the disease was transmitted through water. The only means of preventing future epidemics was through the provision of pure water supplies.

By the time the cholera bacillus was definitively described by Robert Koch in 1883,[25] the health of the nation was benefiting from improved water and was less at risk from epidemics of cholera. Snow had been dead for over 30 years when John Simon, Chief Medical Office of Health finally acknowledged that Snow's work on the transmission of cholera stood for one of the most significant scientific truths of the 19th century.[26]

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