

Snow—An Appreciation

By A. BRADFORD HILL, C.B.E., F.R.S.

Introduction.—It has been said that “The progress of Science renders useless the very books which have been the greatest aids to that progress. As those works are no longer useful, modern Youth is naturally inclined to believe they never had any value; it despises them and ridicules them if they happen to contain any superannuated material whatever”. That will surely never be the fate of a classic that must always fascinate and inspire the student of epidemiology and preventive medicine—John Snow’s short treatise “On the Mode of Communication of Cholera”. It should be read once, wrote Wade Hampton Frost, “as a story of exploration”—in that sense, I would add, it should be read quickly, for its fascination,—“many times as a lesson in epidemiology”. In that sense, like all closely-reasoned statistical studies, it must be taken slowly, carefully and critically with every piece of evidence weighed by the reader and its relevance studied.

What we now celebrate is the centenary of publication of the *second* edition of Snow’s masterpiece. The first edition was published in 1849 and it may seem odd that we have, for this celebration, awaited the second. The answer is not so much that the first issue was slender both in size and content, to be swallowed up later in the much enlarged work of 1855, but that this early work could not, in fact, contain the main, and most convincing, part of the observations bearing on Snow’s belief that cholera was water-borne. It could not contain that evidence for the very good reason that that evidence did not exist. Snow could not put his views, well developed as they were in 1849, to the critical test until the epidemic of 1854–55. His views were formed in the earlier year and were, as events proved, sound. But they lacked proof. It was the events in London in 1854 and 1855 that could provide the proof and to which Snow unsparingly devoted himself—letting, as Richardson says, nothing personal stand in the way of his scientific pursuits. The results were incorporated in the book of less than 150 pages and published in 1855, a work in the preparation and publication of which, it was said, Snow “spent more than £200 in hard cash, and realized in return scarcely so many shillings”.

THE THEORY

Omitting the illustrative cases, which were many, and the discussion which was full and lucid, the logical development of Snow’s theory can be set out in half a dozen sentences taken (or adapted) from his early pages. Thus:

Innumerable examples show that cholera can be communicated from the sick to the healthy.

Diseases which are communicated from person to person are caused by some material which has the property of increasing and multiplying in the systems of the persons it attacks.

This material, or morbid matter, may be transmitted to a distance, e.g. on soiled linen; in other words proximity to the patient and to his “emanations” is not essential.

Cholera invariably commences with an affection of the alimentary canal.

It follows that the morbid material producing cholera must be introduced into the alimentary canal and not through some other system, e.g. the lungs.

Thus runs the basic theory. And thus, from a consideration of the *pathology* of the disease, Snow first approaches its mode of communication.

THE FACTS

In support of this theory Snow believes that the instances in which minute quantities of the ejections and dejections of cholera patients must be swallowed are sufficiently numerous to account for the spread of the disease. He seeks to see whether the known facts of cholera fit in with the theory:

The disease is found to spread most where the facilities for this mode of communication are greatest—amongst the poor, eating, living and sleeping in cramped and crowded quarters. In the better kind of houses it hardly ever spreads from one member of the family to another.

Want of light in some of the dwellings of the poor has often been commented on as increasing the prevalence of cholera. Deficiency of light is a great obstacle to cleanliness; it prevents dirt from being seen and it must aid very much the contamination of the food with cholera evacuations.

On the other hand the *post-mortem* inspection of the bodies of cholera patients has hardly ever been followed by the disease, this being a duty that is necessarily followed by careful washing of the hands; and it is not the habit of medical men to be taking food on such an occasion.

These, and other facts that he advances are not incompatible with the theory but they are clearly insufficient to explain the characteristics of widespread epidemic cholera. And so Snow moves on. “If the cholera had no other means of communication . . . it would be constrained to confine itself chiefly to the crowded dwellings of the poor, and would be continually liable to die out accidentally in a place, for want of the opportunity to reach fresh victims; but there is often a way open for it to extend itself more widely, and to

reach the well-to-do classes of the community; I allude to the mixture of the cholera evacuations with the water used for drinking.”

THE WATER SUPPLY

He illustrates his case against water by accounts of epidemics in London and the provinces, in the army in India and in the Black Sea fleet. I shall pass this evidence by, extremely convincing as some of it is, with but one (unconvincing) quotation. The drainage from cesspools had found its way into the well attached to some houses in a village near Bath and the cholera “became very fatal. The people complained of the water to the gentleman belonging to the property, who lived at Weston, in Bath, and he sent a surveyor, who reported that nothing was the matter. The tenants still complaining, the owner went himself, and on looking at the water and smelling it, he said that he could perceive nothing the matter with it. He was asked if he would taste it, and he drank a glass of it”. That, I regret to say, was the end of the poor owner; he was dead of cholera three days later. While, of course, that may be an admirable cautionary tale for “gentlemen belonging to properties” it clearly adds no real evidence to Snow’s thesis. The same sequence of events *could* have occurred if the epidemic had been one of plague with its very different mode of spread.

THE BROAD STREET PUMP

It is clearly impossible to celebrate the publication of Snow on Cholera without some reference to his most famous field study—that of the Broad Street Pump. Indeed I think it is necessary in this centenary year once more to point out that Snow’s claim to fame does *not* rest upon the removal of a pump handle and a *post hoc propter hoc* argument which he would, I believe, have despised. Yet that belief is still widespread. It may well have its origin in Sir Benjamin Ward Richardson’s fine memoir of Snow for this is what Richardson wrote:

“On the evening of Thursday, September 7th, the vestrymen of St. James’s were sitting in solemn consultation on the causes of the visitation. They might well be solemn, for such a panic possibly never existed in London since the days of the great plague. People fled from their homes as from instant death, leaving behind them, in their haste, all which before they valued most. While, then, the vestrymen were in solemn deliberation, they were called to consider a new suggestion. A stranger had asked, in modest speech, for a brief hearing. Dr. Snow, the stranger in question, was admitted and in few words explained his view of the ‘head and front of the offending’. He had fixed his attention on the Broad Street pump as the source and centre of the calamity. He advised the removal of the pump-handle as the grand prescription. The vestry was incredulous, but had the good sense to carry out the advice. The pump-handle was removed, and the plague was stayed.”

It is difficult to resist the final dramatic touch; it is almost sacrilege to attempt to *de-bunk* it. Yet perhaps it is fair in a centenary year to see what Snow himself wrote. He shows the sequence of events as determined by his inquiry into the 616 fatal attacks which I give below in slightly shortened form.

Date	No. of fatal attacks commencing on each day
August 26	1
27	1
28	1
29	1
30	8
31	56
September 1	143
2	116
3	54
4	46
5	36
6	20
7	28
8*	12
9	11
10	5
11	5
12	1
13	3
14-30	18
Date unknown	45

*Pump handle removed

Though conceivably there might have been a second peak in the curve, and though almost certainly some more deaths would have occurred if the pump handle had remained in situ, it is clear that the end of the epidemic was not dramatically determined by its removal. The deaths had already been declining from a very marked peak for at least five days.

Wholly recognizing these facts Snow himself wrote: "There is no doubt that the mortality was much diminished . . . 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, 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." He never occupied the flimsy pedestal upon which some would place him.

His evidence lay principally in the geographical distribution of the deaths around the pump and in the fact, from his personal inquiries, that almost all the dead had used the pump water.¹ Taken alone, obviously more than one explanation could fit these facts but there were other, and very odd, observations which had to be fitted in at the same time. How was it that the inmates of the workhouse went almost unscathed though surrounded by houses in which deaths from cholera took place? The workhouse had its own water

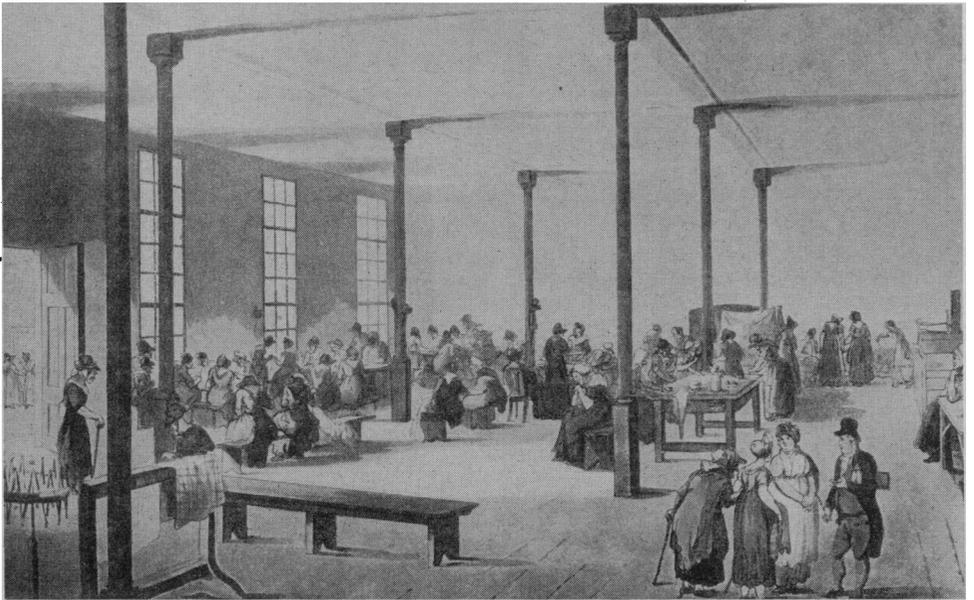


FIG. 4.—St. James's Workhouse, Poland Street. (London County Council collection.)

supply. That no cholera affected the 70 men employed in the local brewery hardly calls for even a rhetorical question and answer. On the other hand at the percussion cap factory where the only vintage supplied was two tubs of Broad Street pump water, 18 of 200 workpeople died. And then there was the astonishing case of the unfortunate widow at Hampstead whose custom it was to have a large bottle of the water brought to her daily and who, with her niece, perished of cholera in a cholera-free area. Snow was right, in my opinion, in regarding that event as "perhaps the most conclusive of all in proving the connexion between the Broad Street pump and the outbreak". But his whole "build-up" of evidence is impressive and should be read in full.

While the scale of the Broad Street disaster and Snow's detailed analysis of it naturally command the limelight, he sets out less well-known but, in my opinion, equally convincing stories. Let, for instance, the reader study the events of July 28 to August 13, 1849, in the "genteel suburban dwellings" of Albion Terrace, Wandsworth Road, where 20 persons died in ten houses and in one house 6 out of the 7 inmates perished. What conceivably could be so local in its effects, leaving untouched "the houses opposite to, behind, and in the same line, at each end of those in which the disease prevailed"? The answer was that they were supplied with water on the same plan, and after the storms of July 26 and August 2 it seems to have been a case almost of "water, water everywhere, nor any drop to drink".

¹In setting out this information Snow acknowledges the kindness of and the help given him by the Registrar-General of 1855. References in epidemiological papers of 1955 would suggest an inheritance of acquired characteristics.

107.

Snow on Cholera.

1853	4/6	5/6	5/6				
Jan	M. Times	23	19	15	Mo. Jour	5	1 1 6
	App. Jour	105	13		Lancet	163	1 3 6
	Circular	134			D. Jour	37	12 0
July	Times	6/6	6/6		Intelligencer	3	1 14 0
	Review	29			D. Jour	197	11 0
	Lish	39	6		Intelligencer	4	2 2 0
		40	+		Ditto	5	1 1 0
1852	Commission						1 6 6
Jan 15	Balance				John Snow		3 12 0
							13 5 6

200

FIG. 5.—An extract from the Publisher's ledgers, showing the cost of advertising, and John Snow's signature in receipt of his profit on sales. 300 copies of the book were printed at a cost of £200 to the author. Only 56 copies were sold.

The following is an extract from "The Times", July 5, 1849. A letter signed by 54 persons.

A SANITARY REMONSTRANCE

We print the following remonstrance just as it has reached us, and trust its publication will assist the unfortunate remonstrants:

THE EDITUR OF THE TIMES PAPER

Sur,

May we beg and beseach your proteckshion and power, We are Sur, as it may be, livin in a Willderniss, so far as the rest of London knows anything of us, or as the rich and great people care about. We live in muck and filthe. We aint got no priviz, no dust bins, no drains, no water-splies, and no drain or suer in the hole place. The Suer Company, in Greek St., Soho Square, all great, rich and powerfool men, take no notice watsomedever of our cumplaints. The Stenche of a Gully-hole is disgustin. We all of us suffur, and numbers are ill, and if the Colera comes Lord help us.

Some gentlemans comed yesterday, and we thought they was comishoners from the Suer Company, but they was complaining of the noosance and stenche our lanes and corts was to them in New Oxforde Street. They was much surprized to see the seller in No. 12, Carrier St., in our lane, where a child was dyin from fever, and would not beleave that Sixty persons sleep in it every night. This here seller you couldnt swing a cat in, and the rent is five shilling a week; but theare are greate many sich deare sellars. Sur, we hope you will let us have our cumplaints put into your hinfluenshall paper, and make these landlords of our houses and these comishoners (the freinds we spose of the landlords) make our houses decent for Christions to live in.

Preaye Sir com and see us, for we are livin like piggis, and it aint faire we shoulde be so ill treted.

We are your respectfull servents in Church Lane, Carrier St., and the other corts.

Teusday, July 3, 1849.

VITAL STATISTICS

Another, and, indeed, perhaps the most important, link in the chain of argument lay in Snow's adept handling of the vital statistics of London in relation to its various water supplies. Very briefly, in 1832 the chief villain was the Southwark Water Company with its unfiltered supply from the Thames at London Bridge. In 1849 there is little to choose between the Southwark (now combined with the Vauxhall) and the Lambeth Companies in their capacity, in friendly rivalry, to kill their customers—at a rate of about 1 in 60. And, then, in 1852 the Lambeth Company removed their water-works to Thames Ditton, “thus obtaining a supply of water quite free from the sewage of London”. The result is immediately reflected in the contrasting mortality rates of 1853. The rates are relatively high in districts served wholly by the Southwark and Vauxhall Company (114 deaths per 100,000), only half that level in districts served by both companies (60 deaths per 100,000) and nil in the three districts served wholly by the Lambeth Company. There follows, in the epidemic of 1854, Snow's fantastic personal inquiry into every death taking place in the districts served by both companies—“where circumstances were so happily adapted for the inquiry” for “the pipes of each Company go down all the streets, and into nearly all the courts and alleys”, “each Company supplies both rich and poor, both large house and small”. It is the almost perfect experiment.

Snow was not, however, able to take entire advantage of it. He could compare the absolute numbers of deaths but he did not know the number of houses served by the two water companies in the districts served by both and so could calculate no rates. There was a return of the total houses served by each Company but in using these he must bring into his comparison districts served by one *or* other Company only, thus somewhat vitiating the natural experiment. In a later publication (1856) he has acquired detailed population statistics and is able to reveal that *in every single sub-district* served by both Companies the cholera death-rate of the customers of the Southwark and Vauxhall Company was grossly higher than the rate of the customers of the Lambeth Company; in total the ratio was about 6 to 1. Frost considered that this later paper was “not altogether essential to Snow's argument, which was already well established, but confirms it in detail and shows his keenness in statistical analysis”. Personally I think that is an underestimate of its importance. The sub-districts had, in fact, quite widely varying rates; the provision of an exposed-to-risk that allows the contrast of the water supplies *within* the sub-districts is almost fundamental. 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.

None but the most stubborn, says Frost, could now deny the influence of contaminated water though the way in which it operated was still questioned. As Professor Mackintosh has observed, the stubborn were still quite thick on the ground. It is well to note, too, that the whole of Snow's case rested upon circumstantial evidence, almost entirely upon statistical observations and relationships. Even the not so stubborn were allergic to that kind of evidence—and are still allergic to it.

CONCLUSION

In conclusion let us, through the eyes of his friend Richardson, look at Snow one hundred years ago, in the epidemic of 1854. “He laboured personally with untiring zeal. No one but those who knew him intimately can conceive how he laboured, at what cost, and at what risk. Wherever cholera was visitant, there he was in the midst. For the time he laid aside as much as possible the emoluments of practice; and when, even by early rising and late taking rest, he found that all that might be learned was not, from the physical labour implied, within the grasp of one man, he paid for qualified labour. The result of his endeavours, in so far as scientific satisfaction is a realization, was truly realized, in the discovery of the statistical fact, that of 286 fatal attacks of cholera, in 1854, occurring in the South districts of the metropolis, where one water company, the Southwark and Vauxhall, supplied water charged with the London faecal impurities, and another company, the Lambeth, supplied pure water, the proportion of fatal cases to each 10,000 houses was to the Southwark and Vauxhall Company's water 71, to the Lambeth 5.”

To those who hold that statistics are dull I commend that simple comparison; to those who hold that the statistical approach is barren and unprofitable I commend Snow on Cholera. “This disease”, he concluded, “may be rendered extremely rare, if indeed it may not be altogether banished from civilized countries.” How right he was. For close upon 100 years we have been free in this country from epidemic cholera, and it is a freedom which, basically, we owe to the logical thinking, acute observations and simple sums of Dr. John Snow.