International Journal of Epidemiology

Vol. 11, No. 2
Printed in Great Britain

The Broad Street Pump Revisited

CHARLES E SMITH*

Smith C E [Department of Biometry, Medical University of South Carolina, 171 Ashley Avenue, Charleston S C 29425, USA]. The Broadstreet pump revisited. *International Journal of Epidemiology* 1982, 11: 99–100.
This historical note examines the effect of population migration on the number of fatal cholera cases reported by John Snow in the Golden Square area of London during the fall of 1854. A method to correct for population migration is given and its relevance to present day epidemiological studies discussed.

The keen observations and reasoning of the British physician, John Snow, have made his studies on cholera in London during the 1850s a classic example of scientific epidemiological investigation.[1] While perhaps his most important contribution was the use of vital statistics in relating cholera prevalance to the water supplies of London (the Southwark and Vauxhall, and the Lambeth water companies), his best known study may be the incident of the Broad Street waterpump. Indeed, the massive outbreak of cholera near Golden Square in the fall of 1854, the implication by Snow of the Broad Street waterpump, and the pumphandle's subsequent removal are events familiar to every student of introductory epidemiology. The proviso is often added, however, that the epidemic had essentially subsided by the time the handle was removed, and this sequence was an early example of 'an epidemiologist riding to glory on the declining tail of an epidemic'.

While the above admonishment may certainly have some validity, the situation deserves further scrutiny. As Snow stated,[1] and Hill emphasized,[2] two issues remain: (1) was the water supply still contaminated, and (2) what effect did the migration of the local residents out of Golden Square have. Snow had noted (reference 1, p 38) that in the six days following the onset of the outbreak (31 August, 1854) around three quarters of the residents had left the Golden Square area. While, in retrospect, there is no way to resolve the first issue, the effects of the population migration can be examined. As recently emphasized by Freeman and Hutchinson,[3] the dynamic state of the study population is an often neglected consideration in epidemiological studies.

In Figure 1A, the number and dates of fatal attacks of cholera as given by Snow[1] (p 49) are shown. This 'epidemic curve' is reproduced in many introductory epidemiology texts (eg[4]) and cited as an example of a point source epidemic. The vertical arrow denotes the date of removal of the pumphandle (8 Sept.). The stipled histogram in Fig. 1A represents the expected number of fatal attacks that would have occurred if the population at risk had not decreased and the water supply

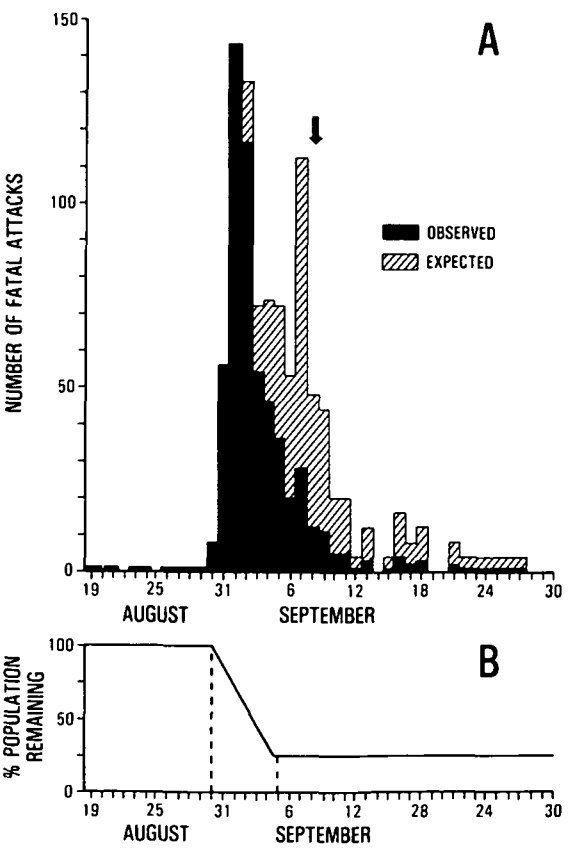

FIG. 1

The occurrence of fatal cholera cases in the Golden Square area of London during August and September, 1854. (A) The solid histogram is the number of fatal cases reported by Snow (reference 1, p 49) The arrow denotes the date (8 Sept.) of the pumphandle's removal. The stipled histogram is the expected number of fatal cases that would have occurred had the population not migrated. (B) The percentage population remaining in the Golden Square area that was used in the calculation is shown.

* Department of Biometry, Medical University of South Carolina, 171 Ashley Avenue, Charleston, SC 29425, USA

had remained contaminated. A linear decline of the population at risk (B) during the six days following the onset of the outbreak was assumed for illustrative purposes. More rapid declines would accentuate the effects seen in (A), while slower declines would diminish them.

The calculation of the effect of migration on the occurrence of fatal attacks consists of two parts. First the proportion of the population remaining (B) must be adjusted to take into account the incubation period of the disease and its variability. Strictly speaking, the curve in (B) should be convolved with the probability density function for the incubation period. To allow the reader to more easily reconstruct this calculation, curve (B) was instead shifted to the right by the median incubation period. The incubation period for cholera is usually two to three days, ranging from a few hours to five days.[5] A value of two days was used for the calculation. Next, for each day the number of fatal attacks in (A) is divided by the corresponding value on the adjusted curve in (B). The result is the expected number of fatal attacks that would have occurred if no migration had occurred.

The above calculation illustrates a general method to correct for the effects of population migration on epidemic curves. Note the method assumes the population that migrates would have had similar attack rates had they remainded. Also note that using the convolution operation will, in general, produce smoother epidemic curves than using the median incubation period.

While including the effect of migration still does not point toward a definitive role for the pumphandle's removal, it does significantly alter the temporal distribution of the occurrence of cholera cases. The point of this historical note is to urge a more careful consideration of the dynamic nature of the population at risk in present day epidemiological studies, particularly in the study of chronic diseases where the incubation period may be 10 to 20 years. In summary, some less cited observations of John Snow may provide another lesson for our introductory epidemiology students and ourselves.

ACKNOWLEDGEMENT

I would like to thank J Crellin, P Hibberd, P Richter, R Shallenberger, G Watt, and J Mandel for helpful discussions, and A M Lilienfeld for his thoughtful comments on a draft of this note.

REFERENCES

[1] Snow J. On the mode of communication of cholera. In Snow on Cholera. pp. 1–175. New York: The Commonwealth Fund. 1936.

[2] Hill A B. Snow—an appreciation. *Proc R Soc Med* 1955; **48**: 1008–12.

[3] Freeman J, Hutchinson G B. Prevelence, incidence, and duration. *Am J Epidemiol* 1980; **112**: 707–23.

[4] MacMahon B, Pugh T F. Epidemiology: Principles and Methods. pp 157–158, Boston: Little, Brown and Co., 1970, p 157.

[5] Benenson A S (Ed.). Control of Communicable Diseases in Man. Twelfth Edition, pp 71–75, Washington, D.C.: American Public Health Association, 1975.

(Received 20 July 1981)