Commentary: The Researcher as Amateur: John Lea, Cholera, and... the Computer Age

Tom Koch

Department of Geography, University of British Columbia, British Columbia, Vancouver, BC, Canada

*Corresponding author. E-mail: tkoch@geog.ubc.ca

It is the brilliant amateur, not the salaried, tenured professional, who has dominated the long history of epidemiology and public health. Into the early twentieth century, science was an open game in which anyone with an idea could play. Irrespective of academic pedigree or training, researchers presented their findings in magazines, newspapers, and academic journals, seeking the broadest possible audience for their work.

In reviewing the history of one such researcher, John Lea, the goal is not simply to review the work of a talented and forgotten researcher who in the 1840s argued local water supplies as a source of pandemic cholera outbreaks. Thinking about John Lea, as he signed his papers, of Cincinnati, Ohio, serves as a reminder of the potential importance of today’s non-professionals in the study of contemporary disease outbreaks and health problems. They may lack university positions and resources, but low-cost computers, enabling inexpensive yet powerful analytic programs, give modern amateurs the tools to study what, a generation ago, seemed to be the sole provenance of the well-funded professional.

John Lea

When pandemic, ‘Asiatic cholera’ swept across the US Atlantic states in 1832, John Lea assumed, as did most physicians, that it was the same disease as ‘cholera morbus’, a diarrheic disorder that in retrospect, we today assume was bacterial food poisoning. Having survived an attack of cholera morbus in 1830, Lea dedicated his spare time to discovering the mode of transmission of this ‘new’ cholera. In the 1840s he proposed a relationship between Asiatic cholera and heavily mineralized water drawn from local wells and ‘passing through strata of marl, producing unwholesome water’. The results of his research were published in Cincinnati, Ohio newspapers, and most importantly, perhaps, in The Western Lancet, one of several non-British, non-European journals that in the
nineteenth century took as their focus American medicine and medical research. Following the then common standard practice of researchers, in Lea 1851 published a pamphlet that summarized his research.\(^2\)

In his pamphlet, Lea began with the assumption, as did most physicians of his day, that cholera was a miasmatic disorder born in and transmitted by the foul, unsanitary airs that pervaded the nineteenth-century city. But, he suggested, its transmission required exposure to specific minerals (calcereous or magnesium salts) found in some well water. As we now know, he was wrong on both counts, but as we also know, was correct in his identification of well water as a source of local outbreaks of cholera.

Lea’s research was read internationally and cited by, among others, John Snow, in his famous 1855 tome On The Mode of Transmission of Cholera.\(^3\) While doubting Lea’s mineral water thesis, Snow adapted Lea’s more general argument emphasizing the importance of water to disease, and specifically to the transmission of cholera. ‘The connection which Mr. Lea has observed between cholera and the water is highly interesting’, Snow wrote in his opus, ‘although it probably admits of a very different explanation from the one he has given’.

The importance of Lea’s published work lies neither in the recognition he received nor in his novel identification of well water as a locus of disease activation. Rather, it lies in the quite extraordinarily complete and efficient methodology he employed, including the detailed study of a Cincinnati neighbourhood outbreak of an infectious disease. His approach demonstrates a research model still used by local and professional researchers (in cancer, cholera, typhoid, etc.) into the twentieth century. It resonates even today with the work of local public-health experts and more likely with non-professional researchers, in the main, to publish online than in professional journals.

The Study: Background

Through most of the nineteenth century, studies of disease were primarily inductive exercises in which the incidence of one or another condition was correlated with one or more environmental and social conditions. Bacteriology awaited both Robert Koch’s methodology—his famous postulates—and advances in microscopy. Geology, however, was a rapidly developing science with a detailed categorization of different minerals and strata of the Earth’s crust. By 1817, for example, the ‘father of American Geology’, William Maclure, published On the Geology of the United States of America, expanding on earlier work that included the first map of national geology in the US in 1809.\(^4\)

During this period the dominant theory of disease—one challenged by John Snow and others in the mid-1850s—was miasmatic. It assumed that epidemic diseases (including cholera, yellow fever, typhoid fever, etc.) were born in the foul airs that pervaded the industrializing city.\(^5\) This theory of environmental disease had been ‘proven’ in studies of yellow fever in the 1790s\(^6\) and seemed to provide a complete explanation for the incidence of disease, its genesis, and its diffusion.\(^7\)

Lea did not challenge the prevailing disease theory of the day. Rather, he argued that certain geologies provided the means by which cholera was activated and then transmitted in populations whose drinking waters had specific mineral contents. His ‘geological theory’ of cholera thus correlated then-current geological knowledge with reports of localized and regional disease incidence. This environmental concept of medicine was well discussed in medical journals of the day\(^8\) and would remain a common theme in studies of disease generally, including investigations of cancer,\(^9\) into the twentieth century.\(^10\) Whatever might be the agent of a disease, different climatic and geological conditions were assumed to either inhibit or promote the incidence of the disease.

The Study: Literature

Lea first reviewed reports of Asiatic cholera outbreaks in the United States in the 1840s, correlating the location (and ferocity) of these outbreaks with the geology and geography of the local environment. His analysis was based on reports in both medical journals and popular news media of outbreaks in Boston MA, Charleston, SC, Mobile, AL, New Orleans LA, New York, NY, and St. Louis, MO. In each case Lea noted the number of people affected and the reported mortality in relation, in most cases, to the general population.

Where possible, Lea then related the incidence of mortality and of morbidity to the underlying geology that, in his theory, activated cholera in well water. For New York City he had a sample of Manhattan well water analyzed and the mineral content listed (murate of magnesia, sulphate of magnesia, carbonate of lime, sulphate of lime, and ‘extractive matter’). As a control group he mentioned, in passing, the states whose geology was distinct and where outbreaks of epidemic cholera had been rare or unreported (e.g. Alabama, Florida, North and South Carolina, Tennessee).

Although it was logical and suggestive, Lea knew that this was far from conclusive. To make his case he needed a large-scale, local example in which he could compare the incidence of disease among persons drinking mineral-tainted water and those not drinking it.

Test Case: Sycamore St., Cincinnati

In Cincinnati, OH, ‘about 35 000 of the population are supplied with the river (Ohio) water in iron pipes by steam power’, and were in the late 1840s ‘exempt in a remarkable degree from the epidemic’, wrote Lea in
his pamphlet. In stark contrast, ‘the pestilence raged with frightful mortality, attacking those who drank well and spring water’. Here, Lea believed, was a ‘natural experiment’ that would prove his thesis.

Sycamore Street, in Cincinnati, existed on the edge of the city in an area that was ‘exempt of (the) malarial content’ of the odoriferous air generated in more densely settled areas of the city where public waste disposal was absent. The single-family houses along Sycamore Street were, in the main, served by well water believed to be clean. Yet along this street, mortality from Asiatic cholera was severe.

Lea mapped the houses along Sycamore Street (Figure 1), distinguishing those whose primary drinking water

Figure 1 Lea’s map of Sycamore Street
came from the local well and those whose water came from another source. To this he added the incidence of cholera mortality. His text expanded upon the map with brief but detailed descriptions of the disease burden of the houses included in his map. The deaths reported were almost always associated with habitations where well water was the preferred source of drinking water.

The result, Lea concluded, was statistically decisive: ‘In the 19 houses on this sketch, 44 persons died; which, if we allow 6 to each house (the average density of habitation that he found in the neighborhood), gives a total of 114, being about 40 per cent; had the whole city been supplied with the water of that spring, we might have suffered a mortality of near 40 000!’ Since that mortality far exceeded the observed mortality in the city, Lea believed that his thesis was statistically proven.

To deepen the argument, Lea then reported on other outbreaks of cholera reported in the United States and elsewhere, some reported to him by correspondents, at locations in which a mineralized water supply seemed to be a contributing and even crucial environmental factor in these outbreaks. ‘The strong array of facts adduced’, he concluded, ‘prove conclusively that water containing certain mineral elements is a proximate cause of Cholera’. The answer, Lea believed, was to encourage persons drinking well water to instead drink rainwater as a means of preventing outbreaks of cholera in those areas in which the ground water was highly mineralized.

Today we would smile were a researcher to expand in this way from a local disease outbreak on a single street to a general, causal explanation of an otherwise inexplicable pandemic condition. But the problem of scale was a largely unconsidered problem in disease statistics until the twentieth century. Indeed, Lea’s use of statistical summarizing of the case-by-case incidence of disease, or what might be called ‘shoe leather epidemiology,’ constituted a state-of-the-art presentation by a medical amateur whose methodology conformed to the best standards of the day. Although limited in its scale, Lea’s report generally follows the methodology of other professional researchers, such as Dr John Sunderland in Great Britain.11

Legacy

Both Lea’s proposed environmental trigger to disease incidence and his use of the large-scale, neighbourhood analysis—mapped and statistically summarized—became accepted elements in disease studies. In cancer research, for example, the idea of a geology that predisposed those living in certain areas to specific cancers was critical to the work of Alfred Haviland, the first to argue an ‘epidemic’ of cancers in Great Britain. Haviland’s work sparked similar investigations and led to similar findings in other countries across the British Commonwealth in the 1880s. In his 1892 *The Geographical Distribution of Disease in Great Britain*, Haviland used biogeographic maps of the geologies of Cumberland and Westmoreland counties to explain the high incidence of cancers in the region through its geology. However, maps had been part of Lea’s environmental disease perspective from the start.12

More generally, amateur and professional researchers used large-scale, neighbourhood maps to
investigate a range of conditions that included, into the twentieth century, not only cancer and cholera but also poliomyelitis and typhoid fever. Although this methodology was later attributed to John Snow, it was in fact an approach already common to researchers of his day, including Lea.

This approach to disease investigation worked extremely well in cases of outbreaks of diseases such as cholera and typhoid fever, which could be traced to a single source, usually a polluted well or reservoir. In Chicago, IL, Hull House physician Dr Alice Hamilton used mapping and mapped statistics in her study of typhoid fever in that city in 1903. Similarly, W. H. Frost mapped epidemics of typhoid fever in his career with the US Public Health and Marine Hospital Service (Figure 2). In 1919 he would help found the public health department at Johns Hopkins University in Baltimore, MD.

The approach pioneered by Lea and others did not serve as well where the etiology of a disease was unclear and both the origin and source of an outbreak were unknown. It did, however, encourage both the generation and then the testing of various hypotheses. Thus, in the late nineteenth and early twentieth centuries a number of articles were published describing what appeared to be local cancer clusters whose origins were seen as either environmental, genetic (‘cancer families’, as they were called) or simply of unknown origin. Local physicians were typically the researchers in this literature. They used data from their individual practices, and local knowledge (often with topographic maps), to suggest and then test theories that although suggestive were not generally conclusive.

Nor did this methodology serve in cases of what we now know to be outbreaks of viral diseases. An example of this was W. H. Frost’s use of this methodology in a study of poliomyelitis in Ohio in 1911. As he had been taught, Frost mapped the incidence of poliomyelitis in the city of Madison, OH, which had been affected by the disease, and then attempted to identify a point of origin of the disease (the church, the school), but was of course unsuccessful in an effort made decades before either the viral nature of poliomyelitics or its paths of transmission were made clear (Figure 3).

Modern applications

In the decades following the Second World War, the computer permitted a level of analysis that was previously inconceivable. With the desktop-computer revolution, the cartographic and statistical tools that had previously been the sole provenance of the professional became increasingly generally available. At the same time, this permitted the application of ever more complex analytical methods—Bayesian statistics, for example—and ever-better cartographic presentations of statistical surfaces. And as a further
effect, it encouraged studies focusing on smaller scale, regional and national disease patterns rather than on large-scale, neighborhood studies of diseases whose etiology was unclear.

The democratization of mapping and statistical programs again encouraged amateur investigators, as well as medical professionals without training in epidemiology, to map and analyze local outbreaks of diseases in their neighborhoods, cities, or regions. Thus, for example, it was not the epidemiologist but the journalist working with federal maps who made public the connection between refuse from uranium mines and the ‘Navajo neuropathies’ that plagued many persons living in thinly settled native lands.18

In the early 1980s, doctors Cedric and Frank Garland perceived a correspondence between maps of natural sunlight gradients and mortality rates from colon cancer. The brothers were both researchers at the University of California San Diego’s school of medicine. The visual correspondence evident in those maps led them into research demonstrating a relationship between body fluid and tissue levels of vitamin D (with sunlight its natural source) and variations in the incidence of cancer.19,20 And, too, it was the mapped incidence of a cluster of local cases of cancer in Denver, CO (the work was popularized by articles in *The New Yorker* by writer Paul Brodeur), that in 1979 began an ongoing public debate21 about the meaning of dense clusters of cancer located near power lines and sources.22

**Proximity, Incidence, and Statistics**

There are also mapped studies by amateurs seeking to describe local clusters of disease. Today these are more typically presented on-line rather than in journals, with their address being to the public rather than professionals. The amateurs writing studies of local diseases on the web are the direct inheritors of Lea’s passionate search for the source of cholera in his life and time. Most of the on-line reporters of local disease present their findings with maps, and many use statistical information easily produced with general software programs such as Microsoft Excel.

For two reasons, their work should not be disparaged. First, they emphasize a limit of public health statistics, its inability to adequately cover what appear to be local ‘hot spots’ of incident disease. Health statistics work best when large numbers are analyzed across broad geographical areas. They serve poorly in the analysis of neighborhood and local clusters of disease. Even under circumstances in which the incidence of a disease appears significant in a local map, the results are typically dismissed as a statistical anomaly that will presumably disappear amidst data covering a more general scale.23 Yet it is not known whether the local hot spot signals an environmental source of disease, a statistical anomaly, or something else.

In other words, we need a statistics that can be applied to small scales as well as to the analysis of large numbers. Why? Because among a multitude of other instances, mapped hot spots of cancer in counties in the state of Virginia in the US were found to reflect the incidence of mesothelioma among ship-builders exposed to asbestos during the Second World War,24 and hot spots of respiratory cancers in two Montana counties were later traced to air pollution with arsenic from a local copper smelter.25

Second, it is often the untutored amateur who will see possible causal connections that a trained epidemiologist will overlook. It is not simply the local knowledge that a nonprofessional brings to a study, but the amateur’s freedom to think outside the parameters of professional assumption, that identifies important factors in the epidemiology of a disease. Recently, for example, chemist Stockholm University chemistry professor Sven Hovmöller was stumped in his attempt to analyze the structure of quasicrystals, aperiodic structures that do not display the rigidly repeating patterns of normal crystals.26 It was only when Hovmöller shared the images of these crystals with his 10-year-old son that the means of their analysis became clear. It was in presenting the problem to a youthful amateur that what had been unclear became understandable, if not obvious. His father says his young son, good at puzzles, saw patterns that he and other professionals had not perceived.

The many advances in medical technology (e.g. electron microscopy), science (e.g. theories of disease transmission), and practice do not mean that there are no lessons left to be learned from medical history. It is important to remember that medical knowledge, while considerable, is not complete. Instances in which our knowledge is deficient, or simply limited, and certainly instances in which theories validate the efforts of an amateur like Lea, serve as both goad and reminders that different perspectives buttressed by local knowledge may lead to a solution to seemingly baffling problems.

**Conflict of interest:** None declared.

**References**


In 1850, John Lea (1782–1862) published his *Cholera, with Reference to the Geological Theory*¹ in Cincinnati, Ohio. Unlike other interpretations of cholera produced around this time, John Lea’s interpretation focused on rocks and soil instead of animalcules, fungi or poisons. Lea relied upon a 50-year-old theory stating calcareous rocks were the cause for diseases due to their alkalinity. It was Lea’s experiences with the 1830 epidemic in Tennessee that led him to develop this theory when a severe Asiatic cholera epidemic struck his town, preceded and followed by its milder form cholera morbus. Earlier versions of this geological theory were posed for such diseases as ‘black-vomit’ in 1800²,³ (for which an opposite relationship was developed), yellow fever between 1800 and 1840⁴ and cholera after the first pandemic.⁵

John Lea’s ability to differentiate Asiatic cholera from cholera morbus was not overly successful, for he was

---

² Seaman V. *Inquiry into the cause of the prevalence of yellow fever in New York*. Medical Repository 1798;1:
³ 303–23.
¹¹ Hamilton H. *The fly as a carrier of typhoid: An inquiry into the part played by the common housefly in the recent epidemic of typhoid fever in Chicago*. JAMA 1903;103:576–83.
¹⁴ Hamilton H. *The fly as a carrier of typhoid: An inquiry into the part played by the common housefly in the recent epidemic of typhoid fever in Chicago*. JAMA 1903;103:576–83.
²⁶ Accepted 18 December 2012

Commentary: John Lea’s Cholera with Reference to Geological Theory, April 1850

Brian Altonen

Department of Community Health, Portland State University, NY, USA

*Corresponding author. E-mail: altonenb@yahoo.com*