

ORIGINS OF EPIDEMIOLOGY

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In this paper we will trace the history of epidemiology from 1800 up to the present time. The history is highly selective because our purpose is to illuminate the evolving relationship of epidemiology with demography. We first describe the common “prehistory” of these two disciplines in the early nineteenth century, and then describe their divergence over three successive eras of epidemiology up to the end of the twentieth century. In the final section, we draw attention to some exceptional individuals who bridged the two disciplines despite the historical trend in the other direction, and express our hope that recent signs of some convergence in the face of globalization and the AIDS pandemic will be borne out in the coming decades.

Prehistory of epidemiology

The earliest attempts to quantify changes in the size and health of populations extend at least as far back as John Graunt who used the Bills of Mortality kept in England in the 17th century.¹ By the eighteenth century, some Scandinavian countries were recording numbers of births and deaths, and by the turn of the century, the population registers established by Napoleon provided a base for collecting vital statistics in other European countries. It was in England in the mid-nineteenth century, however, that the process was first articulated, systematized, applied to a large population, and used to draw implications for health policy.²⁻⁶ Thus, we must look to England during the period of the Industrial Revolution in order to understand how the foundations were laid for the modern disciplines of epidemiology and demography.

We shall refer to the period before 1850 in England as the “prehistory” of epidemiology and demography. By 1850 in England, the census was well established, Parliament had legislated sanitary reform, and vital statistics were being used to support inferences about population growth, patterns of health and disease, and public health policy. Therefore, by mid-nineteenth century, epidemiology and demography were recognizable, though not labeled as such.

The social context for the prehistory was the Industrial Revolution. England was being transformed, as masses of people migrated to urban areas, taking employment as wage laborers in the new factories, and living and working under deplorable conditions.⁷ The advent of the factory system brought dramatic growth in production, unprecedented in history. It also brought social unrest, and the real threat of revolution. Politicians and philosophers alike were preoccupied with the perceived threat to the social order, which they often expressed as a concern for “the condition of England”. Like others of the time, the progenitors of epidemiology and public health were preoccupied with “the condition of England” and their early writings are best seen in that light.^{5,2,1}

One of the predominant social philosophers in this period was Thomas Malthus.⁸ Malthus argued that lawful relations could be discerned in the growth of populations. He is often considered as the first veritable student of demography. In a simplified form, the Malthusian view was that in the short term the growth of populations was exponential but the growth of food supply was not. Consequently growing populations tend to outstrip their food supply, leading to increased mortality, which acts as a check on population growth. Malthus’ views were actually somewhat more complex and allowed a role for fertility as well as mortality,⁸ but this simplified Malthusian view was popularized and extremely influential at the time.

The Malthusian view posed a major dilemma for the emergence of epidemiology and public health. The mission of epidemiology is to understand and improve the health of populations. In the Malthusian view, this kind of effort is misguided. A socially engineered reduction in mortality, for example, would interfere with the lawful operation of increased mortality as a check on population growth, and might very well lead to unintended adverse consequences.

The influence of Malthus was so profound that the founders of epidemiology and public health felt compelled to justify their mission by either refuting, or more often modifying, the Malthusian view. They saw questions of population growth and health as being intertwined, and saw both as of great importance for “the condition of England”. The

sociologist Max Weber was said to be engaged in “dialogue with the ghost of Marx”; it may perhaps also be said that some of the pioneers of epidemiology and public health were in dialogue with the ghost of Malthus. To illustrate this point, which underscores the common origins of epidemiology and demography, we shall consider two key figures of this period: William Farr and Edwin Chadwick.

William Farr

William Farr was indisputably one of the “founding fathers” of epidemiology.⁹ He shares this distinction with his English contemporary John Snow, Louis Villerme in France, Peter Ludwig Panum in Denmark, and others in Europe at this time. Perhaps more than any of these others, however, William Farr laid the foundations for the future numerical practice of the discipline. Farr is especially appropriate for this selective history because he is also considered by some to be a founding father of demography.

Farr came from humble origins, and never received a classical education. Although he managed to obtain a license to practice medicine, he failed to establish a lucrative practice. Nonetheless, his intellectual interests and talents were remarkable, and the radical editor of the *Lancet*, Thomas Wakley, was among those who recognized them and sponsored his career. The landmark event in Farr’s professional life was his appointment as Compiler of Abstracts in the General Register Office in 1839. From this position, he took responsibility for designing and analyzing the census over a period of more than 30 years, and played a key role in creating the British system of vital statistics, and demonstrating its uses for what we now call epidemiology and demography.

With respect to professional identity, he saw himself as a “statistician” and was active throughout his career in the London Statistical Society, at one time serving as its President. At the time, statistics meant the science of social reform, and it encompassed questions about the population and its health on the one hand, and questions about economic growth on the other hand. Indeed, statisticians were often

concerned with the relation between the two. It may be noted that Malthus was a founding member of the London Statistical Society.

As he defined his professional identity, a central concern for Farr was to develop a response to Malthus. He had to show that improving health and reducing mortality could be compatible with stabilizing “the condition of England”. Farr argued, first, that Malthus had overemphasized the role of increasing mortality - as opposed to declining fertility - in checking population growth, and second, that the advent of the Industrial Revolution had opened the possibility of exponential growth in food supply as well as in population.

Hence the debate over the growth of population and its implications for social unrest was the crucible for the emergence of epidemiology as a discipline. To motivate the establishment of a reliable and systematic collection of vital statistics, needed for both epidemiology and demography, William Farr actively engaged in this debate and developed the professional stance that guided the the first phase of epidemiology described below. Thus, epidemiology and demography truly have common origins, more so than has generally been noted.

Edwin Chadwick

Just as William Farr was a founding father of epidemiology, his contemporary and sometime ally Edwin Chadwick was a founding father of public health.

Edwin Chadwick, however, poses a dilemma for modern observers. Without knowledge of the historical context, Chadwick seems like a Jekyll and Hyde figure.

Chadwick’s two grand achievements were the new Poor Law of 1834 and the Public Health Act 1848. He spent decades in developing both of these pieces of legislation, and securing their passage through Parliament. In both of them, he played a greater role than any other individual.

Then and now, the new Poor Law seems to epitomize the government's cold lack of human compassion for the working classes. The new Poor Law eliminated the traditional parish-based welfare payments for the destitute, substituting a harsh and punitive system of relief which depended on the notorious workhouses. The new system was designed as a deterrent; the conditions of relief were meant to be so onerous and humiliating that applicants would apply for relief only as a very last resort. Under the principle of "less eligibility", the pain of accepting relief had to be made greater than the pain of living in poverty without relief; this was no small task given the miserable conditions of the unrelieved poor. For the mass of the population, the new poor law was one of the most hated pieces of legislation in the Victorian era.

The Public Health Act, by contrast, is generally seen as a landmark in progressive and humanitarian legislation. In the process of developing and advocating for the Act, Chadwick and his colleagues compiled the famous *Report on the Sanitary Condition of the Labouring Population of Great Britain*,¹⁰ documenting the miserable conditions of working people of the time, and calling for improvements. The legislation set the stage for sanitary reform and was the first great public health legislation of modern times. The Act was significant not only for the important sanitary reforms that it propelled, but also, because it inaugurated an explicit role for government in promoting the health of the population.

How can Edwin Chadwick have been responsible for the most punitive as well as the most progressive legislation of the epoch? He was not fickle, in fact, he was legendary for being a dogmatic man, and for sticking to his opinions far longer than he should have. The answer must be sought in some common theme across the two measures, that may have been far more apparent to contemporaries than to the modern eye.

A recent reinterpretation of Chadwick by Christopher Hamlin provides at least part of the answer.⁵ Chadwick was in both cases dealing with the "condition of England", that is, the maintenance of the social order. Chadwick – and many others of the time-- believed that the reform of the relief system was essential to the economic growth of the nation.

Similarly, the sanitary measures were essential to social stability. It seemed evident that something had to be done about the recurrent epidemics and the overall poor health of the population. Sanitary reform provided the alternative to more radical measures advocated by Wakley and others, who saw ill health as bound up with the living conditions of the poor in a much broader sense. With sanitary reform the debate on health was shifted from social revolution to engineering. The sewer pipes would uplift the health of the people, by controlling the miasmas and other ill effects emanating from the extraordinary filth in English towns and cities, but they must have the right diameter and shape and be made of the right materials.

To promote both the new Poor Law and the Sanitary Reform, Chadwick had to refute the Malthusian view. He argued that the deterrence built into the use of relief under the Poor Law would ensure it served the working rather than the unwanted “pauper” population, and furthermore, that the maintenance of the working population was an economic benefit, needed to fuel the growth of Britain’s new industries. This argument could lead to a contradiction, however, in that the conditions required for deterrence may be so severe that they could be detrimental to health. Chadwick escaped this logic by taking the position that destitution did not so much cause poor health, as poor health caused destitution. The way to reduce destitution and improve economic growth, then, was to promote health, by some means other than better living conditions for the poor. Sanitary reform provided the answer. Without requiring any reorganization of the social order, it would reduce the widespread illness that was a cause of destitution and was a drain on productivity. The economic growth, in turn, would increase the food supply and the size of the population that could be sustained.

Thus, seen in historical context, Chadwick’s two pieces of legislation do fit together into a single theme. They can be understood as efforts to deal with the condition of England, to promote economic growth and maintain the social order. Seen from this perspective, the ideology of public health emerges from the dialogue with Malthus.

Successive eras of epidemiology

The modern history of epidemiology and public health begin in the mid-nineteenth century. The Public Health Act of 1848 is as good a landmark as any to mark its arrival. The ensuing history of epidemiology is better known than its early origins, and we will deal with it more briefly, focusing primarily on the relation of epidemiology to demography across successive eras. Along the lines of our previous papers,¹¹⁻¹² we define three main eras, each of which was characterized by a distinct causal paradigm: sanitary reform, infectious disease, and chronic disease (see table 1).

The era of sanitary reform

The era of sanitary reform in England spanned most of the second half of the nineteenth century: from the Public Health Act up to the dominance of infectious disease epidemiology. “The condition of England” had stabilized. The threat of revolution receded, economic growth progressed to new heights, and the living conditions of working people began to improve.

The dominant causal paradigm was that of “miasma”. Miasma was seemingly a kind of vapor that emanated from decaying organic matter, and produced disease as it spread across the environment. Sanitary reformers believed that the extraordinary filth in the growing urban areas had produced the conditions for the spread of “miasma”. They viewed causation of disease on a broad ecologic level, and similarly, the reforms advocated at this time were often on the same broad level.

For purposes of the present discussion, what is important in this era is the way in which epidemiology began to diverge from demography. In the prehistory of epidemiology and public health described above, “the condition of England” was the central preoccupation, and the question of population size and growth was inextricable from the question of population health. In the sanitary reform era, these questions were gradually distinguished, and became separate domains of enquiry. (In addition, epidemiology began to differentiate itself as a profession; see David Lilienfeld on the emergence of the London Epidemiological Society).¹³

William Farr was the central figure in this development. He remained in the General Register Office throughout the era. On the other hand, Edwin Chadwick, always a political figure and highly controversial, was deposed from power. John Simon, a man of very different background and character, was then selected to be the chief figure responsible for public health within the government. Unlike Chadwick, Simon was trained in medicine, and cloaked in the prestige of a wealthy London practice.⁴

The differentiation can be seen best in two of the paths taken by Farr in this period. Farr began to analyze and report the distribution of mortality within the population. He examined social inequalities in mortality, regional differences, and the mortality of specific populations. As he increasingly compared the mortality experience of one population subgroup with another, he created a field of epidemiologic enquiry that was distinct from demography.

His study of mortality among the inpatients of asylums of England offers a remarkable example. In what was perhaps the first intimation of a systematic clinical follow-up study using a cohort design, he examined the mortality rate among patients admitted to the innovative Hanwell asylum, and compared it to the mortality rate among patients of other asylums. The annual mortality rate of paupers in Hanwell was 12%; in other asylums the annual mortality ranged from 11% up to 27%, “as high as ... the British troops upon the western coast of Africa ...” (p.430).¹⁴

In addition, Farr turned his attention to cause specific mortality. He was initially reluctant, and interestingly, this came about under prodding by John Simon.¹⁵ Ultimately, he devised a classification of diseases for use in vital statistics. As he compared the mortality patterns of one disease with another, he moved away from describing the size and growth of the population, and toward a disease specific epidemiology, a critical shift for our purposes.

The era of infectious disease epidemiology

This era was ushered in by the discovery of microorganisms, and lasted up to the second World War. The dominant causal paradigm changed rapidly from miasma to germ theory. Over a short and dramatic period toward the end of the nineteenth century, microorganisms were discovered, and were established as causes of syphilis, diphtheria, cholera, and other epidemic diseases.¹⁶ The landmark event was the paper of Robert Edward Koch in 1882 on the tubercle bacillus, showing that the paradigm had the power to identify the causative agent for the most important disease of the newly industrialized countries.

With this shift in paradigm, the focus of epidemiologists tended to narrow still further, away from the mortality and fertility of the overall population, and toward the causes, consequences, and potential actions for prevention and treatment of specific diseases. Following the famous Henle-Koch postulates, epidemiologists sought to establish germs as necessary and sufficient causes of major diseases. Each disease had to be investigated separately, to discover the germ responsible for it. The paradigm for public health intervention, likewise, shifted from ecologic measures such as sanitary reform and improved living conditions, to methods designed specifically to interrupt the path of transmission of a certain microorganism in the population. The increasing focus on transmission patterns of specific diseases was accompanied by a decline in large scale epidemiologic analyses of secular trends, regional differences, and social differences in morbidity and mortality.

The center of epidemiology and public health shifted, too, away from England to the United States.^{17, F} The first application of the new paradigm to public health on a large scale was in New York City. Under the leadership of Mitchell Pruden, Hermann Biggs, and William Park, the New York City Department of Health established in 1892 a Division of Pathology, Bacteriology, and Disinfection and

^F There was notable work in the United States (and other countries) during the Sanitary era—for instance, the renowned *Shattuck Report*¹⁸ --- but the forefront was in England.

began to use it for population based interventions designed around specific microbes. Shortly thereafter they launched a campaign against diphtheria in New York City.¹⁷

The diphtheria campaign was innovative on many levels. One of the greatest challenges was to make the wide scale use of bacteriologic diagnosis of diphtheria both feasible and acceptable. The introduction of the new method of diagnosis met with considerable resistance from physicians as well as the general public. In response, William Park developed a user-friendly culture kit, complete with tube, swab, and instructions (p.76).¹⁷ Depots were established throughout New York City where physicians could pick up and deposit the culture kits.

The era of chronic disease epidemiology

The separation of epidemiology from demographic questions reached its height during the succeeding era of chronic disease epidemiology, which roughly extended from World War II up to the end of the twentieth century. Chronic disease epidemiology arose in response to the alarming epidemics of cardiovascular disease, cancer, and peptic ulcer that had become evident in the industrialized countries by the end of World War II. The signal event in the transition was the demonstration that cigarette smoking caused lung cancer, a discovery that depended upon the multiple cause paradigm of chronic disease epidemiology and that could not have been made using the methods of infectious disease epidemiology.^{11,12,19}

The causal paradigm of chronic disease epidemiology – perhaps more appropriately termed risk factor epidemiology – was the “web of causation”. Under this paradigm, a disease has many causes, each of which may increase the risk of disease but may be neither necessary nor sufficient for the occurrence of the disease. Under this paradigm, the logical approach for epidemiologists is to seek to identify risk factors- exposures or characteristics that confer increased risk- for disease, rather than to look for a one to

one relationship between cause and disease. The logical approach for public health intervention is to alter the risk profile of individuals within the population.

The efforts of a risk factor epidemiologist are most often directed to learning why some individuals are at higher risk than others individuals within a given population. The size and growth of the population itself are taken as a given, as a background context, fixed at least for the purposes of the analysis. Thus, in a given study, the dynamic interplay of population change with health, and the comparison of health across populations of different composition, do not usually enter the picture.

This is well illustrated by the classic case-control studies of smoking as a cause of lung cancer,²⁰⁻²¹ which were pivotal in establishing that the risk factor methodology could illuminate the causes of chronic diseases. The study by Doll and Hill provides a good example. Although Doll and Hill were acutely aware of the historical origins of patterns of smoking and of the societal barriers to changing these patterns, these influences were extraneous to the question they sought to answer with their case-control design. Their case-control design was meant to isolate the relation of smoking to lung cancer, by comparing individuals with lung cancer (cases) and controls drawn from the same population, with respect to their history of smoking.

Chronic disease epidemiology was continually refined over the next 50 years, and as the risk factor methods became fully established, demography gradually disappeared from epidemiology textbooks and training. In the chronic disease era, epidemiologists were very much focused on the individual level of causation, more so than they were in the era of sanitary reform or infectious disease epidemiology. As demographic questions are first and foremost on the population level, they are not easily incorporated by chronic disease epidemiologists.

Notable exceptions

Our history would be seriously incomplete without mention of epidemiologists who struggled to bridge and even sometimes to integrate epidemiology with demography.

They were evident and influential in all eras, notwithstanding their departures from the dominant paradigm. Among the most eminent of these were Sir Arthur Newsholme²², Edgar Sydenstricker²³, Ronald Ross²⁴, Rene Dubos²⁵, Kermack²⁶, John Ryle²⁷, Mervyn Susser¹, and Thomas McKeown²⁸. We shall provide a brief synopsis of two of these: Edgar Sydenstricker and Thomas Mckeown.

Edgar Sydenstricker was trained as an economist and was exceptional in taking a broad view of the relation of health to social change.²³ Sydenstricker saw that public health was related in important ways to the economic health, size, and composition of populations. He practiced public health at the height of the infectious disease era: from his appointment as the first public health statistician in the U.S. Public Health Service in 1915 until his death in 1936. Yet, he had a profound influence on broadening the purview of epidemiology and public health. Together with Joseph Goldberger, in the 1920s he carried out a series of classic studies in the mill towns of South Carolina, ultimately demonstrating that dietary deficiency rather than infection was the cause of pellagra, and furthermore, documenting how the social conditions of these towns lay behind the dietary deficiencies of their inhabitants. Particularly germane to the present discussion, at the Milbank Fund in the 1930s, Sydenstricker was a proponent of population studies, and played an important role in funding the work on contraception and fertility that led to Pearl's 1939 *The Natural History of Populations*.²⁹⁻³⁰

In the chronic disease era, Thomas McKeown was the leading advocate and practitioner of bridging epidemiology with demography.²⁸ Like Sydenstricker, his approach was out of step with his time, but still had enormous influence. Although he was concerned with identifying risk factors for chronic diseases, and contributed to the development of the case-control design,³¹ McKeown also went far beyond that domain of enquiry. He took on the daunting task of explaining the increase in population size that came with the Industrial Revolution, and drawing lessons for public health. McKeown argued as have others that a decline in mortality was the key factor. His more controversial point was that medical interventions had almost no impact on the decline in death rates, and public health measures only a modest impact. He inferred

that the main influence was improving living standards and particularly nutrition. McKeown's conclusions may have been too strong, but much of his argument has held up to the thorough scrutiny it has received. His work exemplifies how research on the dynamic interplay of population and health, while extremely difficult, can lead to vital insights.

The emergent era

In the present time, epidemiology is in transition from the chronic disease era. It is still in flux so that it is uncertain what the outcome will be. Perhaps in part because the authors wish it to be so, we anticipate that the new era will be characterized along the lines of eco-epidemiology as described originally by Susser and Susser.^{12,19} Briefly, eco-epidemiology means considering all levels of causation and intervention, from the microlevel of the molecule up to the level of individual and then social phenomena and finally to the global level of planetary ecology.

The perspective of eco-epidemiology allows a central place for demographic questions. The dynamic interplay between the changing size and composition of the population and its changing health patterns become a natural focus of epidemiologic enquiry. To be effective in this arena, epidemiologists will need to join with demographers, and learn from them about the approaches that have been proved effective in their discipline. They need not, however, adopt the social norms of demographers, which tend to separate the researcher from the social impact of the research. Epidemiology is squarely rooted in public health, and advocacy for improved health is at its essence.

We have reason to think that whether or not the dominant epidemiologic paradigm in the coming era is eco-epidemiology, it will be one that reverses the separation from demography. The events of our times are propelling epidemiologists in this direction. One important force is "globalization", which though variously defined, clearly encompasses a trend toward cross-national systems of economic production, depletion of forests and other ecologic resources, and rapid migrations of vast numbers of people

across great distances. Another is the AIDS pandemic, which is in part a manifestation of globalization, and in part a force in its own right.

The AIDS pandemic is the benchmark public health event of the present time. The pace and scope of the pandemic in some regions, notably sub-Saharan Africa, has been nothing short of catastrophic.³² In light of the long latency of HIV disease prior to its manifestation as AIDS, the huge numbers already infected with HIV, and the slow progress toward an AIDS vaccine, we can anticipate that this pandemic will be the defining public health event of the coming era. Therefore, when peering into the future to catch a glimpse of the evolving relation of epidemiology with demography, it behooves us to examine the impact of AIDS in Africa.

One of the distinctive and most devastating features of AIDS in Africa is its impact on the size and composition of populations. In Southern Africa, the epidemic has already reached such drastic proportions that – modeling lifetime risk of AIDS death using current infection rates -- 65% of 15 year old males are at risk of dying from AIDS if the current levels of risk are maintained (figure 1).³³ Figure 2 displays the anticipated effect on the populations of these countries.³⁴ Because the epidemic has its greatest effect on mortality in young children and middle aged adults, it is transforming the population structure, from the classic pyramid to a shape more like a chimney.

The AIDS epidemic poses a challenge to epidemiologists. It cannot be traced, anticipated, or controlled, without understanding the population changes which it brings and which in turn influence its spread. It poses a no less fundamental challenge to demographers. To be effective in this arena, demographers will need to develop new theories or at least adapt old ones; due to the population impact of AIDS, the Southern African countries are not undergoing the “demographic transition” as predicted by classic demographic theory, but rather, are entering some unknown realm of population change. Perhaps more important, the epic tragedy of the AIDS pandemic calls on demographers to reconsider the detached stance they have often taken toward the

implications of their results for public health. Surely, if ever there was occasion for epidemiologists and demographers to join together in common cause, this is it.

Conclusion

The many historical precedents for interweaving epidemiology and demography indicate that the task of building bridges between these two disciplines is neither unnatural nor too difficult to achieve. Moreover, we deem this task essential to for meeting the foremost challenges to the health and wellbeing of populations in the present day. To be effective, epidemiologists and demographers will be compelled to maintain a constant two-way flow of ideas and methods. We need not only to promote social interaction between our disciplines, but also, to hasten the emergence of an integrated perspective on populations and their health, encompassing both specialties in a unified framework. What are the first steps to attaining this? Certainly one eminently feasible step is the inclusion of demography in the training of epidemiologists, and vice versa.

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