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Reviews and Commentary

AN INTRODUCTION TO THE WORK OF WILLIAM FARR¹

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William Farr must be counted a founder, even the founder, of epidemiology in its modern form. Among the special contributions of men like Quételet and Galton to biostatistics, of John Snow to the survey as an explanatory instrument, and of Pasteur and Koch to specifications of environmental agents and host immunity, Farr's contributions surely cover the broadest range of the activities of contemporary epidemiologists. In his 40 years as statistician to the General Register Office, beginning in 1839, Farr studied many aspects of the

distribution and determinants of health disorders in populations, and not least the applications of such studies to their prevention and control. The evidence for these claims is conveniently collected in a selection from Farr's own chronicles of his life's work published two years after his death in 1883 (1).

One way of judging the significance of this work is by its impact on other heroes of reform and revolution in the 19th century; another way is by its impact on the work of his successors and the persistence of his contributions in current thinking. We shall begin with his contemporaries. Edwin Chadwick, more than anyone, was the executive and driving force of the new movement for sanitary reform in the second quarter of the 19th century. In developing the case for drainage and sanitation, his great bludgeoning *Report on the Sanitary Condition of the Labouring Populations of Great Britain of 1842* (2) gives a prominent place to the Registrar General's tables of mortality by area. John Simon succeeded to an executive position comparable to Chadwick's for the third quarter of the century, and he was not less indebted to Farr (3). For both these men Farr provided critiques of their statistical errors as well as ammunition for their reforms (4, 11).

¹ The New York Academy of Medicine has recently reprinted the monograph entitled *Vital Statistics: A Memorial Volume of Selections from the Reports and Writings of William Farr*, with a new introduction by Mervyn W. Susser and Abraham Adelstein. The Editors of the *American Journal of Epidemiology* are pleased to include in this issue an abridged version of this introduction, printed here by permission of the Academy. It reviews the writings and influence of William Farr from the perspective afforded by a century and more, and provides support for the claim that this remarkable man was "a founder, even the founder, of epidemiology in its modern form."

Humphreys, N. A. (editor): *Vital Statistics: A Memorial Volume of Selections from the Reports and Writings of William Farr*. London, Sanitary Institute, 1885. Reprinted for the New York Academy of Medicine by the Scarecrow Press, Inc., Metuchen, NJ, 1975.

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Epidemiologists probably will see Farr's most cogent influence in the evolution of John Snow's classic studies of cholera, through which he anticipated the germ theory by almost 20 years. Although we have not sought to document the relations between these two men beyond their published work, the interplay between them, as their parallel studies of the major pestilence of the times proceeded, is plainly evident. Farr provided tabulations of cholera mortality by source of water supply in his 1848 Cholera Report. On the basis of these data, Snow formulated precisely his hypothesis that the cause of cholera was a self-reproducing organism excreted by the victims of the disease and spread by fouled water supplies. In the 1853-1854 outbreak, when Snow proposed a test of the hypothesis by survey among London households almost randomly supplied by water companies drawing on sources with different likelihoods of being contaminated, Farr ensured that weekly mortality reports for the study areas were made available.

Farr himself was led to an ultimately less decisive result by his exhaustive analyses of the distribution of cholera mortality and morbidity. He demonstrated a close correlation of altitude with cholera mortality in London, and recognized the likely relation to altitude of water supplies contaminated by organic matter. Unlike Snow, however, he then fitted his results into a conclusion congruent with the theory of miasma (1, pp. 348-351).

In the 1859 report, Farr fully credited Snow's demonstration of the crucial role of water supplies (1, p. 361), and in the 1866 Cholera Report we find Farr's account of the tracking down of that outbreak to a water company's careless and illegal use of unfiltered waters (1, p. 371). In these various reports, Farr shows his growing awareness of the epidemic process; he deduces that the distribution of cholera in the population is much wider than the fatalities, and even wider than the diagnosed

cases; beyond this he postulates subclinical forms, and unaffected persons infected but resistant to the disease (1, p. 351).

Snow and Farr clearly held each other in mutual respect. Snow changed the scientific paradigm of his times with a few brilliant strokes, by demonstrating the plausibility of a new theory of disease that was much more cogent and specific than any that preceded it. Farr helped to change the paradigm by demonstrating over a lifetime the necessity for population studies to describe states of health, and to establish causes of health disorders and prevent them.

With Florence Nightingale, William Farr had an extensive and productive relationship. Much of her success in her many campaigns flowed from her masterly collection and deployment of fact and statistical data. A good instance is a vast health survey of all the military stations of the British East India Company. The inquiry sought to relate invaliding and mortality by age and length of service to the amenities and situation of each station. This survey she conducted by mail from London, where for years she lay housebound in the firm conviction that she was near death. The report filled 1000 folio pages of small type. In the analysis of this and other surveys Florence Nightingale relied heavily on William Farr. For long stretches he visited her almost daily to pore over the returns of the survey. Some of her surviving notes and letters make plain her dependence on him, and her respect for him in a common endeavor (5).

Many others had recourse to the statistical reports of the Registrar General, from great reformers such as Lord Shaftesbury to great revolutionaries such as Friedrich Engels. The young Engels in his *The Condition of the Working Class in England in 1844* (6) made good use of the epidemiologic background provided by Farr. The lineaments of the Marxist confutation of Malthus can be found in the "Letter to the

Register General" in the 4th Annual Report, and again in the report of the Census of 1851 and in the supplement to the 35th Annual Report. Farr makes the general point that production is not static and is promoted both by advancing technology and by increasing manpower. He goes on to a demographic critique of the Malthusian laws. Here Farr turns to secular trends in fertility and mortality, including such factors as age at marriage. "In order, therefore, to understand the rate of increase by birth, it will be necessary to inquire how many persons are married, by how many marriage is foregone, and how long marriage is delayed after puberty?" (4th Annual Report (1, p. 20)). Later in the report on the 1851 Census, Farr again states, and proceeds to illustrate, the complex interrelations to demographic factors:

The numbers, and consequently the increase or decrease, of people in a civilized country, depend upon the age at marriage and the age of the parents when their children are born—the numbers who marry, the fertility of the marriages—the duration of life—the activity of the migration flowing into and out of the country. These acts more or less influence each other and in the present state of statistical observation, the precise effect of change in any of them involving others cannot be determined. It will be sufficient to indicate the effect of a change in each element, while the others remain constant (Census Report, 1851; Vol. 1, pp. xxxi-ii).

There is indirect evidence that Farr contributed to quite another revolution than that of the Marxian construct, that is, to what has been called the first therapeutic revolution in the treatment of mental disorder. John Conolly introduced "moral treatment" at the Hanwell Asylum in the 1830s and advocated the abolition of personal coercion. William Farr, in a paper to the Statistical Society, analyzed the mortality of patients in a variety of institutions for the insane including Hanwell. He showed that "the annual mortality of both male and female paupers in the licensed homes was *nearly twice as great as the*

mortality of paupers at Hanwell, and twice as great as the mortality of other lunatics in the licensed houses" (1, p. 429).

The belief that the incidence of mental disorder was increasing was current then as now. Farr observed in passing that the increased numbers in institutions for the insane were no indication of the increased frequency, since more humane treatment prolonged the lives of inmates and increased the number of survivors. He constructed a "nosometrical table," which is precisely the cohort life table so heavily used in recent years to analyze mental hospital usage, and survival in chronic diseases such as cancer. Farr noted that from such a table "the lives of lunatics can be insured." He saw its significance for treatment as with contemporary eyes.

The table is an instrument by which the effects of treatment on the mortality—the number of recoveries—and the duration of all diseases, can be accurately measured. It enables us to compare two or three different plans of treatment, and to determine their effects upon the principal results at which all medical treatment aims—the reduction of the mortality, and of the duration of the disease (1, p. 434).

We now turn to judge the impact of Farr's work and thought on his successors, work embodied in current thinking. Like John Graunt, upon whose shoulders he stood, Farr's creative mind was not reined in by the regular education of a scholar and a gentleman, and this may perhaps account for some of his originality. The story of his early life reads like that of a picaresque novel of the times (1, 7-9). Born of poor parents in a remote Hampshire village, he was adopted into the home of an elderly and quite prosperous man, a cab owner who enabled him to pursue his elementary schooling, and eventually also the study of "physick" under the guidance of a Shrewsbury doctor, who likewise left him an inheritance. Farr proceeded to Paris to further his medical studies. At that time the statistical method was being

applied by one of his teachers, Pierre Louis. For instance, Louis suspected that bleeding by leeches, which reached vast proportions with the advocacy of the eminent Broussais, was more likely a danger than a help (7). He devised a notable trial that helped end the vogue of bleeding as a panacea (10).

Whatever the stimulus—Farr was a self-taught mathematician—the signs are that by the time of his appointment to the General Register Office in 1839 at the age of 31, he was uniquely prepared for the task he undertook. Although he qualified in 1832 as a licentiate of the Society of Apothecaries—which is to say as a general practitioner—he seems to have had an inconsiderable practice and small earnings. On the other hand, he offered courses of lectures in hygiene, and wrote articles on hygiene and vital statistics for the *Lancet*, which its crusading editor Thomas Wakley had established in 1823. In 1837, Farr had contributed a major article, "Vital Statistics," to McCullough's *Statistical Account of the British Empire*. He also assisted Dr. James Clark (probably with the preparation of data for his book on phthisis). Clark, who had recently been appointed physician to the Queen, is thought by Greenwood to have recommended Farr for the new position of Compiler of Statistical Abstracts at the General Registry Office, although Edwin Chadwick (in a recently published letter) himself laid claim to having recommended Farr (11).

From the outset Farr had a clear conception of what he was about. In our view, his genius lies precisely in his conceptualization of the nature of the daunting problems of public health as population problems, in his capacity to forge the statistical means to approach those problems, and finally in his unremitting application of those means on a national scale. Much of this was presaged in the first Annual Report of 1839.

The registration of births, marriages, and deaths was devised primarily to serve

individual and local needs. Almost single-handed Farr set out to use the system as an instrument both for *describing* and *explaining* the state of public health throughout the nation. To do this, he combined registration data as numerator with the decennial census as denominator.

In his first report, Farr announced his intention to *describe* by substituting "numerical formulae" for literary phrases. The terms that had been used even by the most accurate of previous writers "admit of no strict comparison with each other." In support he cited Sydenham speaking of smallpox:

1661, "It prevailed a little, but disappeared again." 1667-9, "The smallpox was more prevalent in town for the first two years of this constitution than I ever remember it to have been."

Farr illustrated the "superior precision of numerical expressions" by comparing Sydenham's phrases with a table of actual numbers of deaths from smallpox made from the London bills of mortality over the years 1661 to 1675 (1, p. 214). He placed his first reliance on the analysis of mortality. As he remarked, "the simple process of comparing the deaths in a given time out of a given number" was "a modern discovery" (2nd Annual Report (1, p. 170)). He was aware as well of "the relations the mortality bears to other orders of facts" (1st Annual Report (1, p. 117)).

Farr took account of the importance of demographic change and of the need for demographic data in determining mortality patterns. Nor did he hesitate to analyze demographic questions in their own right, as in the Malthusian controversy. His reports examine secular change in mortality, specific causes of death, and deaths by area, by occupation, and by marital state. Farr made the census serve not only as the denominator for the numerators derived from the registration system, but as the vehicle for national surveys of the prevalence of the "infirmities" of blindness and

deafness. By extending descriptive statistics to institutions. Farr illuminated the characteristics and the ill-effects of hospitals, asylums for the insane, workhouses, and prisons.

Further, Farr envisaged, but did not live to implement, a national system of morbidity statistics that would embrace hospitals and other services. Thus he wrote in 1874:

The thing to aim at ultimately is a return of the cases of sickness in the civil population as complete as is now procured from the army in England. It will be an invaluable contribution to therapeutics as well as to hygiene; for it will enable the therapist to determine the duration and the fatality of all forms of disease under the several existing systems of treatment in the various sanitary and social conditions of the people. Illusions will be dispelled; quackery as completely as astrology suppressed; a science of therapeutics created; suffering diminished, life shielded from many dangers. The national returns of cases, and of causes of death will be an arsenal which the genius of English Healers cannot fail to turn to account (Supplement to 35th Annual Report).

Farr was an intrepid explorer and interpreter of the vast and cumulating mass of national data. He aimed not merely to describe, but to explain, that is, to generate causal hypotheses and test them. He wrote in his first letter to the Registrar General of 1839 that "diseases are more easily prevented than cured, and the first step to their prevention is the discovery of their exciting causes." In another passage he added:

The deaths and causes of death are scientific facts which admit of numerical analysis; and science has nothing to offer more inviting in speculation than the laws of vitality, the variations of those laws in the two sexes at different ages, and the influence of civilization, occupation, locality, seasons, and other physical agencies, either in generating diseases and including death, or in improving the public health (1, p. 213).

Farr's most intensive explanatory effort revolved around the cholera epidemics, but

he addressed many other questions. He observed the association of mortality with density of population, and although he sought at first to explain the association in terms of the miasma theory, he refined the hypothesis to include such factors as water pollution and air pollution (5th Annual Report (1, pp. 161-165)).

His theory of causality was clearly multifactorial. Thus in the first Annual Report he commented that "mortality increases with density but the unhealthful tendency can be counteracted by artificial agencies" (1, p. 168). Farr's analytic approach was a flexible one. Despite the powerful conditioning of his medical education, his analyses were not bound to those starting from the outcome in particular diseases, although his analyses of specific causes of death are perhaps the single distinguishing mark that made British vital statistics of the 19th century so valuable. In contrast to this instinctive medical approach to analysis, many of Farr's analyses begin with experience and attributes, and examine outcome in relation to these antecedents. Notable for this approach are the analyses of mortality by occupation. From these he deduced, for example, the ill-effects of tobacco and of alcohol on those exposed to them in the course of their occupations (1, pp. 282-287), and of dusty occupations on pulmonary diseases. He approached marital state and other attributes in the same fashion.

The breathtaking reduction of complex data to simple elements that characterizes the work of many great scientists is not absent from Farr's work. Thus, from mortality over a 15-month period of 1838-1839 in a smallpox epidemic, he derived a general "law of epidemics" in the second Annual Report (1, p. 318). Twenty-five years later during the rinderpest epidemic, Farr did not hesitate to use his law of epidemics to confute the prophecies of doom declared by Robert Lowe. Farr was a civil servant, Lowe an influential leader of

the parliamentary opposition. To the later amazement of Major Greenwood, an epidemiologist and a considerable statistician, Farr made the bold prediction that the epidemic would decline on the basis of a mere four four-week series of mortality rates. Among other major generalizations, Farr recognized that the prevalence of chronic conditions was a function of incidence and survival. In the marriage rate he perceived "a barometer of national prosperity."

While he simplified, Farr well comprehended the complexity of population phenomena. He was much aware of "counteracting tendencies" and of the unanticipated consequences of supposedly beneficial change. Contrary to Malthus, he regarded the increase of population in 19th century Britain as the necessary foundation of productivity, empire and prosperity, but he did not neglect to contrast these benefits with the ill-effects of congregation in cities on disease and mortality (1, p. 63).

In discussing the question of whether "lifetime (can) be prolonged by a knowledge of the causes that cut it short" (35th Annual Report (1, p. 133)), Farr anticipated that the prevention of particular causes of death would expose the survivors to other causes of death. For studying this problem of competing causes, he devised a life-table method (1, p. 133). He agreed that drainage of the refuse previously retained in the houses had been an "advance on the previous state of things; but the sewers were charged with impurities; they put houses by their effluvia in communication with each other, and poured zymotic elements into the waters which were distributed by companies to the houses of both the wealthy and the indigent." He observed that "out of pity for poor children foundling hospitals were erected, but the babies nearly all perished, a greater number than ever were abandoned."

Farr was quick to apply new knowledge and understanding to practical problems

within his own demesne, and to point out applications in the demesnes of others. He built on the old London bills of mortality to set up a system of regular weekly reports to monitor epidemics and other undue variations in mortality in locales across the country. He used institutional data as a measure of the effectiveness of hospitals, asylums and workhouses. He refined the life-table invented by Halley and developed by others to estimate benefits in terms of expectation of life. Not without appreciation of the oversimplifications involved, he developed William Petty's idea of estimating the economic value of populations.

In pointing out the implications of his findings, Farr did not hide behind the neutrality so adaptive for civil servants. He did not hesitate to admonish the Royal colleges for failing to train doctors and midwives in obstetrics, thus permitting appalling maternal death rates to persist. In the cholera epidemic of 1854, the water companies were chided for purveying water dangerously contaminated; in the cholera outbreak of 1866 those responsible were traced, named, and chastised.

Farr pioneered the whole range of the activities encompassed by modern epidemiology. He described the state of health of the population, he sought to establish the determinants of the public health, and he applied the knowledge gained to the prevention and control of disease. To execute all these tasks, however, he had to create the means and methods for himself. Little indeed in the way of methods existed before his advent at the General Register Office. The creation of means and methods involved two broad types of problems. First, he had to superintend the collection of population data that was complete or representative, in a form sufficiently standard and reliable for purposes of comparison, and bearing on events that comprised the numerators in a manner that could be related to the appropriate populations as denominators. Hence he constantly strove

to improve the extent and the quality of the data collected. In this task his aims were greatly forwarded by the Registrar General, Major Graham, who was evidently an excellent organizer. The work of data collection, coding, and calculation was done by hand, and its scale was immense in relation to the available manpower. Life Table No. 3, published in 1864, covered the 17 years 1838 to 1854, and the two censuses of 1841 and 1851; 6,470,720 deaths were analyzed. In this instance the calculations were made with the aid of a calculating machine (1, p. 484).

In order that the data could be reduced to usable form, standard nomenclature and classifications had to be developed. He devised classifications for the multifarious causes of death and for the multifarious occupations of industrial Britain. Farr's pre-occupation with the obdurate problems of nosology began with his Letter in the Appendix of the 1st Annual Report (1, p. 210) and continued lifelong.

The recorded causes of death are exceedingly numerous; and it often happened that the same cause was returned under different names, which will be found in the alphabetical list at the end of the Nosology. Some classification of these causes was necessary, and I at first tried Cullen's classification, and then endeavoured to use Mason Good's, but found that neither of them would work. It was impossible to arrange the diseases as returned under the classes and orders of the existing classifications. In casting about for a classification, it struck me that it should have special reference to the causation and prevention of death; and that would be most effectually accomplished by making three distinct groups of 1) deaths by epidemic, endemic, and contagious diseases; 2) deaths by sporadic diseases; and 3) deaths by evident external causes.

This classification was framed and used in forming the abstracts of causes of death for 1837 (38th Annual Report (1, p. 261)). The classification of disease developed by Farr came into international use, and its categories are the antecedents of the International Classification of Diseases.

The second type of problem Farr faced

involved data analysis: the procedures of tabulation, comparison, and inference. Here he made a number of contributions, to some of which we have already referred. His brilliant statistical handling of the most imprecise or tenuous data enabled him to make extraordinary contributions to our understanding of the changing patterns of disease. He measured the death-toll by defining standard rates for comparison, for instance the infant mortality rate which takes as the denominator births in the same year rather than the population under one year of age (1, p. 206). He invented the standardized mortality rate, so that he could compare areas and occupations by means of summary statistics unconfounded by demographic differences in age and sex (1, p. 128). We have noted above that Farr put lifetables to ingenious use, such as estimating the effects of prevention on expectation of life, and the probable effects of competing causes if prevention were to be successful. We have also noted that he was by a long way the first to derive a mathematical model to describe epidemic curves, and to use such a model for prediction. Farr was not less fertile in his examination of questions other than health, especially those bearing on the quality of life. An example in his study of trends in literacy rates (1, p. 517). Here he used as his indicator the frequency with which the parties to marriage signed their names in the registers or had to resort to making a cross.

We shall conclude this introduction to Farr's work by citing his own words:

How the people of England live is one of the most important questions that can be considered; and how—of what causes, and at what ages—they die is scarcely of less account; for it is the complement of the primary question teaching men how to live a longer, healthier, and happier life. . . .”

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