Florence Nightingale

Passionate Statistician

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Nightingale's passionate commitment to statistics was based on her faith in a god of order, who created a world that ran by law. God's laws could be known through research, as a result of which suitable interventions to better the world could be applied. Statistics were a vital component in her holistic approach to health care as a system. They served both to indicate serious problems and to assist in policy making, and then again to monitor the effects of the new policies. She pioneered the use of evaluative statistics and saw reforms achieved as a result of her advocacy. This article explores three key aspects selected from Nightingale's more than 40 years of applied statistical work: her adaptation of Quetelet's methodological foundations, the use of statistics in monitoring public health care systems, and her pioneering study of maternal mortality in childbirth.

Keywords: statistics; health care; public health

Nightingale's passionate commitment to statistics was intimately related to her spirituality. God was a god of order, who created the world and let it run by law. We should not pray to be delivered from plague, pestilence, and famine, but to learn how to intervene in nature to prevent such disasters. Nightingale complained at length about how impractical the medieval mystics were. Spiritual retreats should equip one for practical action in the world, into which one returned refreshed and strengthened. Statistics helped one by indicating precisely what to do to second God's creative work, to be a fellow worker with God.

Statistics were a vital component of Nightingale's systemic approach to health care. She advocated health promotion and disease prevention as a better use of resources than treatment of the ill on a case-by-case basis after they succumbed. Her mentor on all things statistical was the Belgian statistician L. A. J. Quetelet (an astronomer, head of Belgium's central statistical agency, and a widely respected expert on the collection of official statistics and probability theory).[1] From Quetelet she learned that "Administration saves more hospital patients than the best medical science,"[2] that is, of course, administration that was based on the best possible knowledge, namely, good statistical data. Sloppy administration was a worse sin than sexual immorality because its consequences harmed so many more people. Nightingale's holistic approach to health care may indeed be said to be based on statistics, for it was statistical analysis that taught her the importance of the environment, social, and biophysical, both in regard to susceptibility to disease and treatment outcomes.

Nightingale was a passionate statistician (the expression comes from a chapter title in E. T. Cook's *Life of Florence Nightingale*), not least of all because she could see the individuals in quantitative data (Cook, 1913). In a letter to Sir John McNeill, a close collaborator from Crimea on, she described unnecessarily high mortality rates in the army (17 to 20 per 1,000 compared with 2 in civilian life) as being criminal, comparable to taking 1,100 men out on Salisbury Plain and shooting them (Kopf, 1916-1917). Similarly, in arguing for a new hospital to be built at Winchester, she compared the death toll from erysipelas (8 out of 24 affected, in a hospital of 100 to 120 beds) as akin to the hospital massacre that occurred for a short period at Scutari, "so that Winchester aspires to rival the most colossal calamity of history in its

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small way" (Nightingale, 1861b). Thus, she used quantitative data to support her arguments for reform in hospital construction.

Nightingale had a prodigious respect for the possibility of unintended harmful results of actions, indeed including those of impeccably humanitarian motivation. She frequently gave as an example the establishment of foundling hospitals for abandoned infants, which resulted in increasing the abandonment of illegitimate children (again Quetelet provided the original examples, but she found subsequent instances of her own). Recourse to statistics, in other words, was essential simply to ensure that one did not cause more harm than good in one's good deeds. As the Victorian era was one of enormous reform activity and social experimentation, her cautions were most germane.

Nightingale's commitment to statistical method spanned her entire working life, from her first royal commission on her return from the Crimean War in 1856 to her last work on India in the 1890s when, although she was unable to send out questionnaires herself to collect data, she helped in the analysis of available material. The gathering of the best data possible became an integral part of the Nightingale method, used in all of her serious projects, what she called her "business." Where good data were already collected, she used them; where they were not, she designed and sent out (or had a government office send out) her own questionnaires. She worked closely with William Farr, Britain's leading social statistician, to improve the routine collection of social data, precisely because she believed in their importance for social planning purposes, notably in health care, housing, and education.

It is telling that one of the last projects of her life, in 1891, was the (unsuccessful) attempt to establish a chair or readership in social physics and their practical application at Oxford University, as a means of training future civil servants how to use statistics in social planning (Oxford was the chief training grounds for the public service; Pearson, 1924).

The following seven areas give an indication of the depth and breadth of Nightingale's statistical achievements.

1. *The collection and presentation of data for the Royal Commission on the Sanitary State of the Army in the East:* Nightingale was instrumental in the establishment of the royal commission, briefing witnesses, and so forth. She gave a succinct analysis of the data, pioneering the use of coxcombs (area charts) for the graphical presentation of mortality data. Government statistics would never be the same as a result, for her example of providing easy-to-visualize bar charts and pie charts was taken up in subsequent routine publications of censuses and other data (Cohen, 1984; Nightingale, 1858a, 1858b, 1859).
2. *The comparative analysis of mortality rates of the army at home with the civilian population:* This resulted in substantial reform in barracks construction, diet, and the provision of medical and nursing services (Nightingale, 1858b).
3. *The collection and analysis of data for the Royal Commission on the Sanitary State of the Army in India:* Nightingale designed the questionnaires that were sent to all stations and analyzed the data returned (Nightingale, 1863a). Her work here led ultimately to massive reforms in the administration of India but only after decades of agitation.
4. *Reform of hospital statistics and the establishment of uniform criteria for reporting disease:* Nightingale, with the collaboration of Quetelet and Farr, obtained the support of the International Statistical Congress held in London in 1860, which led to the first attempts to standardize statistics on disease and its treatment (Keith, 1988; Nightingale, 1860b; Stolley & Lasky, 1995).
5. *Fighting the Contagious Diseases Acts for the compulsory inspection/treatment of prostitutes:* Nightingale recognized the high toll that venereal diseases took in the armed forces, but she used statistics in a briefing note to show that they were not reduced where compulsory inspection and treatment of suspected prostitutes were in use (Nightingale, 1862). She was not successful in preventing the legislation, which was first passed in 1864 and was not repealed until 1886 after a long struggle led by Josephine Butler. Nightingale's statistical arguments were used throughout the campaign, as were her and others' arguments based on religious principles, civil liberties, and so forth.[3]
6. *The collection of data on mortality and morbidity of native children in colonial schools:* Nightingale devised the questionnaire that was sent out by the colonial office. She analyzed the collected data and made recommendations, which resulted in improved administration (Nightingale, 1863b).

7. *The analysis of data on surgical outcomes:* Nightingale used a paper to the 1863 International Statistical Congress in Berlin as the means to provide an early example of evaluative statistics (Nightingale, 1863c; see also Spiegelhalter, 1997).

All of the above-mentioned projects will be related in my *Collected Works of Florence Nightingale* currently in preparation[4] (McDonald, 2001–). Selected for fuller discussion here is her work on Quetelet, which elucidates her philosophical approach to statistics, the use of statistics in monitoring the public health care system, and the use of statistics in her pioneering study of mortality of women in childbirth (with related recommendations for midwifery practice).

Nightingale and Quetelet

Nightingale carefully worked her way through Quetelet's major publications on statistics. Quetelet was well-known in Britain, where he had assisted in the founding of the statistics section of the British Association for the Advancement of Science in 1834. He gave Nightingale a copy of his two-volume *Physique Sociale* (Quetelet, 1869), which she extensively annotated and translated and then drew on for an essay, "In Memoriam," which she wrote on his death in 1874 (Diamond & Stone, 1981). She knew a number of his earlier works, but it seems that she did not know the English translation of the shorter first edition, published in 1835 as *A Treatise on Man and the Development of His Faculties* (Quetelet, 1842).

It was Quetelet who solved for her the great dilemma of how to reconcile an orderly universe, run by law, and an active program of intervention in it. Social research became the investigation of God's laws, conceptually the same for the social world as for the biophysical. In the opening of her "In Memoriam" essay, she referred to the

> application of his discoveries to explaining the plan of God in teaching us by these results the laws by which our moral progress is to be attained, or rather explaining the road we must take if we are to discover the laws of God's government of His moral world.

Quetelet was no less than the discoverer of the science "upon which alone social and political philosophy" could be based, which should not be limited to the administrative or legislative domain but "be the interpreter of all *theodike*, all divine government and its laws, embracing the smallest and most accidental to the greatest and most universal actions and phenomena of our moral and physical life." It was "the germ of a vast reform to be made in the world's morality, not by confessing and bewailing our *desperate wickedness* but by practically growing the new moral world out of the discovery of what the laws are." This would permit us no less than to exchange *original sin* for *original goodness*, by discovering the laws of God's "vast scheme of universal order."[5]

Moral laws of God can be found by induction as well as by physical laws. Indeed, God's moral, social, and physical laws act and react on one another. By Quetelet's method, moral (social) laws can be stated in exact numerical results.[6]

A law does not govern or subordinate and it does not compel people to commit crime or suicide. On the contrary, it puts the means into our hands to prevent them, if we did but observe and use these means. It simply reduces to calculation observed facts; this is all that a law means—the causes influencing the social system are to be recognized and modified. From the past we may predict the future.[7]

Monitoring the Health Care System

Nightingale's health care system had a strong social–environmental component. The key was to build health by giving infants/children a good start, which required good nutrition, safe water, and adequate housing (all rare for the great majority of the poor at that time in Britain). Onto that base, measures would be added for treating ill people, both at home with nurse/health visitors and in hospitals with trained nurses, of course. There would be a variety of institutions and asylums for convalescent care (in the country) and for the care of the chronically ill, disabled, mentally ill, and handicapped. All of these institutions would collect and centrally report their statistics (mortality, admissions, duration of stay, etc.). Comparative analysis of success and failure would permit wiser administrative decisions to be made in the future. Nightingale was a tax-and-spend Democrat in contemporary political terms, but she always wanted good value in spending the taxpayers' money. With uniform reporting procedures, comparisons could be made not only regionally but internationally, permitting the recognition of particularly

good (or bad) methods of treatment (Nightingale, 1861a).

As well as the institutional data to be collected, Nightingale envisaged the routine collection and analysis of benchmark health data. As early as the preparation for the 1861 Census, she proposed the addition of questions on health status and housing for precisely this purpose. She was not successful at that time; health surveys now play the role Nightingale projected for the census.

A good health care system extended from the international level to the local in the case of Britain, with county sanitary committees to investigate local conditions and monitor progress when reforms were instituted. Nightingale herself analyzed local data in Buckinghamshire, the area where her sister and brother-in-law had their country home and where she visited frequently (Nightingale, 1894a). *Notes on Nursing* itself includes attention to occupational health, not least of all for nurses and doctors. Nightingale as well pointed out that "The places where poor dressmakers, tailors, letter-press printers and other similar trades have to work for their living are generally in a worse sanitary condition than any other portion of our worst towns" (Nightingale, 1860a/1996, p. 26).

Midwifery

Midwifery for Nightingale would be a key part of regular practice of trained nurses. Provisions for training nurse midwives was indeed the second project undertaken by the Nightingale Fund after the Crimean War (the first, of course, being the institution of secular training for nurses at St. Thomas Hospital). Yet Nightingale soon closed the lying-in institution associated with King's College Hospital when statistics showed an unacceptably high rate of puerperal fever—26 deaths out of 780 women, or 33.3 per 1,000, compared with a national rate of 5.1 (Nightingale, 1871). Her book *Introductory Notes on Lying-In Institutions* (1871) is a remarkable document for the lucidity of its arguments for its basic principles (childbirth being a natural phenomenon that should have minimal medical involvement) and the practicality of the arrived-at reform measures. Because basic data on mortality in childbirth were lacking, Nightingale had to begin with the collection of statistics by sending out questionnaires to a variety of institutions, such as hospitals and workhouse infirmaries.

Conceptually, she had to work through the question of what was the real normal death rate, or the rock-bottom mortality that could not be avoided even with the best care. This was the work for which she most relied on Quetelet's methodology. In setting up the training institution in the first place, she had been convinced that good training required an institutional setting. When high rates of mortality became evident (although they were still lower than in some Continental hospitals), she had to consider that training midwives at home deliveries might be the only acceptable solution. Throughout, her judgments were based on statistical analysis.

> With all their defects, midwifery statistics point to one truth, namely that there is a large amount of preventable mortality in midwifery practice and that, as a general rule, the mortality is far, far greater in lying-in hospitals than among women lying-in at home. (Nightingale, 1871, p. 3)

Nightingale also considered the role of secondary influences, such as the age of the mother, number of pregnancies and duration of labor, general health and stamina, and social conditions such as the patient's social class. It might have been expected that women giving birth in workhouse infirmaries, because of their generally poor health, would have had higher mortality rates than women giving birth in a specialized midwifery institution that charged fees. Yet the workhouse mortality rates were lower. Nightingale concluded that the effect of the institution was greater than that of social conditions. Midwifery wards at general hospitals should be closed and home births encouraged. Training institutions for midwives should be small enough so that conditions could emulate those of home births. Training institutions could be justified at all only if they were as safe for birthing mothers as home deliveries. Otherwise, this was to "ensure killing a certain number of mothers for the sake of training a certain number of midwives" (Nightingale, 1871, p. 71).

Nightingale's data also showed higher mortality rates where the women were in contact with doctors and medical students. She concluded that there should be as little medical involvement as possible and that medical students should be entirely banned (Nightingale, 1871). It is a small wonder that *Introductory Notes on Lying-In Institutions* got a nasty review (Anonymous, 1871) in the *British Medical Journal*. Although laced with sexist sarcasm (including references to the "kind womanly heart" of

the "authoress" and her "purely sentimental" arguments), the review rages most against her statistical analysis, "ingenuously urged as if it were a logical thunderbolt" (p. 559).

> On considering these figures (says she) the first impression they convey is not that either the Registrar-General or LeFort [a medical statistician] is wrong. But it is a very painful impression of another kind altogether. One feels disposed to ask whether it can be true that, in the hands of educated accoucheurs, the inevitable fate of women undergoing, not a diseased, but an entirely natural condition, at home, is that one out of every 128 must die? If the facts are correct, then one cannot help feeling that they present a very strong *prima facie* case for inquiring, with the view of devising a remedy for such a state of things. (Anonymous, 1871, p. 559)

Nightingale's proposals for remedy, including improved standards for hospital construction, are qualified as hints, which the book throws out.

Introductory Notes on Lying-In Institutions are as much imbued with a holistic philosophy as *Notes on Nursing*, yet they have effectively disappeared from the literature. They show how much Nightingale was a pioneer in midwifery, instituting a training institution for nurse midwives, opposing the medicalization of a natural process, and not least, insisting that all measures be rigorously scrutinized with the use of quantitative data. She herself wanted to do more statistically on the issue—notably, to collect better data on mortality from home births—but illness prevented her.

Conclusion

Nightingale had the satisfaction of seeing many of her reforms realized, never as fast or as completely as she would have hoped (and much more slowly for reforms in India), but enormous changes were made in sanitary reform and in the provision of health care services. The administrative reforms arising from her first royal commission were promptly applied not only within the British Army but in the northern United States for use in the Civil War. Her statistical achievements were recognized by the leaders of the profession. In 1858, her colleague William Farr, himself later a president of the organization, proposed her for membership in the London Statistical Society (later the Royal Statistical Society). In 1874, the American Statistical Association elected her an honorary member. Farr not only helped her with her projects over decades but also took advantage of her expertise to solve problems at the central statistical bureau where he worked, the Registrar-General's Office. Unpublished correspondence shows him thanking her for advice that saved him from making a professional blunder. Oxford University finally honored her in 1997 by instituting an annual lecture on statistics in her name.

Nightingale never wavered on these great principles of a statistically tested holistic framework, for example, addressing issues of rural health as late as 1894 (Nightingale, 1894a, 1894b). An unpublished note still later exclaims,

> Oh teach health, teach health, teach health, to rich and poor, to educated and, if there be any uneducated, oh teach it all the more: to men—to women especially—to mothers, to young mothers especially . . . for the health of their children comes before Greek and grammar.[8]

Notes

1. On Quetelet's social science/statistics, see McDonald (1993). This material is reported in detail in the *Collected Works of Florence Nightingale*, vol. 5.

2. The source is Nightingale's annotation on her copy of Quetelet's *Physique Sociale*, University College Archives, 1, 418-419, published in Diamond and Stone (1981). Quetelet himself used a British source for key points, Hawkins (1829).

3. Nightingale's role in the campaign is related in McDonald (1994, 1998).

4. There are volumes also on her theology, spirituality, nursing and nurse training, war and the military, the foundation of public health care, hospital reform and India. Electronic publication of the transcribed texts is planned, to follow the full print publication. The two major volumes on nursing are vol. 12, *Florence Nightingale and the Nightingale School*, and vol. 13, *Florence Nightingale on Extending Nursing*, both 2009.

5. Nightingale, F. Private note. British Library Additional Manuscripts 45842 f153, Diamond and Stone (1981).

6. Nightingale, F. Private note. British Library Additional Manuscripts 45842 f51.

7. Nightingale, F. Private note. British Library Additional Manuscripts 45842 ff157-58, Diamond and Stone, 1981.

8. Nightingale, F. Private note. British Library Additional Manuscripts 45844 f232.

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Suggested Further Readings

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