

# Florence Nightingale: 200 Years Since Her Birth and We Are Still Making the Same Errors With Data

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**M**ay 2020 sees the bicentenary of the birth of Florence Nightingale. She is best known by the general public as a nurse, ‘The Lady with the Lamp’, but mathematicians think of her as the first female Fellow of the Royal Statistical Society and creator of the famous rose diagram, depicting the causes of mortality for British soldiers in the Crimean War. However, she did much more than that: she used her mathematical and statistical skills to transform the way the British Army used and managed data. She worked with some of the best statisticians of the time, including the Belgian statistician Lambert Adolphe Jacques Quetelet, and William Farr, the Chief Statistician in the General Register Office. Her influence spanned a variety of occupational disciplines across several continents.

My fascination with Nightingale began in 2007 when I was asked to talk about her for one of Peter Rowlett’s podcasts in his *Travels in a Mathematical World* series. Immersing myself in her books, letters and diagrams at the Wellcome Library, I soon realised she was much more than a Victorian nurse who created some interesting graphs. Her writings were pithy; her tone often sarcastic with a heavy dose of irony. Indeed, commenting on one of her publications, *The Lancet* [1] described her as having ...

... a great command over terse phrases, which she uses with telling effect, sometimes almost to the dismay of those whose souls are attuned to the sober diction and brown-suited dullness of the treatises which have appeared on such subjects up to this time.

It was this that made me want to find out more about this fascinating woman.

## Early influences

She was born in Florence, Italy, in 1820 to a wealthy young couple, William and Fanny Nightingale. After her birth the family moved back to England and brought up Florence and her sister Parthenope (two years her senior) at their country estates, Lea Hurst in Derbyshire and Embley in Hampshire. Her parents mixed with the political and social movers and shakers of the day, enabling the girls to meet people like Lady Byron, Ada Lovelace, Mary Somerville and Charles Darwin. William Nightingale took responsibility for the girls’ education, ensuring that they learned modern and classical languages alongside the more usual female subjects such as art and textiles. Florence is said to have ‘discovered’ mathematics when she was about 18. Her sister described her having ‘taken to mathematics – and like



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Portrait of Florence Nightingale

everything else she undertakes she is deep in them and working very hard.’ [2, p. 72]. According to the Curator of the Florence Nightingale Museum, her father also mentioned her interest in the subject in letters that he wrote (which is something that I would like to research further).

Nightingale’s interest in mathematics is described by one of her biographers, Mark Bostridge. One of her cousins, Henry Nicholson (who was studying mathematics at Trinity College, Cambridge), came to stay at Lea Hurst while the family were in the process of moving to Embley Park for the winter. Florence and Henry ‘soon became absorbed in logarithms’ [2, p. 68] ignoring the chaos around them. She tutored several of her male cousins although their father urged them to keep this quiet as they would

have faced ridicule if it had become known that they were being tutored by a woman! It is said by some that Florence was herself tutored by J.J. Sylvester, as this is recorded in one of Sylvester’s obituaries. Despite this not being mentioned elsewhere it is possible, given the Cambridge connection between Sylvester and Florence’s cousins, and that Sylvester mixed in some of the same circles as her parents.

Reading, studying and attending dinner parties were not enough for Florence, who spent much of her younger years wanting to ‘do’ something. She felt she had a destiny, which she perceived as a calling from God. She was privileged to take several trips to Europe accompanying family and friends and on some of them (those without her family) spent time working in a hospital in Kaiserswerth, Germany. This is where she developed her passion for nursing. She met many new friends along the way, including Sidney and Elizabeth Herbert, who were to be very influential in her future career. Despite giving the girls the sort of education usually received by boys, Florence and Parthenope’s parents still expected them to follow many of the societal norms of the day, including the convention that girls of their class should marry and certainly should not work. Parthenope obliged but Florence turned down all the proposals of marriage that she received.

At that time the only professions open to women were teaching and nursing. Nursing in particular was considered a very menial job, to be undertaken only by those in the lower social classes, so her parents were initially very much opposed to Florence taking up this kind of work. However, when her sister became ill, it was necessary for Florence to move away from the family home and in 1853 she was finally allowed to move to London to take up the role of Superintendent at the Home for Sick Gentlewomen in Harley Street. A year later the Crimean War broke out and *The Times* newspaper carried many reports detailing the appalling conditions for the sick and wounded soldiers. Moved by these stories, Florence wrote to her friend Sidney Herbert, the then

Secretary of State for War, asking if she could go out there, and at exactly the same time Sidney wrote to her inviting her to go.

Before this, Florence's interest in mathematics had extended to include statistics. She wrote in 1847 that she could 'never be sufficiently thankful to Papa for having given me an interest in Statistical and Political matters' [3]. She had begun to read, and indeed comment, on the work of Quetelet, who became her mentor, and in 1853 she analysed the results of the 1841 census. However, most of her mathematical and statistical work came about after her return from the Crimea despite enduring recurrent periods of illness caused by contracting 'Crimean Fever' at the end of the war.

## The use of data visualisations

Whilst in the Crimea she had kept up a lively correspondence with many key political figures, telling them about conditions, requesting further supplies, liaising with the Royal Commission on the Sanitary Condition of the Army and commenting on the managing and reporting of data concerning hospital records and mortality. Upon her return, the new Secretary of State for War, Lord Panmure, asked her to write a confidential report on the sanitary requirements of the British Army. The resulting report was a hefty tome entitled *Notes on Matters Affecting the Health, Efficiency and Hospital Administration of the British Army*, which included correspondence, recipes and notes on nursing as well as a chapter headed 'Notes on the Inaccuracy of Hospital Statistics and the Necessity of a Statistical Department'. The report was accompanied by a pamphlet of diagrams that Herbert described as her 'Coxcomb' (see Figures 1–3 for example). Her foreword to the Coxcomb sums up her view on data visualisations [4, p. 1]:

Diagrams are of great utility for illustrating certain questions of vital statistics by conveying ideas on the subject through the eye, which cannot be so readily grasped when contained in figures.

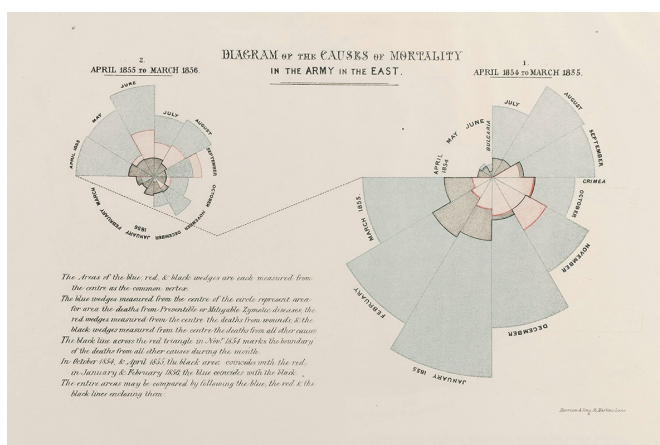


Figure 1: Polar area (or rose) diagram of the causes of mortality in the army in the East. Credit: Wellcome Collection, [wellcomecollection.org/works/x6kqdmr8](https://wellcomecollection.org/works/x6kqdmr8). CC BY 4.0.

Many did not agree with this view at this time; even her colleague, William Farr was suspicious of diagrams, saying that statistics should be 'the driest [sic] of all reading' and complained that Nightingale's attempts were not 'sufficiently dry' despite her worries to the contrary [5]. Today, data visualisation is a discipline in its own right and much time is spent on finding the appropriate way to represent data to convey a particular point to one's audience.

Although she is well known for her polar area diagrams, it is important to note that Nightingale used many other sorts of diagrams including bar charts and line graphs. Wondering why she chose a polar area diagram to represent the data on mortality in the Crimea (Figure 1), I graphed her data using bar, line and pie charts and realised that, with this range of data, other graphs are not nearly as visually impactful as her polar area diagrams. Nightingale used her diagrams to bring data alive, to inform and change opinions. The last two graphs in her Coxcomb do this particularly well.

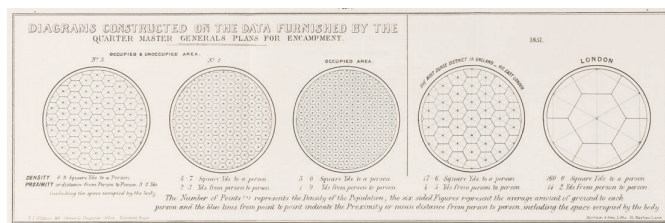


Figure 2: Diagrams constructed on the data from the Quartermaster General's plans for encampment. Credit: The RAMC Muniment Collection in the care of the Wellcome Library.

The first of these (Figure 2) is a series of five circles filled with hexagons representing differing densities with the dot inside each hexagon representing a person. The first three circles show how closely packed the army would be in the Quartermaster General's plans for army encampments. The latter circles show how densely packed the inner city of London was and the population of London in general. It is obvious from these graphs that the Quartermaster General was proposing something that anyone could see was going to be problematic knowing how unhealthy densely populated areas of London were.

The last diagram in the Coxcomb (Figure 3) shows her foresight. In the left-hand graph she depicts the situation regarding the current effectiveness of the British Army in terms of the numbers who are ill, invalided etc. Then in the right-hand graph she shows the potential effectiveness of the army if the soldiers were as healthy as the general male population. By forecasting this potential effectiveness, she makes the point that the army at rest were experiencing higher degrees of mortality than the general male population, despite the soldiers starting off as being among the fittest. This was something that exercised Nightingale greatly. She came to realise that there were problems in the way soldiers were housed and cared for when sick, which led to their mortality rates being higher than the average British male, despite their previous better health and fitness. Her work in this area led to army barracks and infirmaries being redesigned.

## The use of data

Nightingale knew how to get her point across to different audiences through what is now called storytelling with data, and I use her work as an example of good practice when teaching data visualisation to mathematics students. Her interest in mortality data was not confined to reporting; she was also interested in how the data were initially gathered, then stored and used in calculations.

My interest in her work on data management increased greatly when I began working in industry as a data scientist: I could see that there were still lessons to be learned from her work with data. I shared her frequent despair over others' use (or misuse)



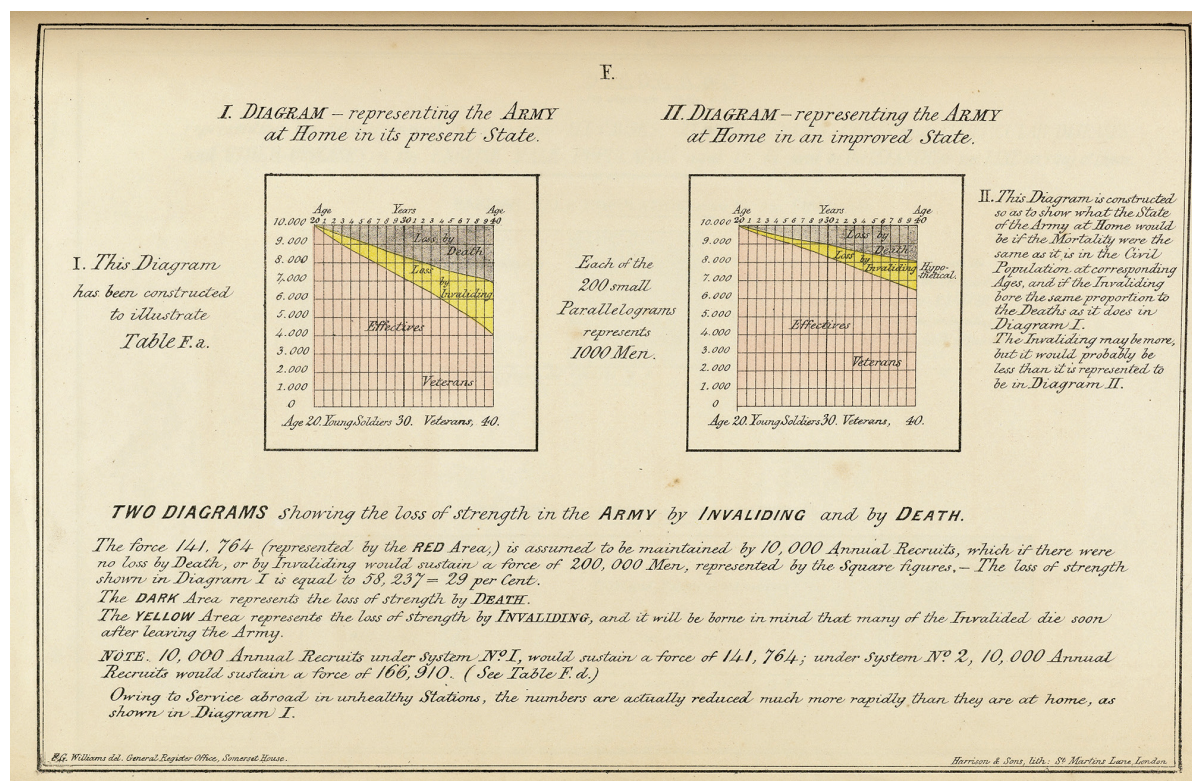


Figure 3: Diagrams showing the loss of strength in the army by invaliding and by death. Credit: Wellcome Collection, [wellcomecollection.org/works/ht2jv6hg](https://wellcomecollection.org/works/ht2jv6hg). CC BY 4.0.

of data. An example can be seen in a letter she wrote to John Henry Lefroy, scientist and military reformer, in June 1856. She mentioned the medical statistics of the Land Transport Corps (a branch of the army that transported military supplies), describing them as being in ‘a state of great confusion, so that it is hardly possible to obtain correct results’ [6]. Nightingale asserted the corps had an ‘extraordinary method (or no method) of keeping statistics’ [6]. She goes on to explain that one of the problems was that sometimes the natives were included in the data and sometimes not, so there was no consistency. In a letter to her friend Lady Canning (1856), she was even more unguarded in her criticism [7, p. 469]:

I could make you laugh at our classification which seems made to deceive and bamboozle government as to the cause of our disease ... I think, if you could see our *real* statistics, you would think that I have been moderate in my statements.

Such comments resonate today with many organisations gathering data on different systems which do not always work well together.

Nightingale’s impatience with incompetent officials and badly designed systems is particularly apparent in a letter to Sidney Herbert in August 1857, where she vented her frustration while awaiting the arrival of important data. When she eventually obtained the data, she used it to work out the mortality of those individuals who had been invalided out of the army. She argued [7, p. 533] that this data must be included in the final mortality figures because ...

... the state loses them equally whether they die or are invalided before their term of service is completed.

She goes on to question the actions of those compiling the data [7, p. 531]:

to have kept back these data shows either utter ignorance of the importance of their bearing, or a willful intention to keep back the truth.

She then described various methods of including this data correctly and provided numerical examples of the differences this additional data made to the reported figures. In a private note to Herbert in the same missive, she confided [7, p. 533]:

The army statistics give no real idea of the mortality. There is this essential difference between the Registrar-General’s and the army’s medical returns. The first give the precise percentage of deaths to population within the army ages. The second give no precise percentage of deaths to army population.

This criticism of army medical data and the process of data collection, as well as her suggestions of more rigorous methods, were pivotal in changing the way that British military data were gathered and recorded.

Nightingale also bemoaned the woeful inaccuracy in recording details of patients, something which had upset the relatives of the sick and the dead. She pointed out that by counting the soldiers in hospital on only one day of each week, many soldiers were missed from these returns. The nature of diseases such as cholera meant that soldiers could enter the hospital and die between counts and so would not be registered as being there at all. Consequently, she estimated that hospital records in the Crimea may have shown only one seventh of the true number of cholera cases. She called for standardisation and explained that for accurate comparisons, it was essential to have a standard measure of time and numbers under observation.

Nightingale rarely seemed to accept someone else's calculations and often challenged the most senior officials' handiwork, particularly when they seemed to be trying to put a positive spin on the mortality rate, which could mislead the military and political leaders back in England. She also despaired over discrepancies in data and commented in her report, 'I have carefully compared the statistics from six different official sources, and none of them agree' [8, p. 309]. She stressed that this discrepancy 'shakes [one's] confidence' in their accuracy. This discrepancy between different data sources is something that is still familiar to many analysts today.

... This comment on the use of data to measure performance is as relevant nowadays as it was then ...

### Later interests

As Nightingale became older her interests and influence broadened. As a result of the success of the Royal Commission on the Sanitary Condition of the Army in Britain, she was allowed to be instrumental in helping to arrange the 1859 Royal Commission that was sent to India to investigate and report on the sanitary state of the army stationed there. This was an unusual accolade for a woman at that time. Unsurprisingly she took a critical interest in the statistics produced by the Indian hospitals. In a letter in 1864 to Charles Hathaway (a special sanitary commissioner for Calcutta) she wrote [9, p. 295]:

I could not help laughing at *your* critics who 'exclude' specific diseases such as 'cholera', accidents 'proving fatal' etc. (It is very convenient indeed to leave out all deaths that *ought not* to have happened, as *not having* happened. And it is certainly a new way of *preventing preventable* mortality to omit it altogether from any statement of mortality.) Then they would 'exclude' 'deaths above 60.' Their principle, if logically carried out, is simply to throw out all ages and all diseases; and then there would be no mortality whatever.

Again, this is a delightfully understated and pithy comment that makes a very powerful point.

Back in England, Nightingale helped to educate the working classes on healthcare and reform Victorian workhouses. She was even consulted on the proposal to introduce new sanitary advisors: she was concerned that neither the doctors nor the government officials had the skills necessary to understand the situation and thus advise on appropriate measures to produce a decrease in general mortality levels.

She was a great believer and pioneer of training for nurses, so she became concerned when she saw how the use of statistics hindered the introduction of this training when they were used as a misleading measure of nursing efficiency in Liverpool. In a note to Charles Langton in 1868, she commented [10, p. 273]:

I cannot help feeling that much injury has been done to the cause by putting forward figures at all as a test of nursing efficiency.

She argued that hospital statistics should represent only the results of different operations and varying modes of treatment and complained that in Liverpool they 'represent nothing, because they have never been kept with reference to any result' [10, p. 273].

She concluded by saying that these figures could not show the efficiency of nursing since the trained nurses looked after the more severe cases and thus, their patients inevitably had a higher mortality. This comment on the use of data to measure performance is as relevant nowadays as it was then.

Nightingale accomplished a tremendous amount during her life and her achievements and work ethic are inspirational. This article gives only a small glimpse of her mathematical and statistical thinking, which remains significant 200 years after her birth.

### Further reading

An extended version of this article was published in Beery et al. [11]. Many of Nightingale's letters and publications can be consulted at the Wellcome Library, London, or viewed online via Lynn McDonald's project *The Collected Works of Florence Nightingale* [12].

### REFERENCES

- 1 Lancet (1864) Relative mortality in town and country hospitals, *The Lancet*.
- 2 Bostridge, M. (2009) *Florence Nightingale*, Penguin Books, London.
- 3 Nightingale, F. (1847) Letter to Parthenope Nightingale, Wellcome 9016/17, [www.uoguelph.ca/~cwfn/archival/index.htm](http://www.uoguelph.ca/~cwfn/archival/index.htm) (accessed 12 January 2020).
- 4 Nightingale, F. (1858) *Mortality of the British Army, at Home, at Home and Abroad, and During the Russian War as Compared with the Mortality of the Civil Population in England*, Harrison and Sons, London.
- 5 Farr, W. (1847) Handwritten note to Nightingale, BL02GEN Add Mss 43397, [cpb-ca-c1.wpmucdn.com/sites.uoguelph.ca/dist/3/30/files/2019/07/BL02GEN.pdf](http://cpb-ca-c1.wpmucdn.com/sites.uoguelph.ca/dist/3/30/files/2019/07/BL02GEN.pdf).P.436 (accessed 17 January 2020).
- 6 Nightingale, F. (1856) *Letter to John Henry Lefroy*, Wellcome 5479/6, in *Florence Nightingale: The Crimean War*, ed. McDonald, L. (2010), Wilfred Laurier University Press, Ontario, pp. 414–418.
- 7 McDonald, L. (2010) *Florence Nightingale: The Crimean War*, Wilfred Laurier University Press, Ontario.
- 8 Nightingale, F. (1858) *Notes on Matters Affecting the Health, Efficiency and Hospital Administration of the British Army*, Harrison and Sons, London.
- 9 Vallee, G. (ed.) (2006) *Florence Nightingale on Health in India*, Wilfred Laurier University Press, Ontario.
- 10 McDonald, L. (2004) *Florence Nightingale on Public Health Care*, Wilfred Laurier University Press, Ontario.
- 11 Beery, J.L., Greenwald, S.J., Jensen-Vallin, J.A. and Mast, M.B. (eds.) (2017) *Women in Mathematics*, in *Association for Women in Mathematics Series, Vol. 10*, Springer, Cham, Switzerland, ch. 11. pp. 197–217.
- 12 McDonald, L. (ed.) (2020) *The Collected Works of Florence Nightingale*, [cwfn.uoguelph.ca/](http://cwfn.uoguelph.ca/) (accessed 12 January 2020).