Florence Nightingale: using graphical statistical analysis to combat the spread of disease

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Sources

- Mark Bostridge: Biography of Florence Nightingale
- Eileen Magnello: Article in BSHM Bulletin
- Wellcome Library for Nightingale’s publications and letters
Outline

- Introduction - myself and this research
- Early life
- Education
- Statistics and statistical diagrams of the day
- Politics and Crimea
- Florence’s statistical writings
- Conclusion
Who was Florence?

- Prolific letter writer
- Administrator / manager
- Nurse and hospital reformer
- Pioneer of women’s rights
- Mathematician / statistician
- Populariser of maths / stats
Early Life

- Born in Florence in 1820 to William and Fanny Nightingale
- Sister Parthenope (Pop)
- Came back to England in winter 1820/21
- Settled in Derbyshire – Lea Hurst – during the summer
Florence was raised in a very disciplined way
An avid letter writer from an early age
Proud of her studies
Visited the poor and sick from a young age
Brought up as a devout Christian
Fanny was a stickler for discipline
I promise to take [a] run before breakfast to gate… ½ an hour’s walk before dinner, long walk after, or if cold & damp long walk before & ½ an hour’s after … to do 20 arms [exercises] before I dress, 10 minutes before breakfast & 10 after exercises, if ill done 10 more … to practice 1 hour a day … to draw ½ an hour regularly … not to lie in bed … to go to bed in proper time …
To read the Bible & pray regularly before breakfast & at night … to visit the poor people and take care of those who are sick … to take medicine when I want it … to go regularly after breakfast on Sundays to church when there is anyone to go with me … to read my books you put out for me …
Florence’s character

- More solitary than her sister
- Retreated into own imaginary world
- Deeply religious
- Very close to her father
- Neat and methodical
- Wrote copious lists and instructions
Listed all the animals she saw on a visit to the zoo:

‘2 leopards, 2 bears, 2 parrots, 2 emus (which are very large birds), 2 rabbits, 1 lion, 2 cockatoos, 3 squirrels, 4 kangaroos, 6 monkies (3 in a cage, 3 chained to a pole with a little house on top).’
Dear Poppa,

I have not put your Scrap Book anywhere, but one day I saw it in the drawer in the Music room, next to the low window, and I think it very odd you did not think of looking for it there!!! We have banded up the kitchen door, (at our house) and made a new one. We have made a shelf and in the kitchen, covered with bichter. Our sarsaparilla is so wet, we cannot stop in them. We have filled up our potato holes in the kitchen, and made a huddle. We have made a great addition to our provisions, viz., Vegetable, Fruits.

Little cole roots, Carrots, Turnips, Parsnips, Pitts, Apples, Peas, Corn, Tomatoes, Rice, Grain, lettuce, and a summer house, and are making

Tabulating contents of fruit and vegetable larder age 10
Taught at home under direction of William Nightingale.

‘I do figures, music ... Latin, making maps of Palestine, ... & then we walk & play & do patchwork & we have such fun.’ (aged 8)

Later Florence’s education was to become more academic as she showed ‘no taste’ for drawing.
Difference between sisters

- Parthe – irresponsible and childish
- Florence – neat, methodical and thoughtful
- Fanny: ‘[Parthenope] has not shown any decided taste excepting for flowers and poetry … [but Florence] is a shrewd little creature with a clear head which makes her thoroughly mistress of all she attempts by dint of thought and diligent application…’
William’s influence

At 16 her education included: chemistry, geography, physics and astronomy. She also studied mathematics, grammar, composition, philosophy and history. She was fluent in French and Italian and later German. She was also impressive in Latin and Greek.

Florence was often to be found reciting Latin / Greek translations to her Father. She would get up very early to prepare her work.
Fanny’s influence

- Florence was much impressed by her mother’s practical abilities as ‘a most excellent manager’.
- Her own skills in this area employed in a more dramatic setting owed much to the example set by her mother.
Developed a passion for mathematics around the age of 18-20 yrs.

Knew Mary Somerville through acquaintances of her mother and was inspired by her dedication of pursuing an occupation in the face of parental opposition.

Knew Lady Byron and her estranged daughter Ada Lovelace.
Her sister wrote: ‘*Florence has taken to mathematics and like everything she undertakes she is deep in them and working very hard.*’

Tutored her cousins, including William Nicholson, for his exam for Sandhurst. His father asked her to keep this secret saying William would be a laughing stock if it was found out he was tutored by a woman.
Statistics of the Day

- Joseph Priestley
- William Playfair
- Andre-Michel Guerry
- Adolphe Quetelet
- William Farr
Statistics of the day

Joseph Priestley (1765)
A NEW CHART OF HISTORY

1769
Use of charts by statisticians – Playfair (1786)
Use of charts etc by statisticians
Playfair’s pie charts
These statistical diagrams were received with scepticism in England but welcomed in Europe.

Polar Area Diagrams – Guerry (1829)

Diagram showing variation of weather in relation to mortality.

Guerry worked with Quetelet

Quetelet had links with Britain
Politics and Statistics

Many early statisticians were involved in social reform but they were slow to adopt statistical diagrams.


Became Superintendent of Statistics at General Register Office.
PLAGUES OF LONDON.

CHOLERA YEAR

Average Mortality of 3 ordinary years.

1849 1850 1851 1852 1853 1854 1855 1856 1857 1858 1859 1860 1861

PLAGUE YEARS

1349 1350 1351 1352 1353 1354 1355 1356 1357 1358 1359 1360 1361

PLAGUE YEARS.

1629 1630 1631 1632 1633 1634 1635 1636 1637 1638 1639 1640 1641

1849: The epidemic, which lasted 4 months, with its usual and annual mortality of 3000, was not accompanied by extraordinary mortality or by extraordinary improvements in the manner of life. The number of deaths was greater than usual, but the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1850: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1851: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849 and 1850, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1852: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, and 1851, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1853: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, and 1852, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1854: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, and 1853, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1855: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, and 1854, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1856: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, and 1855, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1857: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, 1855, and 1856, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1858: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, and 1857, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1859: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, and 1858, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1860: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, and 1859, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

1861: The epidemic, which lasted 6 months, with its usual and annual mortality of 3000, was accompanied by extraordinary mortality, as it was in 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, and 1860, and the proportion of deaths to the births, and the proportion of deaths to the total population, was not greater than the average of the preceding years.

Note: In each of these years, the number of deaths exceeded the number of births, and the proportion of deaths to the total population was greater than the average of the preceding years.
‘I can never be sufficiently thankful to Papa for having given me an interest in Statistical and Political matters.’ (1847)

Studied the work of Quetelet.

Became friendly with Sidney and Liz Herbert (Rome 1847)

Became independent from her family in 1853.
Taught in Ragged School in London
Wanted to nurse from 1844
Visited Kaiserwerth in 1850.
Became Superintendent of the Establishment for Gentlewomen during Illness (1853)
‘The Government has asked, I should say entreated, Flo to go out and help in the hospital in Scutari.’ Parthenope 1854
Reports of her time in Turkey led to her becoming something of an icon in England.

Contracted Cholera before her return home in 1856.

On return met with Queen Victoria

Panmure and PM agreed to Royal Commission

Palmerston urged Florence to write a report.

She did this aided by Farr.
‘It has been said that figures rule the world. Maybe. But I am sure that figures show us whether it is being ruled well or badly.’
Notes on Matters

Lancet:

‘Terse phrases’ providing a welcome change from the ‘brown-suited dullness’ of other books on the subject.
Contents

 Reads like a diary
 Copious lists
   Stores
   Conditions
   Diseases
   Correspondence
 Much description and discussion about the stock (or lack of stock) of lime juice.
Mathematics and diagrams

Florence doesn’t just present the diagrams she discusses and challenges the maths of the day:

In constructing a Table of Mortality we take 100 men, eight die the first year, there are left 92—two die the second year, there are left 90. The usual method of stating this mortality would be to take the hundred over again and strike the difference, thus—

\[
100 + 100 = 200 \quad 8 + 2 = 10
\]

\[
\frac{10}{2} = 5
\]

Therefore, it is a mortality of 5 per cent., per annum. Now, this is manifestly wrong, and gives the Secretary of State no idea of his accumulated loss.
A singular Statistical problem is thus stated by the Commandant, for the official information of Her Majesty's Government, p. xi:—“Sickness has very much diminished and so has the Mortality. In January last the number of deaths was 1,480, in February, 1,254, and in March, 424, every month showing a steady decrease over the preceding one. The average mortality, at present, is 5½ per diem.” This problem is much like the celebrated riddle, “Given the height of the mast, to tell the captain’s name.” Not given the numbers in Hospital, to tell whether there is a “steady decrease” in its mortality. The real fact, alas! stood thus,—there was an appalling increase of mortality, up to the end of February, reaching nearly 43 per cent., in that month, of cases treated, from 32 per cent., which it was in January. The numbers in Hospital had diminished. Up to March 17th the mortality, although diminished,
DIAGRAM REPRESENTING THE MORTALITY IN THE HOSPITALS,
AT SCUTARI AND KULALI, FROM OCT. 1st 1854, TO SEPT. 30th 1855.

The area within the dotted circumference represents the average annual Mortality in the Military Hospitals in and near London - 20.3 per 1000 such as given by the Registrar-General for 1857. The Black wedges presented from the Centre represent by their Area the Mortality per 1000 of sick treated in the Hospitals at Scutari and Kulali in 1854. 55.
Diagram of the Causes of Mortality
in the Army in the East.

The areas of the blue, red, and black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent areas for ages and deaths from Preventable or Mitigable Zymotic diseases, the red wedges measured from the centre the deaths from wounds, and the black wedges measured from the centre the deaths from all other causes.

The black line across the red triangle in Nov. 1854 marks the boundary of the deaths from all other causes during the month.

In October 1854, & April 1855, the black areas coincide with the red; in January & February 1856, the blue coincides with the black.

The entire areas may be compared by following the blue, the red, & the black lines enclosing them.
The dotted circle represents what the Mortality would have been, had the Army been as healthy as Manchester - 12.4 per 1000 per Annum. The Area of each Monthly division exhibits the relative Mortality in the Army during the Month.

Each wedge admits of Comparison, area for area, with every other wedge, and with the Manchester Circle, and each wedge shows the Mortality per 1000 per Annum for the Month.

The dark Area outside the Manchester circle exhibits the excess of Mortality in the Army for the same age over that of one of the most unhealthy Towns in England. The figures show the Mortality per 1000 per Annum.
DIAGRAM

showing the Annual Rate of Mortality in Camp on the
SICK POPULATION at SCUTARI,
FROM OCTOBER 7TH 1854 TO JUNE 20TH 1855.

Fig. 2
On zymotic disease

‘One has killed its thousands and others its tens of thousands’.

The book continues with tables of nutrients, plans of hospitals and kitchens and many recipes!
‘Diagrams, one of the great utility for illustrating certain questions of vital statistics by converging ideas on the subject through the eye which cannot be so readily grasped when contained in figures.’
### Representing the Relative Mortality of the Foot Guards and of the English Male Population at Corresponding Ages

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Deaths Annually to 1000 Living</th>
<th>Englishmen</th>
<th>Foot Guards</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-25</td>
<td>8.4</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td></td>
<td>21.6</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td>25-30</td>
<td>9.2</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td></td>
<td>21.1</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td>30-35</td>
<td>10.2</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td></td>
<td>19.5</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td>35-40</td>
<td>11.6</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
<tr>
<td></td>
<td>22.4</td>
<td>Englishmen</td>
<td>Foot Guards</td>
</tr>
</tbody>
</table>

*Note.—The Mortality of the English Male Population, at the above ages, is taken from English Life Table (1849-53).*
‘Guards are physically very select…. One could say… that a soldier…. was the most likely to enjoy perfect health and a long life.’
Representing the relative annual mortality from all causes, zymotic diseases, chest and tubercular diseases, and other diseases in the English male population aged 15-45, and in the infantry of the line serving at home.

**English Male Population Aged 15-45 (1848-54)**

<table>
<thead>
<tr>
<th>Zymotic Diseases</th>
<th>Chest and Tubercular Diseases</th>
<th>All other Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6 (to 1000 living)</td>
<td>4.3 (to 1000 living)</td>
<td>3.3 (to 1000 living)</td>
</tr>
</tbody>
</table>

(This dotted parallelogram represents the additional area which would be occupied by the mortality among the English male population if they were as unhealthy as the infantry of the line, at home.)

**Infantry of the Line (Serving at Home) (1857-46)**

<table>
<thead>
<tr>
<th>Zymotic Diseases</th>
<th>Chest and Tubercular Diseases</th>
<th>All other Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4 (to 1000 living)</td>
<td>10.1 (to 1000 living)</td>
<td>3.2 (to 1000 living)</td>
</tr>
</tbody>
</table>

Deaths annually to 1000 living from all causes 47.9
Comparisons

‘It will be seen that the least crowded of the QMGs plans affords about a twentieth part of the area per man allotted to each inhabitant of the metropolis; that it is about half the amount of that in the most densely peopled part of London; and that the population on the occupied area of the camp is above 50 times more crowded than the population of London.’
Forecasting

I. Diagram - representing the Army at Home in its present State.

II. Diagram - representing the Army at Home in an improved State.

1. This Diagram has been constructed to illustrate Table E. a.

Each of the 200 small Parallelograms represents 1000 Men.

II. This Diagram is constructed so as to show what the State of the Army at Home would be if the Mortality were the same as it is in the Civil Population at corresponding Ages, and if the Invaliding bore the same proportion to the Deaths as it does in Diagram I. The Invaliding may be more, but it would probably be less than it is represented to be in Diagram II.

TWO DIAGRAMS showing the loss of strength in the Army by INVALIDING and by DEATH.

The force 141, 764 (represented by the RED Area, ) is assumed to be maintained by 10,000 Annual Recruits, which if there were no loss by Death, or by Invaliding would sustain a force of 200, 000 Men, represented by the Square figures. - The loss of strength shown in Diagram I is equal to 58, 237 = 29 per cent.

The DARK Area represents the loss of strength by DEATH.

The YELLOW Area represents the loss of strength by INVALIDING, and it will be borne in mind that many of the Invalided die soon after leaving the Army.

NOTE. 10,000 Annual Recruits under System No. I, would sustain a force of 141, 764; under System No. 2, 10,000 Annual Recruits would sustain a force of 166, 910. (See Table F. d.)

Owing to Service abroad in unhealthy Stations, the numbers are actually reduced much more rapidly than they are at home, as shown in Diagram I.
Achievements

- Significantly lowered the mortality rate of the British Army
- Reorganisation of Army Medical Statistics
- Commission to inquire into the state of the British Army in India
- Redesigning of hospitals
- Nursing training schools – especially district nursing
Who was Florence Nightingale?

- Prolific letter writer
- Administrator / manager
- Nurse and hospital reformer
- Pioneer of women’s rights
- Mathematician / statistician
- Populariser of maths / stats
- Used maths and statistics to change lives
Operational Researcher?
Thank you for Listening
Questions?
References

- Nightingale, F., 1858 *Notes on Matters on the health, efficiency and hospital administration of the British Army*, London: Harrison & sons
- Nightingale, F., 1858 *Mortality of the British Army compared with the mortality of the civil population*, London