

Florence Nightingale: how she used, managed and explained data to save lives

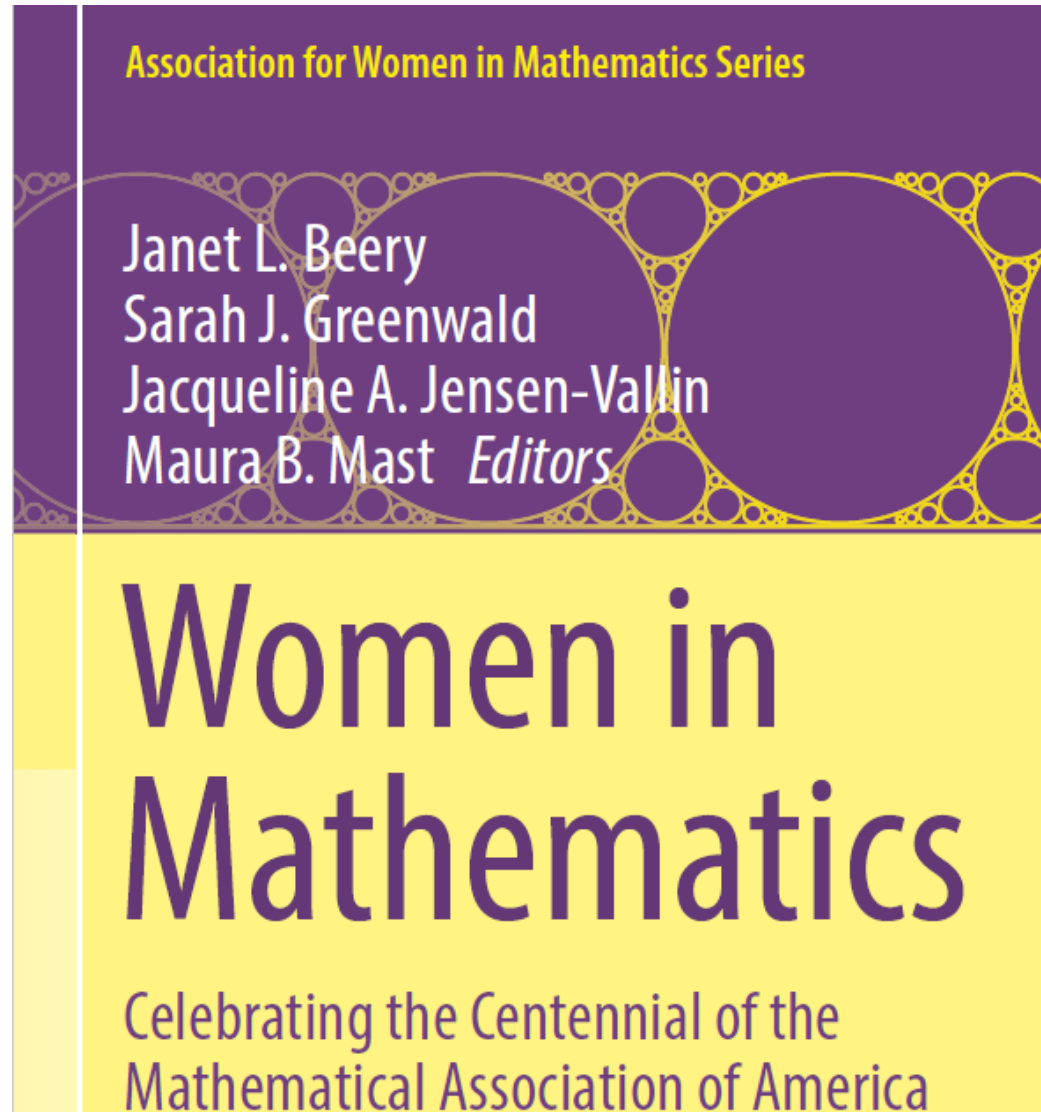


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My background

- Chair the UKs Joint Mathematical Council (JMC)
- Worked in industry – Senior Data Scientist (Retail)
- Senior Manager in Higher Education



Research

- Nightingale's biographies
- Lynn McDonald's work
- Nightingale's publications and letters

Outline

- Early life and Education
- How she ended up in the Crimea
- Work accomplished after the conflict
 - Mortality rate
 - Her commentary on statistical method and data management
 - Improving conditions for poor
- Conclusion





Early life

- Born in Florence, Italy on 12/5/1820
- Grew up in England in Lea Hurst, Derbyshire (summer) and Embley Park, Hampshire (winter).
- Died 13/8/1910



Education

- She had a great **passion for learning**; several of her early letters to her mother and sister are **written in French** and testify to her language skills.
- There are many anecdotes from friends and family members mentioning her accomplishments in **Latin and Greek**.
- Comment from a potential suitor: *“a capital young lady that, if she hadn’t floored me with her Latin and Greek.”*



Letter to grandmother aged 8

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 squirrells, 4 kangaroos, 6 monkeys (3 in a cage, 3 chained to a pole with a little house on top).'

Tabulating fruit and vegetables

Letter to her sister

but one day I saw it in a drawer in the Music-room, next to the
bow-window, and I think it very odd, you did not think of
looking for it there!!! We have banked up the kitchen-door,
(at our house) and made a new one. We have made a sofa of sand in
the kitchen, covered with haystr. Our mattresses are so wet, we cannot sleep
in them. We have filled up our potato-boxes in the kitchen, and made
a ladder. We have made a great addition to our provisions, viz.

Vegetable	Fruit
Little Lamb Potatoes	Large Potatoes
	Cherry
	Apple
	Pear
Long Lamb Potatoes	Strawberries
	at Garden
at Garden	at Garden
at Garden	at Garden

We intend to make a ^{softer} ladder. We have made
3 other paths to different parts
of our house. We have made a path
and a summer-house, and are making

Education:

*“I can never be sufficiently thankful to Papa for having given me an interest in **Statistical and Political** matters.”*



Mathematics

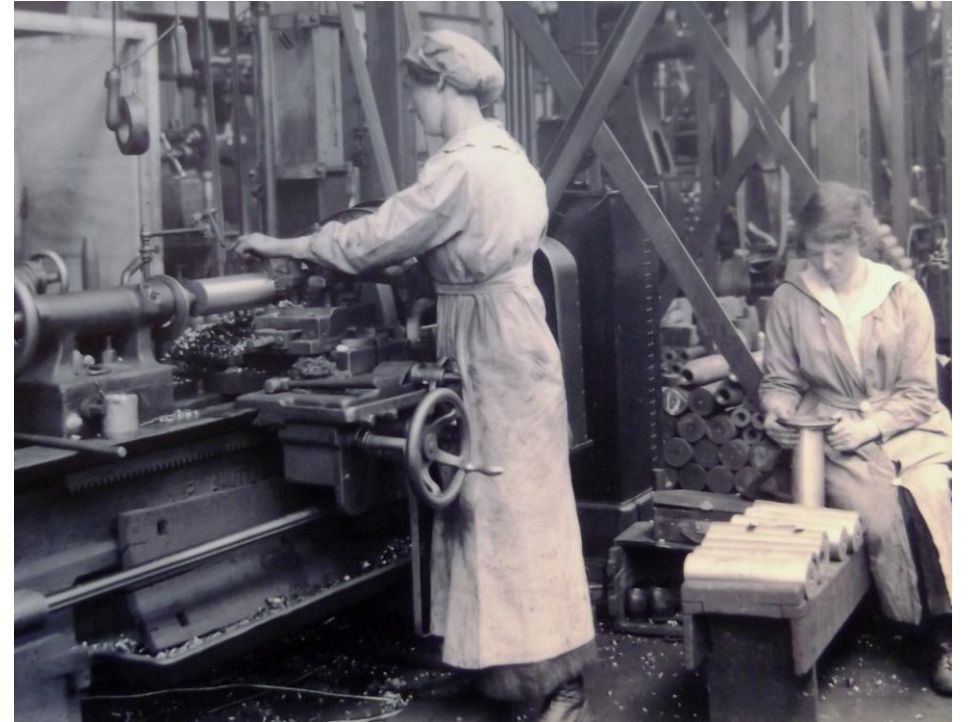
- Developed a passion for mathematics around the age of 18-20 yrs.
- Tutored her cousins.
- Parthenope said: “***Florence has taken to mathematics - and like everything else she undertakes she is deep in them and working very hard.***”
- Bostridge recounts a story of Nightingale being engrossed in a conversation about **logarithms** whilst the family were moving to a newly renovated Embley.
- But her mother was not impressed: “***Of what possible use could maths be to a young woman?***”



Interest in mathematics and statistics

- Read and commented on the work of **Lambert Adolphe Jacques Quetelet**, the Belgian statistician
- What initially started as an interest and a pastime was later to become a **pivotal tool** which Nightingale used to gain influence and bring about change.
- Met in 1860, when he chaired the **International Statistical Congress (ISC)** in London and after which they kept up a lively correspondence.

Careers for Victorian women...



Pre-Crimean War

- Travelled extensively in Europe.
- Frustrated by the fact she was **not allowed to work** despite entreating her parents several times.
- Ended up **training to nurse** at a hospital in Germany.



Pre-Crimean War

- Eventually allowed to become **Superintendent of the Establishment for Gentlewomen During Illness** in Harley Street.



Crimean War
broke out in
October 1853.



Crimean war

Conditions were reported in newspapers.

Nightingale immediately wrote to **Sidney Herbert (Secretary at War)** offering her services.





At exactly the same time Herbert wrote to her asking (or, according to Parthenope, “entreating”) her to **travel to the Crimea** and assist in tackling the medical chaos which was just starting to be reported.

She returned at
the end of the war
in 1856

*"I stand at the
alter of the
murdered men
and while I live, I
fight their cause."*





After her return

- Most of her work was done after her return from the Crimea
- She was very ill and bedridden for much of her life
- But she had a very strong work ethic and was very good at delegating.
- She started by writing a lengthy report requested by the PM Viscount Palmerston which was published in 1858

Reports

The **first draft of the report was 567pp** but a later preface by Nightingale indicates that she received a large amount of new material (much of it data) which she inserted into the beginning of several chapters.

The original pages of the report have Arabic numbers but the additional pages have Roman numerals which are duplicated in each section. The resulting 853 pp, as McDonald noted, are “extremely difficult to follow”, but nonetheless make for **fascinating reading!**

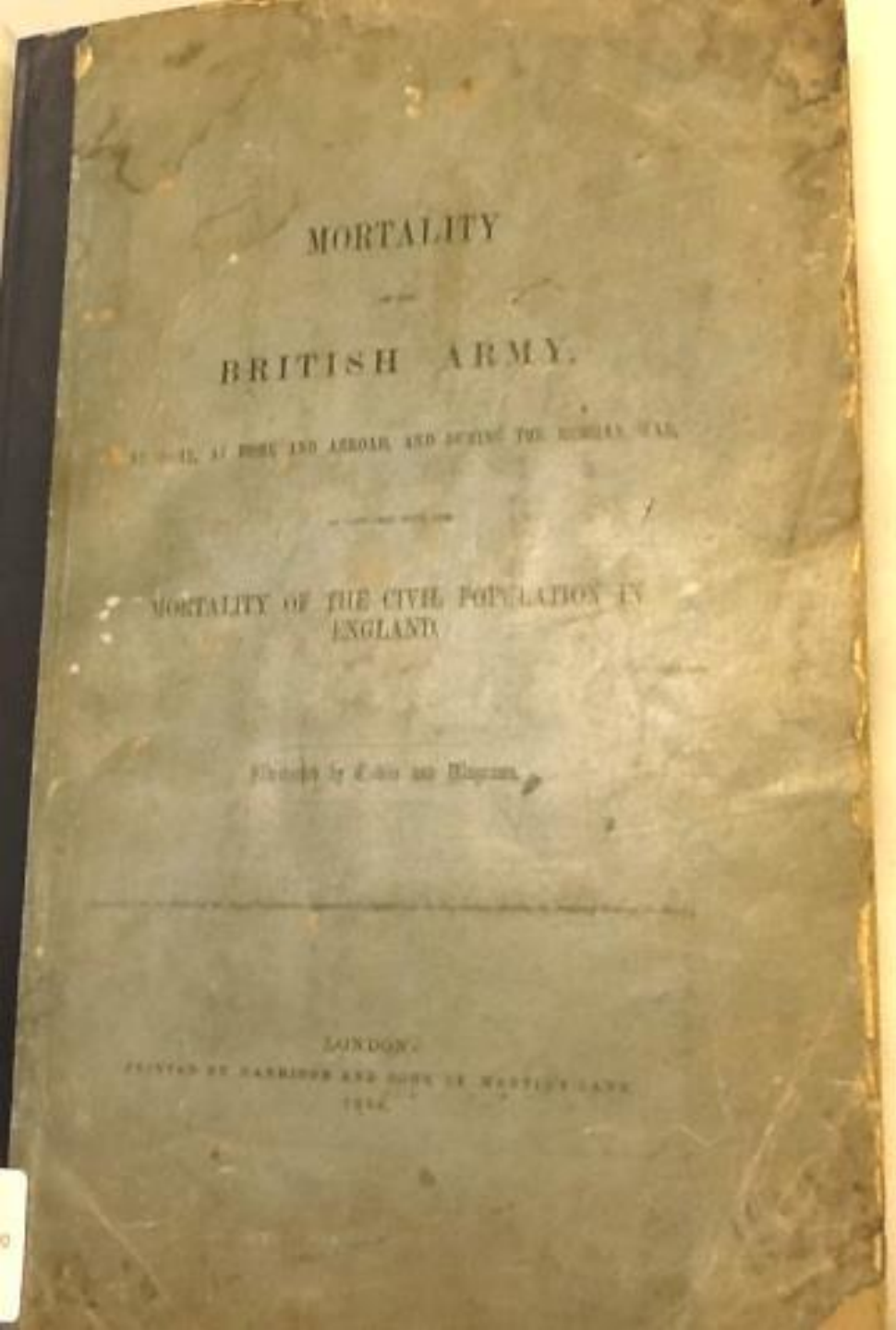


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CONTENTS.		iii
	PAGES.	
Preface to Section X.	I—XLIV	
Part I.—Authorities for the Statistics used in the Section, with an Inquiry as to their Sufficiency	I—XXXIII	
Part II.—Abstract of Sanitary Recommendations made by the Medical Authorities, regarding the Camp in the Crimea....	XXXIV—XLIV	
X.—Notes on the necessity of Special Sanitary Function- aries, in connection with Military Hospitals and with the Army in General, both abroad and at home	235—287	
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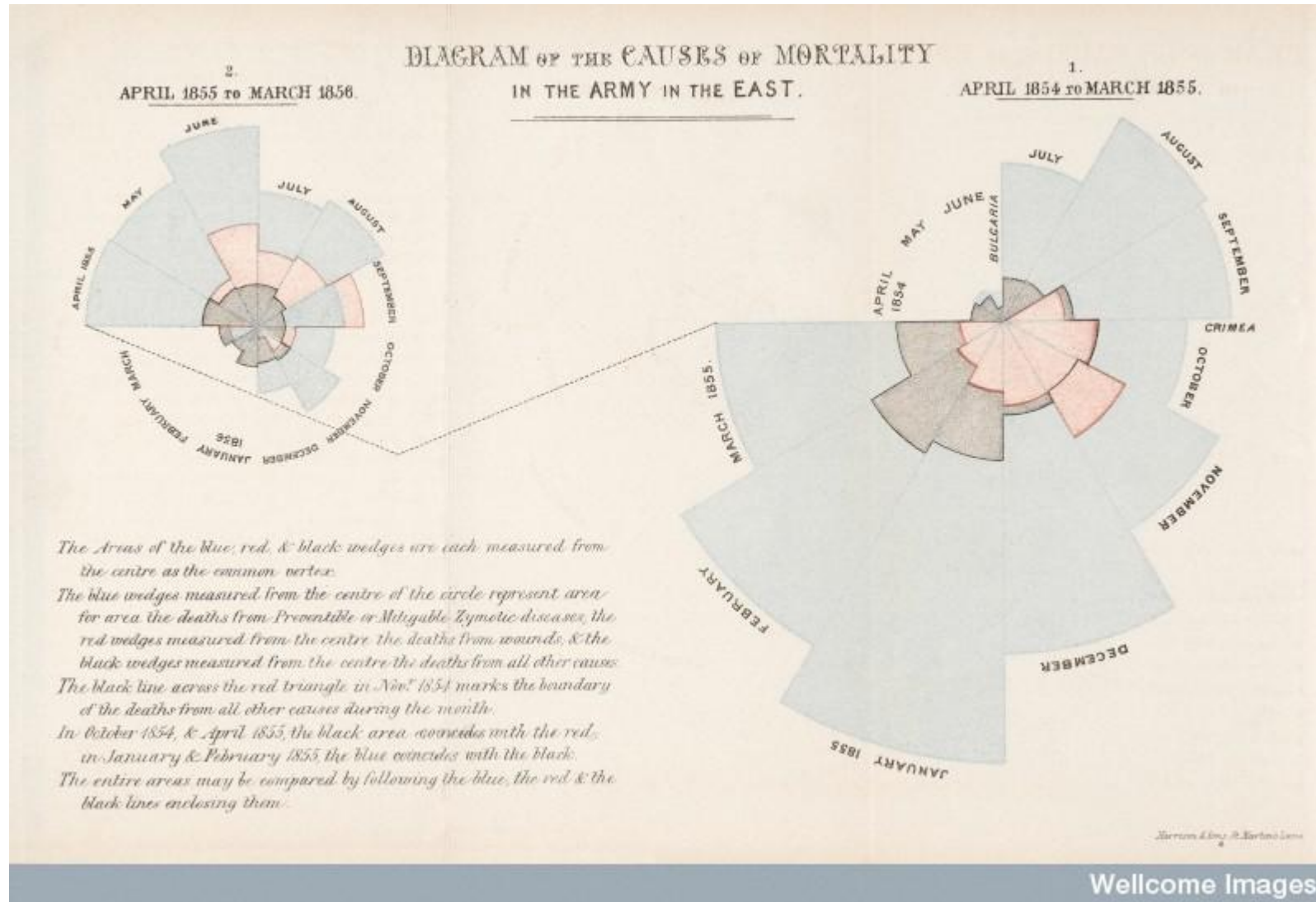
The Coxcomb

“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.”

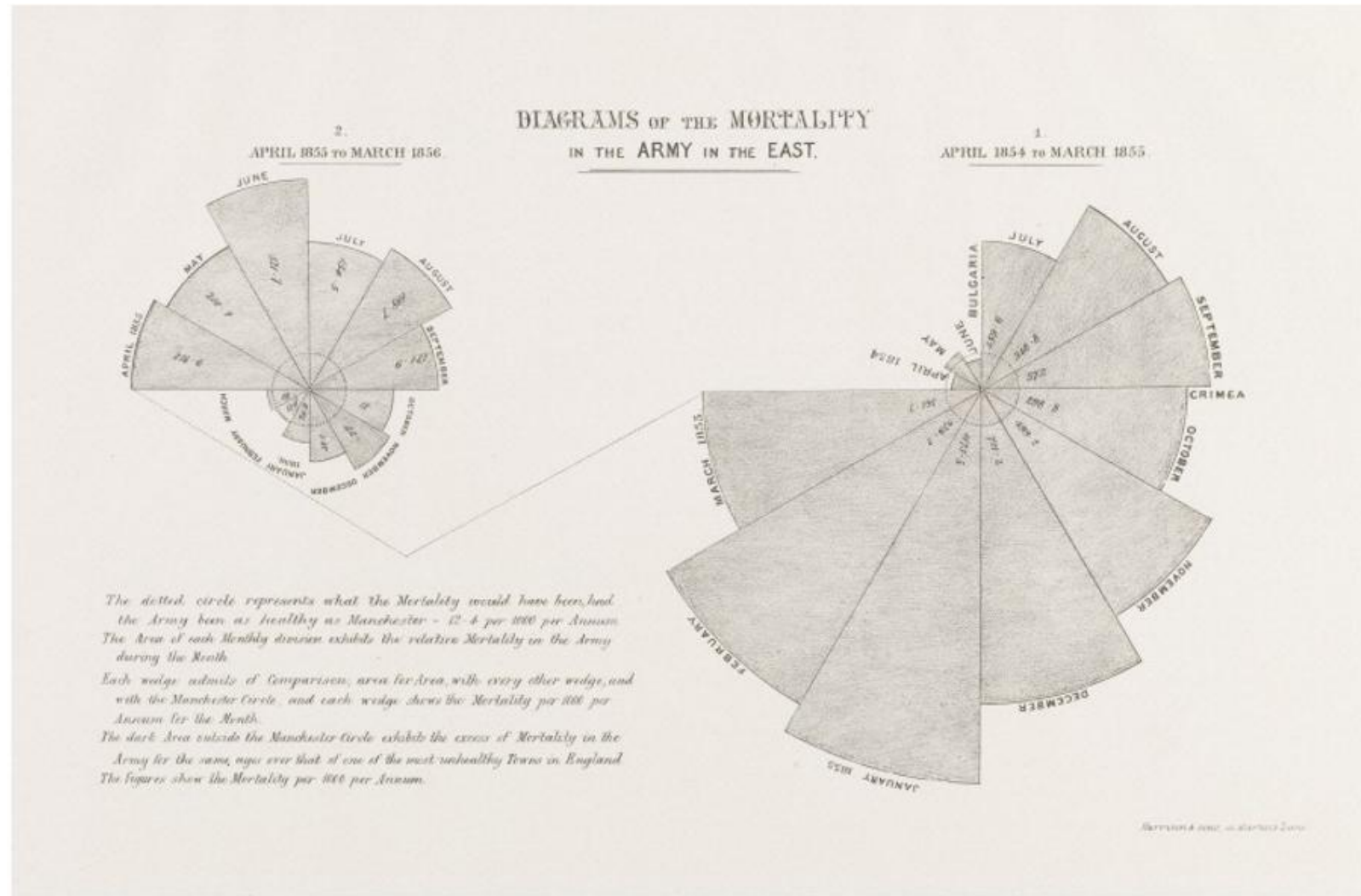
The Coxcomb

- Accompanying Nightingale's report was her **pamphlet of tables and diagrams** (referred to by Herbert as her "Coxcomb") which was publicised more widely.
- In a letter to Herbert on Christmas Day 1857, she concluded that she didn't think anyone would read the tables and diagrams.
- Yet she went on to compile a lengthy list of categories of 'ordinary' people who should receive it, including Queen Victoria. 'She may look at it because it has pictures'!
- It was written to give ***"greater clearness to the numerical results in the body of the report and appendix"***.

Causes of death

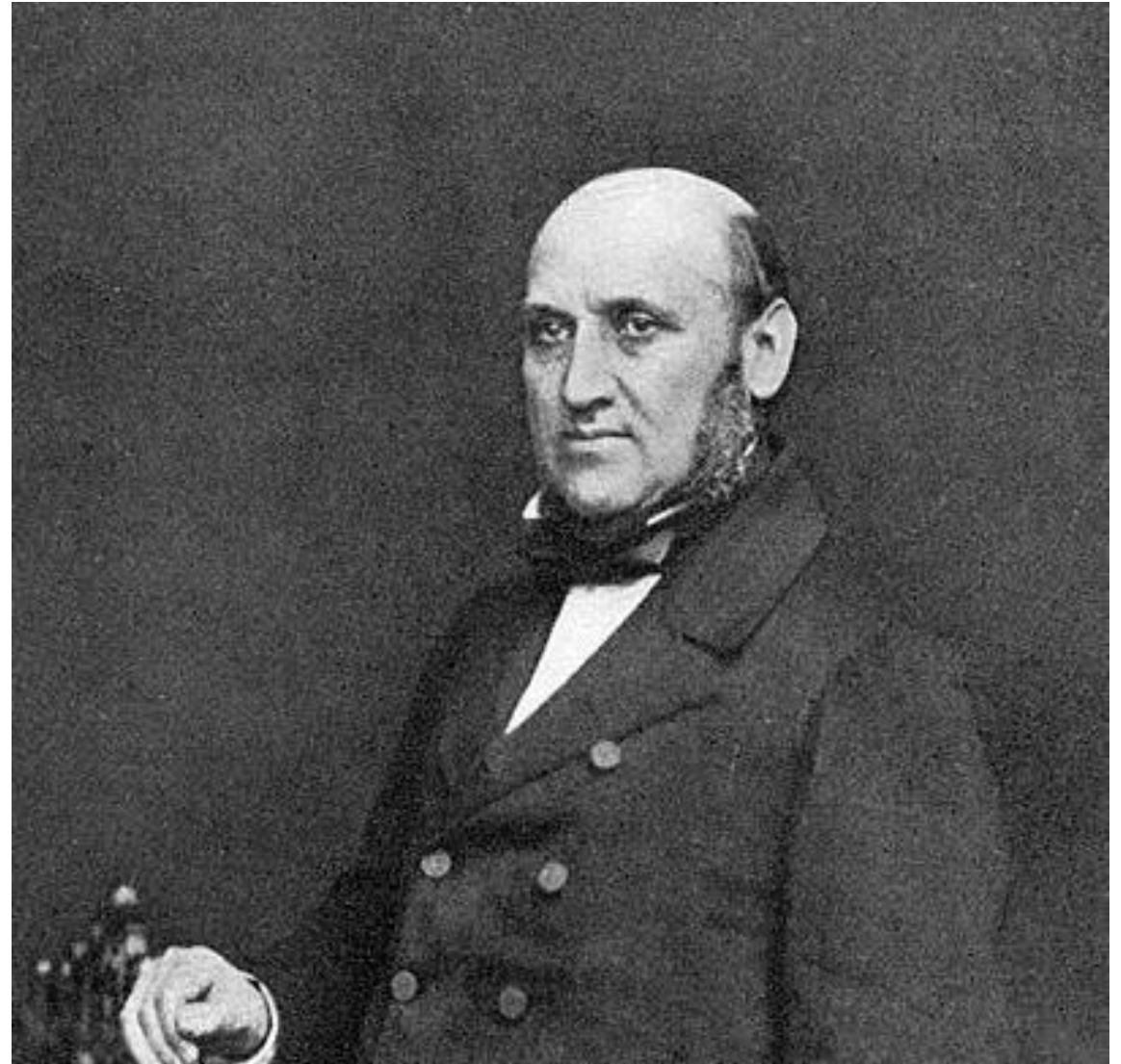


Comparison with Manchester



William Farr

- **Chief Statistician in the General Register Office**, introduced statistical diagrams into the *Journal of the Royal Statistical Society* (RSS).
- Farr remained suspicious of representing data in pictorial form saying at one point that statistics should be **“the driest [sic] of all reading”** and complaining that Nightingale’s attempts were **not “sufficiently dry”** despite her worrying that they were too dry.
- It is clear that she did not agree with this as **she was keen to use diagrams to ensure that the data was clearly understood**. There is no indication that Nightingale made any attempt to address Farr’s comments.

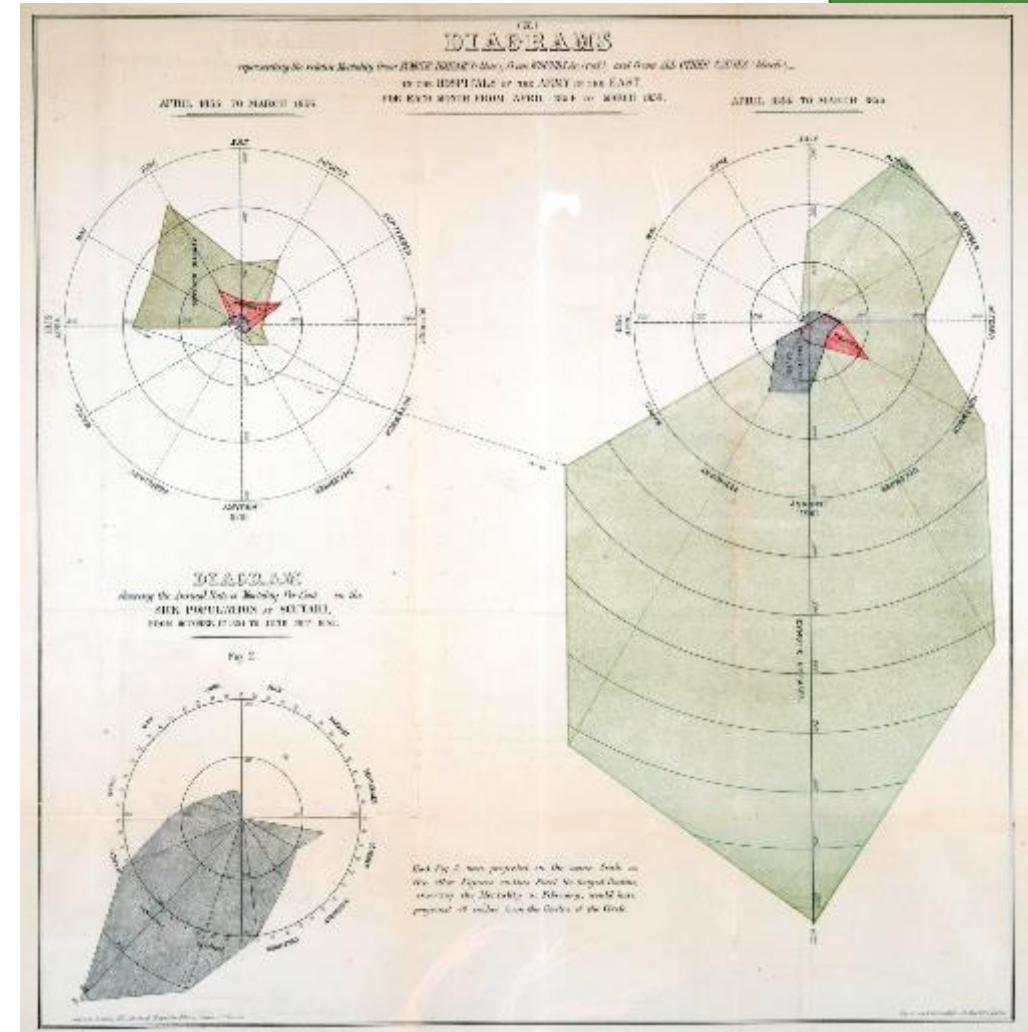


Batwing error

A potential misunderstanding:

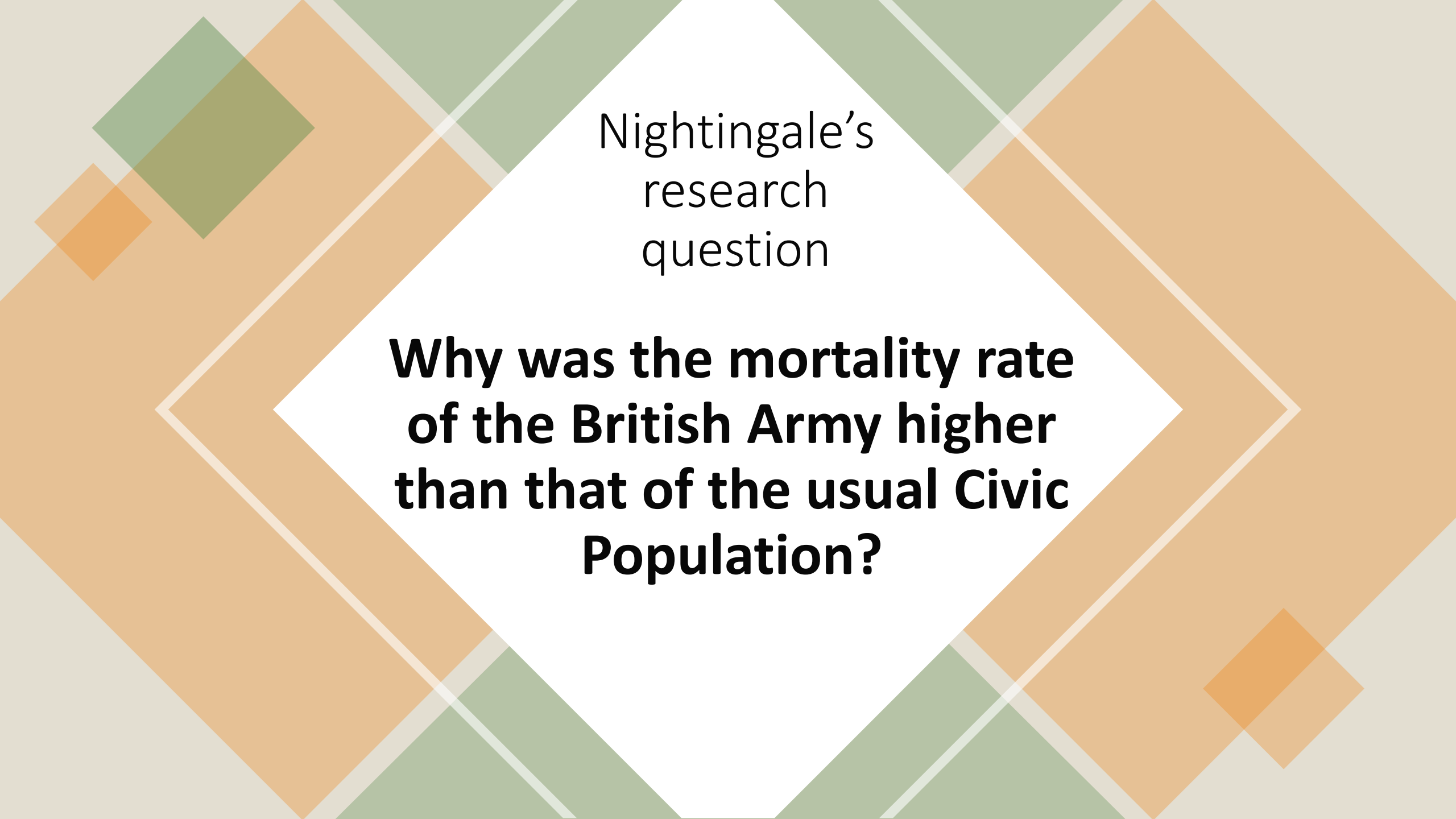
“it is not intended that the larger area should be contrasted with the smaller but simply the longer with the shorter line”.

However it is only ***“ignorant people [who] conceive that the comparison is intended to be between the areas”.***



Statistics in her report

- Two main sections on Statistics:
- Preface to Section X – **Statistics on Recruiting and Statistics on Invaliding**
- Section XI (plus preface) – **Notes on the inaccuracy of hospital statistics and the necessity of a statistical department**
- There are numbers, calculations, tables all through the report. As well as recipes and commentary on diet and clothing and hospital management.
- It shows Nightingale's attention to detail, her grasp of mathematics and statistics, and her passion for seeing this portrayed correctly and relevantly to different audiences in order to change the way they thought.



Nightingale's
research
question

**Why was the mortality rate
of the British Army higher
than that of the usual Civic
Population?**

Data collection

- Data collection when recruiting soldiers:

“The extremely imperfect manner in which our recruiting statistics are kept prevents us from arriving at any general or accurate conclusions”.

- Some recruiting centres **didn't collect data**
- Others conducted primary and secondary inspections but the results were **all mixed up** so it was very hard to know why and how many soldiers were rejected.
- Reasons for rejecting were **inconsistent**.
- Not possible to conclude the condition of the soldier at the point of entry.

Data collection

- Hospital admissions (Bed ticketing)
 - Nightingale points out that by only counting the soldiers in hospital on one day per 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 not be registered as being there. Consequently she estimated that hospital records in the Crimea may have **only shown one seventh of the cholera cases**.
 - When they did start collecting data on admission there was often a delay of a day and so **many soldiers died before they could give their names**.
 - They also mixed up new admissions with those remaining so **many soldiers were counted numerous times**.

Data collection

- **Cause of death**

There was a lack of consistency in recording the cause of death and was often based on what the patient saw as the worst symptom: So pains in back and legs was often recorded as Chronic Rheumatism rather than Scurvy.

- **Bodies lost at sea**

Many soldiers died at seas and bodies were thrown overboard without names being collected.

- **Conclusion**

“No one was to blame ... but that there was no system ready organised of registration”.

(In)Accuracy of data and lack of organisation

When she compared the returns on the causes of death she wrote, *“I have carefully compared the statistics from six different official sources, and **none of them agree**”*. She stressed that the great discrepancies in the numbers *“**shake [one’s] confidence**”* in their accuracy and render it difficult to make use of them for statistical purposes.

“I could make you laugh at our classification which seems 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”.

Data reporting

- Data was used for show rather than any meaningful decision making.
- Officials quoted numbers rather than rates, ratios or percentages.

Mortality rate

A singular Statistical problem is thus stated by the Com-mandant, for the official information of Her Majesty's Govern-ment, 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 $5\frac{1}{7}$ 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 mor-tality, 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 was 43 per cent., on cases treated.

"Numbers on their own are useless without the strength. $5\frac{1}{7}$ deaths per day = 1877/annum. But whether this is out of 8000 or 3000 makes a big difference".

(In)Accuracy of reporting data

Officials:

Everything is fine.

Deaths are decreasing:

January — 1,480

February — 1,254

March — 424

Nightingale:

*The actual mortality rate
was increasing.*

January — 32%

February — 43%...

Problems with Averages

Table III

Table showing the rate of Invalided to Strength on Home-Service.

TABLE NO. III.*

1839—53. Fifteen Years.	1. Under 7 Years' Service.	2 7—14 Years' Service.	3. 14—21 Infantry. 14—24 Cavalry.	4. Total under 21 or 24.	Als 21 2
HOUSEHOLD CAVALRY.					
Strength	8,332	4,988	4,188	17,508	6
Invalided	52	68	147	267	2
Ratio Invalided per 1,000 serving } CAVALRY (LINE.)	6.2	13.6	35.1	15.2	5.3
Strength	43,541	21,721	15,453	85,715	1.4
Invalided	713	510	568	1,791	1.5
Ratio Invalided per 1,000 serving } FOOT GUARDS.	14.7	23.5	36.7	20.9	7.
Strength	36,761	20,731	12,707	70,199	3.1
Invalided	526	335	254	1,115	1.7
Ratio Invalided per 1,000 serving } INFANTRY (LINE.)	14.3	16.1	20.	15.9	3.4
Strength	195,628	70,549	39,097	305,274	3.5
Invalided	3,105	1,486	2,174	6,765	3.4
Ratio Invalided per 1,000 serving }	15.9	21.1	55.6	20.8	9.

* These data are obtained from the Returns made annually by the Regiment to the War Department.

- An engineer doesn't calculate the average velocity of the whole river but takes it in sections.

Age.	English Soldiers.				Comple Years of Service
	Living.	Dying and Invalided.	Dying.	Invalided.	
20	10,000	350	169	181	0
21	9,650	325	168	157	1
22	9,325	305	166	139	2
23	9,020	289	164	125	3
24	8,731	278	162	116	4
25	8,453	270	160	110	5
26	8,183	265	159	106	6
27	7,918	264	158	106	7
28	7,654	263	157	106	8
29	7,391	266	155	111	9
30	7,125	271	153	118	10
31	6,854	275	150	125	11
32	6,579	282	147	135	12
33	6,297	288	145	143	13
34	6,009	296	144	152	14
35	5,713	302	144	158	15
36	5,411	307	143	164	16
37	5,104	313	141	172	17
38	4,791	315	138	177	18
39	4,476	318	135	183	19
40	4,158				20

New version
by Farr

Misuse of data

- She frequently described officials' calculations as novel – meaning incorrect.
- When trying to get data on the mortality of the British Army she was appalled that officials were leaving out the numbers who had been invalided.

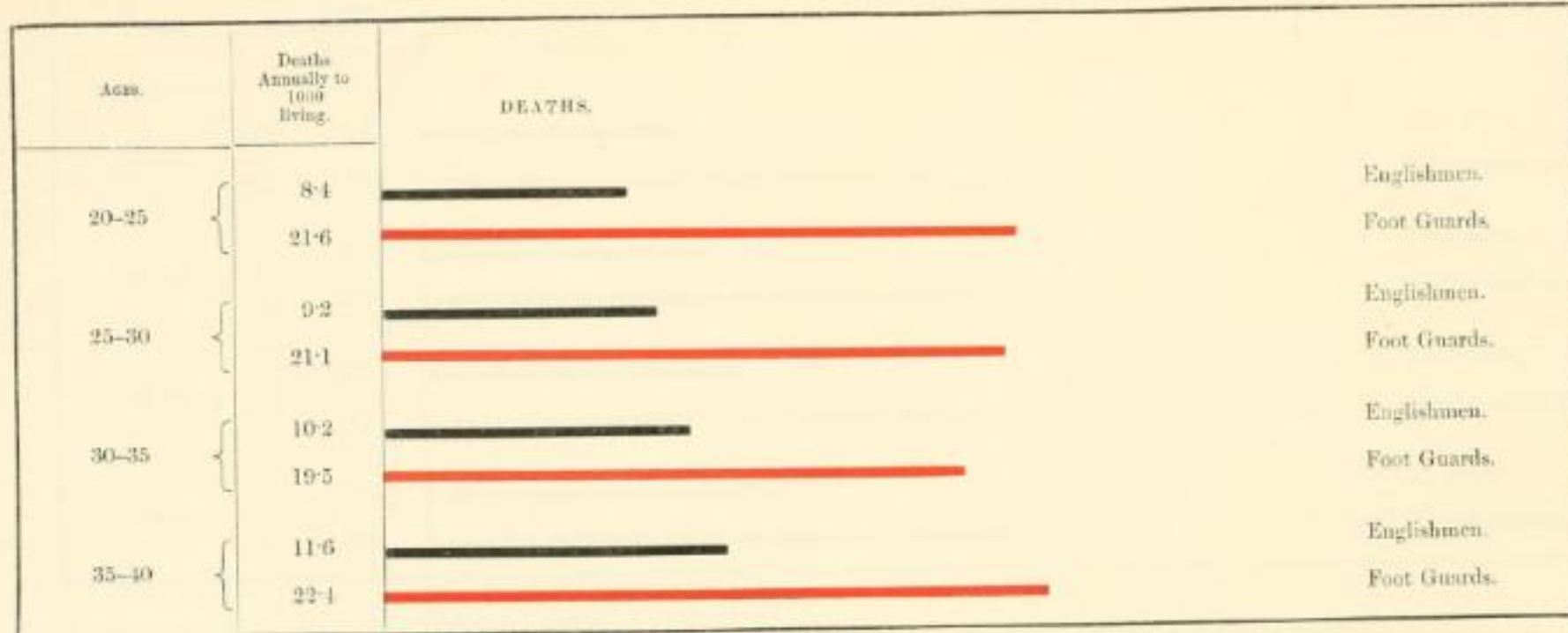
“the state loses them equally whether they die or are invalided before their term of service is completed – to have kept back this data shows either utter ignorance of the importance of their bearing, or a wilful intention to keep back the truth”.

Immortality

*“To say that the mortality in the guards is double that of civil life is to **make an understatement of the truth**. It is more nearly treble. For the army mortality merely shows the deaths among those staying in the service long enough to die in it. It **does not show the deaths among those discharged to die elsewhere**. A low mortality, therefore, may imply not a high state of health, but a high rate of invaliding . . . For if every man likely to die were invalided, **the army would appear immortal**, for not a man in it would ever die.”*



Representing the Relative Mortality of the Foot Guards and of the English Male Population at corresponding Ages.



JAMES LEWIS, del., General Register Office, Somerset House.

NOTE.—The Mortality of the English Male Population, at the above ages, is taken from English Life Table (1849-53).

Line graphs

(G.)

DIAGRAMS

(to illustrate Table G.)

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).

<i>Zymotic Diseases</i> 2·6 to 1000 living	<i>Chest and Tubercular Diseases</i> 4·5 to 1000 living	<i>All other Diseases</i> 3·2 to 1000 living	(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.)
Deaths Annually to 1000 living from All Causes 9·8			

INFANTRY OF THE LINE (SERVING AT HOME) (1857-46).

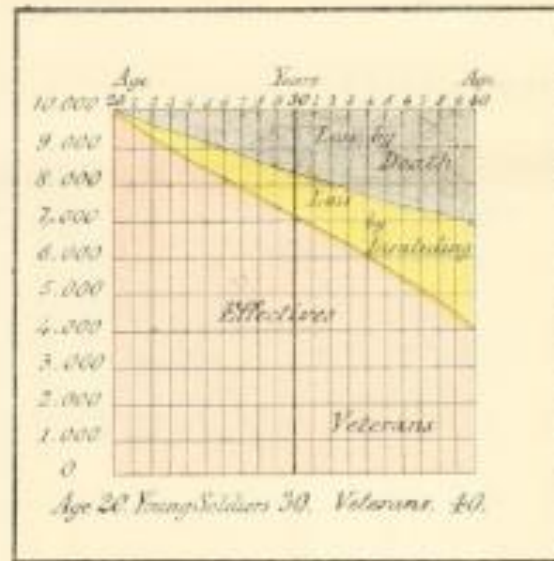
<i>Zymotic Diseases</i> 4·4 to 1000 living	<i>Chest and Tubercular Diseases</i> 10·4 to 1000 living	<i>All other Diseases</i> 3·7 to 1000 living
Deaths Annually to 1000 living from All Causes 17·9		

Cost of mortality

- She even **attempted to put a cost to the country** on this premature invaliding.
- Having done this she provided a **new method for calculating the mortality by including the invaliding** and the fact that at the start, those selected for service, excluded the sick. With these new measures she stated that the *“real annual mortality percent of the foot guards, after correction, is **26 annual deaths to 1000 living**, whereas the mortality of the male population, at the same ages, is about **9 annual deaths to 1000 living.**”*

*I. DIAGRAM – representing the ARMY
at Home in its present State.*

*I. This Diagram
has been constructed
to illustrate
Table F.a.*



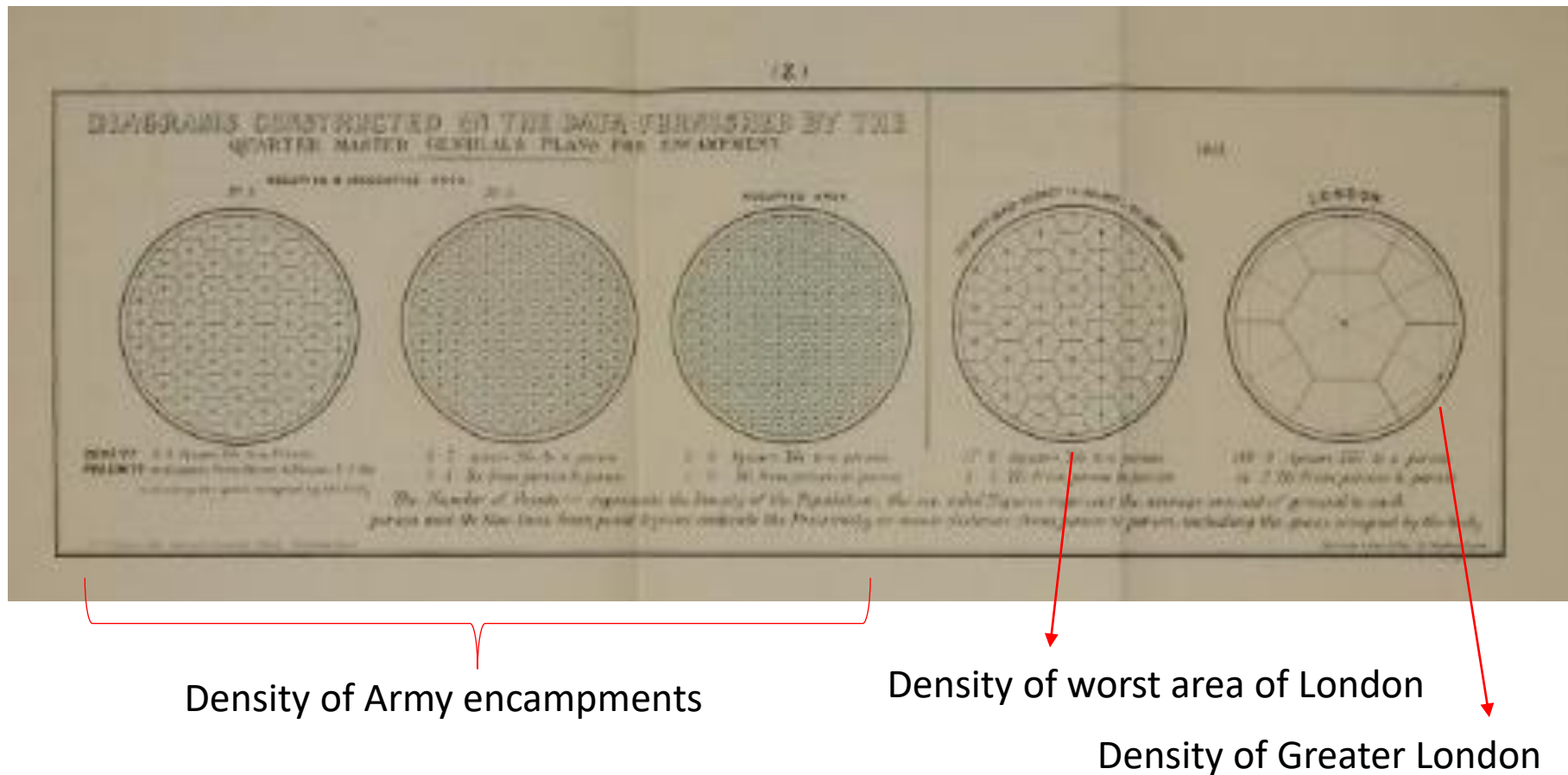
*Each of the
200 small
Parallelograms
represents
1000 Men.*

*II. DIAGRAM – representing the ARMY
at Home in an improved State.*



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

- “By comparing the red areas of both diagrams **the great loss of efficiency in the army in its present state becomes more apparent**”.
- She went on to comment that these diagrams “show the loss of life, of service and of money value entailed on the country by the neglect of sanitary measures in the army in time of peace.”
- “The invaliding maybe more but it would probably be less than it is represented to be in Diagram II”.



India

*“I have a ‘melancholy satisfaction’ in recording that there is one government office worse organised than the War Office, and that is the great India House. 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...**”*



Notes on Hospitals 1863

Nightingale explained her view that mortality statistics gave little information on the efficiency of a hospital performance. *The Lancet* commented favourably on this publication, describing Nightingale 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.”**

Reformation of workhouses

- Pioneered the use of **trained nurses in the Liverpool Workhouse**
- Wrote a report for Parliament, entitled "Suggestions on the Subject of Providing, Training, and Organising Nurses for the Sick Poor in Workhouse Infirmaries,"
 - To insist on separating the sick, the insane, the incurable, and the children in workhouse schools into four separate divisions separate from each other and from the usual population of paupers;
 - To advocate a single central administration to ensure uniformity and economy in all workhouses;
 - To support the sick, the insane and incurable through a Medical Relief Fund to be raised through general taxes.

Champion of poor

"Never think that you have done anything effectual in nursing in London till you nurse, not only the sick poor in workhouses, but those at home."

*"At home: it is there that the bulk of sick cases are. **But where can nurses be trained for them?** In hospitals: it is there only that skilled nurses can be trained. All this makes real **nursing of the sick at home the most expensive kind of nursing at present.**"*

Training nurses and performance

According to Nightingale, the misleading use of statistics brought damage to the notion of training nurses.

“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 only represent the results of different modes of treatment.

She concluded by saying that these figures could not show the efficiency of nursing as **the trained nurses look after the more severe cases and thus their patients will inevitably have a higher mortality.**

Proposed Chair of Statistics

Nightingale and Jowett proposed a Chair of Social Physics (Statistics) at Oxford in memory of Quetelet.

The idea of this Chair was to provide the means of continuing the work in this area and, better still, introducing it to those who could best make use of it in society. It was first proposed in her essay on Quetelet's death in 1874, but the serious work was not carried out until 1890–91.

However, despite Nightingale and Jowett's lobbying, the proposal was unfortunately turned down by the Oxford authorities owing to the subject not having a Final Honour School.

Proposed Chair of Statistics

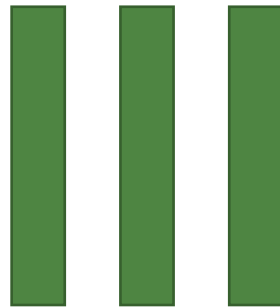
- Regardless of this, in 1891, Oxford did appoint a statistician, Francis Ysidro Edgeworth, to a Chair, although this was a Chair in Political Economy rather than Statistics. Edgeworth went on to receive the Royal Statistical Society's (RSS) Guy Medal in 1907 and served as the President of the RSS during 1912–14.
- **There can be no doubt that Nightingale's work, bringing statistics into the public domain, helped to contribute to the acceptance of statistics as a worthwhile academic subject in its own right.**

Conclusion

- Her guidelines on the collection of hospital statistics were ratified by the ISC, and this and her work comparing the mortality rates of the army at rest with the civic male population **paved the way for new guidelines concerning the construction of new barracks and hospitals**. These, in turn, played a major role in **improving the health of the armed forces and gaining Nightingale recognition as a statistician**.
- Nightingale's analytical work **helped government and the armed forces to make better decisions**.
- As a result of her diagrams representing mortality data, **government statistics were never the same again**. Indeed, her easy-to-visualise charts were taken up subsequently in the routine publication of census and other data.

The main aim of statistics

*“The main end of statistics should not be to inform the government as to how many men have died, but **to enable immediate steps to be taken to prevent the extension of disease and mortality.**”*



References

- Slide 3 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.
- Slide 7 Nightingale, Florence. 1828. Letter to Grandmother. Wellcome 8991/3. <http://www.uoguelph.ca/~cwfn/archival/index.htm>. Accessed 29 October 2016.
- Slide 8 Nightingale, Florence. 1830. Letter to Parthenope Nightingale. Wellcome 8991/3. <http://www.uoguelph.ca/~cwfn/archival/index.htm>. Accessed 29 October 2016.
- Slide 9 Bostridge, Mark. 2008. Florence Nightingale. London: Penguin Books.
- Slide 10 Nightingale, Florence. 1857. Letter to Sydney Herbert. Wiltshire County Record Office, Pembroke Collection 2057/F4/66. In McDonald, Lynn, 2010. Florence Nightingale: The Crimean War. Ontario: Wilfred Laurier University Press.

References

- Slide 11 Bostridge, Mark. 2008. Florence Nightingale. London: Penguin Books.
- Slide 25, 26, 30 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.
- Slide 38, 40 and 41 Nightingale, Florence. 1858. *Notes on Matters Affecting the Health, Efficiency and Hospital Administration of the British Army*. London: Harrison and Sons.
- Slide 44 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.
- Slide 45 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.
- Slide 47 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.
- Slide 49 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.
- Slide 40 Wellcome Library, London. 2016. The Collections at the Wellcome Library. <http://wellcomelibrary.org/collections/>. Accessed 30 October 2016.