

Identifying Signature Features of Epidemic Diseases in 19th Century All-cause Mortality Data

Rasmus Kristoffer Pedersen

Postdoc, PandemiX Center
Dept. Science and Environment,
Roskilde University, Denmark
Email: rakrpe@ruc.dk

Joint work with

*Mathias Mølbak Ingholt, Maarten van Wijhe,
Viggo Andreasen & Lone Simonsen*

Epidemics 9, November 30th, 2023



Danmarks
Grundforskningsfond
Danish National
Research Foundation

Introduction

- ▶ Historical data provides us with more examples of epidemics than modern data alone.

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

General discussion



Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

General discussion

Introduction

- ▶ Historical data provides us with more examples of epidemics than modern data alone.
- ▶ Our response to emerging diseases come from historical experience.





Image from The New York Times article "*The Mask Slackers of 1918*", Aug. 3, 2020
<https://www.nytimes.com/2020/08/03/us/mask-protests-1918.html>



Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

General discussion

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

General discussion

- ▶ Historical data provides us with more examples of epidemics than modern data alone.
- ▶ Our response to emerging diseases come from historical experience.
 - ▶ Quarantine - e.g. plague
 - ▶ Restriction of movement (*cordon sanitaire*) - e.g. cholera
 - ▶ Social distancing - e.g. 1918 influenza
 - ▶ Masks - e.g. 1918 influenza



Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Representative signature
features

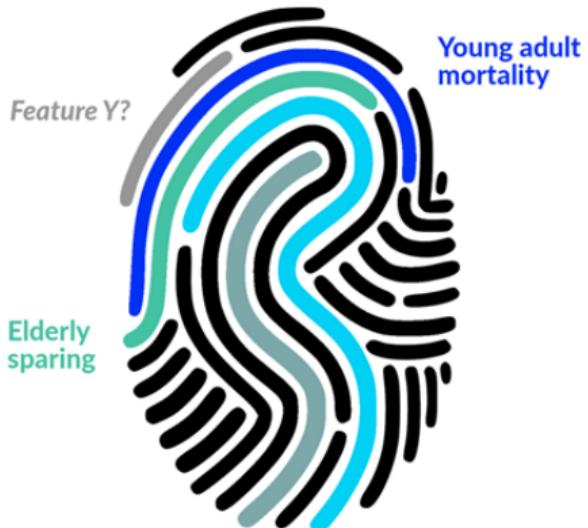
Grouping crises

General discussion

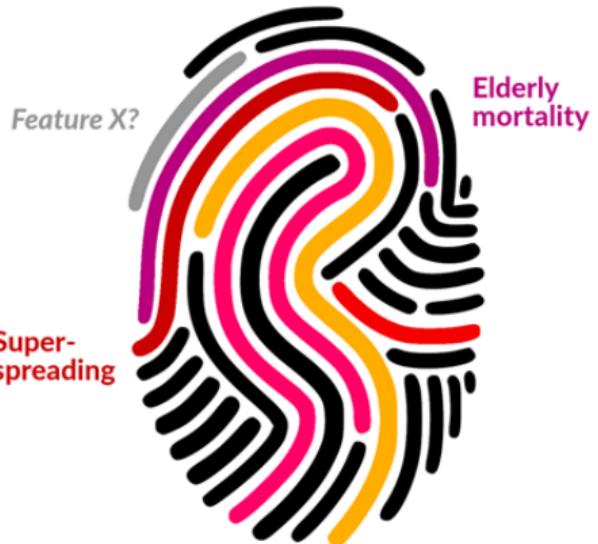
- ▶ Historical data provides us with more examples of epidemics than modern data alone.
- ▶ Our response to emerging diseases come from historical experience.
 - ▶ Quarantine - e.g. plague
 - ▶ Restriction of movement (*cordon sanitaire*) - e.g. cholera
 - ▶ Social distancing - e.g. 1918 influenza
 - ▶ Masks - e.g. 1918 influenza
- ▶ The pandemics of recent years may only be a subset of potential threats to consider for surveillance.



1918 Influenza



SARS-CoV-2



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Representative signature
features

Grouping crises

General discussion

Overview of talk

In this talk, I will talk about:

- Our recent study of epidemics in 19th century Denmark.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**Representative signature
features

Grouping crises

General discussion

Overview of talk

In this talk, I will talk about:

- ▶ Our recent study of epidemics in 19th century Denmark.
- ▶ Mortality baseline calculation.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**Representative signature
features

Grouping crises

General discussion

Overview of talk

In this talk, I will talk about:

- ▶ Our recent study of epidemics in 19th century Denmark.
- ▶ Mortality baseline calculation.
- ▶ Age pattern analysis.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**Representative signature
features

Grouping crises

General discussion

Overview of talk

In this talk, I will talk about:

- ▶ Our recent study of epidemics in 19th century Denmark.
- ▶ Mortality baseline calculation.
- ▶ Age pattern analysis.
- ▶ Reflect on what we learned.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Data source

No.	Dødsdagen.	Begravelsedagen.	Den Dødes Navn og tilnavn.	Stand, Haandtering og Opbevaring.	Ålder.	Hvem an- først i det almindeligt gæ. Den foretak Registret.	Emner.
35.	29. August	4. Sept.	Jønders Jønson	Fus i Kjøbge	53 Års	692. 138	
36.	31. August	4. Sept.	Hans Carlsen	Fus. i Skælvøen	63 Års	692. 139	
37.	30. August	3. Sept.	Ole Jensen	Ukjendmann i Skælvøen	39 Års	692. 140	
38.	3. Sept.	7. Sept.	Olger Larsen	Fus i Kjøbge	70 Års	692. 141	
39.	31. August	4. Sept.	Hans Olen	Fus og Enge i Kjøbge	42 Års	692. 142	
40.	4. Sept.	6. Sept.	Niels Pedersen	Fus. i en afgrøde	61 Års	692. 143	
41.	5. Sept.	9. Sept.	Ole Hansen	Ukjendmann i Kjøbge	63 Års	692. 144	
42.	4. Sept.	9. Sept.	Niels Christensen	Fus i Kysten	57 Års	692. 145	
43.	7. Sept.	12. Sept.	Niels Larsen	Fus. i Kysten	80 Års	692. 146	
44.	6. Sept.	12. Sept.	Jens Andersen	Ukjendmann i en afgrøde	62 Års	692. 147	
45.	8. Sept.	13. Sept.	Hans Lachsen	Fus i Kysten	42 Års	692. 148	
46.	5. Sept.	9. Sept.	Lars Christophersen	Ukjendmann i Skælvøen	9.3. Års	692. 149	
47.	12. Sept.	16. Sept.	Kristian Thomassen	Fus i Skælvøen	78 Års	692. 150	
48.	11. Sept.	14. Sept.	Tharic Larsen	Fus i Skælvøen	49 Års	692. 151	



Data source

Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

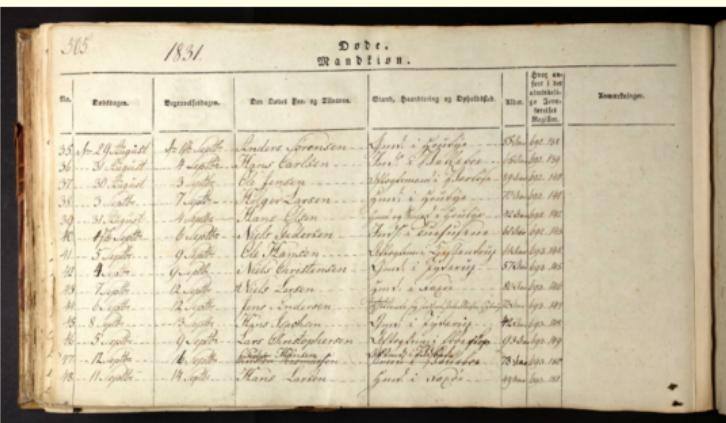
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

General discussion



Scan of parish register for "Fakse" parish.

Data source

- Parish registers for Danish church parishes between 1815-1915
- Approximately 4 million burials

MS 1831

Døde.

Ramfjord.

nr.	Eftfølger.	Baptismal dato.	Dødels dato.	Årsak til døden og dødsårsak.	Begravelses dato.	Tilhørige.
25.	Jørgen Christ.	1. 1. 1810	Lindet. Sørensen	Avd. i 1810	1810. 1. 1. 1810	
26.	3. Sigurd.	8. 1. 1810	Hans Carlsen	Avd. i 1810	1810. 1. 1. 1810	
27.	30. Sigurd.	3. 1. 1810	Ole Jensen	Aldermanns døde	1810. 1. 1. 1810	
28.	3. Otto.	7. 1. 1810	Hans Larsen	Quæst. i 1810	1810. 1. 1. 1810	
29.	31. Sigurd.	4. 1. 1810	Hans Olof	Quæst. i 1810	1810. 1. 1. 1810	
30.	1. Peter.	6. 1. 1810	Niels Andersen	Port. i 1810	1810. 1. 1. 1810	
31.	2. Peter.	6. 1. 1810	Ole Hansen	Aldermanns døde	1810. 1. 1. 1810	
32.	3. Peter.	9. 1. 1810	Ole Hansen	Aldermanns døde	1810. 1. 1. 1810	
33.	4. Peter.	9. 1. 1810	Niels Christensen	Quæst. i 1810	1810. 1. 1. 1810	
34.	5. Peter.	1. 2. 1810	Ole Hansen	Quæst. i 1810	1810. 1. 1. 1810	
35.	6. Peter.	1. 2. 1810	Jens. Sørensen	Aldermanns døde	1810. 1. 1. 1810	
36.	7. Peter.	3. 2. 1810	Hans. Larsen	Quæst. i 1810	1810. 1. 1. 1810	
37.	8. Peter.	4. 2. 1810	Niels Christensen	Aldermanns døde	1810. 1. 1. 1810	
38.	9. Peter.	4. 2. 1810	Niels Christensen	Aldermanns døde	1810. 1. 1. 1810	
39.	10. Peter.	11. 2. 1810	Hans. Hansen	Quæst. i 1810	1810. 1. 1. 1810	
40.	11. Peter.	14. 2. 1810	Hans. Larsen	Quæst. i 1810	1810. 1. 1. 1810	

Scan of parish register for "Fakse" parish.

Data source

- ▶ Parish registers for Danish church parishes between 1815-1915
 - ▶ Approximately 4 million burials
 - ▶ Individual level information
Includes date of death, date of burial, gender, age and parish

Nr.	Festtagen.	Begrænselsdatoen.	Den første Fest ved tilkørsel.	Dato, Bemærkning og Deltagelse.	Størst. af de fest. i kvar størrelse med første Begiven.	Tidspunkte.
25.	1. d. 24. August	1. d. 24. August	Lindens Søndre	Fest i Lindens Søndre	Slægt. 94	
26.	2. d. 25. August	2. d. 25. August	Hans Carsten	Fest i Hans Carsten	Slægt. 124	
27.	3. d. 26. August	3. d. 26. August	Cla. Jensen	Slægtensmøn i Cla. Jense	Slægt. 107	
28.	4. d. 27. August	4. d. 27. August	Egger Larsen	fest i Egger Larsen	Slægt. 106	
29.	5. d. 28. August	5. d. 28. August	Hans Elton	fest i Elton	Slægt. 96	
30.	6. d. 29. August	6. d. 29. August	Niels Elton	fest i Niels Elton	Slægt. 96	
31.	7. d. 30. August	7. d. 30. August	Viggo Andersen	Fest i Viggo Andersen	Slægt. 96	
32.	8. d. 31. August	8. d. 31. August	Cla. Hansen	Fest i Cla. Hansen	Slægt. 96	
33.	9. d. 1. Sept.	9. d. 1. Sept.	Cla. Hansen	Slægtensmøn i Cla. Hansen	Slægt. 96-97	
34.	10. d. 2. Sept.	10. d. 2. Sept.	Niels Christensen	Fest i Niels Christensen	Slægt. 96	
35.	11. d. 3. Sept.	11. d. 3. Sept.	Viggo Leth	fest i Viggo Leth	Slægt. 96	
36.	12. d. 4. Sept.	12. d. 4. Sept.	Jens Endresen	fest i Jens Endresen	Slægt. 96-97	
37.	13. d. 5. Sept.	13. d. 5. Sept.	Hans Carsten	Fest i Hans Carsten	Klæmme. 20	
38.	14. d. 6. Sept.	14. d. 6. Sept.	Lars Christensen	Gjæstegæst i Lars Christensen	Slægt. 97	
39.	15. d. 7. Sept.	15. d. 7. Sept.	Andreas Hansen	fest i Andreas Hansen	Slægt. 100-101	
40.	16. d. 8. Sept.	16. d. 8. Sept.	Hans Larsen	fest i Hans Larsen	Slægt. 100-101	

Scan of parish register for "Fakse" parish.

Data source

- Parish registers for Danish church parishes between 1815-1915
- Approximately 4 million burials
- Individual level information
 - Includes date of death, date of burial, gender, age and parish
- Property of the Danish National Archives, but digitized and transcribed by *Ancestry*

Sn.	Født.	Døde.	Dødsdag.	Årsal.	Bur.	Tidspunkt af Begravelse.	Sted.	Antal dage fra Begravelse.	Antal dage fra Begravelse.	Tidspunkt af Begravelse.
25.	Jørgen	Søren	1. Jan.	1831	1. Jan.	1831	Kjøbmanden	1831	1831	1831
26.	3. Søn	Hans	2. Jan.	1831	2. Jan.	1831	Kjøbmanden	1831	1831	1831
27.	3. Søn	Oluf	3. Jan.	1831	3. Jan.	1831	Kjøbmanden	1831	1831	1831
28.	3. Søn	Niels	7. Jan.	1831	7. Jan.	1831	Kjøbmanden	1831	1831	1831
29.	3. Søn	Niels	11. Jan.	1831	11. Jan.	1831	Kjøbmanden	1831	1831	1831
30.	3. Søn	Niels	12. Jan.	1831	12. Jan.	1831	Kjøbmanden	1831	1831	1831
31.	3. Søn	Niels	13. Jan.	1831	13. Jan.	1831	Kjøbmanden	1831	1831	1831
32.	3. Søn	Niels	14. Jan.	1831	14. Jan.	1831	Kjøbmanden	1831	1831	1831
33.	3. Søn	Niels	15. Jan.	1831	15. Jan.	1831	Kjøbmanden	1831	1831	1831
34.	3. Søn	Niels	16. Jan.	1831	16. Jan.	1831	Kjøbmanden	1831	1831	1831
35.	3. Søn	Niels	17. Jan.	1831	17. Jan.	1831	Kjøbmanden	1831	1831	1831
36.	3. Søn	Niels	18. Jan.	1831	18. Jan.	1831	Kjøbmanden	1831	1831	1831
37.	3. Søn	Niels	19. Jan.	1831	19. Jan.	1831	Kjøbmanden	1831	1831	1831
38.	3. Søn	Niels	20. Jan.	1831	20. Jan.	1831	Kjøbmanden	1831	1831	1831
39.	3. Søn	Niels	21. Jan.	1831	21. Jan.	1831	Kjøbmanden	1831	1831	1831
40.	3. Søn	Niels	22. Jan.	1831	22. Jan.	1831	Kjøbmanden	1831	1831	1831
41.	3. Søn	Niels	23. Jan.	1831	23. Jan.	1831	Kjøbmanden	1831	1831	1831
42.	3. Søn	Niels	24. Jan.	1831	24. Jan.	1831	Kjøbmanden	1831	1831	1831
43.	3. Søn	Niels	25. Jan.	1831	25. Jan.	1831	Kjøbmanden	1831	1831	1831
44.	3. Søn	Niels	26. Jan.	1831	26. Jan.	1831	Kjøbmanden	1831	1831	1831
45.	3. Søn	Niels	27. Jan.	1831	27. Jan.	1831	Kjøbmanden	1831	1831	1831
46.	3. Søn	Niels	28. Jan.	1831	28. Jan.	1831	Kjøbmanden	1831	1831	1831
47.	3. Søn	Niels	29. Jan.	1831	29. Jan.	1831	Kjøbmanden	1831	1831	1831
48.	3. Søn	Niels	30. Jan.	1831	30. Jan.	1831	Kjøbmanden	1831	1831	1831
49.	3. Søn	Niels	31. Jan.	1831	31. Jan.	1831	Kjøbmanden	1831	1831	1831
50.	3. Søn	Niels	1. Feb.	1831	1. Feb.	1831	Kjøbmanden	1831	1831	1831
51.	3. Søn	Niels	2. Feb.	1831	2. Feb.	1831	Kjøbmanden	1831	1831	1831
52.	3. Søn	Niels	3. Feb.	1831	3. Feb.	1831	Kjøbmanden	1831	1831	1831
53.	3. Søn	Niels	4. Feb.	1831	4. Feb.	1831	Kjøbmanden	1831	1831	1831
54.	3. Søn	Niels	5. Feb.	1831	5. Feb.	1831	Kjøbmanden	1831	1831	1831
55.	3. Søn	Niels	6. Feb.	1831	6. Feb.	1831	Kjøbmanden	1831	1831	1831
56.	3. Søn	Niels	7. Feb.	1831	7. Feb.	1831	Kjøbmanden	1831	1831	1831
57.	3. Søn	Niels	8. Feb.	1831	8. Feb.	1831	Kjøbmanden	1831	1831	1831
58.	3. Søn	Niels	9. Feb.	1831	9. Feb.	1831	Kjøbmanden	1831	1831	1831
59.	3. Søn	Niels	10. Feb.	1831	10. Feb.	1831	Kjøbmanden	1831	1831	1831
60.	3. Søn	Niels	11. Feb.	1831	11. Feb.	1831	Kjøbmanden	1831	1831	1831
61.	3. Søn	Niels	12. Feb.	1831	12. Feb.	1831	Kjøbmanden	1831	1831	1831
62.	3. Søn	Niels	13. Feb.	1831	13. Feb.	1831	Kjøbmanden	1831	1831	1831
63.	3. Søn	Niels	14. Feb.	1831	14. Feb.	1831	Kjøbmanden	1831	1831	1831
64.	3. Søn	Niels	15. Feb.	1831	15. Feb.	1831	Kjøbmanden	1831	1831	1831
65.	3. Søn	Niels	16. Feb.	1831	16. Feb.	1831	Kjøbmanden	1831	1831	1831
66.	3. Søn	Niels	17. Feb.	1831	17. Feb.	1831	Kjøbmanden	1831	1831	1831
67.	3. Søn	Niels	18. Feb.	1831	18. Feb.	1831	Kjøbmanden	1831	1831	1831
68.	3. Søn	Niels	19. Feb.	1831	19. Feb.	1831	Kjøbmanden	1831	1831	1831
69.	3. Søn	Niels	20. Feb.	1831	20. Feb.	1831	Kjøbmanden	1831	1831	1831
70.	3. Søn	Niels	21. Feb.	1831	21. Feb.	1831	Kjøbmanden	1831	1831	1831
71.	3. Søn	Niels	22. Feb.	1831	22. Feb.	1831	Kjøbmanden	1831	1831	1831
72.	3. Søn	Niels	23. Feb.	1831	23. Feb.	1831	Kjøbmanden	1831	1831	1831
73.	3. Søn	Niels	24. Feb.	1831	24. Feb.	1831	Kjøbmanden	1831	1831	1831
74.	3. Søn	Niels	25. Feb.	1831	25. Feb.	1831	Kjøbmanden	1831	1831	1831
75.	3. Søn	Niels	26. Feb.	1831	26. Feb.	1831	Kjøbmanden	1831	1831	1831
76.	3. Søn	Niels	27. Feb.	1831	27. Feb.	1831	Kjøbmanden	1831	1831	1831
77.	3. Søn	Niels	28. Feb.	1831	28. Feb.	1831	Kjøbmanden	1831	1831	1831
78.	3. Søn	Niels	29. Feb.	1831	29. Feb.	1831	Kjøbmanden	1831	1831	1831
79.	3. Søn	Niels	30. Feb.	1831	30. Feb.	1831	Kjøbmanden	1831	1831	1831
80.	3. Søn	Niels	1. Mar.	1831	1. Mar.	1831	Kjøbmanden	1831	1831	1831
81.	3. Søn	Niels	2. Mar.	1831	2. Mar.	1831	Kjøbmanden	1831	1831	1831
82.	3. Søn	Niels	3. Mar.	1831	3. Mar.	1831	Kjøbmanden	1831	1831	1831
83.	3. Søn	Niels	4. Mar.	1831	4. Mar.	1831	Kjøbmanden	1831	1831	1831
84.	3. Søn	Niels	5. Mar.	1831	5. Mar.	1831	Kjøbmanden	1831	1831	1831
85.	3. Søn	Niels	6. Mar.	1831	6. Mar.	1831	Kjøbmanden	1831	1831	1831
86.	3. Søn	Niels	7. Mar.	1831	7. Mar.	1831	Kjøbmanden	1831	1831	1831
87.	3. Søn	Niels	8. Mar.	1831	8. Mar.	1831	Kjøbmanden	1831	1831	1831
88.	3. Søn	Niels	9. Mar.	1831	9. Mar.	1831	Kjøbmanden	1831	1831	1831
89.	3. Søn	Niels	10. Mar.	1831	10. Mar.	1831	Kjøbmanden	1831	1831	1831
90.	3. Søn	Niels	11. Mar.	1831	11. Mar.	1831	Kjøbmanden	1831	1831	1831
91.	3. Søn	Niels	12. Mar.	1831	12. Mar.	1831	Kjøbmanden	1831	1831	1831
92.	3. Søn	Niels	13. Mar.	1831	13. Mar.	1831	Kjøbmanden	1831	1831	1831
93.	3. Søn	Niels	14. Mar.	1831	14. Mar.	1831	Kjøbmanden	1831	1831	1831
94.	3. Søn	Niels	15. Mar.	1831	15. Mar.	1831	Kjøbmanden	1831	1831	1831
95.	3. Søn	Niels	16. Mar.	1831	16. Mar.	1831	Kjøbmanden	1831	1831	1831
96.	3. Søn	Niels	17. Mar.	1831	17. Mar.	1831	Kjøbmanden	1831	1831	1831
97.	3. Søn	Niels	18. Mar.	1831	18. Mar.	1831	Kjøbmanden	1831	1831	1831
98.	3. Søn	Niels	19. Mar.	1831	19. Mar.	1831	Kjøbmanden	1831	1831	1831
99.	3. Søn	Niels	20. Mar.	1831	20. Mar.	1831	Kjøbmanden	1831	1831	1831
100.	3. Søn	Niels	21. Mar.	1831	21. Mar.	1831	Kjøbmanden	1831	1831	1831
101.	3. Søn	Niels	22. Mar.	1831	22. Mar.	1831	Kjøbmanden	1831	1831	1831
102.	3. Søn	Niels	23. Mar.	1831	23. Mar.	1831	Kjøbmanden	1831	1831	1831
103.	3. Søn	Niels	24. Mar.	1831	24. Mar.	1831	Kjøbmanden	1831	1831	1831
104.	3. Søn	Niels	25. Mar.	1831	25. Mar.	1831	Kjøbmanden	1831	1831	1831
105.	3. Søn	Niels	26. Mar.	1831	26. Mar.	1831	Kjøbmanden	1831	1831	1831
106.	3. Søn	Niels	27. Mar.	1831	27. Mar.	1831	Kjøbmanden	1831	1831	1831
107.	3. Søn	Niels	28. Mar.	1831	28. Mar.	1831	Kjøbmanden	1831	1831	1831
108.	3. Søn	Niels	29. Mar.	1831	29. Mar.	1831	Kjøbmanden	1831	1831	1831
109.	3. Søn	Niels	30. Mar.	1831	30. Mar.	1831	Kjøbmanden	1831	1831	1831
110.	3. Søn	Niels	31. Mar.	1831	31. Mar.	1831	Kjøbmanden	1831	1831	1831
111.	3. Søn	Niels	1. Apr.	1831	1. Apr.	1831	Kjøbmanden	1831	1831	1831
112.	3. Søn	Niels	2. Apr.	1831	2. Apr.	1831	Kjøbmanden	1831	1831	1831
113.	3. Søn	Niels	3. Apr.	1831	3. Apr.	1831	Kjøbmanden	1831	1831	1831
114.	3. Søn	Niels	4. Apr.	1831	4. Apr.	1831	Kjøbmanden	1831	1831	1831
115.	3. Søn	Niels	5. Apr.	1831	5. Apr.	1831	Kjøbmanden	1831	1831	1831
116.	3. Søn	Niels	6. Apr.	1831	6. Apr.	1831	Kjøbmanden	1831	1831	1831
117.	3. Søn	Niels	7. Apr.	1831	7. Apr.	1831	Kjøbmanden	1831	1831	1831
118.	3. Søn	Niels	8. Apr.	1831	8. Apr.	1831	Kjøbmanden	1831	1831	1831
119.	3. Søn	Niels	9. Apr.	1831	9. Apr.	1831	Kjøbmanden	1831	1831	1831
120.	3. Søn	Niels	10. Apr.	1831	10. Apr.	1831	Kjøbmanden	1831	1831	1831
121.	3. Søn	Niels	11. Apr.	1831	11. Apr.	1831	Kjøbmanden	1831	1831	1831
122.	3. Søn	Niels	12. Apr.	1831	12. Apr.	1831	Kjøbmanden	1831	1831	1831
123.	3. Søn	Niels	13. Apr.	1831	13. Apr.	1831	Kjøbmanden	1831	1831	1831
124.	3. Søn	Niels	14. Apr.	1831	14. Apr.	1831	Kjøbmanden	1831	1831	1831
125.	3. Søn	Niels	15. Apr.	1831	15. Apr.	1831	Kjøbmanden	1831	1831	1831
126.	3. Søn	Niels	16. Apr.	1831	16. Apr.	1831	Kjøbmanden	1831	1831	1831
127.	3. Søn	Niels	17. Apr.	1831	17. Apr.	1831	Kjøbmanden	1831	1831	1831
128.	3. Søn	Niels	18. Apr.	1831	18. Apr.	1831	Kjøbmanden	1831	1831	1831
129.	3. Søn	Niels	19. Apr.	1831	19. Apr.	1831	Kjøbmanden	1831	1831	1831
130.	3. Søn	Niels	20. Apr.	1831	20. Apr.	1831	Kjøbmanden	1831	1831	1831
131.	3. Søn	Niels	21. Apr.	1831	21. Apr.	1831	Kjøbmanden	1831	1831	1831
132.	3. Søn	Niels	22. Apr.	1831	22. Apr.	1831	Kjøbmanden	1831	1831	1831
133.	3. Søn	Niels	23. Apr.	1831	23. Apr.	1831	Kjøbmanden	1831	1831	1831
134.	3. Søn	Niels	24. Apr.	1831	24. Apr.	1831	Kjøbmanden	1831	1831	1831
135.	3. Søn	Niels	25. Apr.	1831	25. Apr.	1831	Kjøbmanden	1831		

Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Data cleaning and managing

Date of burial	Name	Age	Gender	Amt	Sogn
1857-01-02	Ane Kirstine Christensen	2	Female	Thisted Amt	Jannerup Sogn (Thisted Amt)
1857-01-02	Birthe Marie Christensen.	0	Female	Thisted Amt	Hundborg Sogn
1857-01-02	Ane Marie Mortensdatter	81	Female	Thisted Amt	Vejerslev Sogn (Mors)
1857-01-02	Gjertrud Jensdatter	82	Female	Thisted Amt	Thisted Sogn
1857-01-02	Karen Christensdatter Wiilsbøll	52	Female	Thisted Amt	Vester Vandet Sogn
1857-01-02	Karen Marie Jensen	21	Female	Thisted Amt	Sennels Sogn
1857-01-02	Ane Christensdatter Krogh	76	Female	Thisted Amt	Vester Vandet Sogn
1857-01-03	Anders Hansen Tülfang	79	Male	Thisted Amt	Gøttrup Sogn
1857-01-03	Marcus Christensen	6	Male	Thisted Amt	Hunstrup Sogn
1857-01-04	Maren Jensen	0	Female	Thisted Amt	Hillerslev Sogn (Thisted Amt)
1857-01-04	Thomas Jensen	0	Male	Thisted Amt	Flade Sogn (Thisted Amt)
1857-01-04	Niels Madsen Thÿstrup	74	Male	Thisted Amt	Skjoldborg Sogn
1857-01-04	Poul Pedersen	72	Male	Thisted Amt	Villerslev Sogn
1857-01-04	Oline Christine Christensen	1	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)
1857-01-04	Maren Cathrine Nielsen	2	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)



Data cleaning and managing

Date of burial	Name	Age	Gender	Amt	Sogn
1857-01-02	Anne Kirstine Christensen	2	Female	Thisted Amt	Jannerup Sogn (Thisted Amt)
1857-01-02	Birthe Marie Christensen.	0	Female	Thisted Amt	Hundborg Sogn
1857-01-02	Ane Marie Mortensdatter	81	Female	Thisted Amt	Vejerslev Sogn (Mors)
1857-01-02	Gjertrud Jensdatter	82	Female	Thisted Amt	Thisted Sogn
1857-01-02	Karen Christensdatter Wilsbøll	52	Female	Thisted Amt	Vester Vandet Sogn
1857-01-02	Karen Marie Jensen	21	Female	Thisted Amt	Sennels Sogn
1857-01-02	Ane Christensdatter Krogh	76	Female	Thisted Amt	Vester Vandet Sogn
1857-01-03	Anders Hansen Tøylfang	79	Male	Thisted Amt	Gettrup Sogn
1857-01-03	Marcus Christensen	6	Male	Thisted Amt	Hunstrup Sogn
1857-01-04	Maren Jensen	0	Female	Thisted Amt	Hillerslev Sogn (Thisted Amt)
1857-01-04	Thomas Jensen	0	Male	Thisted Amt	Flade Sogn (Thisted Amt)
1857-01-04	Niels Madsen Thystrup	74	Male	Thisted Amt	Skjoldborg Sogn
1857-01-04	Poul Pedersen	72	Male	Thisted Amt	Villerslev Sogn
1857-01-04	Oline Christine Christensen	1	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)
1857-01-04	Maren Cathrine Nielsen	2	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)

- ▶ Temporal resolution:
- ▶ Daily

- ▶ Geographical resolution:
- ▶ Individual parishes



Data cleaning and managing

Date of burial	Name	Age	Gender	Amt	Sogn
1857-01-02	Anne Kirstine Christensen	2	Female	Thisted Amt	Jannerup Sogn (Thisted Amt)
1857-01-02	Birthe Marie Christensen.	0	Female	Thisted Amt	Hundborg Sogn
1857-01-02	Ane Marie Mortensdatter	81	Female	Thisted Amt	Vejerslev Sogn (Mors)
1857-01-02	Gjertrud Jensdatter	82	Female	Thisted Amt	Thisted Sogn
1857-01-02	Karen Christensdatter Wilbøll	52	Female	Thisted Amt	Vester Vandet Sogn
1857-01-02	Karen Marie Jensen	21	Female	Thisted Amt	Sennels Sogn
1857-01-02	Ane Christensdatter Krogh	76	Female	Thisted Amt	Vester Vandet Sogn
1857-01-03	Anders Hansen Tøylfang	79	Male	Thisted Amt	Gettrup Sogn
1857-01-03	Marcus Christensen	6	Male	Thisted Amt	Hunstrup Sogn
1857-01-04	Maren Jensen	0	Female	Thisted Amt	Hillerslev Sogn (Thisted Amt)
1857-01-04	Thomas Jensen	0	Male	Thisted Amt	Flade Sogn (Thisted Amt)
1857-01-04	Niels Madsen Thystrup	74	Male	Thisted Amt	Skjoldborg Sogn
1857-01-04	Poul Pedersen	72	Male	Thisted Amt	Villerslev Sogn
1857-01-04	Oline Christine Christensen	1	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)
1857-01-04	Maren Cathrine Nielsen	2	Female	Thisted Amt	Kollerup Sogn (Thisted Amt)

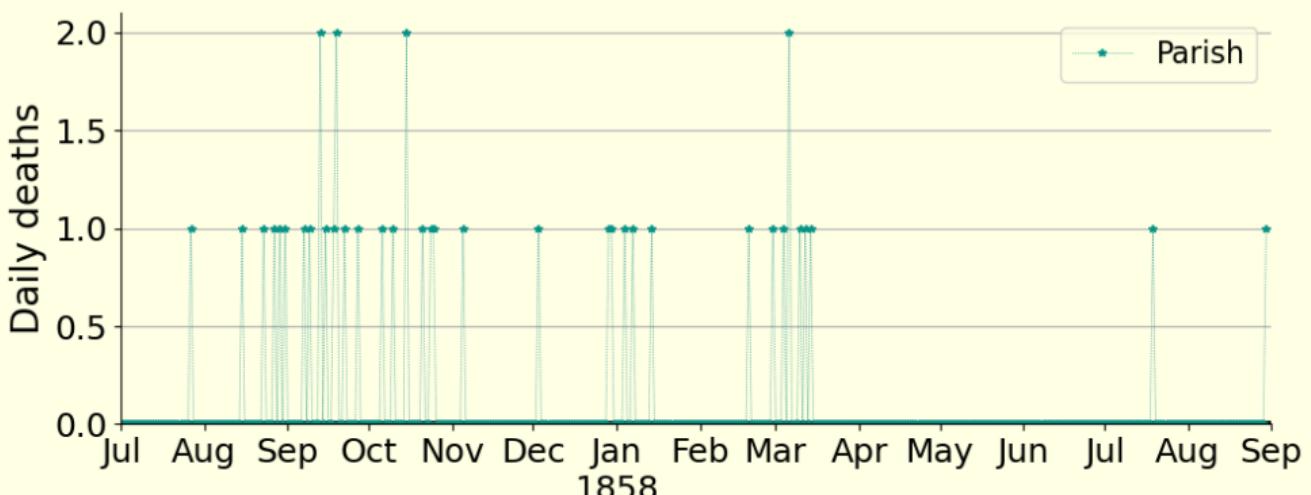
► Temporal resolution:

- Daily
- Weekly
- Monthly
- Yearly

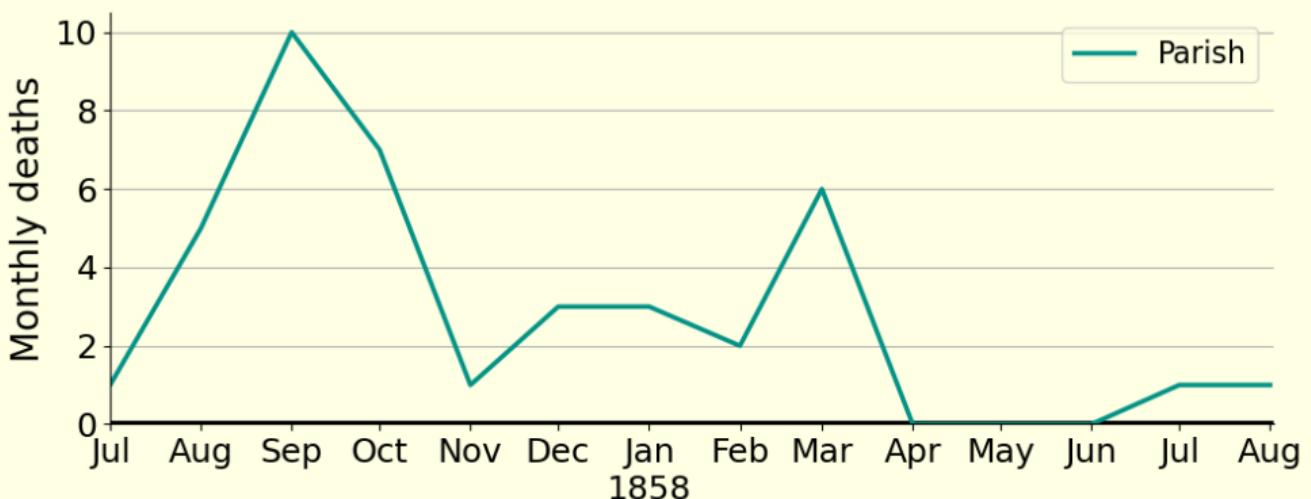
► Geographical resolution:

- Individual parishes
- Shire
(groups of 5 to 10 parishes)
- Counties
(groups of 5 to 10 shires)





Data cleaning and managing



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

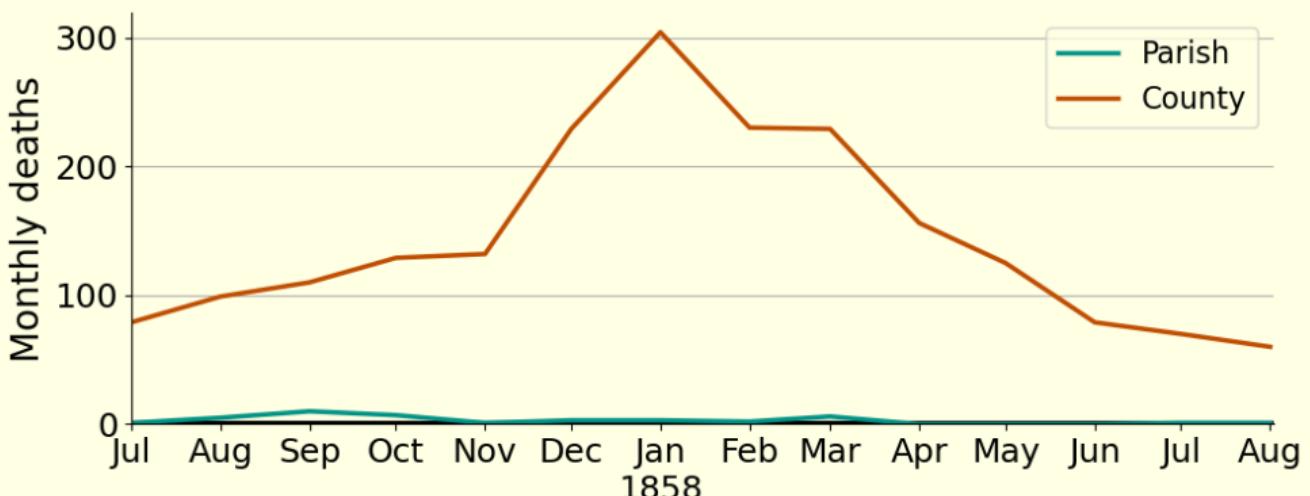
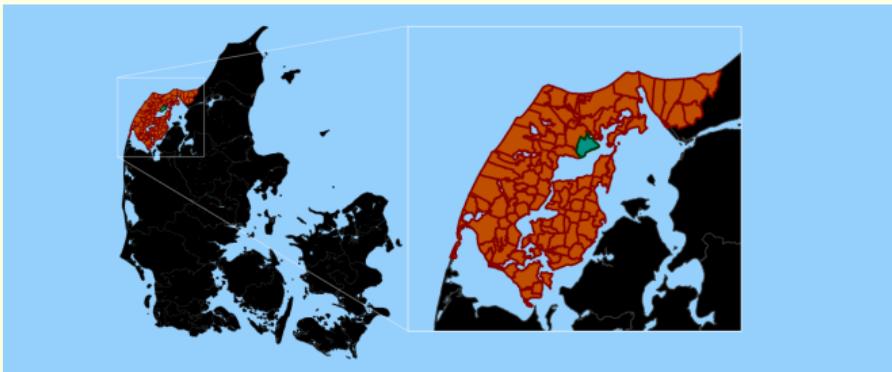
Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

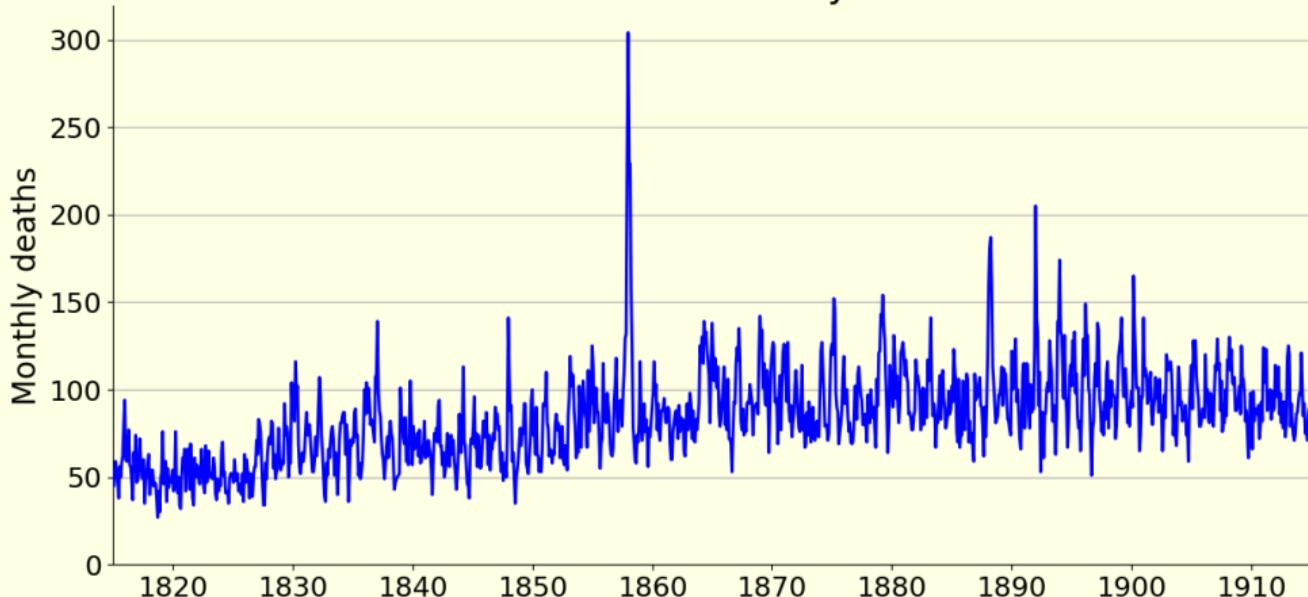
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

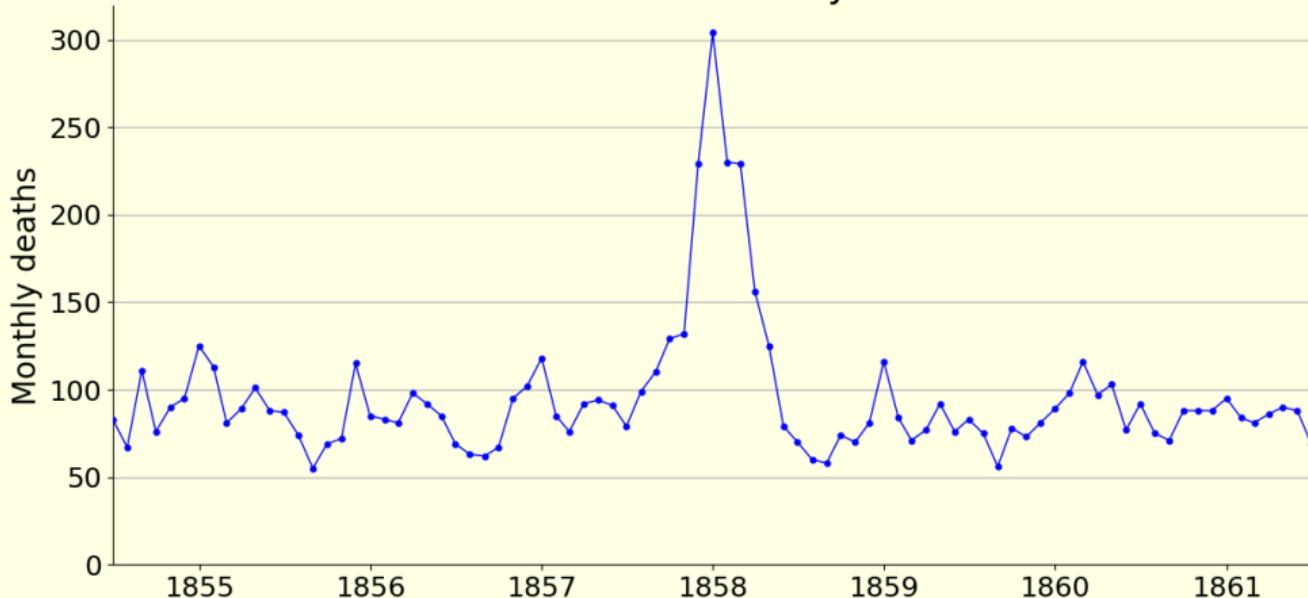
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

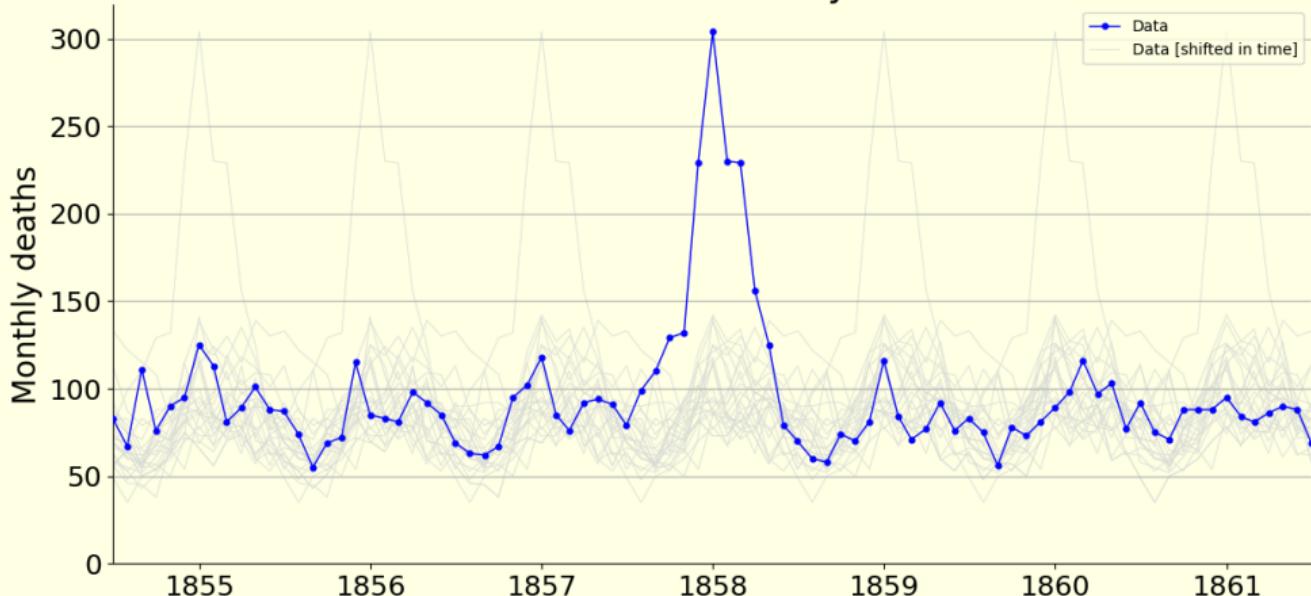
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

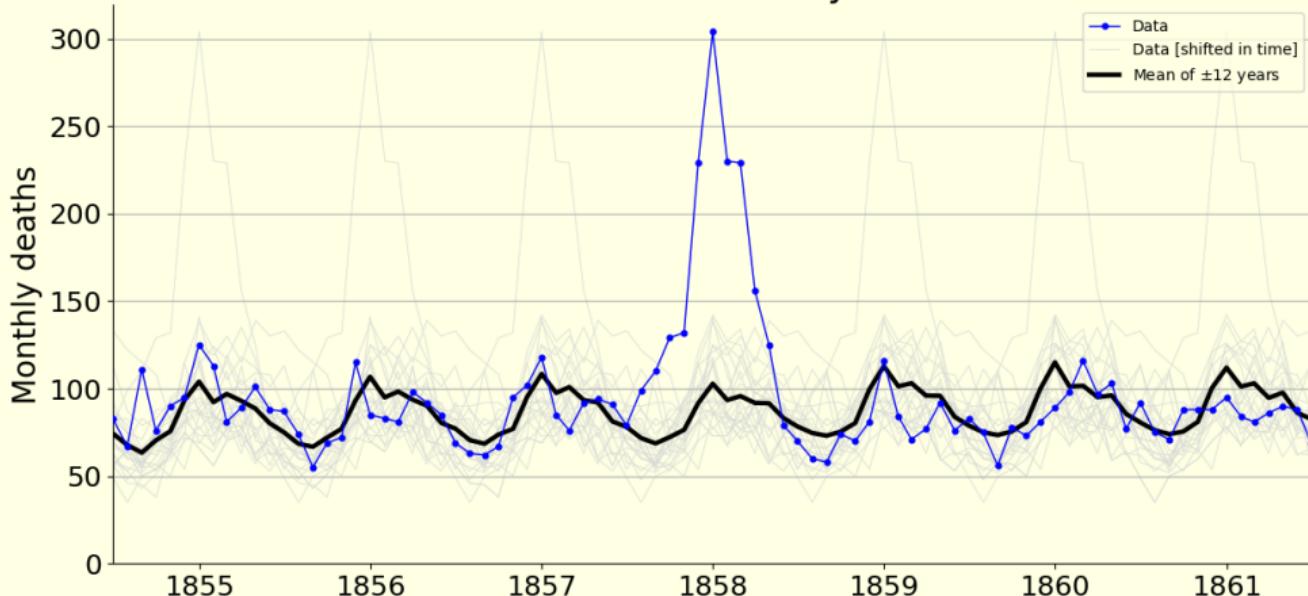
Calculating the mortality baseline

Thisted county



Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

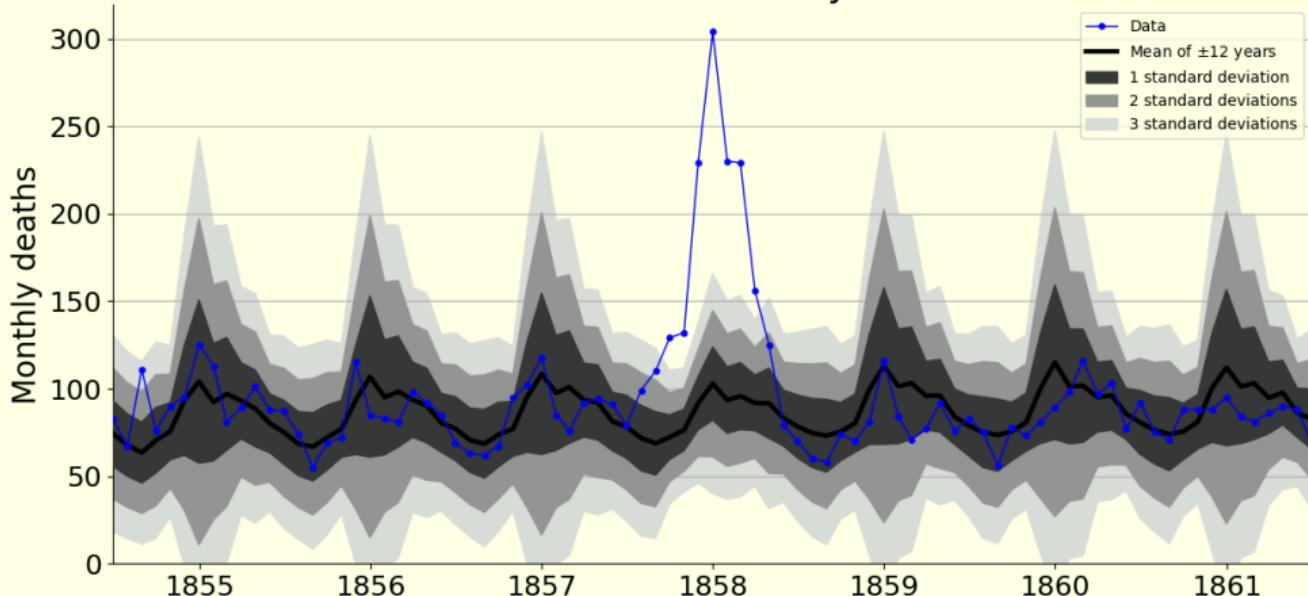
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

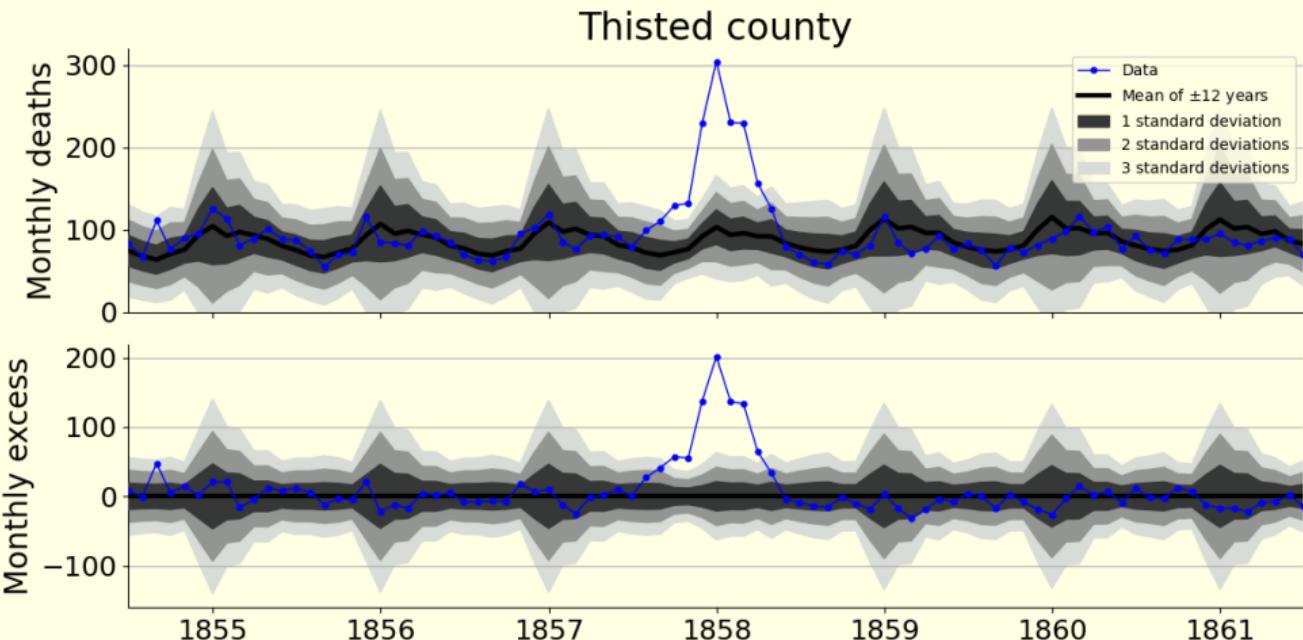
Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

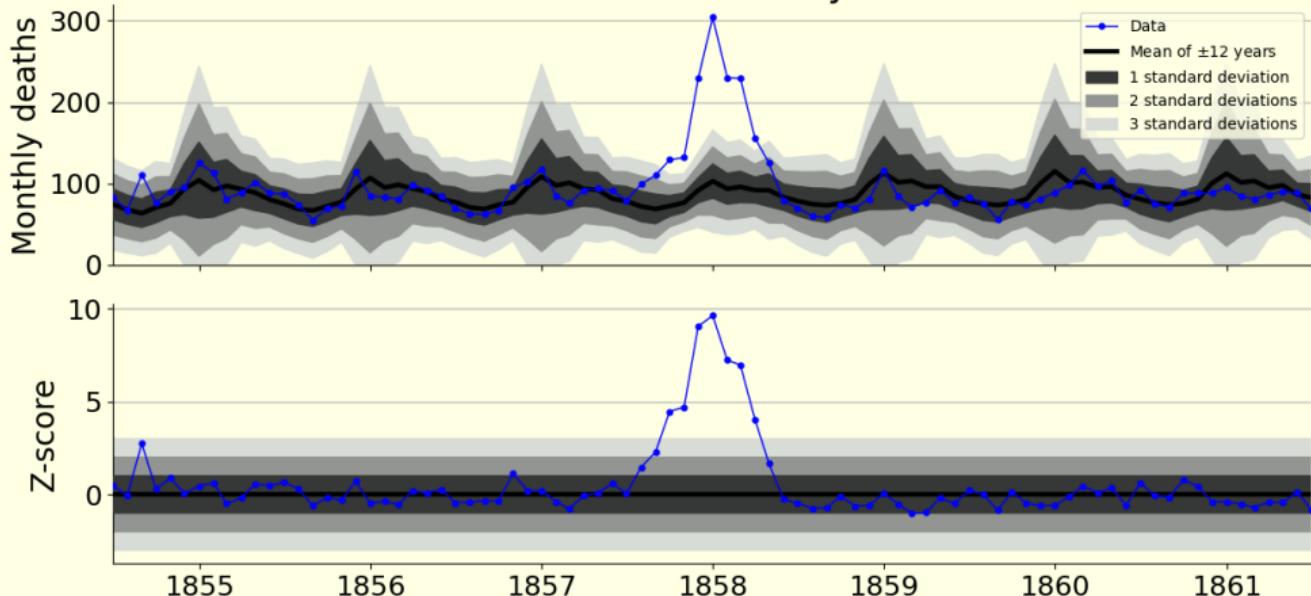
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

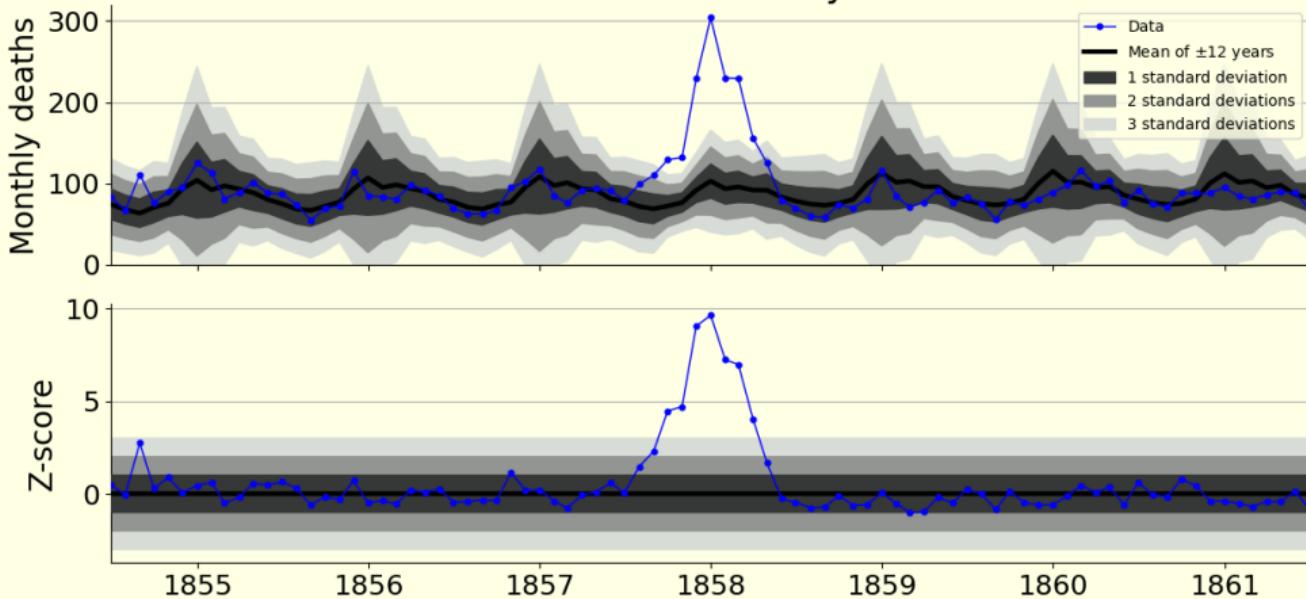
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



From historical demography¹: "Mortality crisis" when Z-score above two.

¹ A. Hinde (2010) "A review of methods for identifying mortality 'crises' using parish record data" - Local Population Studies



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

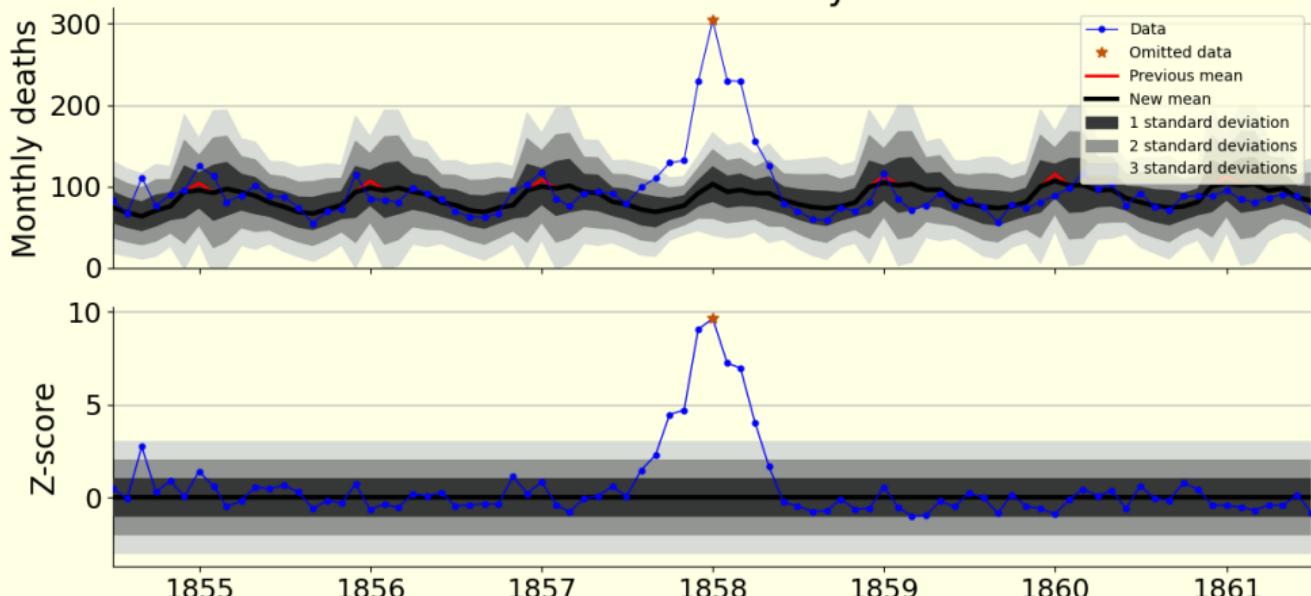
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

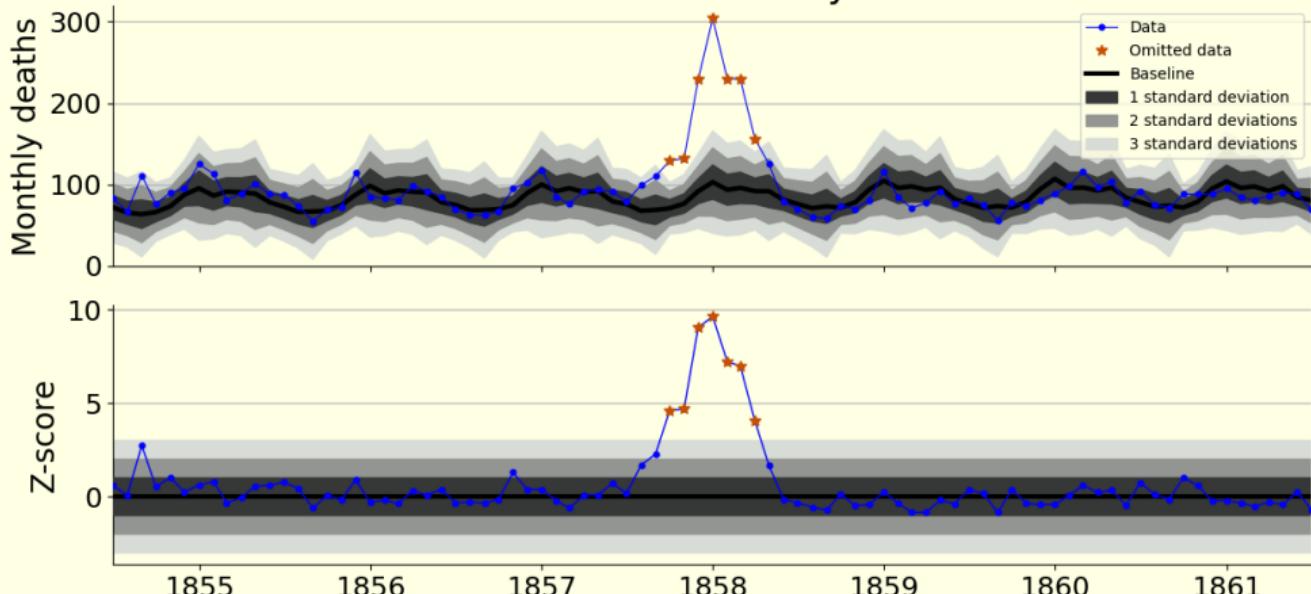
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

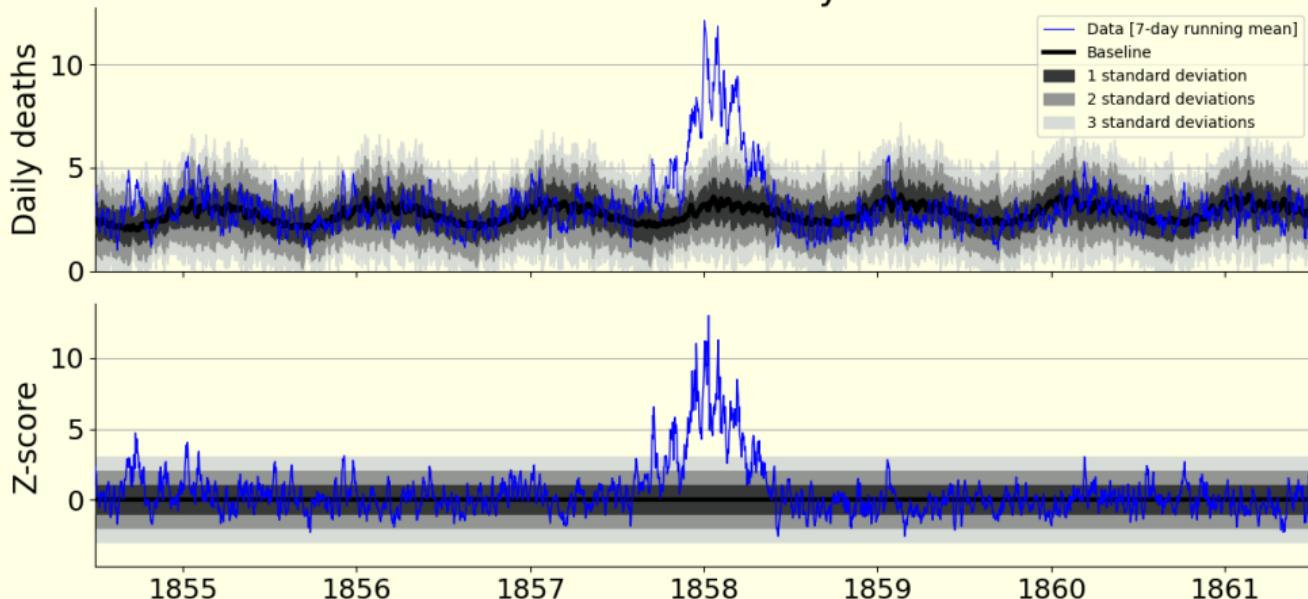
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Calculating the mortality baseline

Thisted county



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

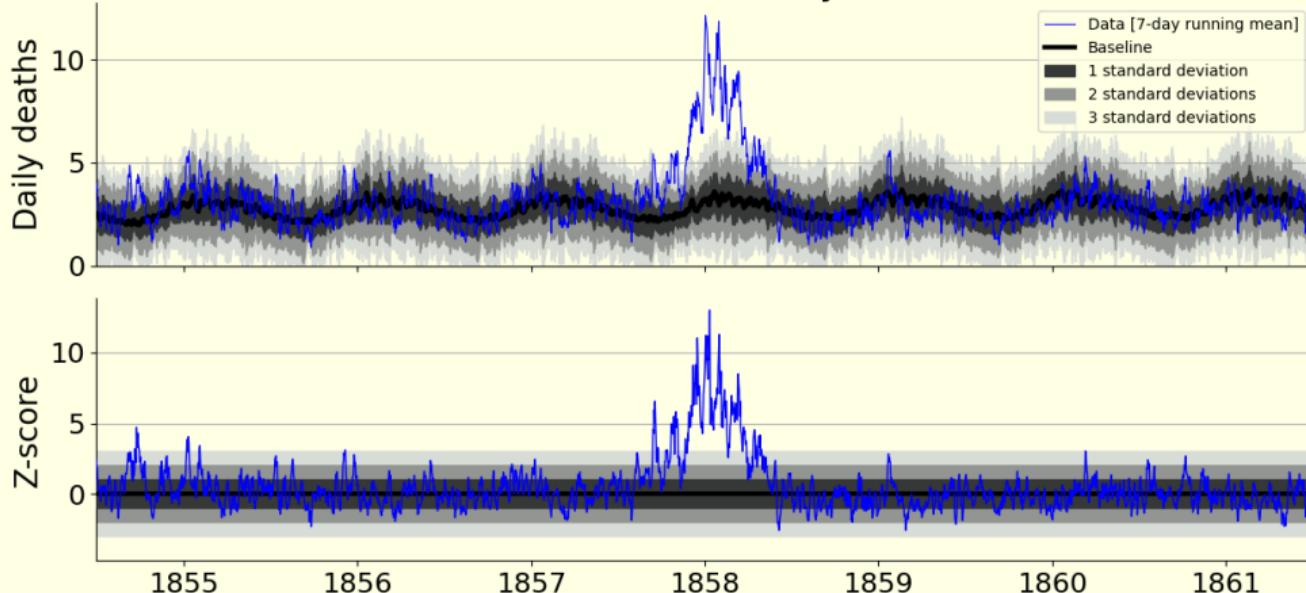
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Identification of "mortality crises"

Thisted county



We wish to identify continuous periods of excess mortality.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

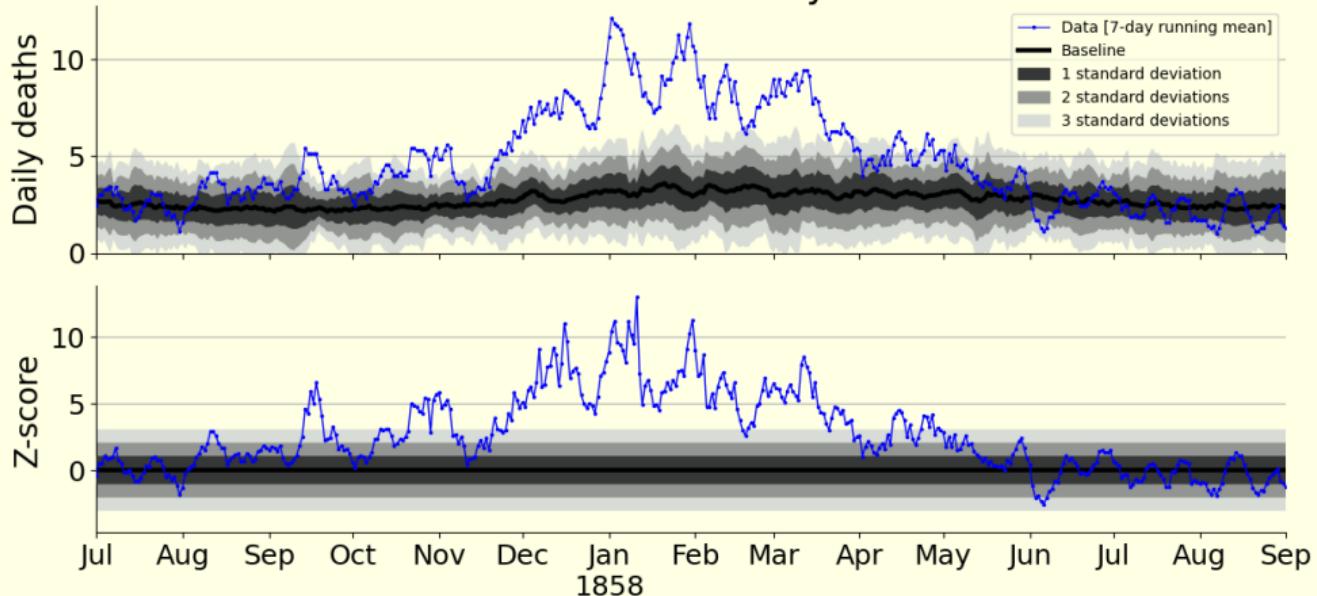
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Identification of “mortality crises”

Thisted county



Zooming in...



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

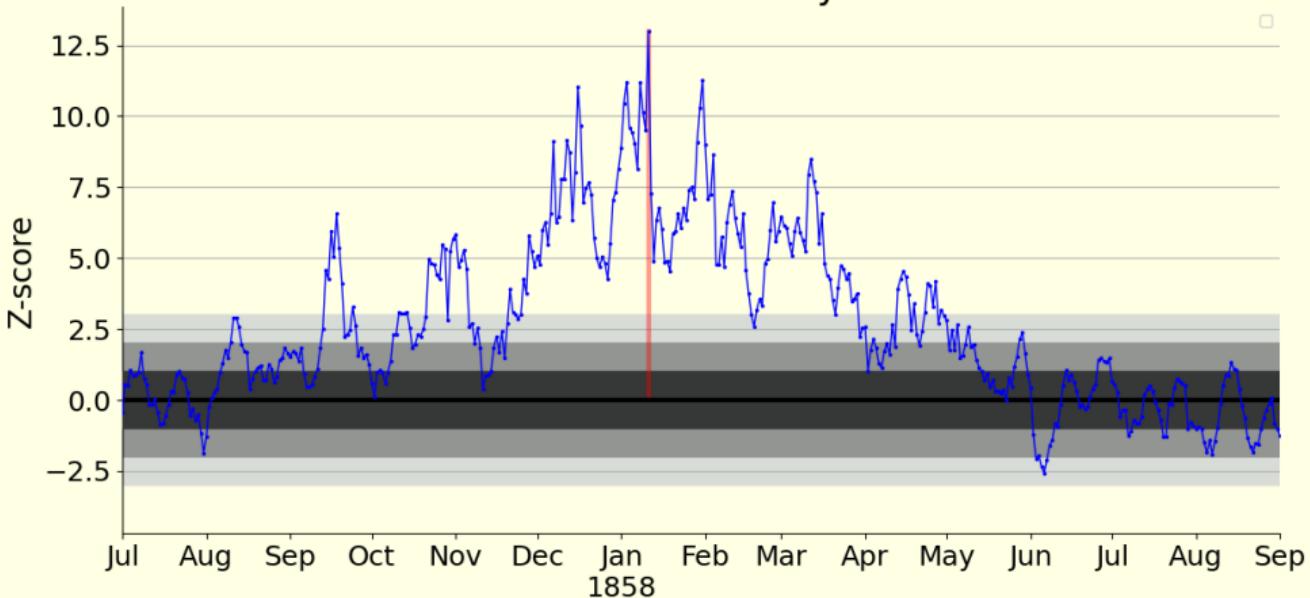
Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Identification of “mortality crises”

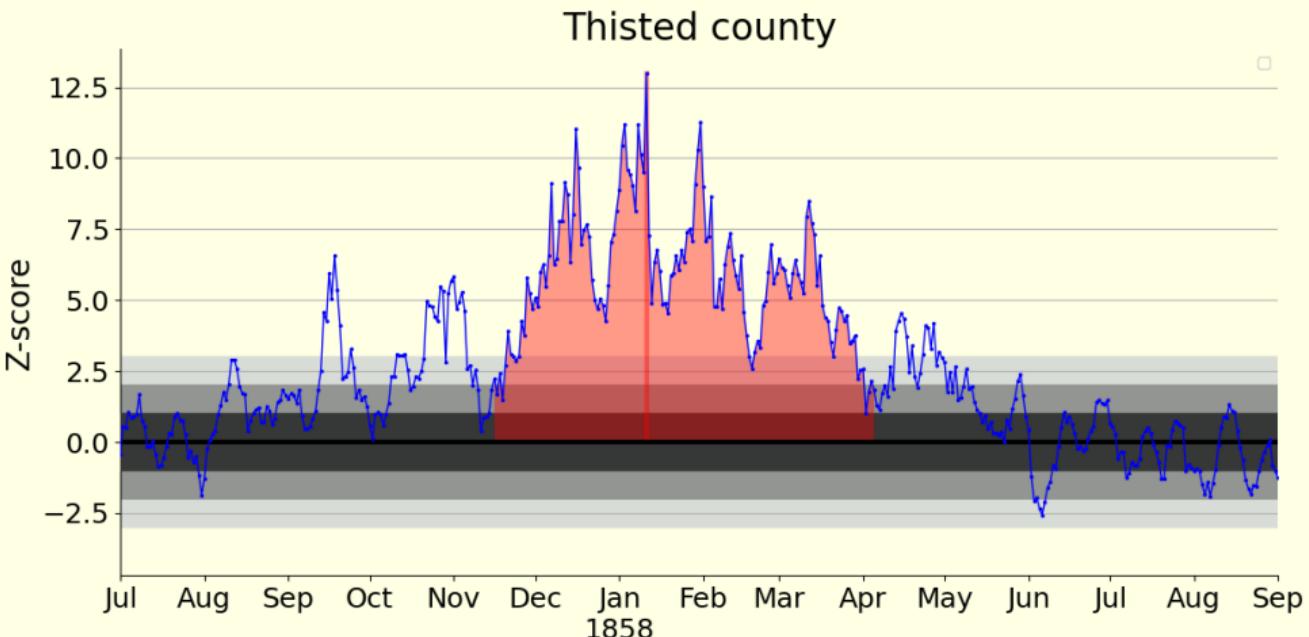
Thisted county



Starting from the date with the highest Z-score...



Identification of “mortality crises”

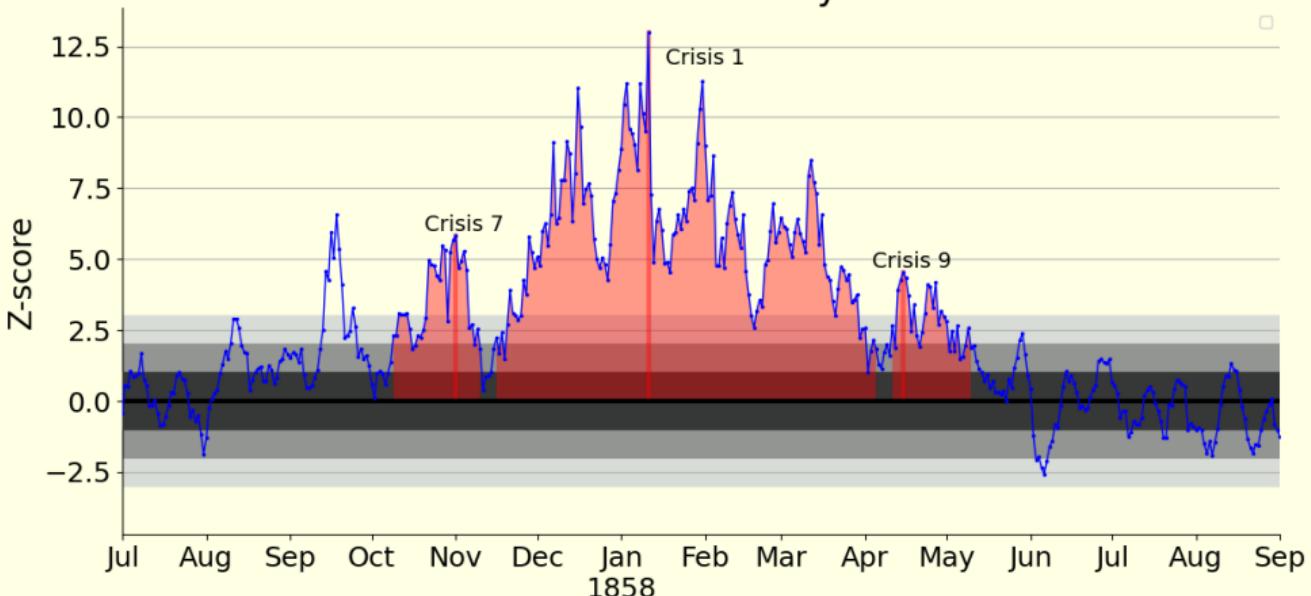


... we group all days with Z-score above three, until the Z-score drops below two for four days or more.



Identification of “mortality crises”

Thisted county



All crises with at least *seven* days above the Z-score threshold of three are considered “mortality crises”.



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

County	#			
Thisted	1			
Thisted	2			
Thisted	3			
:	:			
Copenhagen	1			
Copenhagen	2			
Copenhagen	3			
:	:			
Aarhus	1			
Aarhus	2			
:	:			



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

County	#			
Thisted	1			
Thisted	2			
Thisted	3			
⋮	⋮			
Copenhagen	1			
Copenhagen	2			
Copenhagen	3			
⋮	⋮			
Aarhus	1			
Aarhus	2			
⋮	⋮			



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

- ▶ Peak-date.

County	#	Peak-date		
Thisted	1	1858-01-23		
Thisted	2	1892-01-23		
Thisted	3	1864-08-07		
⋮	⋮	⋮		
Copenhagen	1	1831-08-30		
Copenhagen	2	1891-12-13		
Copenhagen	3	1853-07-31		
⋮	⋮	⋮		
Aarhus	1	1892-01-06		
Aarhus	2	1853-08-24		
⋮	⋮	⋮		



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

- ▶ Peak-date.
- ▶ Excess deaths.

Significant on a county level
(Population-sizes $\approx 100,000$).

County	#	Peak-date	Total excess	
Thisted	1	1858-01-23	655	
Thisted	2	1892-01-23	114	
Thisted	3	1864-08-07	105	
⋮	⋮	⋮	⋮	
Copenhagen	1	1831-08-30	592	
Copenhagen	2	1891-12-13	573	
Copenhagen	3	1853-07-31	552	
⋮	⋮	⋮	⋮	
Aarhus	1	1892-01-06	400	
Aarhus	2	1853-08-24	194	
⋮	⋮	⋮	⋮	



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

- ▶ Peak-date.
- ▶ Excess deaths.
Significant on a county level
(Population-sizes $\approx 100,000$).
- ▶ Duration.
e.g. "lasting two months"

<i>County</i>	<i>#</i>	<i>Peak-date</i>	<i>Total excess</i>	<i>Duration</i>
Thisted	1	1858-01-23	655	140 days
Thisted	2	1892-01-23	114	43 days
Thisted	3	1864-08-07	105	61 days
⋮	⋮	⋮	⋮	⋮
Copenhagen	1	1831-08-30	592	57 days
Copenhagen	2	1891-12-13	573	69 days
Copenhagen	3	1853-07-31	552	57 days
⋮	⋮	⋮	⋮	⋮
Aarhus	1	1892-01-06	400	61 days
Aarhus	2	1853-08-24	194	49 days
⋮	⋮	⋮	⋮	⋮



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

- ▶ Peak-date.
▶ Excess deaths.
Significant on a county level
(Population-sizes $\approx 100,000$).
▶ Duration.
e.g. "lasting two months"
▶ Timing and seasonality.
e.g. "peaking in winter" or
"late summer"

<i>County</i>	<i>#</i>	<i>Peak-date</i>	<i>Total excess</i>	<i>Duration</i>
Thisted	1	1858-01-23	655	140 days
Thisted	2	1892-01-23	114	43 days
Thisted	3	1864-08-07	105	61 days
⋮	⋮	⋮	⋮	⋮
Copenhagen	1	1831-08-30	592	57 days
Copenhagen	2	1891-12-13	573	69 days
Copenhagen	3	1853-07-31	552	57 days
⋮	⋮	⋮	⋮	⋮
Aarhus	1	1892-01-06	400	61 days
Aarhus	2	1853-08-24	194	49 days
⋮	⋮	⋮	⋮	⋮



Identifying main "signature features"

Using this methodology, we identify 319 mortality crises.

For each crisis,

- ▶ Peak-date.
- ▶ Excess deaths.
Significant on a county level
(Population-sizes $\approx 100,000$).
- ▶ Duration.
e.g. "lasting two months"
- ▶ Timing and seasonality.
e.g. "peaking in winter" or
"late summer"

<i>County</i>	<i>#</i>	<i>Peak-date</i>	<i>Total excess</i>	<i>Duration</i>
Thisted	1	1858-01-23	655	140 days
Thisted	2	1892-01-23	114	43 days
Thisted	3	1864-08-07	105	61 days
⋮	⋮	⋮	⋮	⋮
Copenhagen	1	1831-08-30	592	57 days
Copenhagen	2	1891-12-13	573	69 days
Copenhagen	3	1853-07-31	552	57 days
⋮	⋮	⋮	⋮	⋮
Aarhus	1	1892-01-06	400	61 days
Aarhus	2	1853-08-24	194	49 days
⋮	⋮	⋮	⋮	⋮

But we also have data on age.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

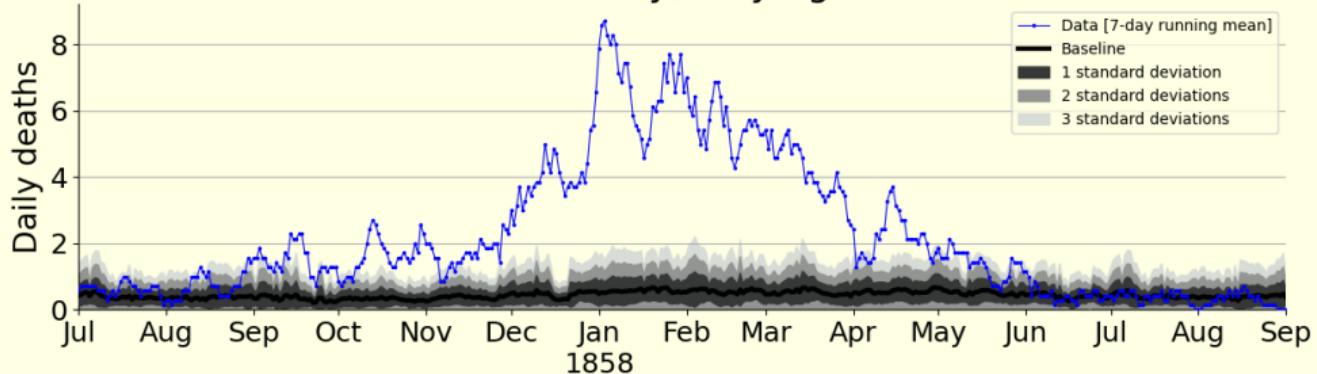
Results and
discussionRepresentative signature
features

Grouping crises

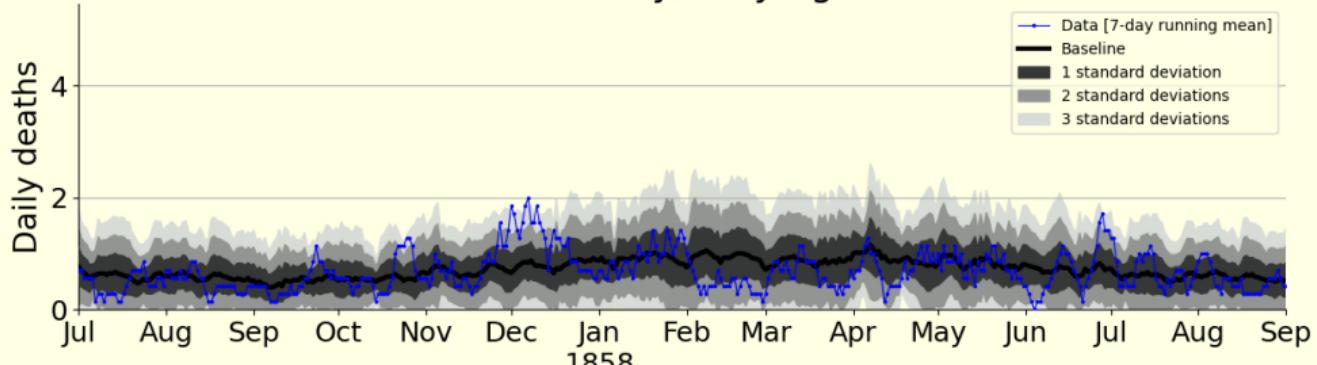
General discussion

Analyzing age-patterns

Thisted county, only ages 1-14



Thisted county, only ages 60+



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

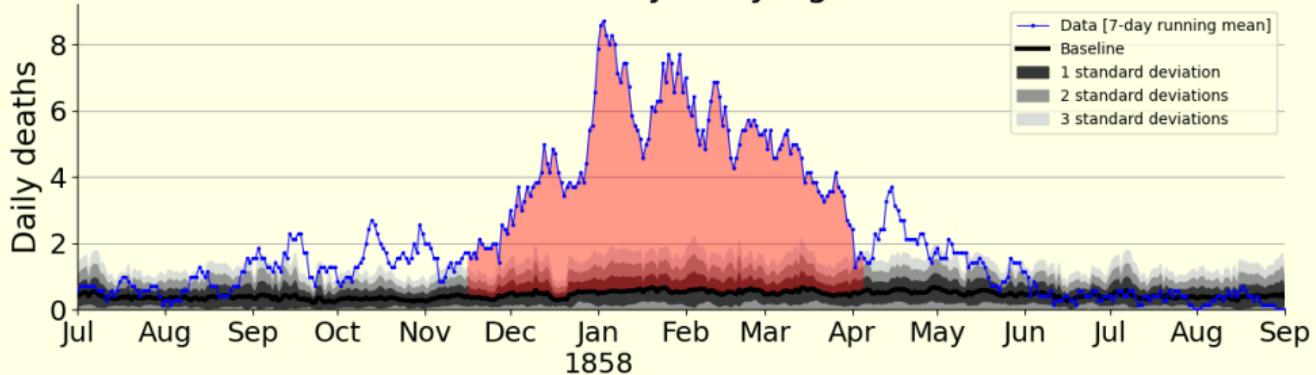
Results and
discussionRepresentative signature
features

Grouping crises

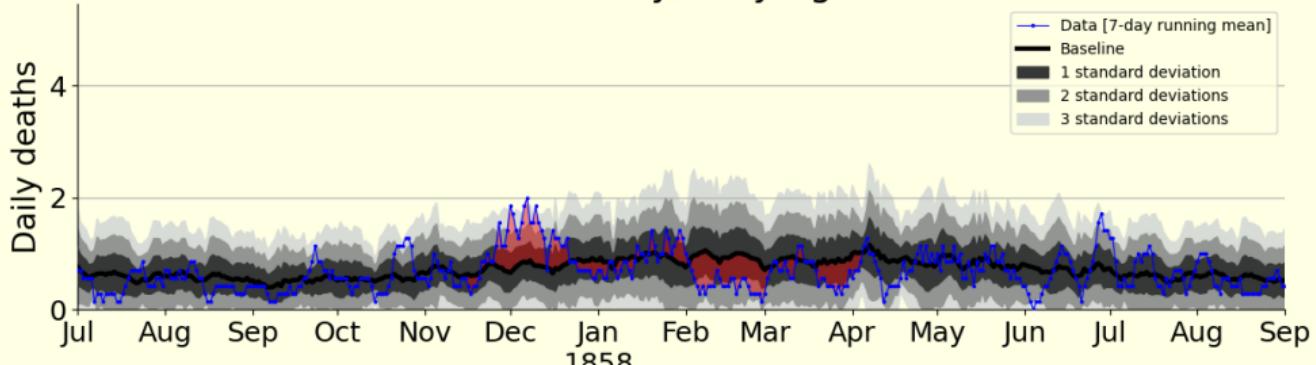
General discussion

Analyzing age-patterns

Thisted county, only ages 1-14



Thisted county, only ages 60+



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

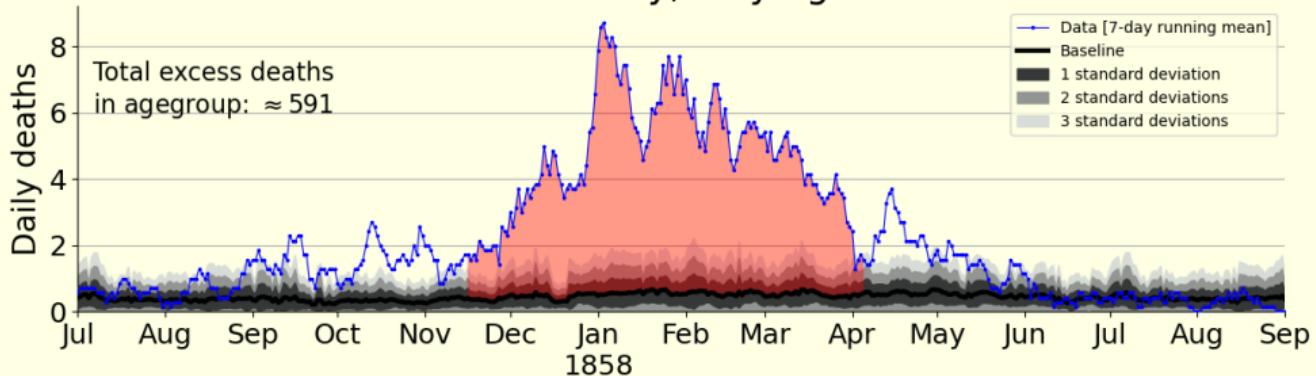
Results and
discussionRepresentative signature
features

Grouping crises

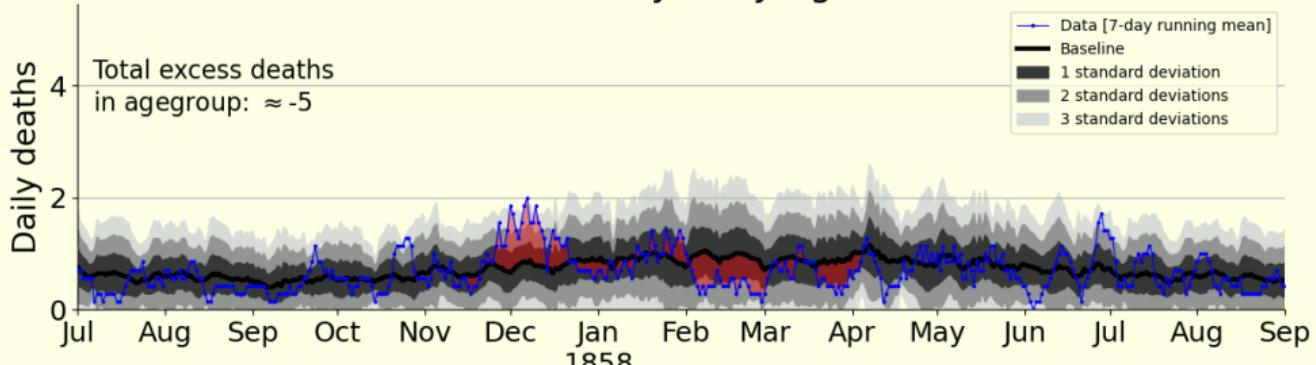
General discussion

Analyzing age-patterns

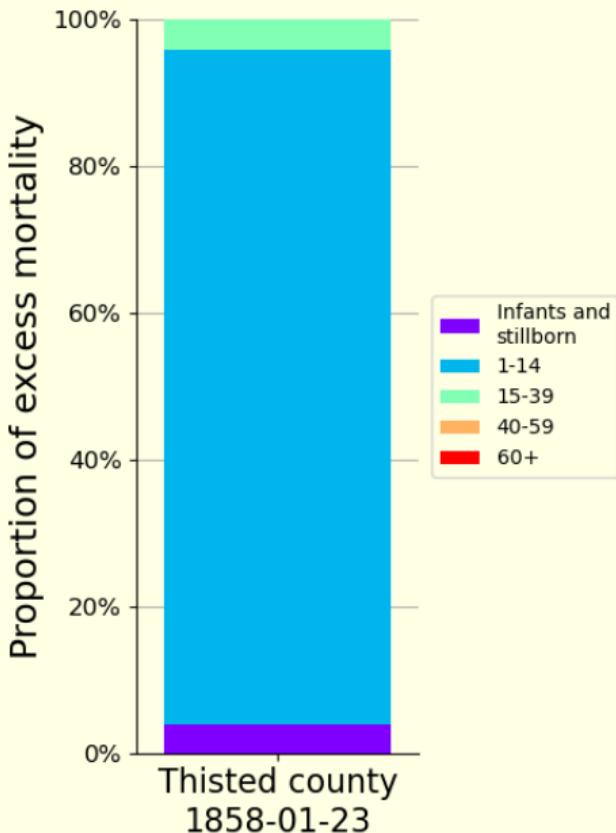
Thisted county, only ages 1-14



Thisted county, only ages 60+



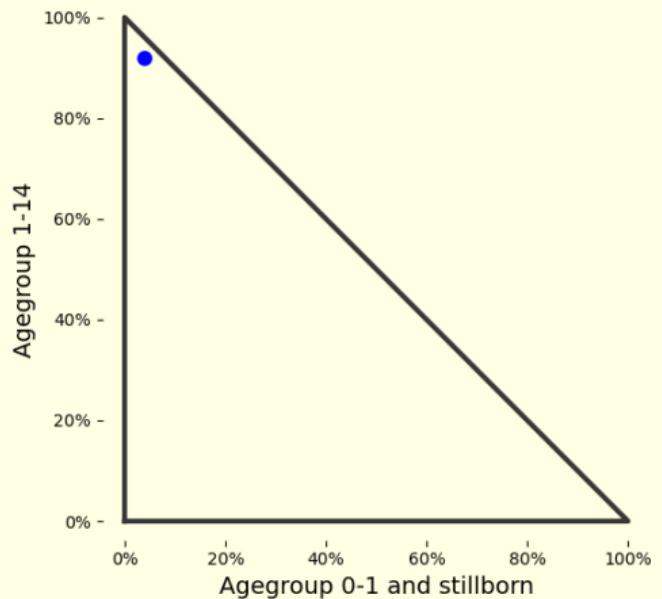
Analyzing age-patterns



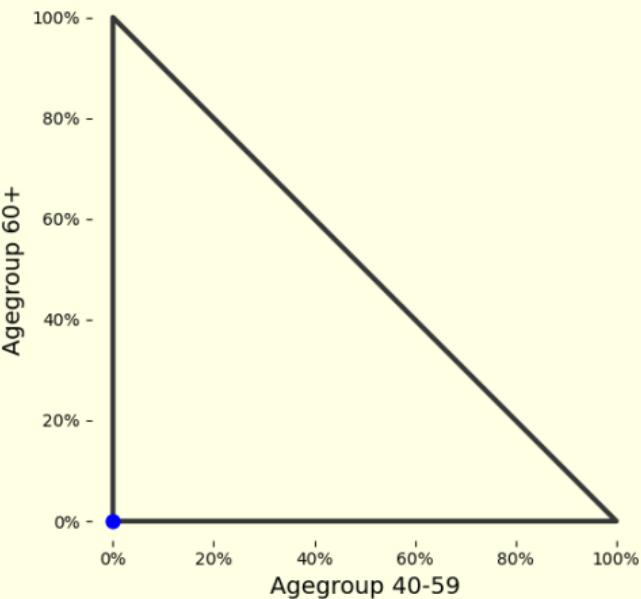
Age-specific excess mortality
in this period:

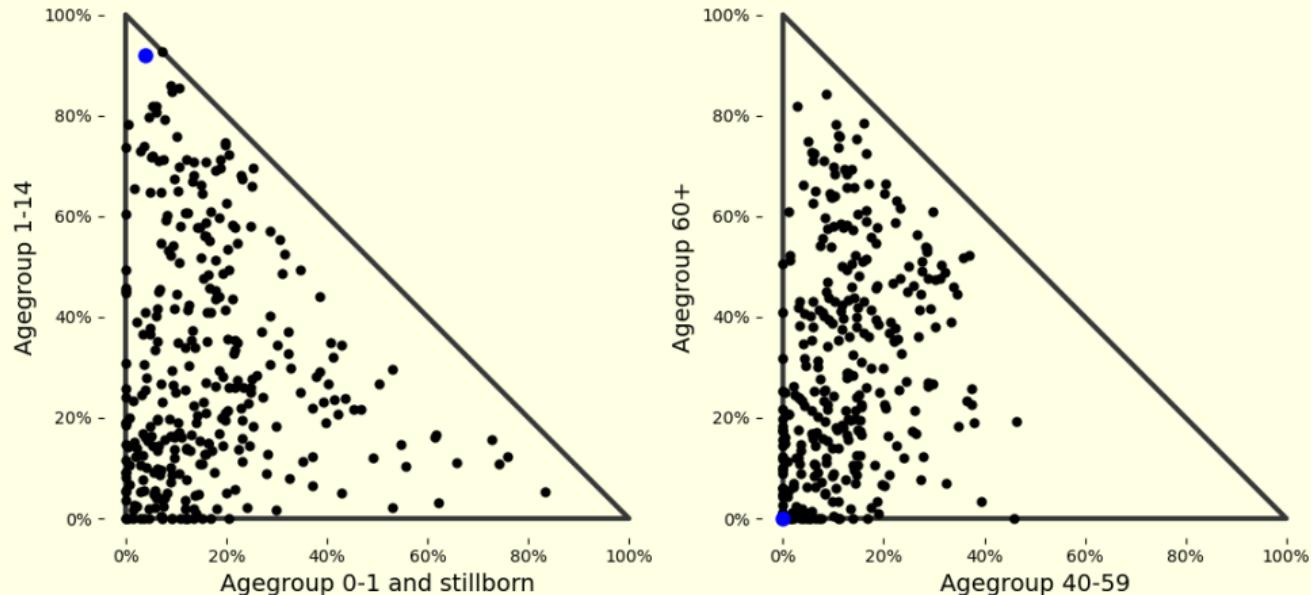
- ▶ Age group "60+": 0%
- ▶ Age group "40-59": <1%
- ▶ Age group "15-39": 3%
- ▶ Age group "1-14": 93%
- ▶ Age group "Below 1 year": 4%





(Age group "15-39" not shown here)

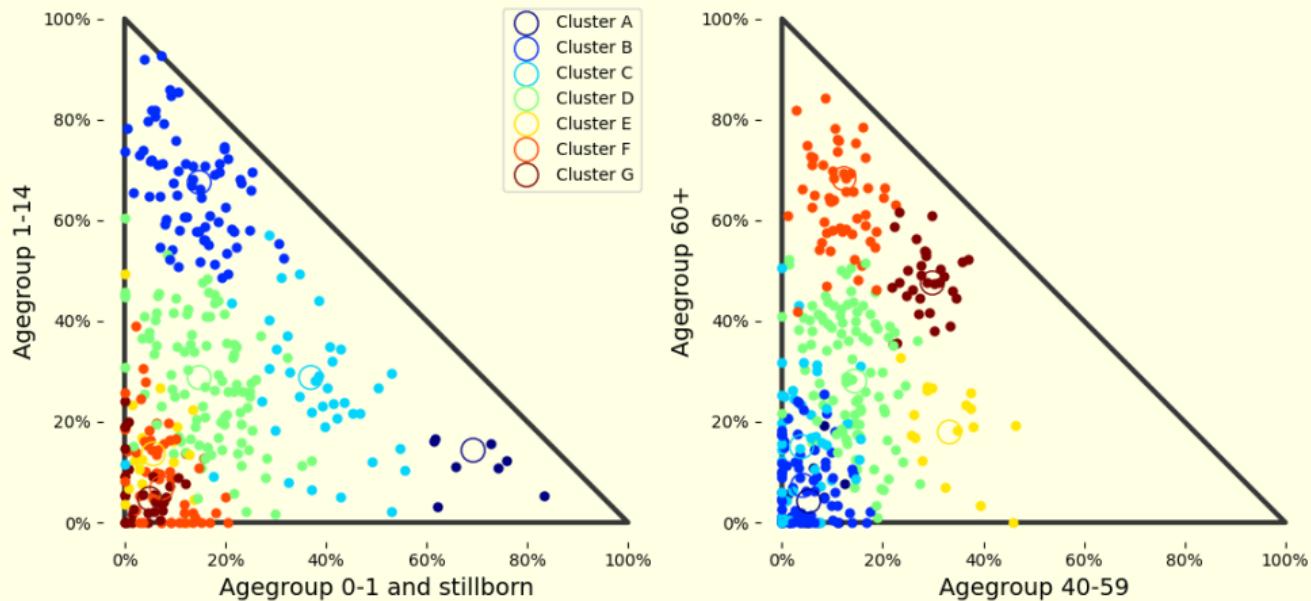




Adding the other 318 mortality crises identified.



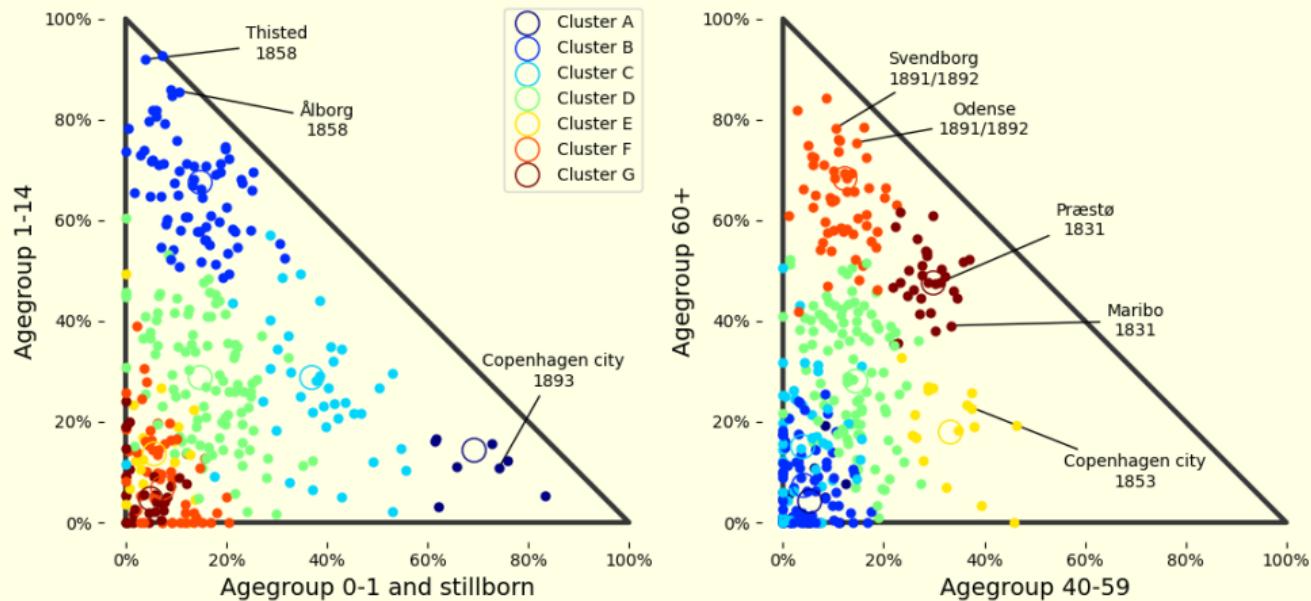
Mortality crises with comparable age patterns



Gaussian mixture modelling on full five-dimensional data.



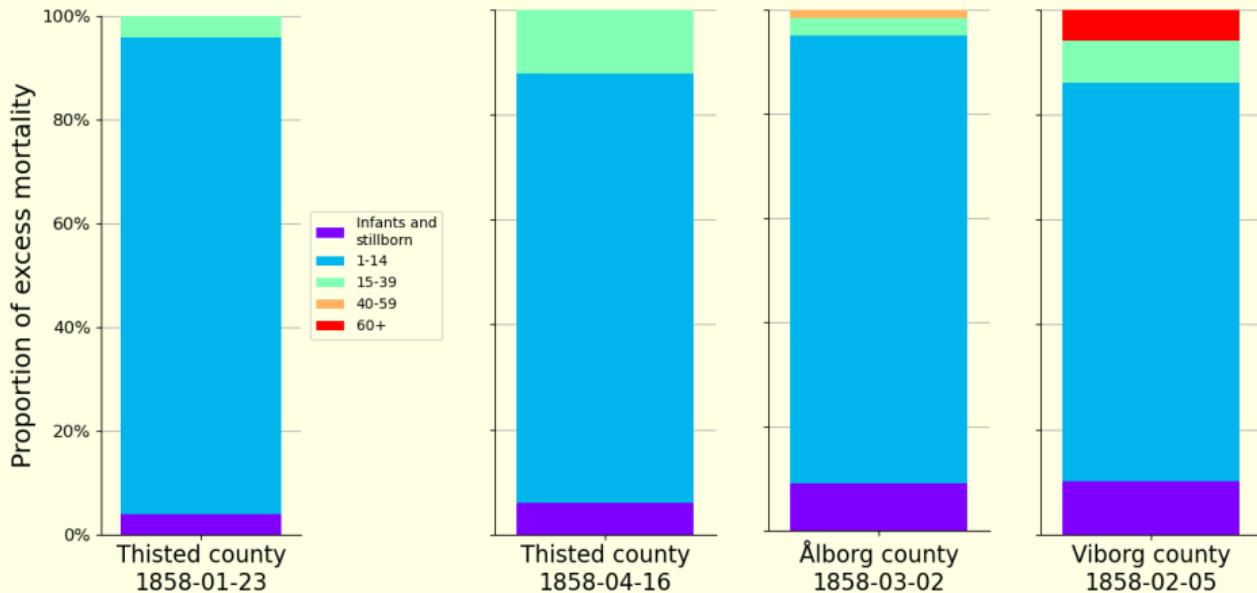
Mortality crises with comparable age patterns



Gaussian mixture modelling on full five-dimensional data.

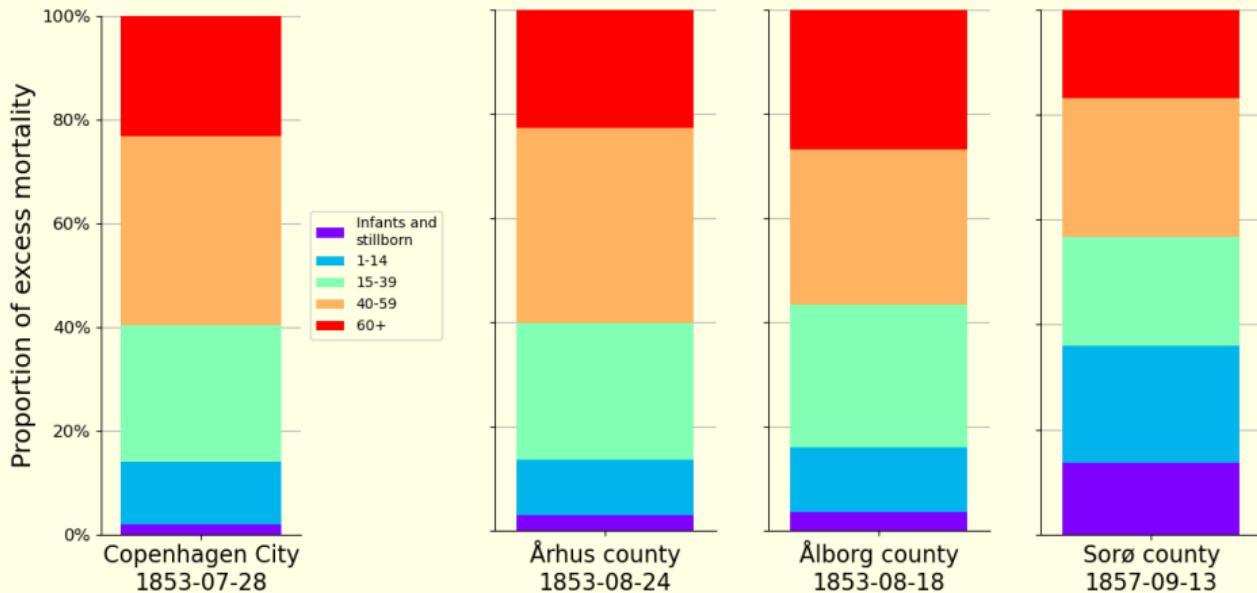
Mortality crises with comparable age patterns

Examples from "Cluster A"



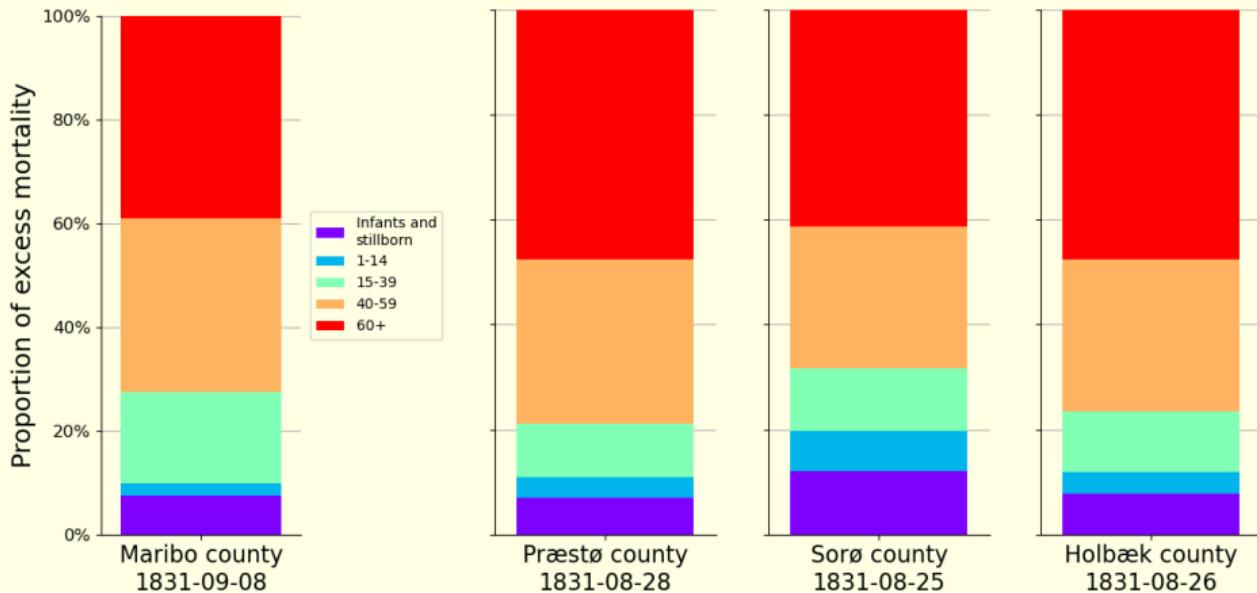
Mortality crises with comparable age patterns

Examples from "Cluster E"



Mortality crises with comparable age patterns

Examples from "Cluster G"



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

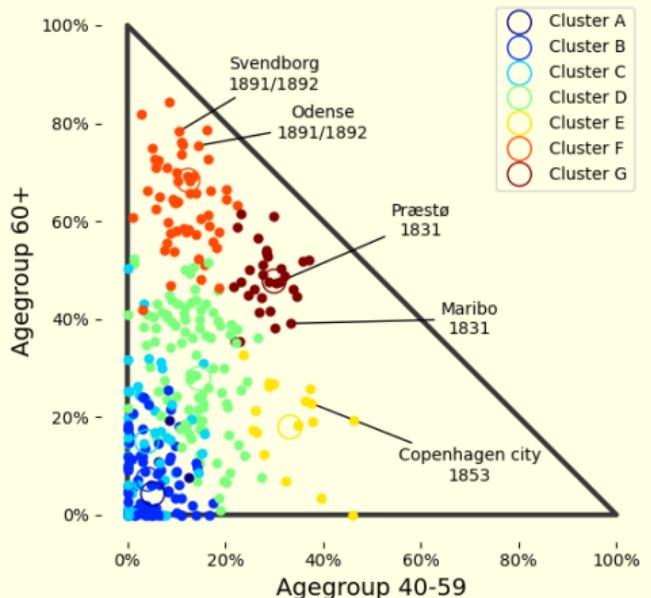
Comparing age patterns

Results and
discussionRepresentative signature
features

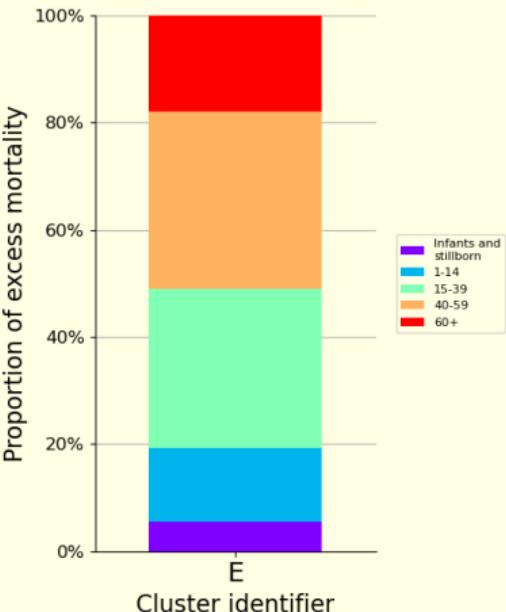
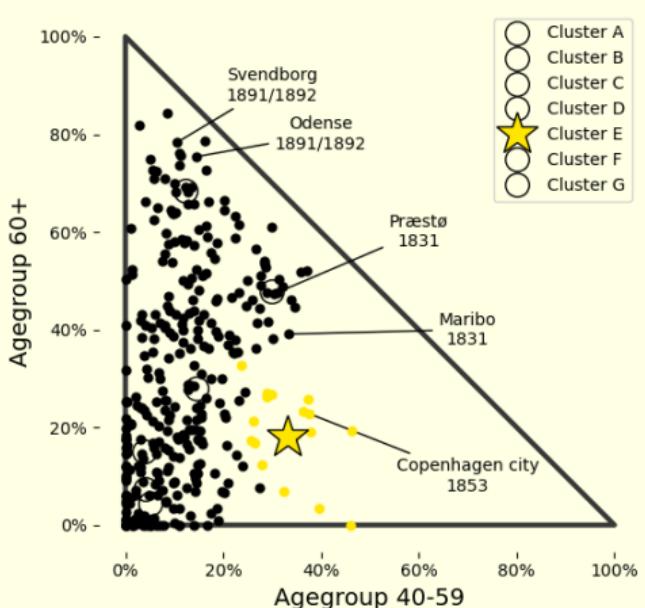
Grouping crises

General discussion

The signature features of certain diseases



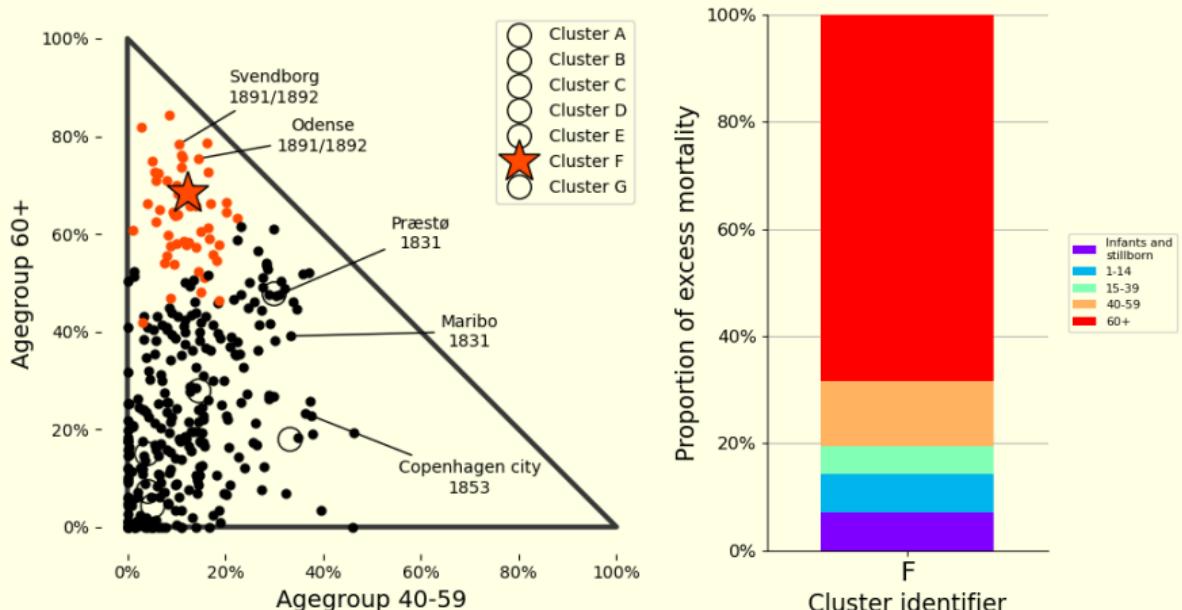
The signature features of certain diseases



Multiple of the mortality crises in cluster E appear to be related to **cholera**.



The signature features of certain diseases



Multiple of the mortality crises in cluster F appear to be related to **pandemic influenza**.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

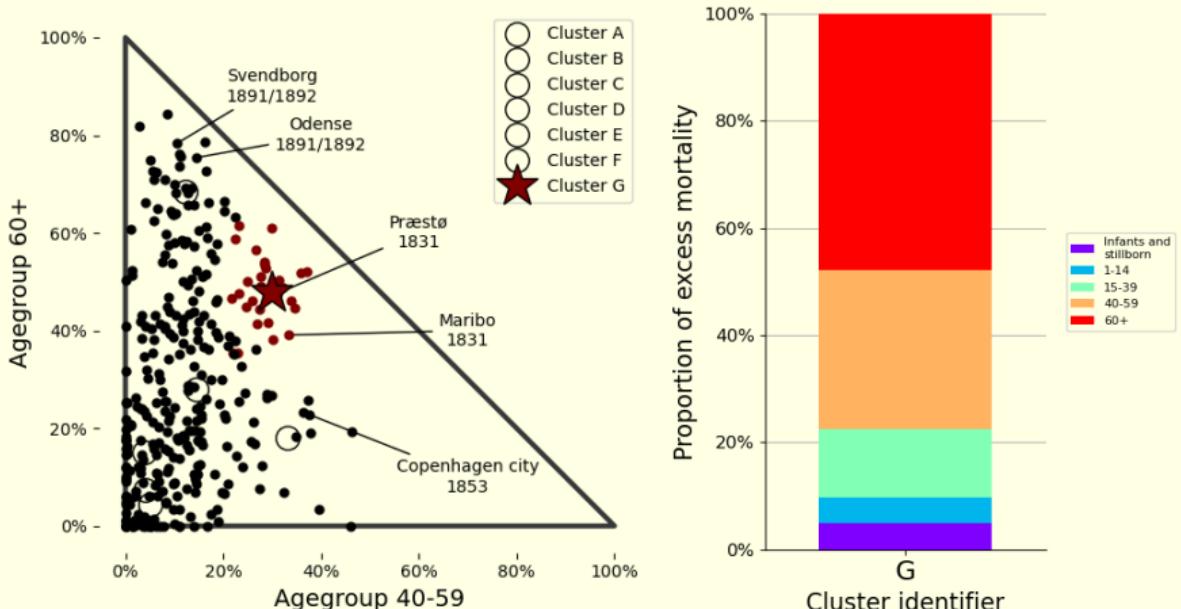
Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

The signature features of certain diseases



Multiple of the mortality crises in cluster G appear to be related to “**the Harvest epidemics of 1826-1832**”.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

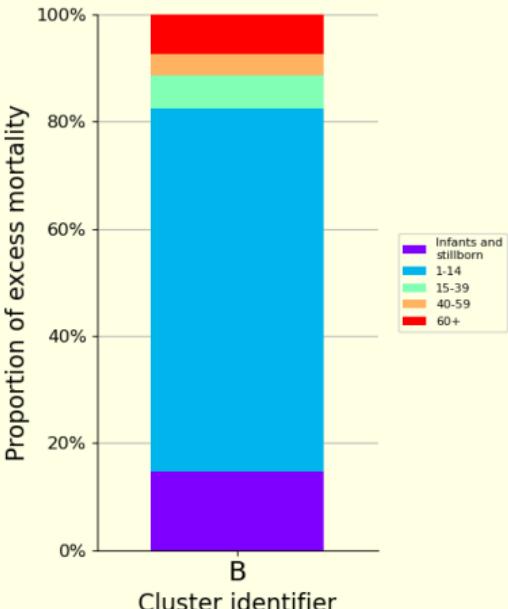
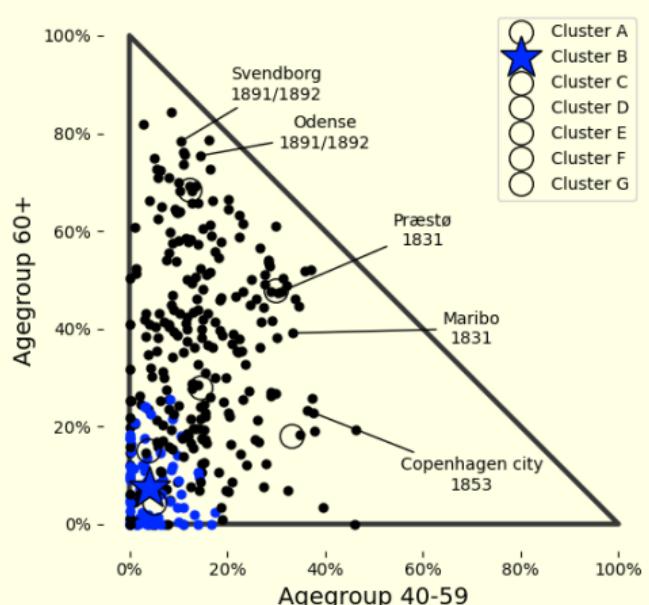
Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

The signature features of certain diseases



Multiple of the mortality crises in cluster B appear to be related to **scarlet fever**.



All epidemics and pandemics in 19th century Denmark

Going through all major mortality crises, and cross referencing with historical records of epidemics:

<i>Disease</i>	<i>Timing</i>	<i>Total excess</i>	<i>Age structure</i>
Cholera	Late summer, 1853 and 1857	5381	Adults Cluster "E"
Scarlet fever	Winter 1857/1858	2451	Children (1-15) Cluster "B"
"Harvest epidemics"¹	Late summer, 1825-1831	10818	Adults Cluster "G"
Pandemic influenza	1892 and 1900	8201	Elderly Cluster "F"

And other epidemics as well as mortality crises unrelated to disease, e.g. war.

¹ Various diseases, aggravated by a subsistence crisis. Discussed in detail by Ingholt (2022) *Scandinavian Journal of History*



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Representative signature
features

Grouping crises

General discussion



Summary

- We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.

Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Summary

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Age-patterns.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Age-patterns.
 - ▶ Timing and seasonality.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Age-patterns.
 - ▶ Timing and seasonality.
 - ▶ Duration.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussionRepresentative signature
features

Grouping crises

General discussion

Summary

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Age-patterns.
 - ▶ Timing and seasonality.
 - ▶ Duration.
 - ▶ Geography.



Summary

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 319 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Age-patterns.
 - ▶ Timing and seasonality.
 - ▶ Duration.
 - ▶ Geography.
- ▶ By comparing these features and validating with historical sources, we are able to determine groups of mortality crises with the same etiology, and estimate the total number of excess deaths during specific epidemics.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Representative signature
features

Grouping crises

General discussion

- Similar methods could be applied to modern data.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Representative signature
features

Grouping crises

General discussion

- ▶ Similar methods could be applied to modern data.
 - ▶ Clustering of age-patterns in modern all-cause mortality data.
A wide range of methods for clustering exists, see e.g. `scikit-learn` for python.



Final comments

- ▶ Similar methods could be applied to modern data.
 - ▶ Clustering of age-patterns in modern all-cause mortality data.
A wide range of methods for clustering exists, see e.g. `scikit-learn` for python.
 - ▶ Excess mortality calculation.
Available online soon, as both Python and R package.



Final comments

- ▶ Similar methods could be applied to modern data.
 - ▶ Clustering of age-patterns in modern all-cause mortality data.
A wide range of methods for clustering exists, see e.g. `scikit-learn` for python.
 - ▶ Excess mortality calculation.
Available online soon, as both Python and R package.
- ▶ Despite demographic differences between 19th century Denmark and modern times, the age patterns in the 19th century may be similar for modern epidemics.



Final comments

- ▶ Similar methods could be applied to modern data.
 - ▶ Clustering of age-patterns in modern all-cause mortality data.
A wide range of methods for clustering exists, see e.g. `scikit-learn` for python.
 - ▶ Excess mortality calculation.
Available online soon, as both Python and R package.
- ▶ Despite demographic differences between 19th century Denmark and modern times, the age patterns in the 19th century may be similar for modern epidemics.
- ▶ As more historical data becomes transcribed, e.g. thanks to improved computer vision, similar studies of other countries will become possible.



Thank you for your attention.



Feel free to email me with
questions or comments

Website: rasmuspedersen.com
Email: rakrpe@ruc.dk

"Identifying Signature Features of Epidemic Diseases in 19th Century All-cause Mortality Data"
Pedersen RK, Ingholt MM, van Wijhe M, Andreasen V & Simonsen L



- Introduction
- Background and data handling
 - Data source
 - Data cleaning
- Methodology
 - Mortality baseline
 - "Mortality crisis"
 - Age-specific mortality
 - Comparing age patterns
- Results and discussion
 - Representative signature features
 - Grouping crises
 - General discussion