

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

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

Introduction

- ▶ Lack of data is a challenge for surveillance of emerging diseases.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

Introduction

- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

Introduction

- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.
- ▶ Our response to threats depend on our experience with past threats.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.
- ▶ Our response to threats depend on our experience with past threats.
 - ▶ SARS-CoV-2 - Experiences from influenza pandemics and SARS-CoV-1.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.
- ▶ Our response to threats depend on our experience with past threats.
 - ▶ SARS-CoV-2 - Experiences from influenza pandemics and SARS-CoV-1.
 - ▶ MPox - Experiences from small pox.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.
- ▶ Our response to threats depend on our experience with past threats.
 - ▶ SARS-CoV-2 - Experiences from influenza pandemics and SARS-CoV-1.
 - ▶ MPox - Experiences from small pox.
 - ▶ Scarlet fever - Experiences from historical scarlet fever.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

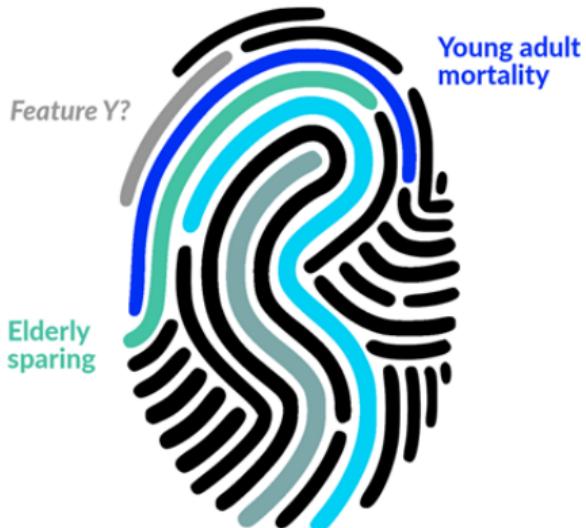
Representative signature
features

General discussion

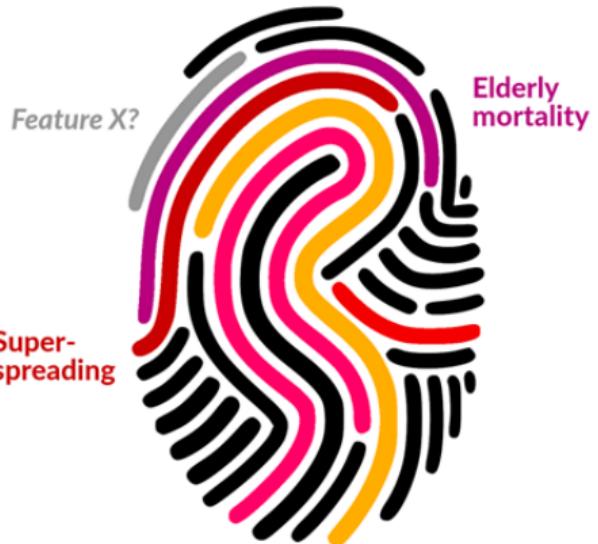
- ▶ Lack of data is a challenge for surveillance of emerging diseases.
- ▶ The epidemics and pandemics of recent years may only be a subset of potential threats to consider.
- ▶ Our response to threats depend on our experience with past threats.
 - ▶ SARS-CoV-2 - Experiences from influenza pandemics and SARS-CoV-1.
 - ▶ MPox - Experiences from small pox.
 - ▶ Scarlet fever - Experiences from historical scarlet fever.
- ▶ Analyzing historical pandemics is a way to study infectious diseases in more details than the study of modern pandemics alone allow for.



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**

Grouping crises

Representative signature
features

General discussion

Overview of talk

In this talk, I will talk about:

- Our recent study of a unique dataset of all-cause mortality.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

Overview of talk

In this talk, I will talk about:

- ▶ Our recent study of a unique dataset of all-cause mortality.
- ▶ Mortality baseline calculations.



Introduction**Background and
data handling**

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

**Results and
discussion**

Grouping crises

Representative signature
features

General discussion

Overview of talk

In this talk, I will talk about:

- ▶ Our recent study of a unique dataset of all-cause mortality.
- ▶ Mortality baseline calculations.
- ▶ Analyzing age patterns to classify epidemics.



Overview of talk

Identifying
Signature Features

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

Grouping crises

Representative signature
features

General discussion

In this talk, I will talk about:

- ▶ Our recent study of a unique dataset of all-cause mortality.
- ▶ Mortality baseline calculations.
- ▶ Analyzing age patterns to classify epidemics.
- ▶ Reflect on what we can learn through historical epidemiology.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

Data source

No.	Dødsdagen.	Begravelsedagen.	Den Dødes Navn og tilnavn.	Stand, Haandtering og Opbevaring.	Ålder.	Hvem an- først i det almindeligt gæ. Sejn- førstet Registret.	Emner.
35.	29. August	4. Sept.	Anders Jørgensen	Fus i Kjøgeby	53 Års	692. 138	
36.	31. August	4. Sept.	Hans Carlsen	Fus. i Skælskør	63 Års	692. 139	
37.	30. August	3. Sept.	Ole Jensen	Allogemanni i Gladsaxe	39 Års	692. 140	
38.	3. Sept.	7. Sept.	Olger Larsen	Fus i Roskilde	70 Års	692. 141	
39.	31. August	4. Sept.	Hans Olen	Fus og Begravt i Hørby	42 Års	692. 142	
40.	4. Sept.	6. Sept.	Niels Pedersen	Fus. i Engholm	61 Års	692. 143	
41.	5. Sept.	9. Sept.	Ole Hansen	Allogemanni i Roskilde	63 Års	692. 144	
42.	4. Sept.	9. Sept.	Niels Christensen	Fus i Lyngby	57 Års	692. 145	
43.	7. Sept.	12. Sept.	Niels Larsen	Fus. i Sæby	80 Års	692. 146	
44.	6. Sept.	12. Sept.	Jens Andersen	Allogemanni i Roskilde	62 Års	692. 147	
45.	8. Sept.	13. Sept.	Hans Lachsen	Fus i Lyngby	42 Års	692. 148	
46.	5. Sept.	9. Sept.	Lars Christophersen	Allogemanni i Roskilde	9.3. Års	692. 149	
47.	12. Sept.	16. Sept.	Anders Hansen	Allogemanni i Roskilde	78 Års	692. 150	
48.	11. Sept.	14. Sept.	Tharic Larsen	Fus i Roskilde	49 Års	692. 151	



Data source

- Parish registers for Danish church parishes between 1815-1915

Scan of parish register for "Fakse" parish.

Data source

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

The table below represents the data extracted from the parish register shown in the image:

No.	Begravelsesdato.	Døde Personens Navn og tilnavn.	Dødsårsak og dødsstidspunkt.	Begravelses dato.
35	1. Januar	Søf. Søf. Leth	Læderet Brøndsen	Januar 1831
36	3. Januar	Augustine - Hans Carlsten	Smert i hovedet	Januar 1831
37	3. Januar	3. mdr. Ol. Jensen	Udrensemænds glemme	Januar 1831
38	3. Januar	7. mdr. H. Jørgen Larsen	Smert i hovedet	Januar 1831
39	3. Januar	Auguste - Hans Olsen	Udrensemænds glemme	Januar 1831
40	4. Januar	Auguste - Niels Andersen	Smert i hovedet	Januar 1831
41	5. Januar	9. mdr. Ole Hansen	Udrensemænds glemme	Januar 1831
42	4. Januar	Georg - Niels Christensen	Smert i hovedet	Januar 1831
43	7. Januar	2. mdr. N. Vilh. Larsen	Smert i hovedet	Januar 1831
44	6. Januar	2. mdr. Jens. Sønderup	Gedrengens udrensemænds glemme	Januar 1831
45	8. Januar	Auguste - Hans Jørgen	Smert i hovedet	Januar 1831
46	5. Januar	9. mdr. Hans Andeby Christensen	Udrensemænds glemme	Januar 1831
47	8. Januar	6. mdr. Hans Christian	Udrensemænds glemme	Januar 1831
48	11. Januar	11. mdr. Hans Larsen	Smert i hovedet	Januar 1831

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, age, sex and parish

No.	Begravelsesform.	Navn	Dato	Køn	Tegnelse.
35	For 2. Ynglingsst.	S. B. Leth	Landet Bronden	Yngl. i 2. Ynglingsst.	Skæb. d. 181
36	3. Kapitel	A. W. Sørensen	Magnus Carlsten	Herr. 3. Kapitels	Skæb. d. 181
37	3. Kapitel	3. mbd.	Ol. Jørgen	Udskrivmænds 3. Kapitel	Skæb. d. 181
38	3. mbd.	7. mbd.	H. Jørgen Larsen	Yngl. i 3. mbd.	Skæb. d. 181
39	3. Kapitel	A. Sørensen	G. Larsen	Udskrivmænds 3. Kapitel	Skæb. d. 181
40	4. Kapitel	B. Sørensen	Niels Andersen	Herr. 4. Kapitels	Skæb. d. 181
41	5. Kapitel	9. mbd.	C. H. Hansen	Udskrivmænds 5. Kapitel	Skæb. d. 181
42	4. mbd.	Georg	Niels Christensen	Yngl. i 4. mbd.	Skæb. d. 181
43	7. Kapitel	B. Sørensen	R. Niels Larsen	Yngl. i 7. Kapitel	Skæb. d. 181
44	6. mbd.	2. mbd.	Jens. Sørensen	Udskrivmænds 6. mbd.	Skæb. d. 181
45	8. Kapitel	B. Sørensen	Hans Jørgen	Yngl. i 8. Kapitel	Skæb. d. 181
46	5. mbd.	9. mbd.	Niels Christensen	Udskrivmænds 5. mbd.	Skæb. d. 181
47	7. Kapitel	B. Sørensen	Andreas Hansen	Udskrivmænds 7. Kapitel	Skæb. d. 181
48	6. mbd.	10. mbd.	Andreas Hansen	Udskrivmænds 6. mbd.	Skæb. d. 181
49	11. Kapitel	B. Sørensen	Hans Larsen	Yngl. i 11. Kapitel	Skæb. d. 181

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, age, sex and parish
- ▶ Property of the Danish National Archives, but digitized and transcribed by *Ancestry*

No.	Døbsdato.	Begravelsesdato.	Den døde Kvin og Børnebarn.	Sted, hvorfra dog og Døbfestdag.	Åldre, om fest i bet rørstidens døde, 200 førstidens Baptiser.	Tommerfølge.
35.	1. Sept.	2. Sept.	Lundest. Brøndsen	Født i Fakseby	Skærbjært 181	
26.	3. Sept.	4. Sept.	Magn. Carlsten	Født i Fakseby	Skærbjært 181	
27.	30. Aug.	3. Sept.	El. Jensen	Birkemose's. Hørby	Skærbjært 181	
28.	3. Sept.	7. Sept.	H. Jørgen Larsen	Født i Fakseby	Skærbjært 181	
29.	31. Aug.	4. Sept.	Car. Olesen	Gudme's. Gudme	Skærbjært 181	
30.	1. Sept.	5. Sept.	Niels Andersen	Født i Fakseby	Skærbjært 181	
31.	2. Sept.	6. Sept.	Cla. Hansen	Født i Fakseby	Skærbjært 181	
32.	3. Sept.	7. Sept.	Niels Christensen	Født i Fakseby	Skærbjært 181	
33.	4. Sept.	8. Sept.	P. Vilh. Lethen	Født i Fakseby	Skærbjært 181	
34.	5. Sept.	9. Sept.	Jens. Sønderen	Født i Fakseby	Skærbjært 181	
35.	6. Sept.	10. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
36.	7. Sept.	11. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
37.	8. Sept.	12. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
38.	9. Sept.	13. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
39.	10. Sept.	14. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
40.	11. Sept.	15. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
41.	12. Sept.	16. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
42.	13. Sept.	17. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
43.	14. Sept.	18. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
44.	15. Sept.	19. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
45.	16. Sept.	20. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
46.	17. Sept.	21. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
47.	18. Sept.	22. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
48.	19. Sept.	23. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
49.	20. Sept.	24. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
50.	21. Sept.	25. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
51.	22. Sept.	26. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
52.	23. Sept.	27. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
53.	24. Sept.	28. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
54.	25. Sept.	29. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
55.	26. Sept.	30. Sept.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
56.	27. Sept.	1. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
57.	28. Sept.	2. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
58.	29. Sept.	3. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
59.	30. Sept.	4. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
60.	31. Sept.	5. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
61.	1. Oct.	6. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
62.	2. Oct.	7. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
63.	3. Oct.	8. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
64.	4. Oct.	9. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
65.	5. Oct.	10. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
66.	6. Oct.	11. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
67.	7. Oct.	12. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
68.	8. Oct.	13. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
69.	9. Oct.	14. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
70.	10. Oct.	15. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
71.	11. Oct.	16. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
72.	12. Oct.	17. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
73.	13. Oct.	18. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
74.	14. Oct.	19. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
75.	15. Oct.	20. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
76.	16. Oct.	21. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
77.	17. Oct.	22. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
78.	18. Oct.	23. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
79.	19. Oct.	24. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
80.	20. Oct.	25. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
81.	21. Oct.	26. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
82.	22. Oct.	27. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
83.	23. Oct.	28. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
84.	24. Oct.	29. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
85.	25. Oct.	30. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
86.	26. Oct.	31. Oct.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
87.	27. Oct.	1. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
88.	28. Oct.	2. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
89.	29. Oct.	3. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
90.	30. Oct.	4. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
91.	31. Oct.	5. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
92.	1. Nov.	6. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
93.	2. Nov.	7. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
94.	3. Nov.	8. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
95.	4. Nov.	9. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
96.	5. Nov.	10. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
97.	6. Nov.	11. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
98.	7. Nov.	12. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
99.	8. Nov.	13. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
100.	9. Nov.	14. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
101.	10. Nov.	15. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
102.	11. Nov.	16. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
103.	12. Nov.	17. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
104.	13. Nov.	18. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
105.	14. Nov.	19. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
106.	15. Nov.	20. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
107.	16. Nov.	21. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
108.	17. Nov.	22. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
109.	18. Nov.	23. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
110.	19. Nov.	24. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
111.	20. Nov.	25. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
112.	21. Nov.	26. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
113.	22. Nov.	27. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
114.	23. Nov.	28. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
115.	24. Nov.	29. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
116.	25. Nov.	30. Nov.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
117.	26. Nov.	1. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
118.	27. Nov.	2. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
119.	28. Nov.	3. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
120.	29. Nov.	4. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
121.	30. Nov.	5. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
122.	1. Dec.	6. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
123.	2. Dec.	7. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
124.	3. Dec.	8. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
125.	4. Dec.	9. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
126.	5. Dec.	10. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
127.	6. Dec.	11. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
128.	7. Dec.	12. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
129.	8. Dec.	13. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
130.	9. Dec.	14. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
131.	10. Dec.	15. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
132.	11. Dec.	16. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
133.	12. Dec.	17. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
134.	13. Dec.	18. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
135.	14. Dec.	19. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
136.	15. Dec.	20. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
137.	16. Dec.	21. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
138.	17. Dec.	22. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
139.	18. Dec.	23. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
140.	19. Dec.	24. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
141.	20. Dec.	25. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
142.	21. Dec.	26. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
143.	22. Dec.	27. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
144.	23. Dec.	28. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
145.	24. Dec.	29. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
146.	25. Dec.	30. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
147.	26. Dec.	31. Dec.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
148.	27. Dec.	1. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
149.	28. Dec.	2. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
150.	29. Dec.	3. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
151.	30. Dec.	4. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
152.	31. Dec.	5. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
153.	1. Jan.	6. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
154.	2. Jan.	7. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
155.	3. Jan.	8. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
156.	4. Jan.	9. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
157.	5. Jan.	10. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
158.	6. Jan.	11. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
159.	7. Jan.	12. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
160.	8. Jan.	13. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
161.	9. Jan.	14. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
162.	10. Jan.	15. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
163.	11. Jan.	16. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
164.	12. Jan.	17. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
165.	13. Jan.	18. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
166.	14. Jan.	19. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
167.	15. Jan.	20. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
168.	16. Jan.	21. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
169.	17. Jan.	22. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
170.	18. Jan.	23. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
171.	19. Jan.	24. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
172.	20. Jan.	25. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
173.	21. Jan.	26. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
174.	22. Jan.	27. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
175.	23. Jan.	28. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
176.	24. Jan.	29. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
177.	25. Jan.	30. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
178.	26. Jan.	31. Jan.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
179.	27. Jan.	1. Feb.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
180.	28. Jan.	2. Feb.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
181.	29. Jan.	3. Feb.	Car. Sørensen	Født i Fakseby	Skærbjært 181	
182.	30. Jan.	4. Feb.	Car. Sørensen			

Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

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	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 Walsbøll	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	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 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)

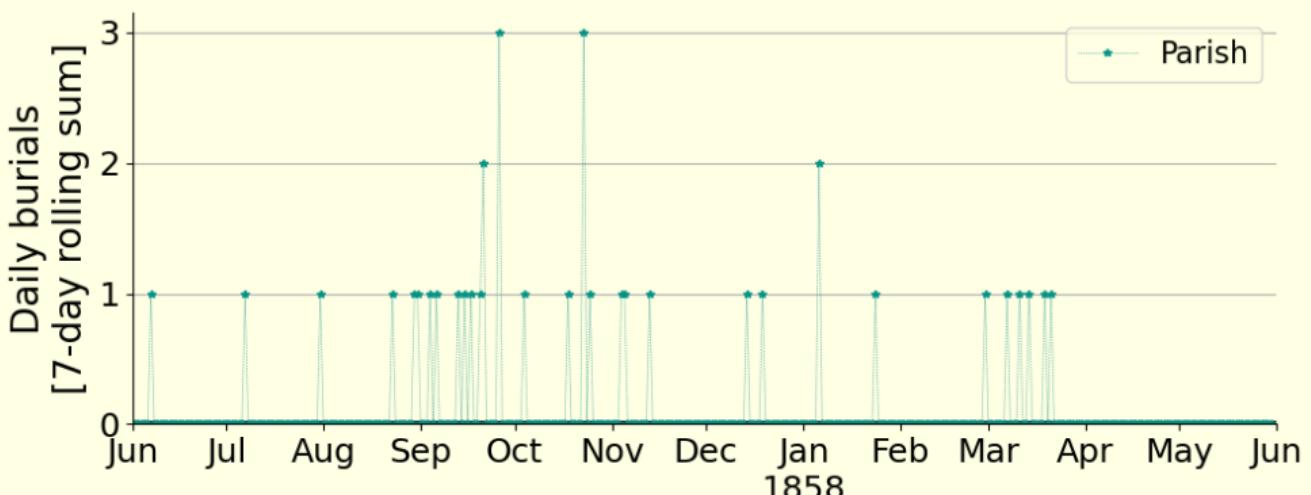
► Geographical resolution:

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

► Temporal resolution:

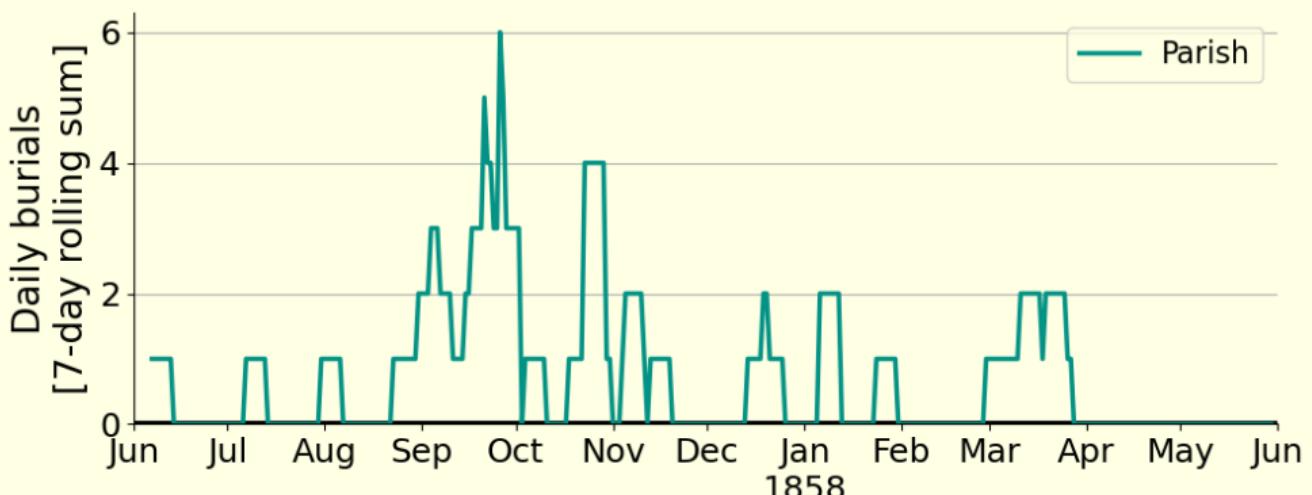
- Daily
- Weekly
- Monthly
- Yearly



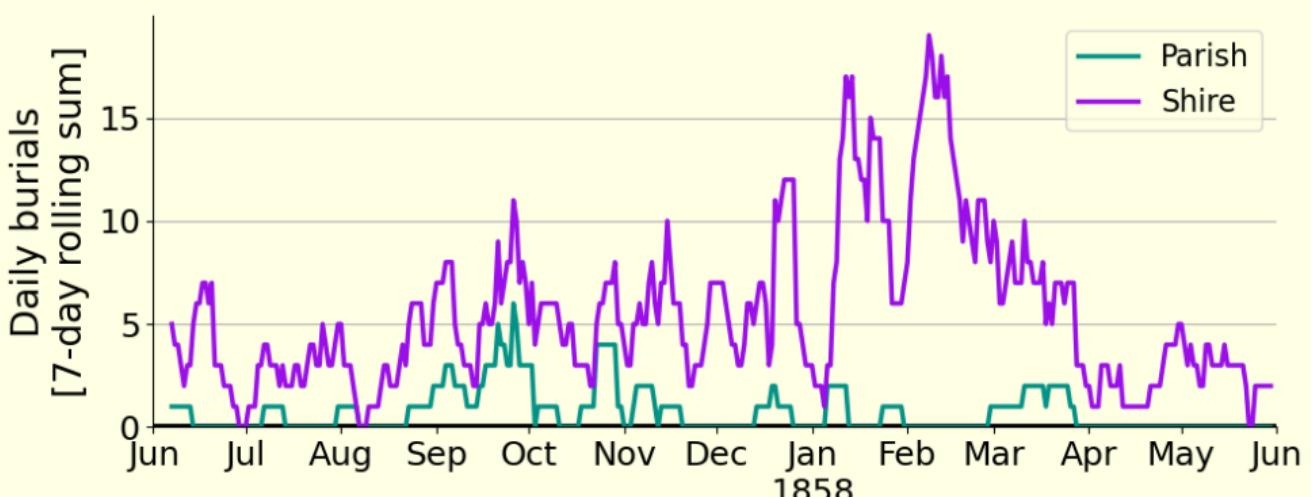




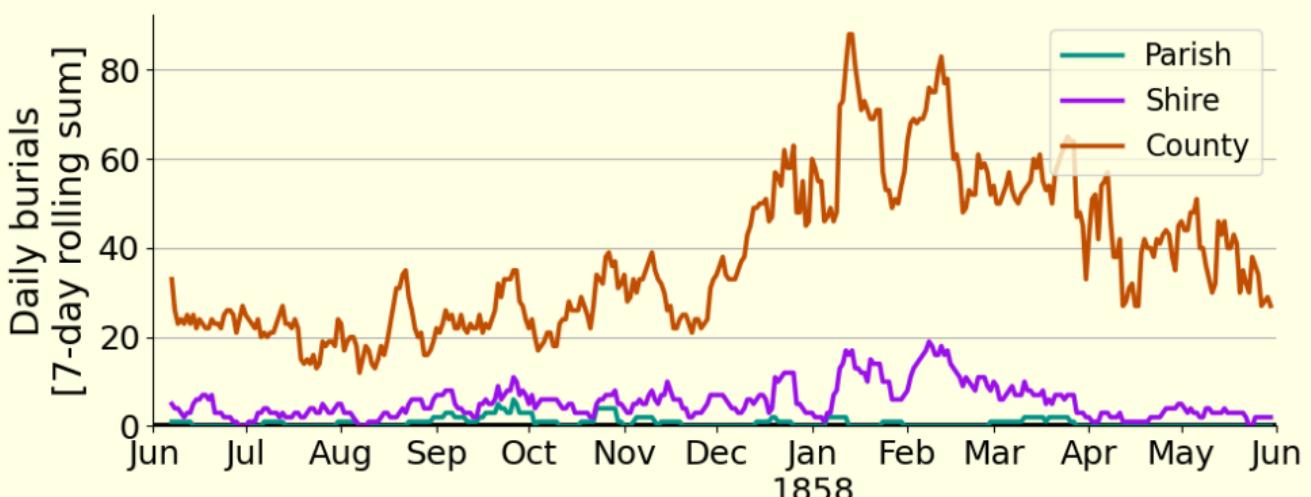
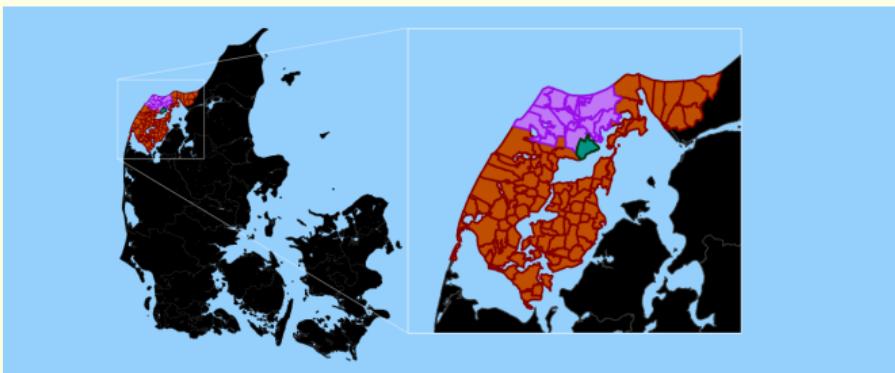
Data cleaning and managing



Data cleaning and managing



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
discussion

Grouping crises

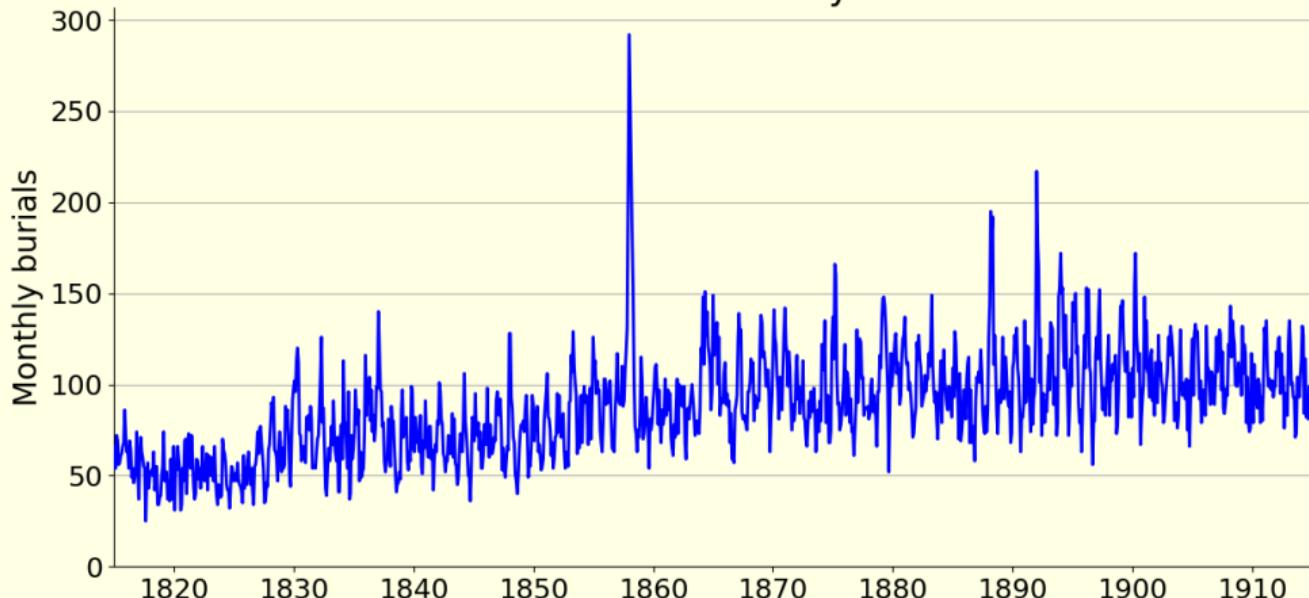
Representative signature

features

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
discussion

Grouping crises

Representative

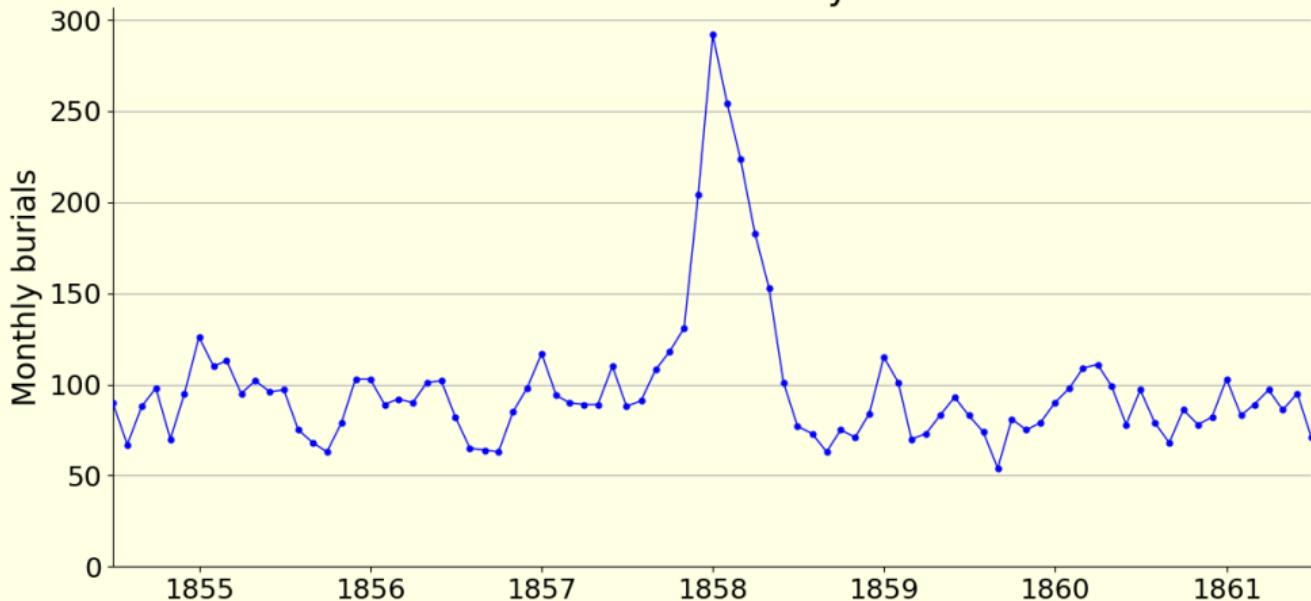
signature

features

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
discussion

Grouping crises

Representative

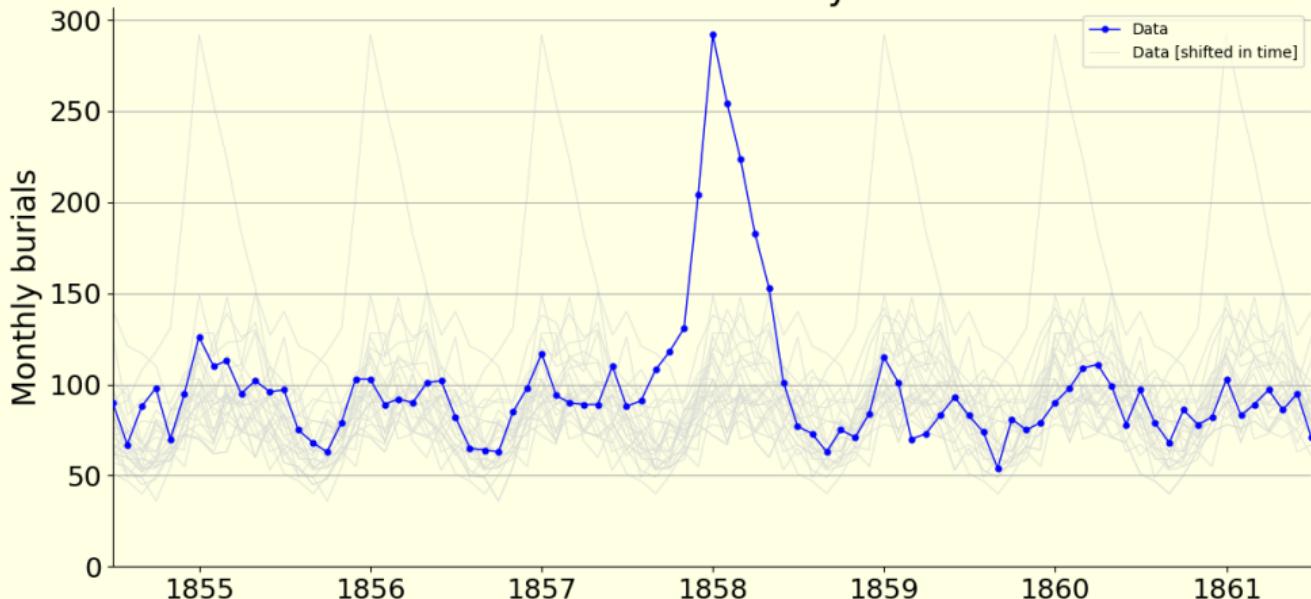
signature

features

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
discussion

Grouping crises

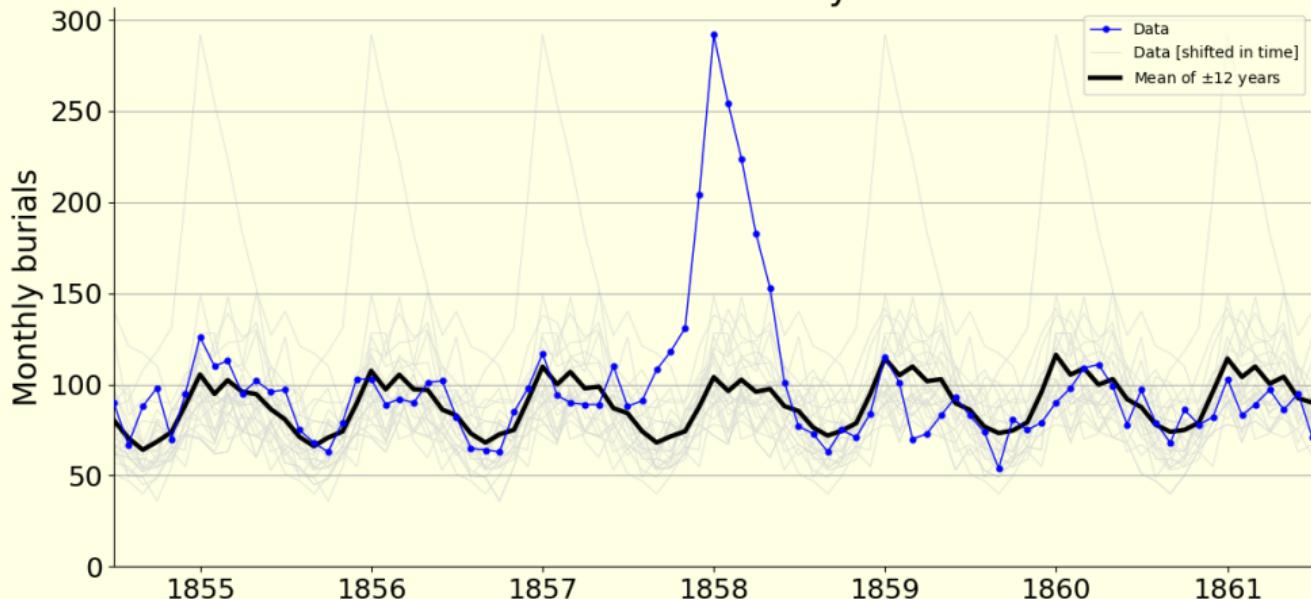
Representative signature

features

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
discussion

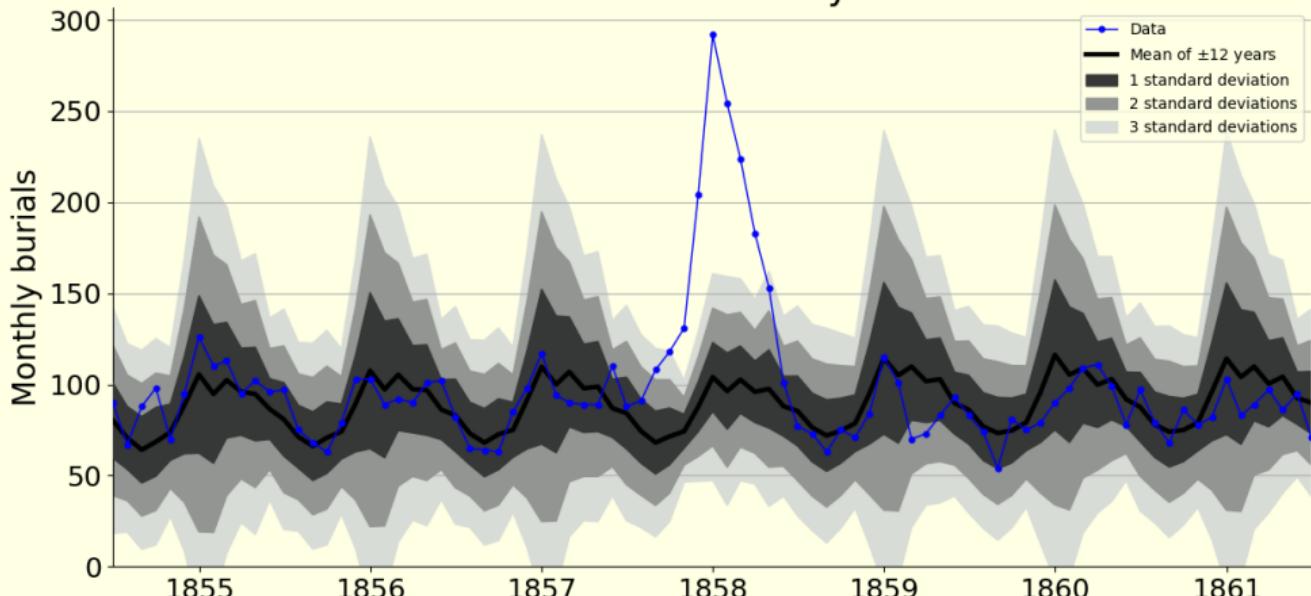
Grouping crises

Representative signature
features

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

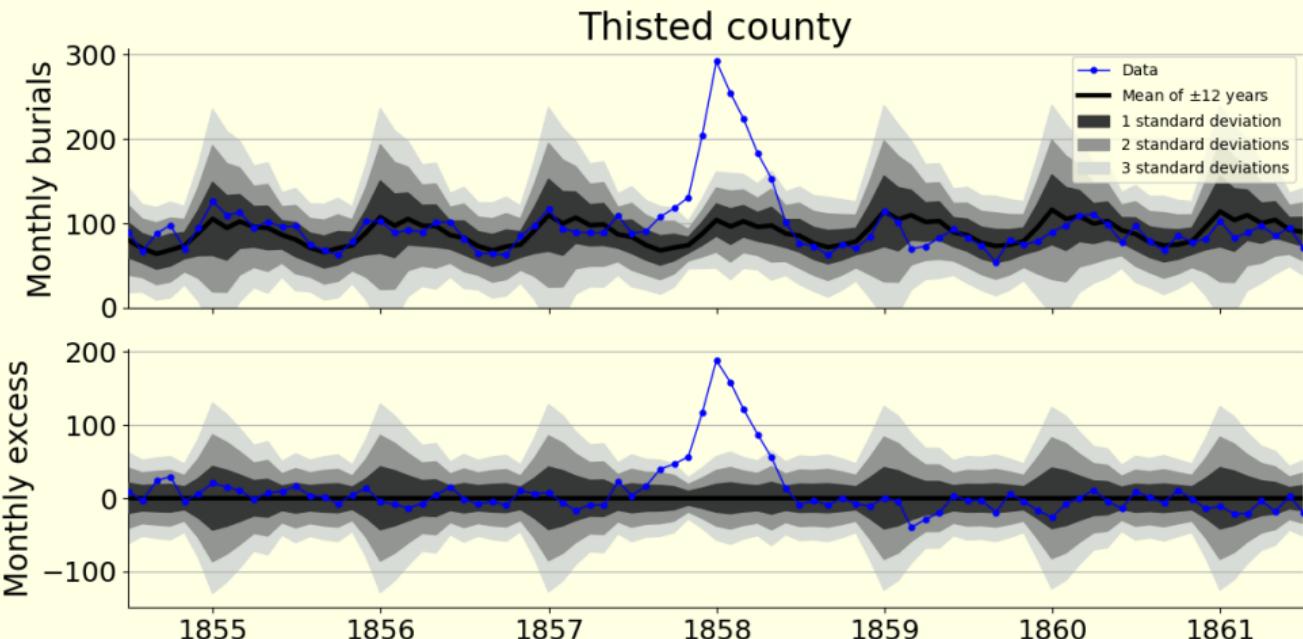
Results and
discussion

Grouping crises

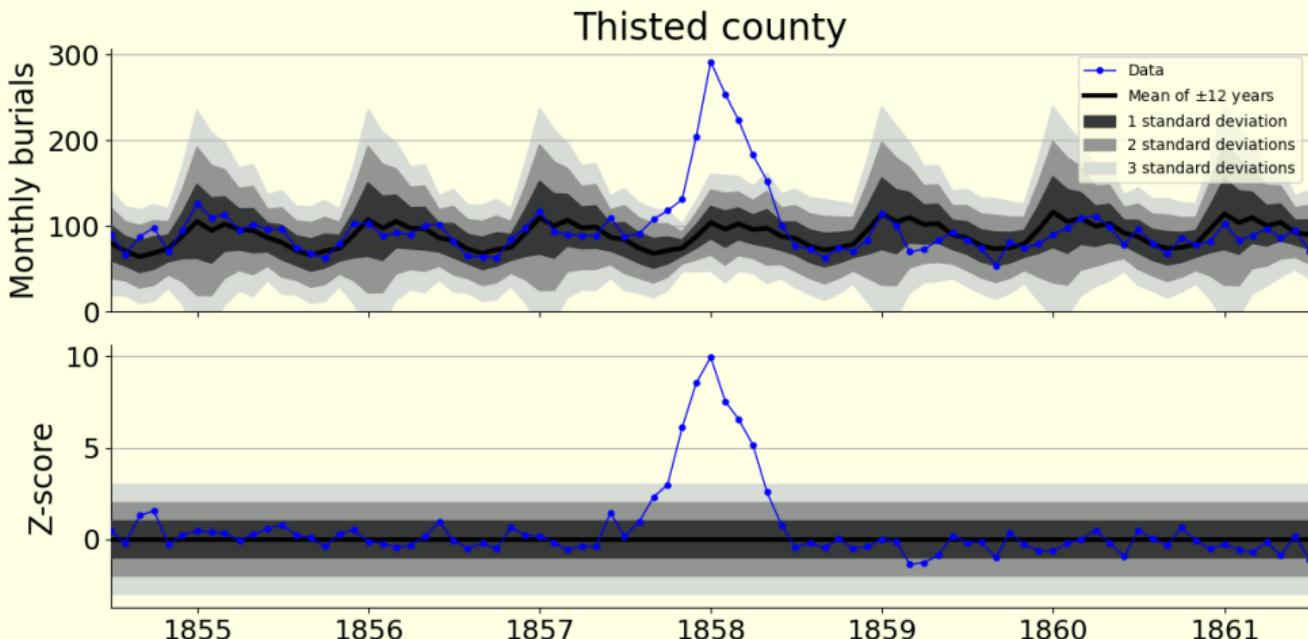
Representative signature
features

General discussion

Calculating the mortality baseline



Calculating the mortality baseline



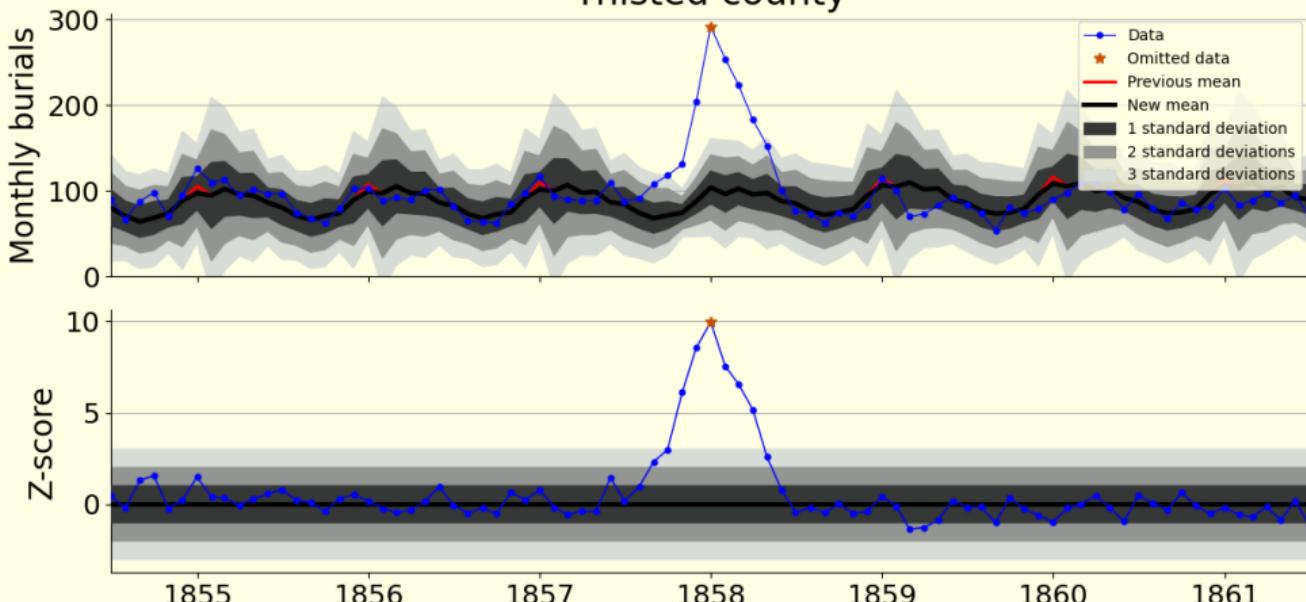
Hinde¹ uses the definition of months with a Z-score above two and three as "mortality crisis" and "severe mortality crisis", respectively

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



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

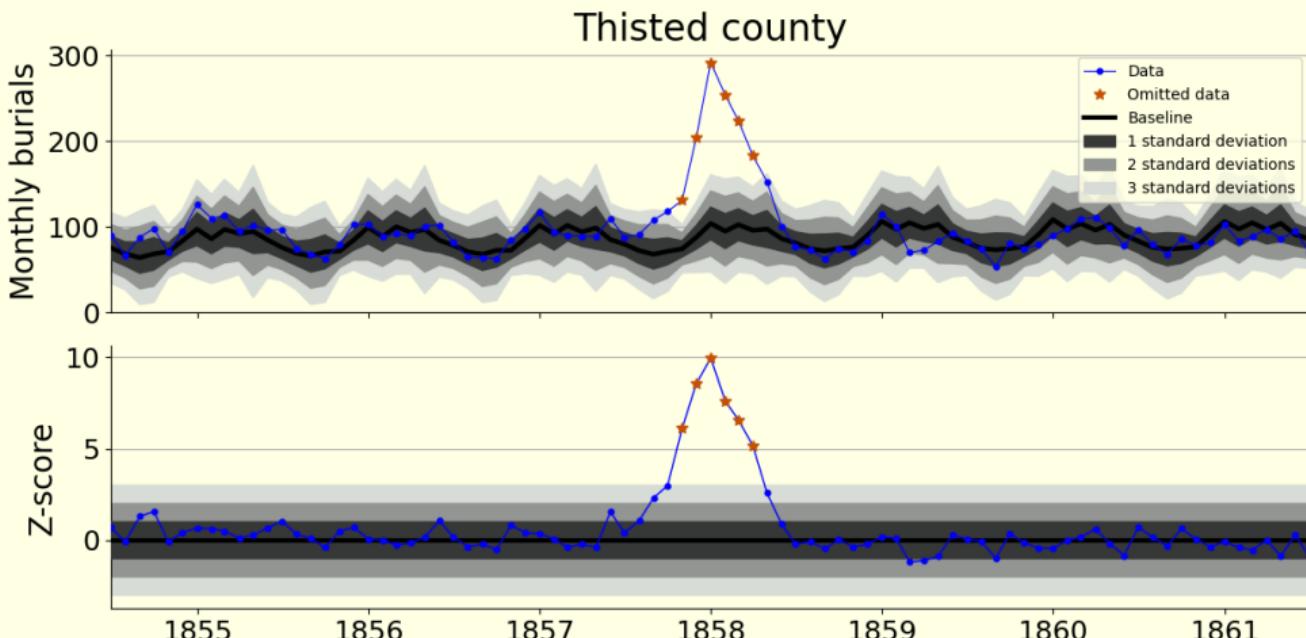
Results and
discussion

Grouping crises

Representative signature
features

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
discussion

Grouping crises

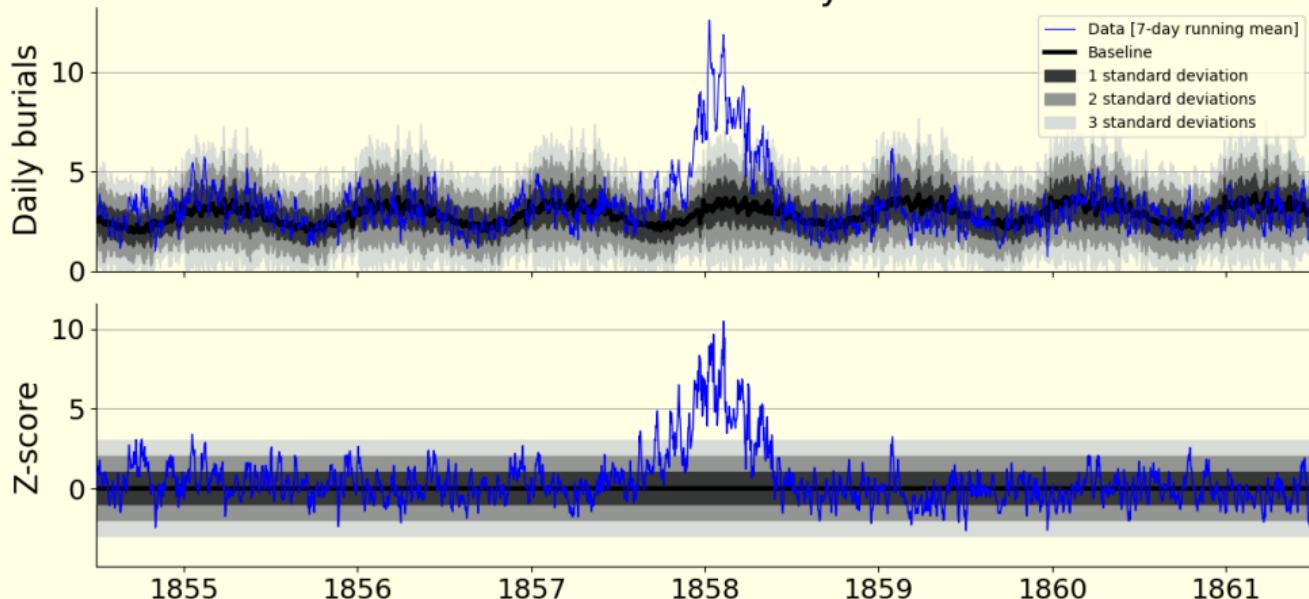
Representative signature

features

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
discussion

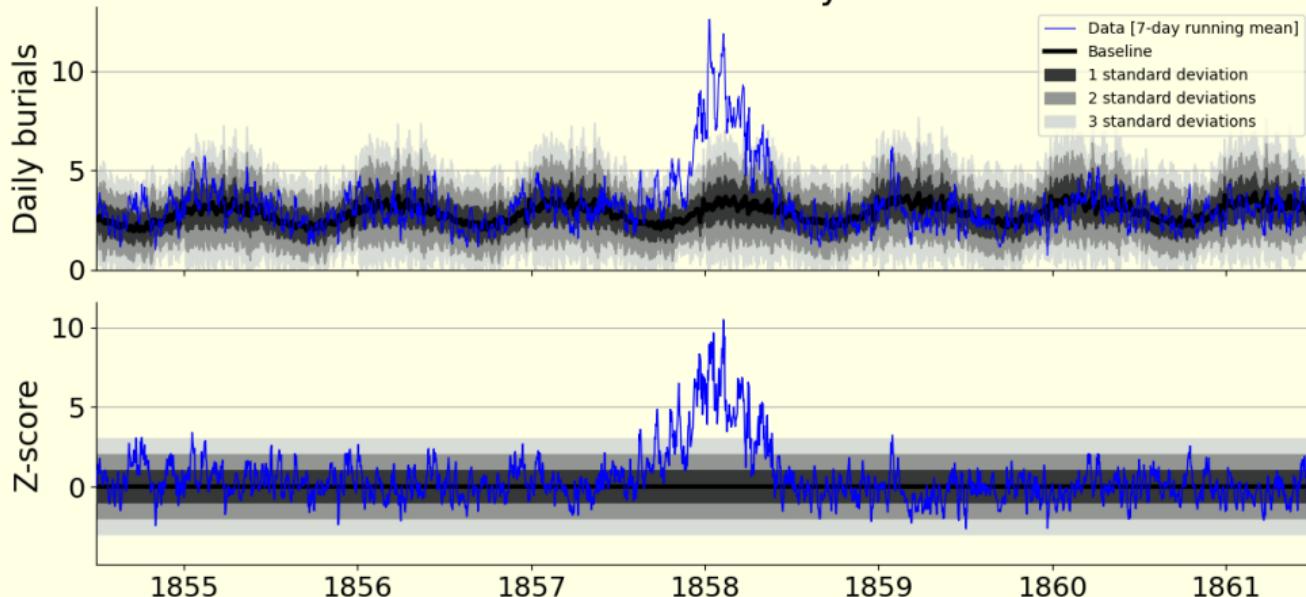
Grouping crises

Representative signature
features

General discussion

Identification of "mortality crises"

Thisted county



We wish to identify periods continuous excess mortality.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

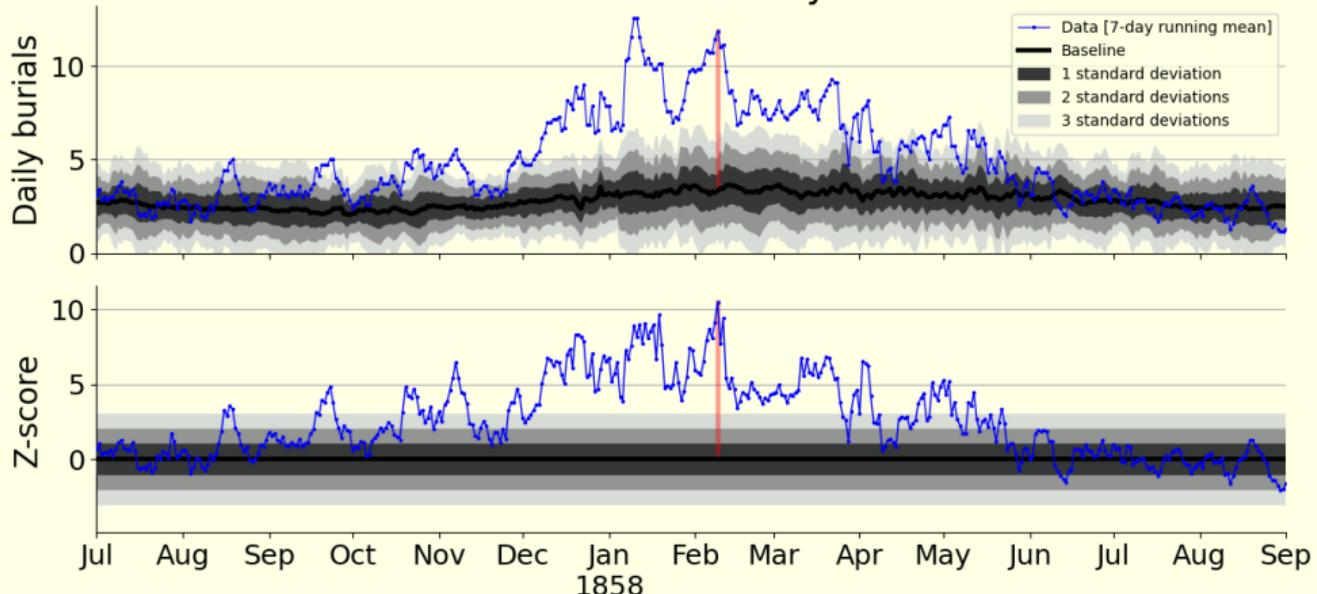
Grouping crises

Representative
signature
features

General discussion

Identification of "mortality crises"

Thisted county



Starting from the date with most burials...



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

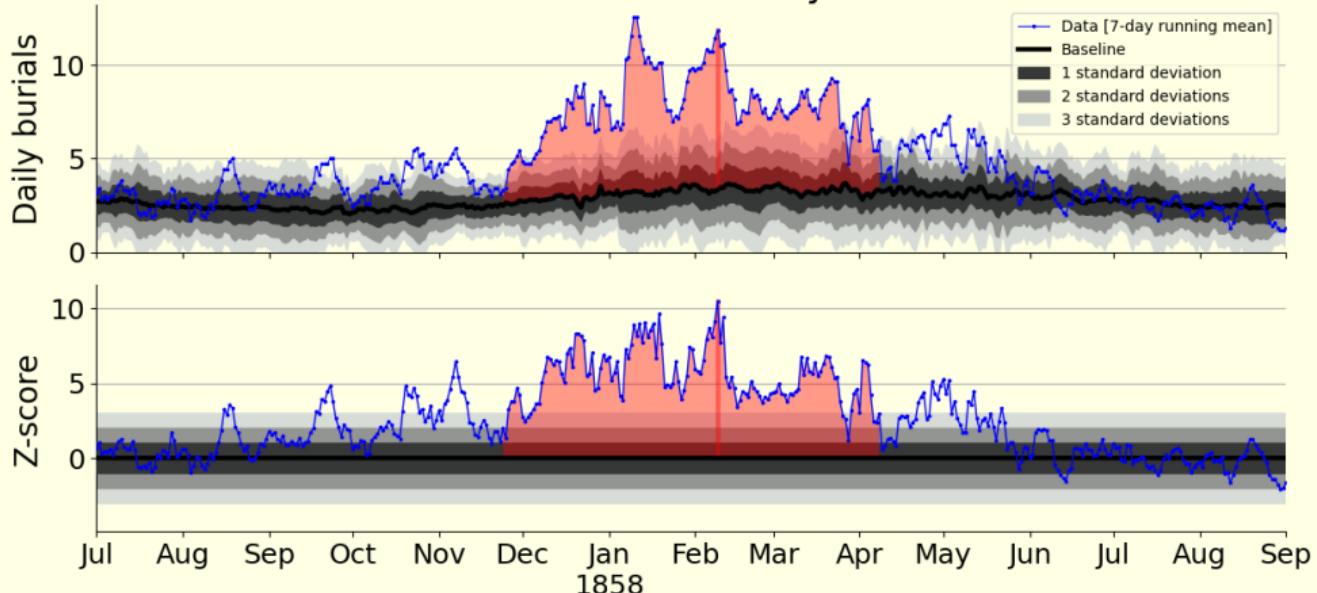
Grouping crises

Representative
signature
features

General discussion

Identification of “mortality crises”

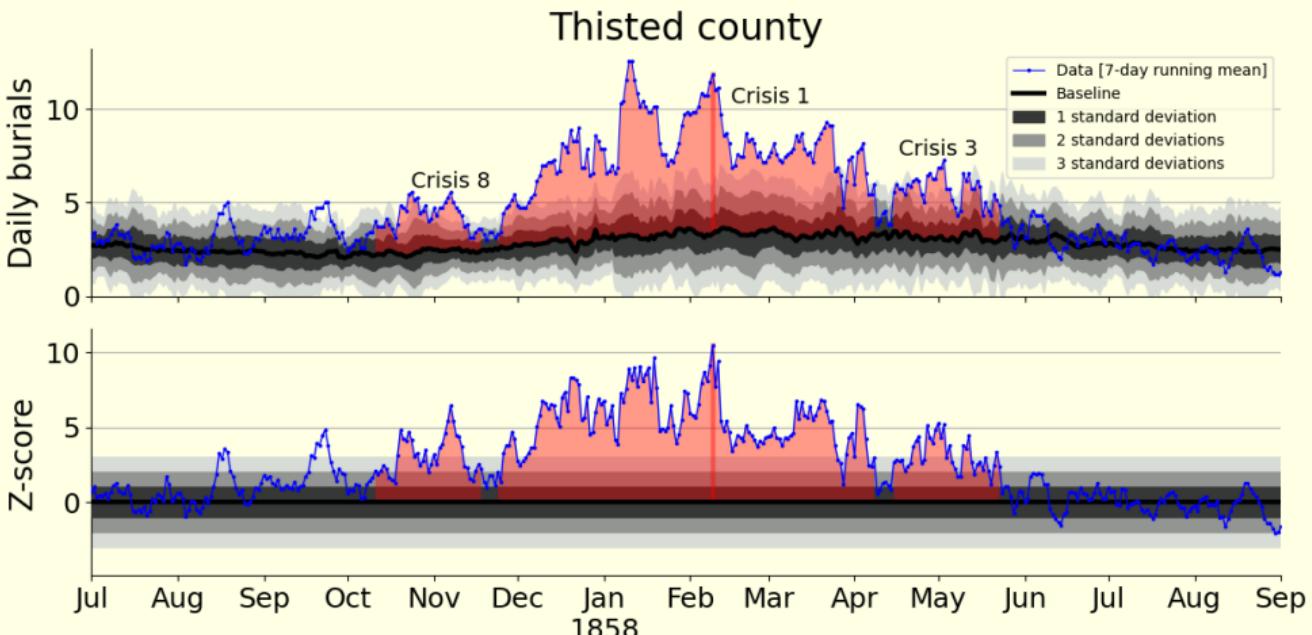
Thisted county



... 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"



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



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

Brief return to the “signature features”

Using this methodology, we identify 320 mortality crises in Denmark between 1820 and 1910.



Brief return to the “signature features”

Using this methodology, we identify 320 mortality crises in Denmark between 1820 and 1910.

For each crisis, we can determine:

- Significant excess mortality.

Enough to cause excess burials on a county level
(Population-sizes $\approx 100,000$).



Brief return to the “signature features”

Using this methodology, we identify 320 mortality crises in Denmark between 1820 and 1910.

For each crisis, we can determine:

- ▶ Significant excess mortality.
Enough to cause excess burials on a county level
(Population-sizes $\approx 100,000$).
- ▶ Timing and seasonality.
e.g. “peaking in winter” or “late summer”



Brief return to the “signature features”

Using this methodology, we identify 320 mortality crises in Denmark between 1820 and 1910.

For each crisis, we can determine:

- ▶ Significant excess mortality.
Enough to cause excess burials on a county level
(Population-sizes $\approx 100,000$).
- ▶ Timing and seasonality.
e.g. “peaking in winter” or “late summer”
- ▶ Duration
e.g. “lasting two months”



Brief return to the “signature features”

Using this methodology, we identify 320 mortality crises in Denmark between 1820 and 1910.

For each crisis, we can determine:

- ▶ Significant excess mortality.
Enough to cause excess burials on a county level
(Population-sizes $\approx 100,000$).
- ▶ Timing and seasonality.
e.g. “peaking in winter” or “late summer”
- ▶ Duration
e.g. “lasting two months”

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
discussion

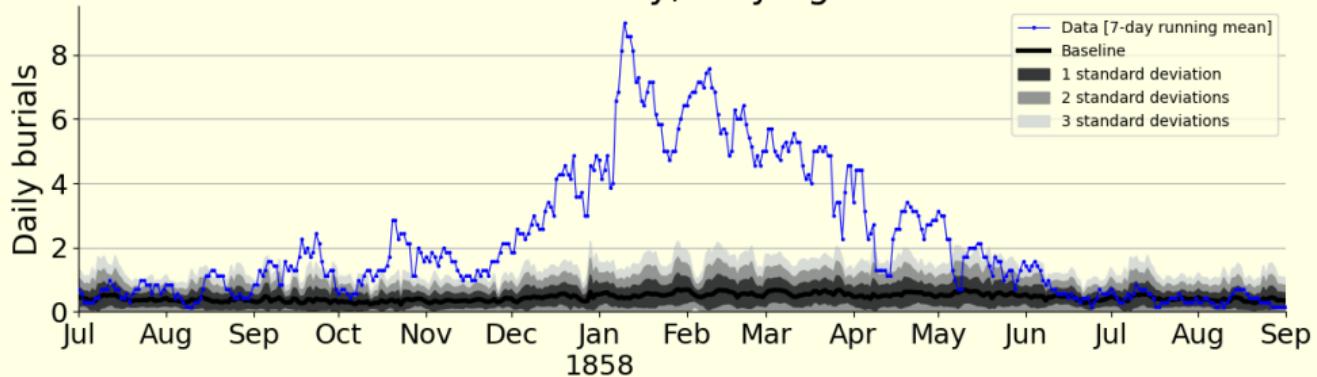
Grouping crises

Representative signature
features

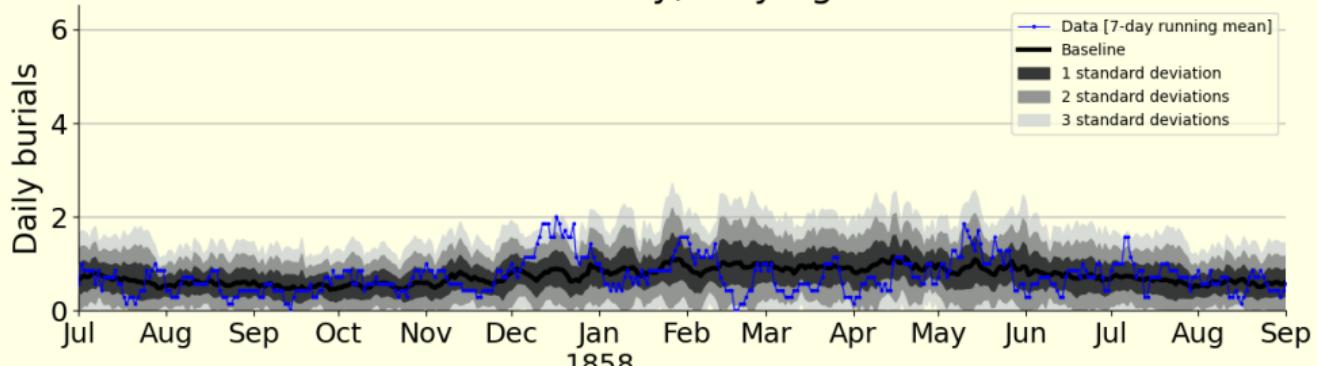
General discussion

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
discussion

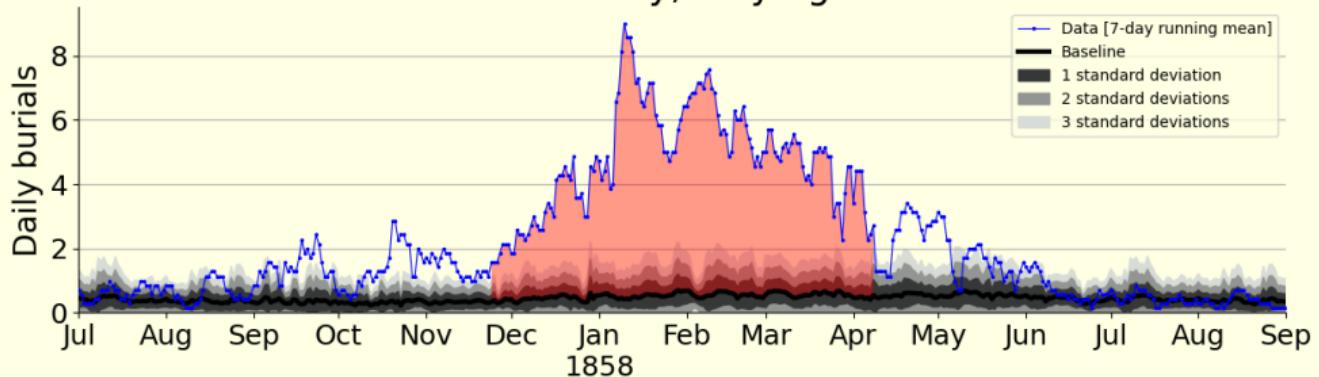
Grouping crises

Representative signature
features

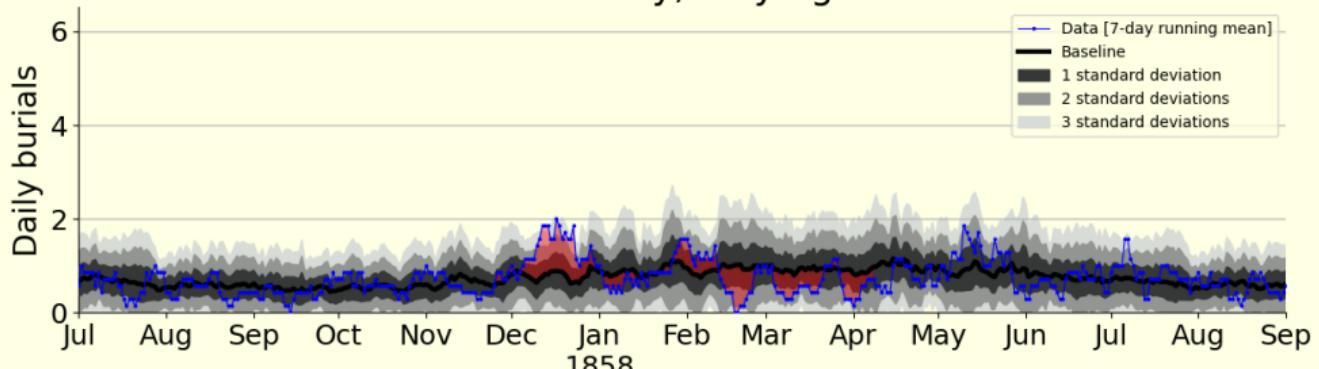
General discussion

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
discussion

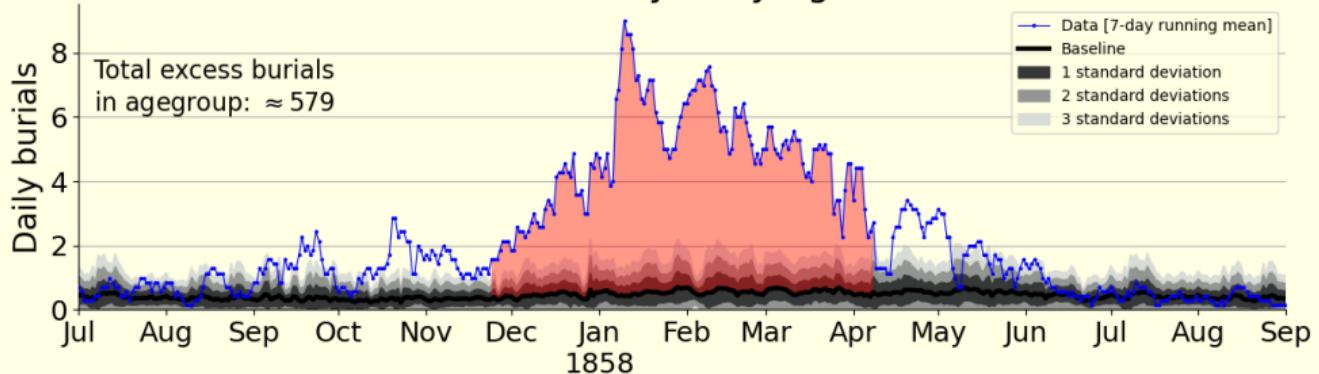
Grouping crises

Representative signature
features

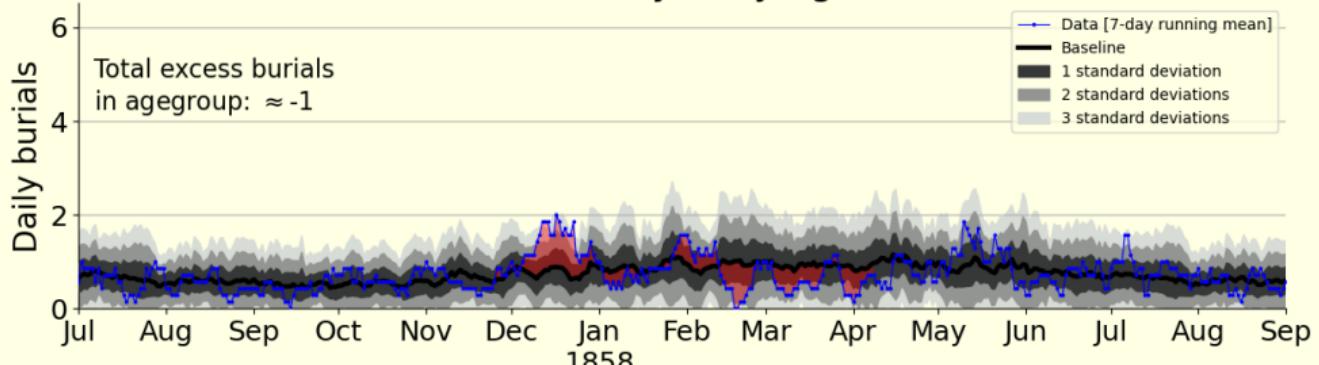
General discussion

Analyzing age-patterns

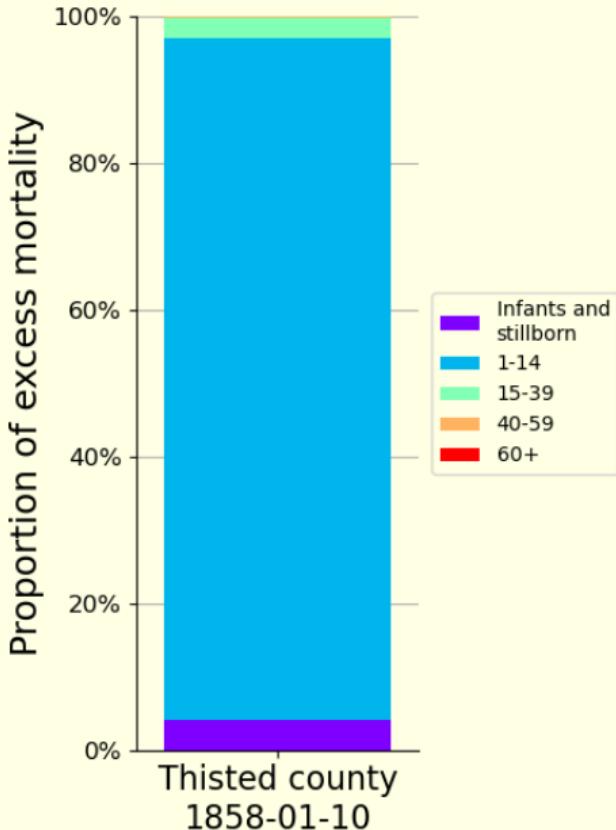
Thisted county, only ages 1-14



Thisted county, only ages 60+



Analyzing age-patterns



Age-specific excess mortality in this period:

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



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

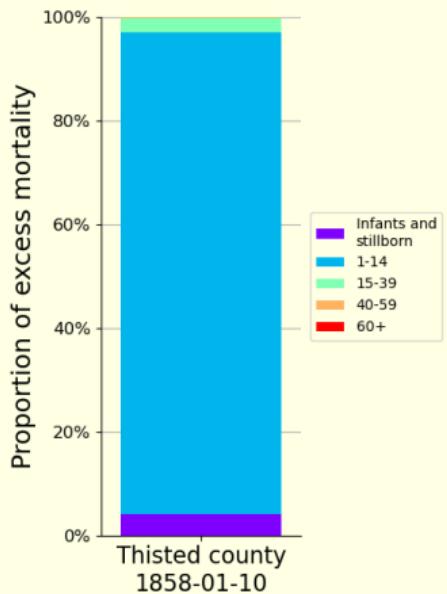
Results and
discussion

Grouping crises

Representative signature
features

General discussion

Mortality crises with comparable age patterns



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

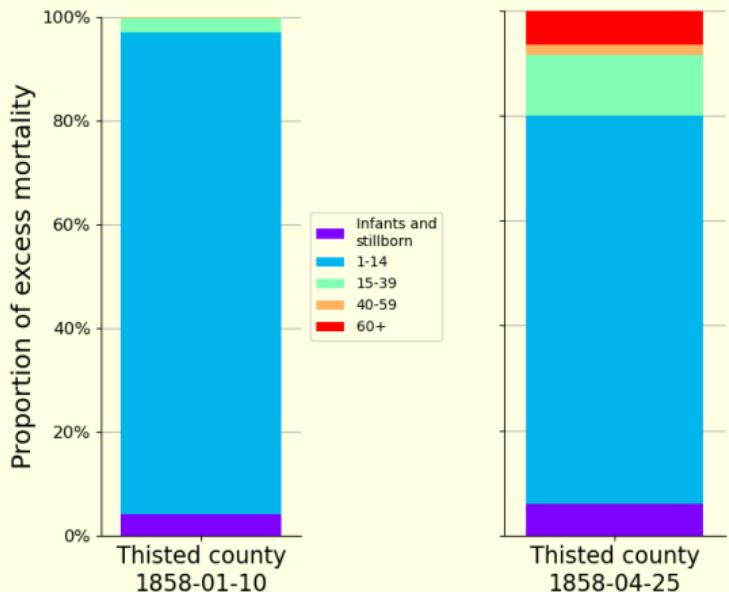
Results and
discussion

Grouping crises

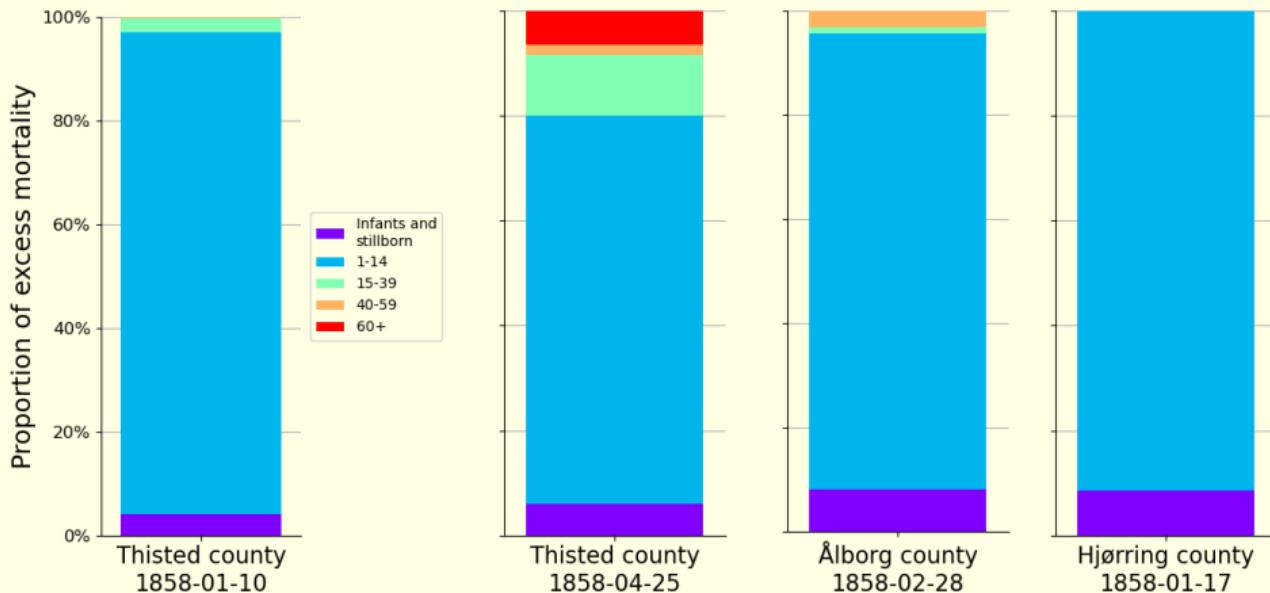
Representative signature
features

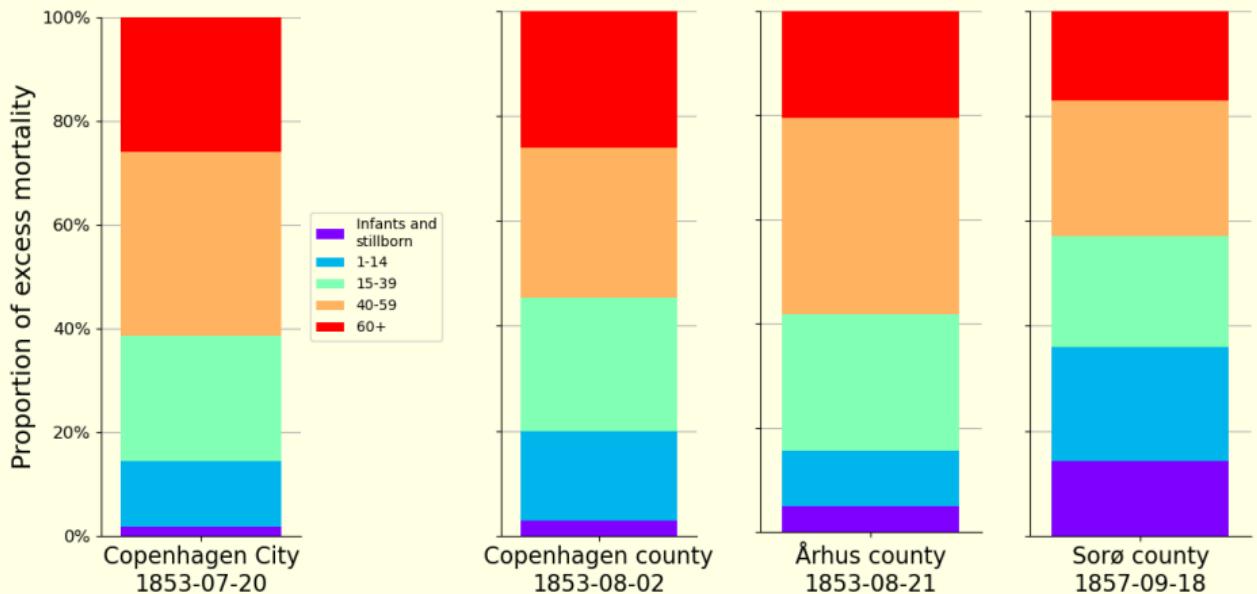
General discussion

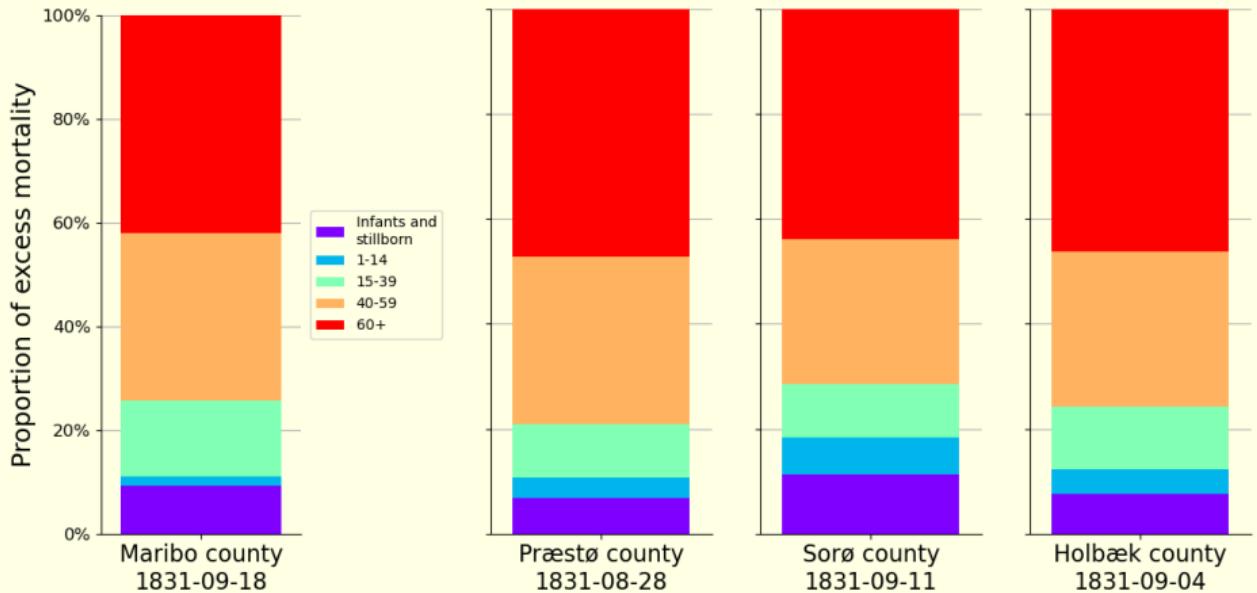
Mortality crises with comparable age patterns

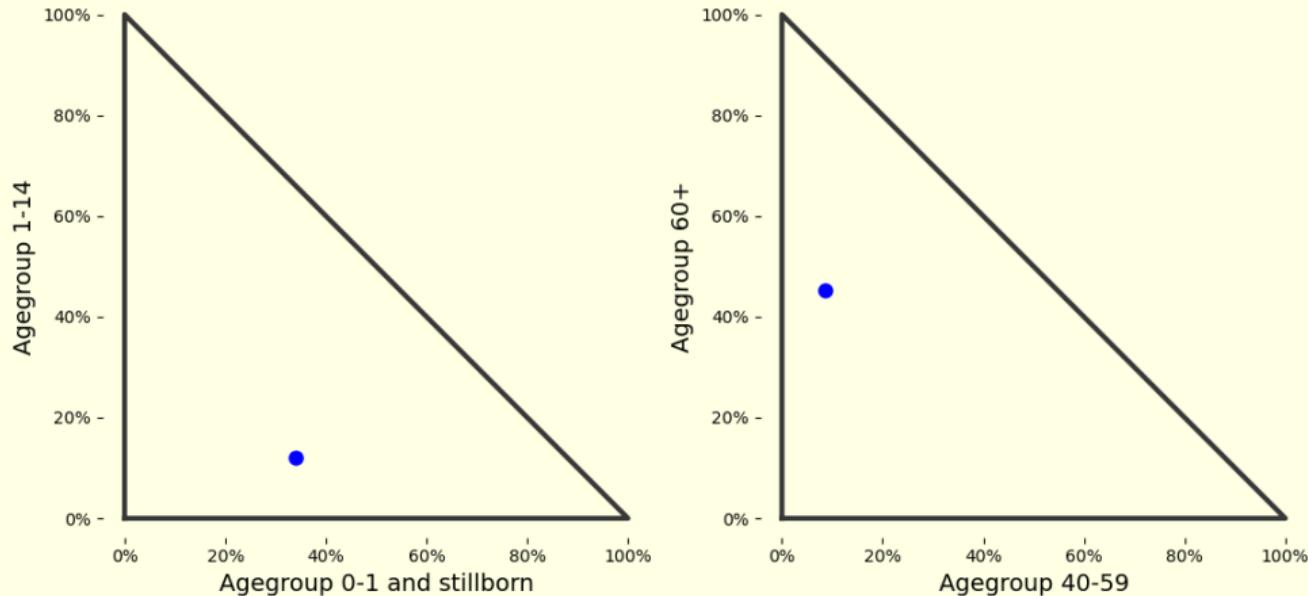


Mortality crises with comparable age patterns



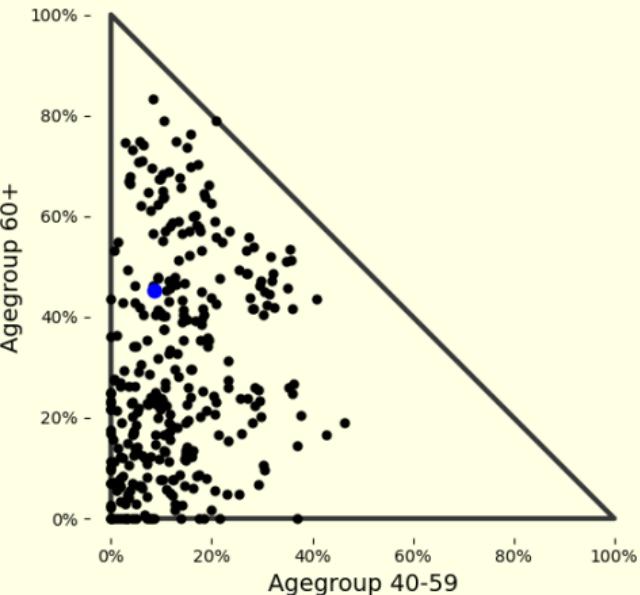
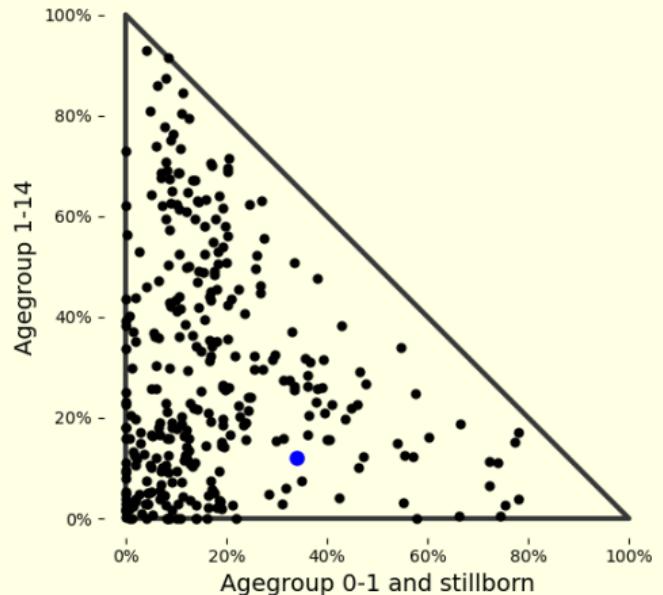






(Age group "15-39" not shown here)

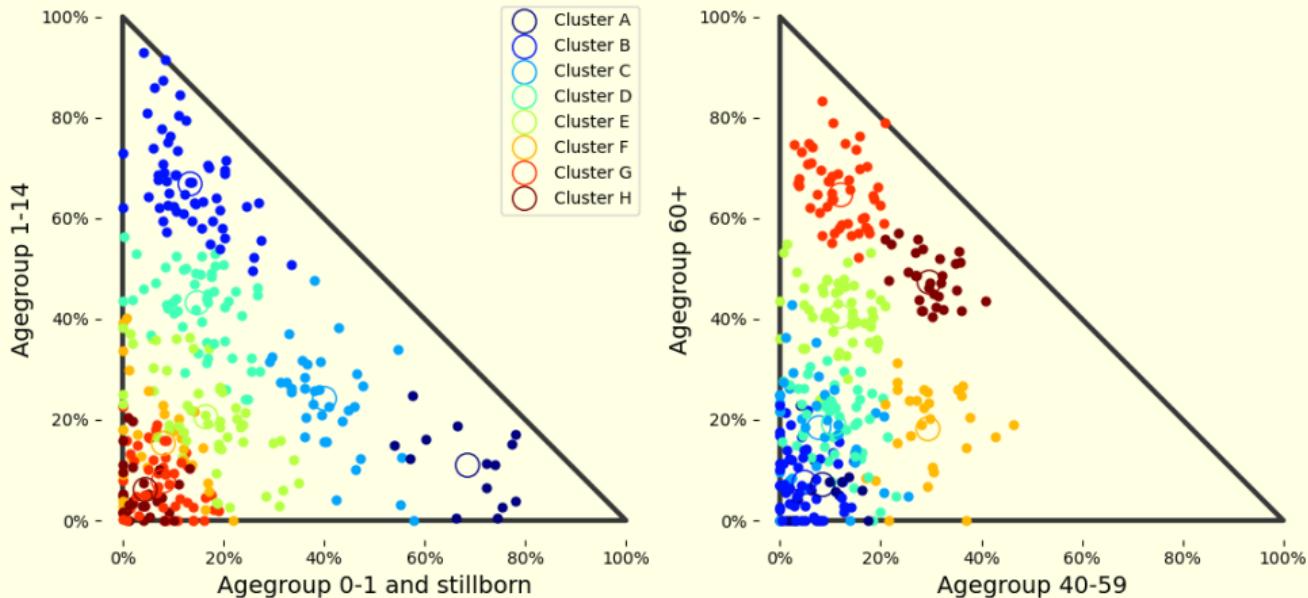




Adding the other 319 mortality crises identified.

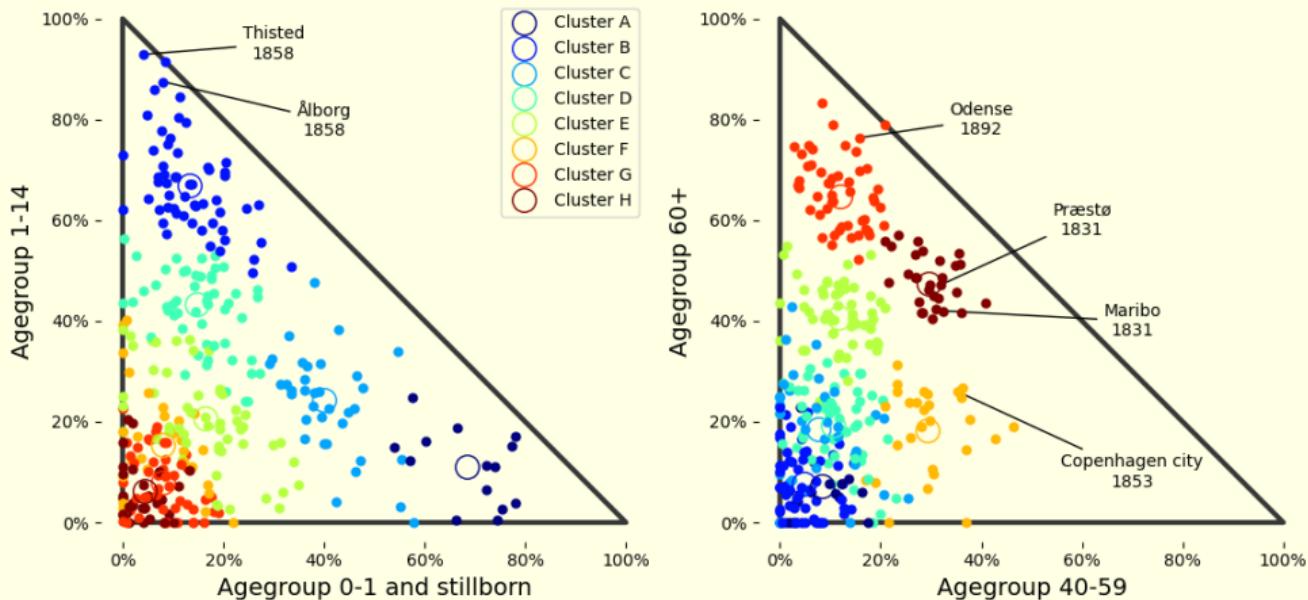


Mortality crises with comparable age patterns



Gaussian mixture modelling on full five-dimensional data.

Mortality crises with comparable age patterns



Gaussian mixture modelling on full five-dimensional data.

Disease	Timing	Total excess	Age structure
Cholera	Late summer, 1853 and 1857	4588	Adults Cluster "F"
Scarlet fever	Winter 1857/1858	2323	Children (1-15) Cluster "B"
"Harvest" epidemic¹	Late summer, 1825-1831	11539	Adults Cluster "H" and "F"
Pandemic influenza	1892 and 1900	9532	Elderly Cluster "G"

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

¹ The cause of this mortality crisis was probably a subsistence crisis as well as a range of diseases. Discussed in detail in Ingholt (2022) *Scandinavian Journal of History*



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

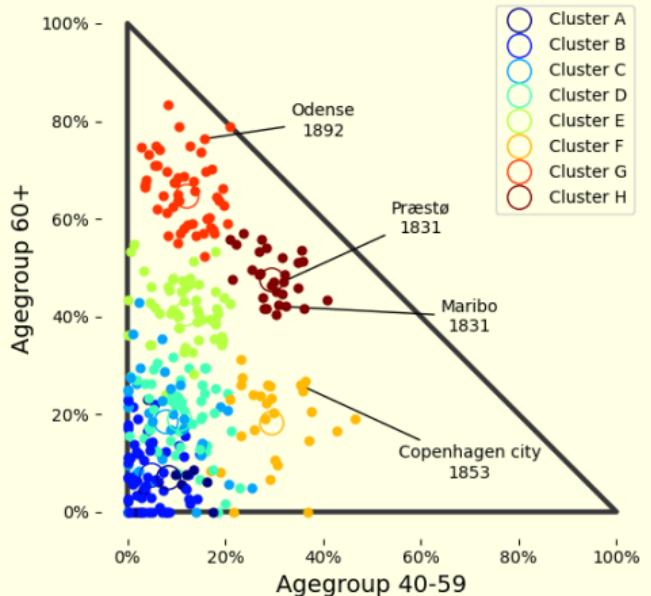
Comparing age patterns

Results and
discussion

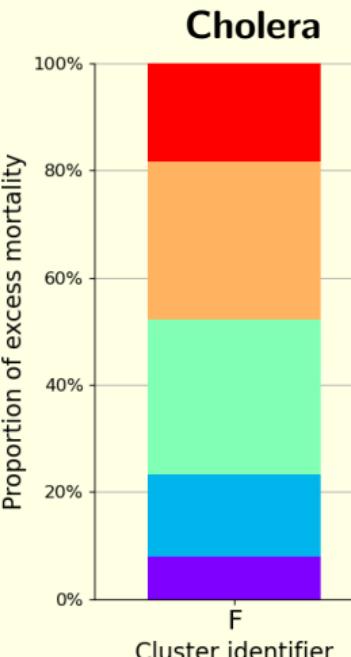
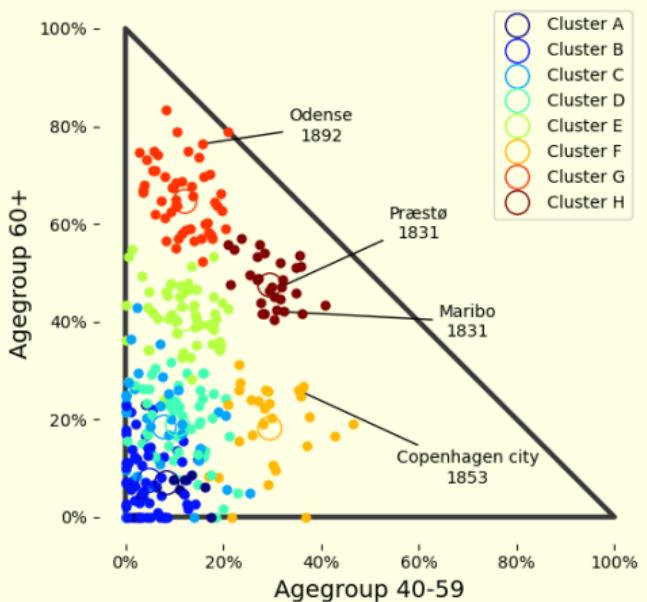
Grouping crises

Representative signature
features

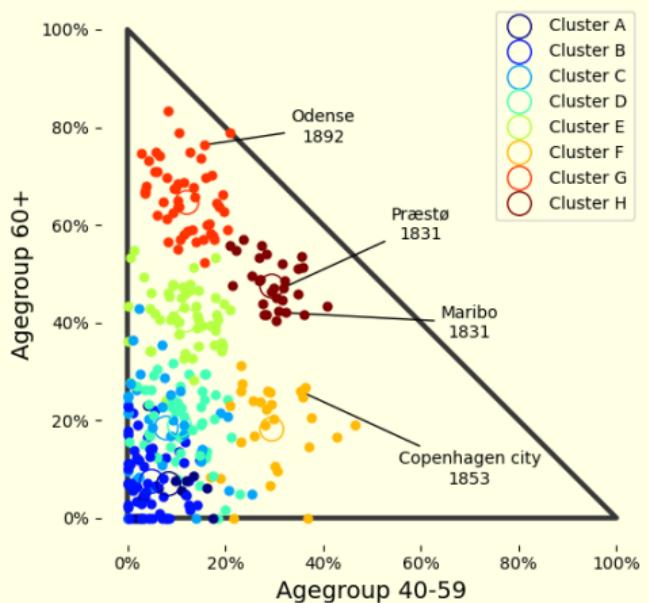
General discussion



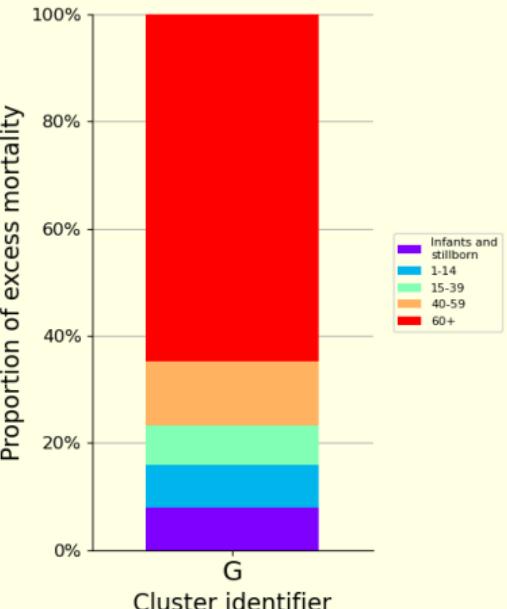
The signature features of certain diseases



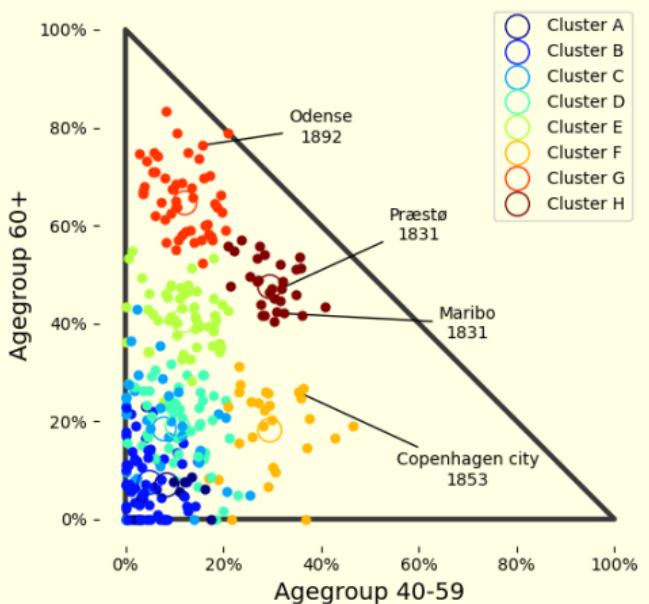
The signature features of certain diseases



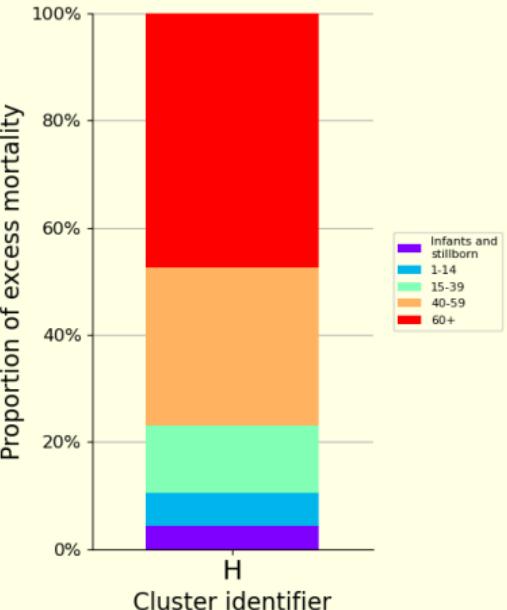
Pandemic influenza



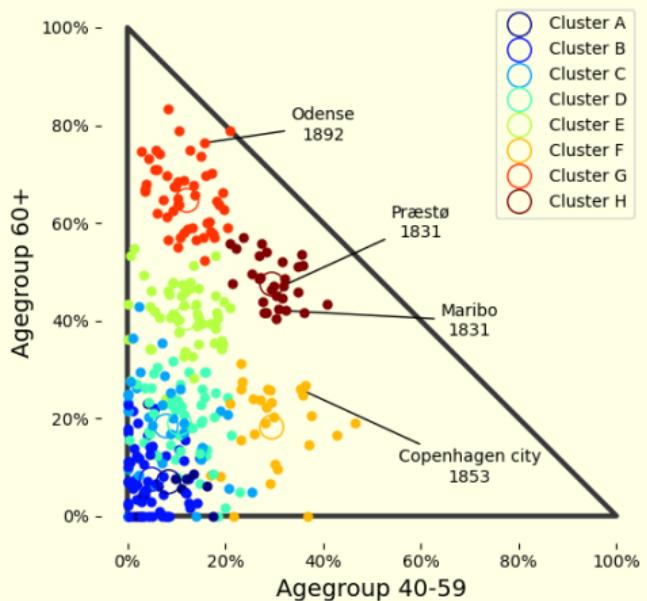
The signature features of certain diseases



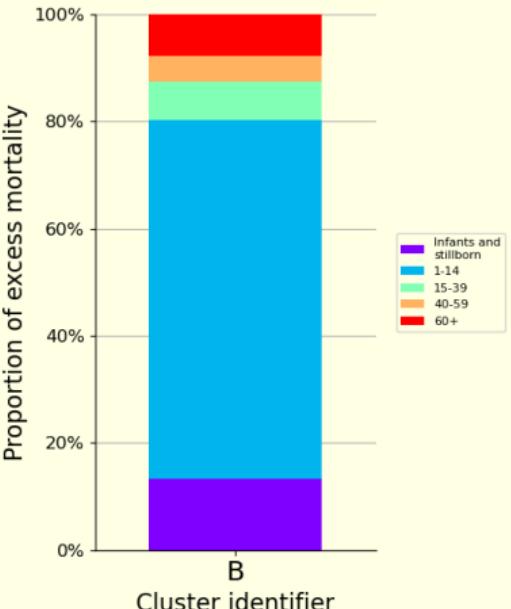
"Harvest epidemics"



The signature features of certain diseases



Scarlet fever



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

- We determine mortality baselines on county-level and estimate excess mortality.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Timing/Seasonality.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Timing/Seasonality.
 - ▶ Duration.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Timing/Seasonality.
 - ▶ Duration.
 - ▶ Geography.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Timing/Seasonality.
 - ▶ Duration.
 - ▶ Geography.
 - ▶ Age-pattern.



- ▶ We determine mortality baselines on county-level and estimate excess mortality.
- ▶ We identify 320 major mortality crises in 19th century Denmark.
- ▶ For each crisis, we determine signature features:
 - ▶ Timing/Seasonality.
 - ▶ Duration.
 - ▶ Geography.
 - ▶ Age-pattern.
- ▶ 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

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in 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

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in modern data.
- ▶ 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

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in modern data.
- ▶ Similar methods could be applied to modern data.
 - ▶ Mortality baseline calculations.
Available online soon, as both Python and R package.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in modern data.
- ▶ Similar methods could be applied to modern data.
 - ▶ Mortality baseline calculations.
Available online soon, as both Python and R package.
 - ▶ Quantitative comparison of age-patterns in modern all-cause mortality data.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in modern data.
- ▶ Similar methods could be applied to modern data.
 - ▶ Mortality baseline calculations.
Available online soon, as both Python and R package.
 - ▶ Quantitative comparison of age-patterns in modern all-cause mortality data.
- ▶ Understanding changes through history of the mortality of specific diseases may help us understand the disease today.



Introduction

Background and
data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and
discussion

Grouping crises

Representative signature
features

General discussion

- ▶ Despite demographic differences between 19th century Denmark, the identified age patterns may still be relevant in modern data.
- ▶ Similar methods could be applied to modern data.
 - ▶ Mortality baseline calculations.
Available online soon, as both Python and R package.
 - ▶ Quantitative comparison of age-patterns in modern all-cause mortality data.
- ▶ Understanding changes through history of the mortality of specific diseases may help us understand the disease today.
- ▶ As more historical data becomes transcribed, e.g. thanks to improved OCR, 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



Danmarks
Grundforskningsfond
Danish National
Research Foundation

