

Identifying Excess Mortality Patterns in 19th Century Denmark

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Joint work with
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Viggo Andreasen & Lone Simonsen*

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Universität
Münster



Danmarks
Grundforskningsfond
Danish National
Research Foundation

- ▶ 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

Summary & discussion

Introduction

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Data source

Data cleaning

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

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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>

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Data cleaning

Methodology

Mortality baseline

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- ▶ 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

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Methodology

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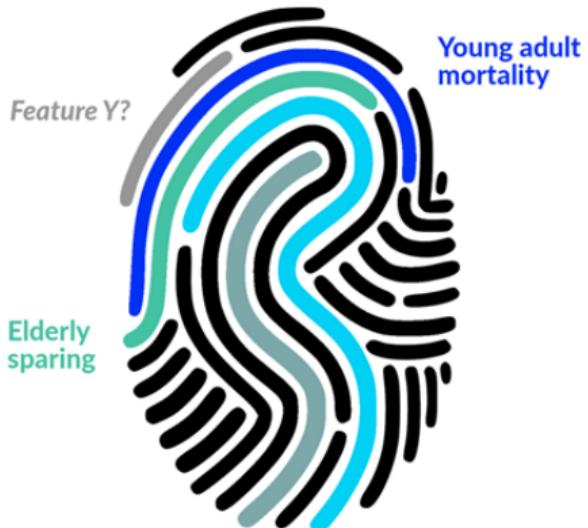
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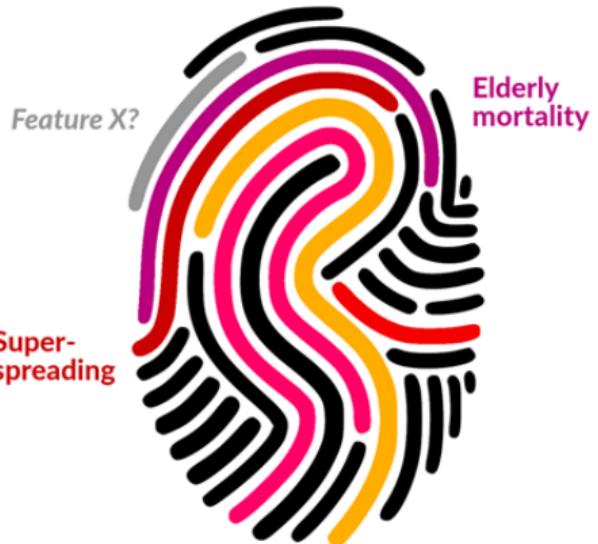
Summary & discussion

- ▶ 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



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Results and discussion

Representative signature features

Grouping crises

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Identifying Excess Mortality

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

Representative signature features

Grouping crises

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Overview of talk

Identifying Excess Mortality

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

Representative signature features

Grouping crises

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Overview of talk

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

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Age-specific mortality

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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.



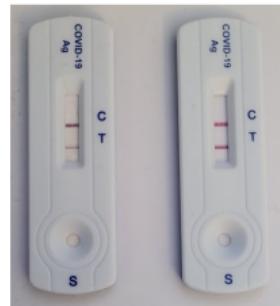
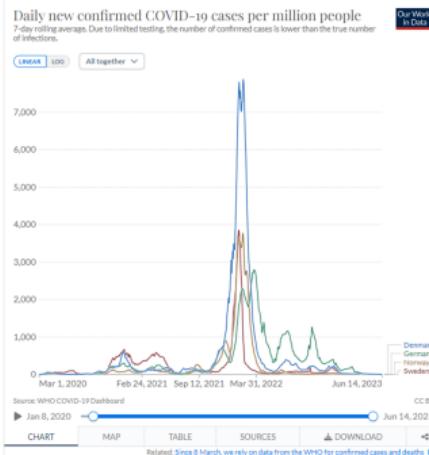
STATENS
SERUM
INSTITUT

Download covid-19-opgørelser

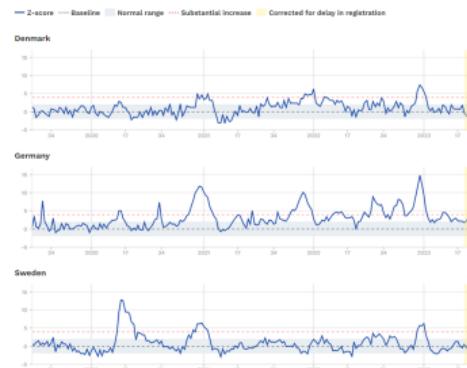
Filer med covid-19-opgørelser fra dashboardet (zip-csv),
den 8. marts 2021 og frem

- [COVID-19-dashboard 14062023 \(zip\)](#) 0.44 MB
- [Covid-19-dashboard 07062023 \(zip\)](#) 0.44 MB
- [Covid-19-dashboard 31052023 \(zip\)](#) 0.44 MB
- [Covid-19-dashboard 24052023 \(zip\)](#) 0.43 MB
- [Covid-19-dashboard 17052023 \(zip\)](#) 0.43 MB
- [Covid-19-dashboard 10052023 \(zip\)](#) 0.43 MB
- [Covid-19-dashboard 03052023 \(zip\)](#) 0.49 MB

Our World
in Data



EUROMOMO



No.	Dobbdagen.	Begravelsesdagen.	Den Dødes Navn og tilnavn.	Stand, Haandtering og Opholdsted.	Alder.	Hvor an- ført i det almindelis- ge Leon- torske Registre.	Emærkninger.
35.	29. August	1. Septbr.	Anders Jørgensen	Sjæl i København	53 Æar	692. 138	
36.	31. August	4. Septbr.	Hans Carlsson	Tørst i Skælskør	65 Æar	692. 139	
37.	30. August	3. Septbr.	Ole Jensen	Blodgårdsmann i Skælskør	89 Æar	692. 140	
38.	3. Septbr.	7. Septbr.	Holger Larsen	Sjæl i Horsens	70 Æar	692. 141	
39.	31. August	4. Septbr.	Hans Olsen	Gjern og Sjæl i Horsens	42 Æar	692. 142	
40.	4. Septbr.	6. Septbr.	Niels Pedersen	Tørst i Espejerslev	66 Æar	692. 143	
41.	5. Septbr.	9. Septbr.	Ole Hansen	Blodgårdsmann i Tønsberg	66 Æar	693. 144	
42.	4. Septbr.	9. Septbr.	Niels Christensen	Sjæl i Tønsberg	57 Æar	693. 145	
43.	7. Septbr.	12. Septbr.	Niels Larsen	Sjæl i Tønsberg	80 Æar	693. 146	
44.	6. Septbr.	12. Septbr.	Jens Andersen	Blodgårdsmann i Tønsberg	72 Æar	693. 147	
45.	8. Septbr.	13. Septbr.	Hans Christian	Sjæl i Tønsberg	42 Æar	693. 148	
46.	5. Septbr.	9. Septbr.	Lars Christophersen	Blodgårdsmann i Horsens	93 Æar	693. 149	
47.	12. Septbr.	16. Septbr.	Peder Hansen	Sjæl i Skælskør	78 Æar	693. 150	
48.	11. Septbr.	14. Septbr.	Hans Larsen	Sjæl i Skælskør	49 Æar	693. 151	

Data source

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- Parish registers for Danish church parishes between 1815-1915

Sn.	Baptism	Begravelse	Den døde Den ig. tilhører	Døds. handling og dødsdag	Ålder ved døden	Gren. ved døden i 100 størrelse af dødsdag	Tilsv. ved døden i størrelse af dødsdag	Tilsv. ved døden
25.	17. Februar 1831	Jørgen	Lindore Sørensen	Avd. i 100 dage	100 dage	94	100	100
26.	31. Des. 1830	August	Hans Carlsten	Avd. i 100 dage	100 dage	129	100	100
27.	30. Des. 1830	3. marts	Ol. Jensen	Udskrivning i 100 dage	100 dage	100	100	100
28.	3. Dec. 1830	7. marts	Hager Larsen	Avd. i 100 dage	100 dage	140	100	100
29.	31. Des. 1830	4. marts	Hans Olof	Udskrivning i 100 dage	100 dage	100	100	100
30.	1. Jan. 1831	6. marts	Niels Andersen	Avd. i 100 dage	100 dage	100	100	100
31.	3. Jan. 1831	9. marts	Ol. Hansen	Udskrivning i 100 dage	100 dage	100	100	100
32.	4. Jan. 1831	12. marts	Niels Carlsten	Avd. i 100 dage	100 dage	100	100	100
33.	7. Jan. 1831	15. marts	Ol. Larsen	Avd. i 100 dage	100 dage	100	100	100
34.	10. Jan. 1831	18. marts	Peter Sørensen	Avd. i 100 dage	100 dage	100	100	100
35.	13. Jan. 1831	21. marts	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
36.	16. Jan. 1831	24. marts	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
37.	19. Jan. 1831	27. marts	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
38.	22. Jan. 1831	30. marts	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
39.	25. Jan. 1831	2. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
40.	28. Jan. 1831	5. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
41.	31. Jan. 1831	8. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
42.	3. Feb. 1831	11. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
43.	6. Feb. 1831	14. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
44.	9. Feb. 1831	17. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
45.	12. Feb. 1831	20. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
46.	15. Feb. 1831	23. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
47.	18. Feb. 1831	26. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
48.	21. Feb. 1831	29. april	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
49.	24. Feb. 1831	1. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
50.	27. Feb. 1831	4. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
51.	1. Mar. 1831	7. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
52.	4. Mar. 1831	10. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
53.	7. Mar. 1831	13. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
54.	10. Mar. 1831	16. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
55.	13. Mar. 1831	19. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
56.	16. Mar. 1831	22. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
57.	19. Mar. 1831	25. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
58.	22. Mar. 1831	28. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
59.	25. Mar. 1831	31. maj	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
60.	28. Mar. 1831	3. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
61.	31. Mar. 1831	6. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
62.	3. Apr. 1831	9. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
63.	6. Apr. 1831	12. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
64.	9. Apr. 1831	15. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
65.	12. Apr. 1831	18. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
66.	15. Apr. 1831	21. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
67.	18. Apr. 1831	24. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
68.	21. Apr. 1831	27. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
69.	24. Apr. 1831	30. juni	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
70.	27. Apr. 1831	3. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
71.	30. Apr. 1831	6. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
72.	3. Mai 1831	9. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
73.	6. Mai 1831	12. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
74.	9. Mai 1831	15. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
75.	12. Mai 1831	18. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
76.	15. Mai 1831	21. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
77.	18. Mai 1831	24. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
78.	21. Mai 1831	27. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
79.	24. Mai 1831	30. juli	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
80.	27. Mai 1831	2. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
81.	30. Mai 1831	5. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
82.	2. Jun. 1831	8. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
83.	5. Jun. 1831	11. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
84.	8. Jun. 1831	14. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
85.	11. Jun. 1831	17. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
86.	14. Jun. 1831	20. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
87.	17. Jun. 1831	23. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
88.	20. Jun. 1831	26. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
89.	23. Jun. 1831	29. Aug.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
90.	26. Jun. 1831	1. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
91.	29. Jun. 1831	4. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
92.	2. Jul. 1831	7. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
93.	5. Jul. 1831	10. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
94.	8. Jul. 1831	13. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
95.	11. Jul. 1831	16. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
96.	14. Jul. 1831	19. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
97.	17. Jul. 1831	22. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
98.	20. Jul. 1831	25. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
99.	23. Jul. 1831	28. Sept.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
100.	26. Jul. 1831	1. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
101.	29. Jul. 1831	4. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
102.	1. Aug. 1831	7. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
103.	4. Aug. 1831	10. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
104.	7. Aug. 1831	13. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
105.	10. Aug. 1831	16. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
106.	13. Aug. 1831	19. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
107.	16. Aug. 1831	22. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
108.	19. Aug. 1831	25. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
109.	22. Aug. 1831	28. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
110.	25. Aug. 1831	31. Oct.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
111.	28. Aug. 1831	3. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
112.	1. Sept. 1831	6. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
113.	4. Sept. 1831	9. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
114.	7. Sept. 1831	12. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
115.	10. Sept. 1831	15. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
116.	13. Sept. 1831	18. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
117.	16. Sept. 1831	21. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
118.	19. Sept. 1831	24. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
119.	22. Sept. 1831	27. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
120.	25. Sept. 1831	30. Nov.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
121.	28. Sept. 1831	3. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
122.	1. Oct. 1831	6. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
123.	4. Oct. 1831	9. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
124.	7. Oct. 1831	12. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
125.	10. Oct. 1831	15. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
126.	13. Oct. 1831	18. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
127.	16. Oct. 1831	21. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
128.	19. Oct. 1831	24. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
129.	22. Oct. 1831	27. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
130.	25. Oct. 1831	30. Dec.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
131.	28. Oct. 1831	2. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
132.	1. Nov. 1831	5. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
133.	4. Nov. 1831	8. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
134.	7. Nov. 1831	11. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
135.	10. Nov. 1831	14. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
136.	13. Nov. 1831	17. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
137.	16. Nov. 1831	20. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
138.	19. Nov. 1831	23. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
139.	22. Nov. 1831	26. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
140.	25. Nov. 1831	29. Jan.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
141.	28. Nov. 1831	1. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
142.	1. Dec. 1831	4. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
143.	4. Dec. 1831	7. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
144.	7. Dec. 1831	10. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
145.	10. Dec. 1831	13. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
146.	13. Dec. 1831	16. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
147.	16. Dec. 1831	19. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
148.	19. Dec. 1831	22. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
149.	22. Dec. 1831	25. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
150.	25. Dec. 1831	28. Feb.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
151.	28. Dec. 1831	1. Mar.	Hans Larsen	Avd. i 100 dage	100 dage	100	100	100
152.	1. Jan. 1832							

Data source

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

Sn.	Dato	Begravelses-	En. Dato En. og Ellerens.	Størst. Begravelse og Begravelses-	Eller. Begravelse og Begravelses-	Års-	Tælling.
25.	17. Februar	1831.	Jørgen Lindersen	Jørgen i 1831	1831	1831	1831
26.	3. Februar	1831.	Hans Carlsen	Hans i 1831	1831	1831	1831
27.	10. Februar	1831.	Ol. Jensen	Ol. Jensen i 1831	1831	1831	1831
28.	3. Marts	1831.	Hans Larsen	Hans i 1831	1831	1831	1831
29.	31. Februar	1831.	Hans Olsen	Hans i 1831	1831	1831	1831
30.	1. Marts	1831.	Vilh. Andersen	Vilh. Andersen i 1831	1831	1831	1831
31.	3. Marts	1831.	Ol. Hansen	Ol. Hansen i 1831	1831	1831	1831
32.	4. Marts	1831.	Niels Christensen	Niels Christensen i 1831	1831	1831	1831
33.	7. Marts	1831.	Ol. Larsen	Ol. Larsen i 1831	1831	1831	1831
34.	8. Marts	1831.	Ol. Larsen	Ol. Larsen i 1831	1831	1831	1831
35.	11. Marts	1831.	Hans Christensen	Hans Christensen i 1831	1831	1831	1831
36.	11. Marts	1831.	Hans Larsen	Hans Larsen i 1831	1831	1831	1831

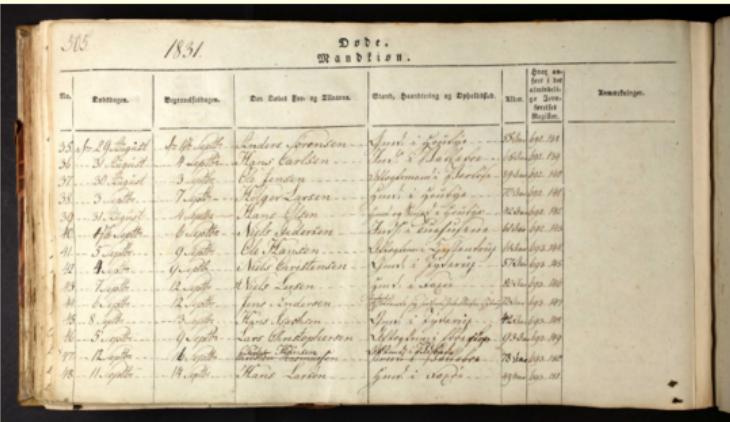
Scan of parish register for "Fakse" parish.

Data source

Identifying Excess Mortality

RK Pedersen

- ▶ 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



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*

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

Sn.	Dato	Begravelsesdag	En. Dato En. og Begravelse	Sted, Begravelse og Begravelsesdag	Alte. af døde	Grav. af døde i 1800-1850	Tilh. til døde	Tilh. til døde fra 1800-1850
25.	17. Februar	17. Februar	Lindore Sørensen	Jens i Fakse	88	Skægk. 1800-1850		
26.	3. Februar	3. Februar	Hans Carsten	Pas i Fakse	150	Skægk. 1800-1850		
27.	30. Januar	3. Februar	Ol. Jensen	Skægk. i Fakse	100	Skægk. 1800-1850		
28.	3. Februar	7. Februar	Hager Larsen	Jens i Fakse	140	Skægk. 1800-1850		
29.	31. Desember	4. Januar	Hans Olof	Jens i Fakse	100	Skægk. 1800-1850		
30.	1. Januar	8. Januar	Vilh. Andersen	Pas i Fakse	100	Skægk. 1800-1850		
31.	3. Januar	9. Januar	Ol. Hansen	Skægk. i Fakse	100	Skægk. 1800-1850		
32.	4. Januar	9. Januar	Niels Christensen	Jens i Fakse	100	Skægk. 1800-1850		
33.	7. Januar	12. Januar	Ol. Vald. Larsen	Jens i Fakse	100	Skægk. 1800-1850		
34.	10. Januar	15. Januar	Jens. Andersen	Skægk. i Fakse	100	Skægk. 1800-1850		
35.	8. Januar	13. Januar	Ol. Hansen	Jens i Fakse	100	Skægk. 1800-1850		
36.	3. Januar	9. Januar	Niels Christensen	Skægk. i Fakse	100	Skægk. 1800-1850		
37.	11. Januar	16. Januar	Hans Hansen	Pas i Fakse	100	Skægk. 1800-1850		
38.	11. Januar	16. Januar	Hans Hansen	Jens i Fakse	100	Skægk. 1800-1850		

Scan of parish register for "Fakse" parish.

Data cleaning and managing

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

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

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

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► Temporal resolution:

► Daily

► Geographical resolution:

► Individual parishes

Data cleaning and managing

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

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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

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

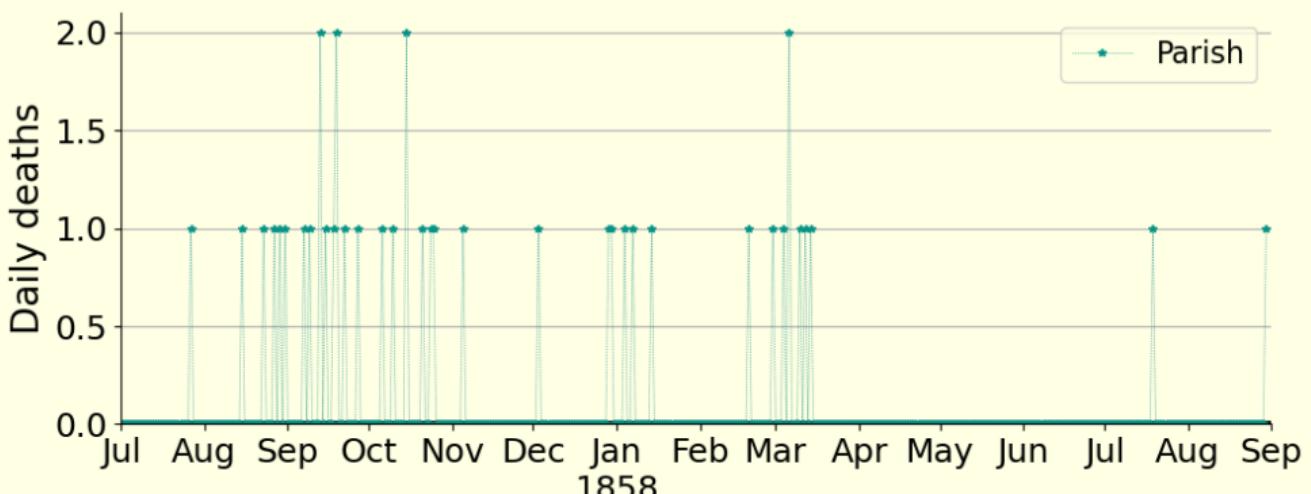
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Data cleaning and managing

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

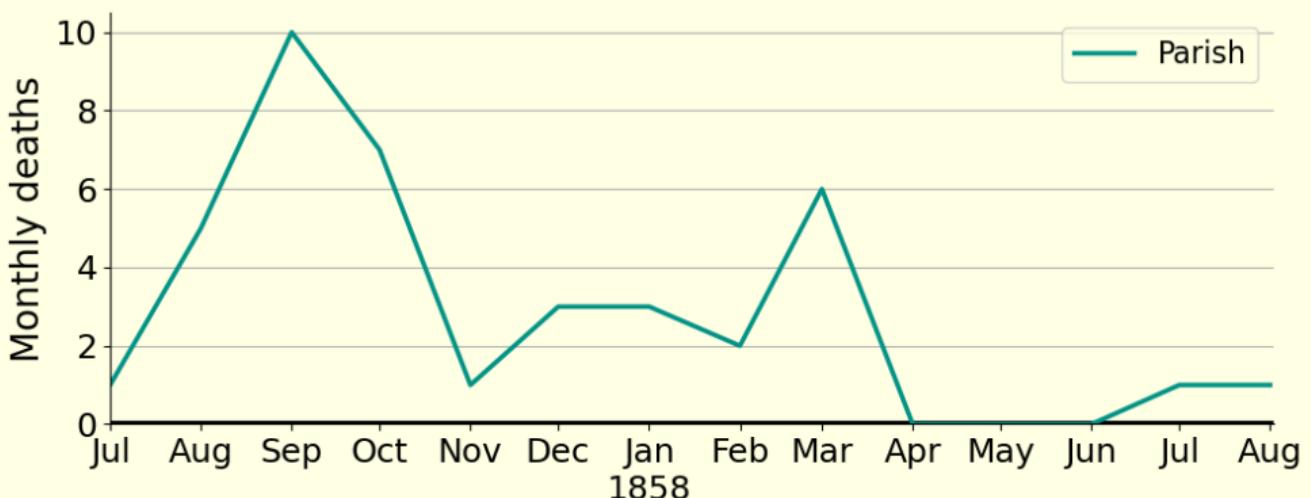
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Data cleaning and managing

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

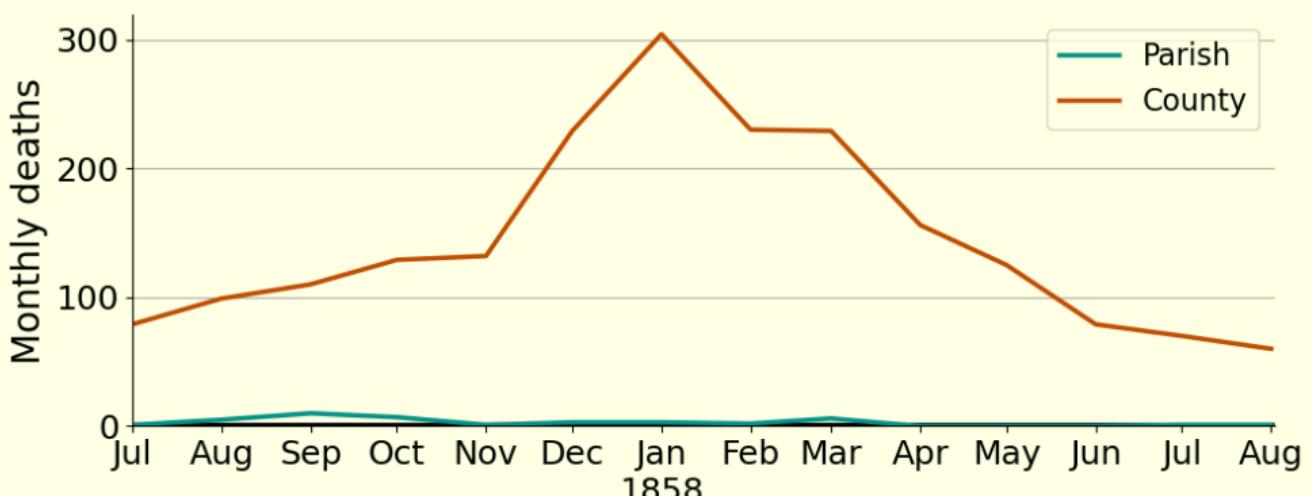
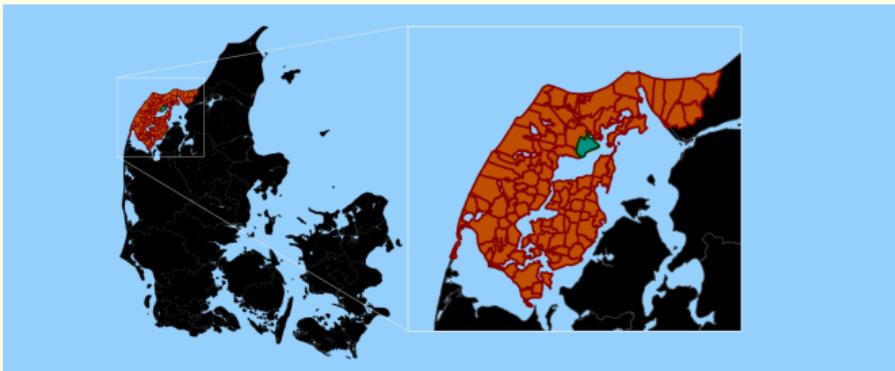
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

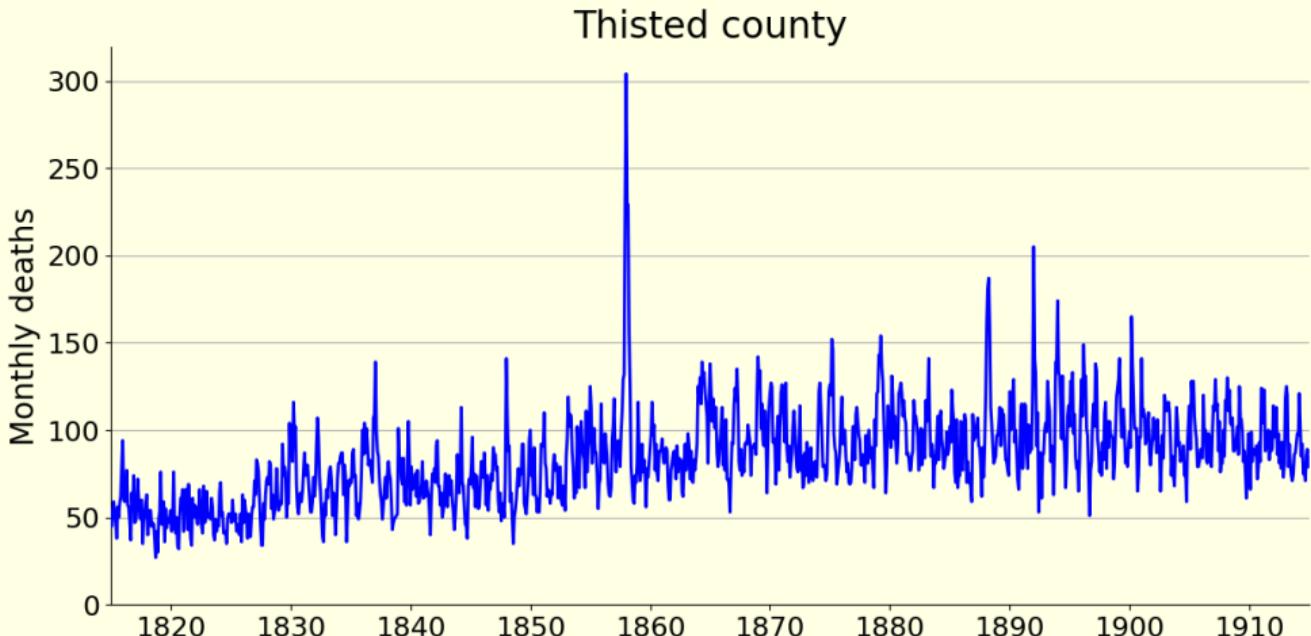
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

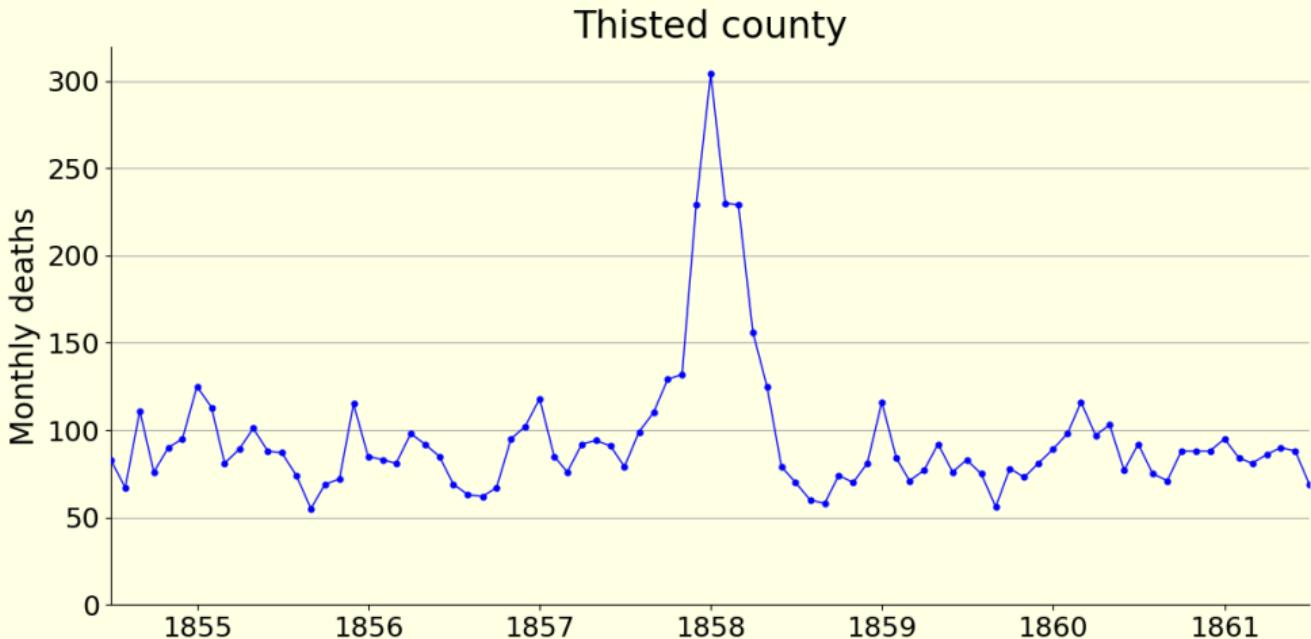
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

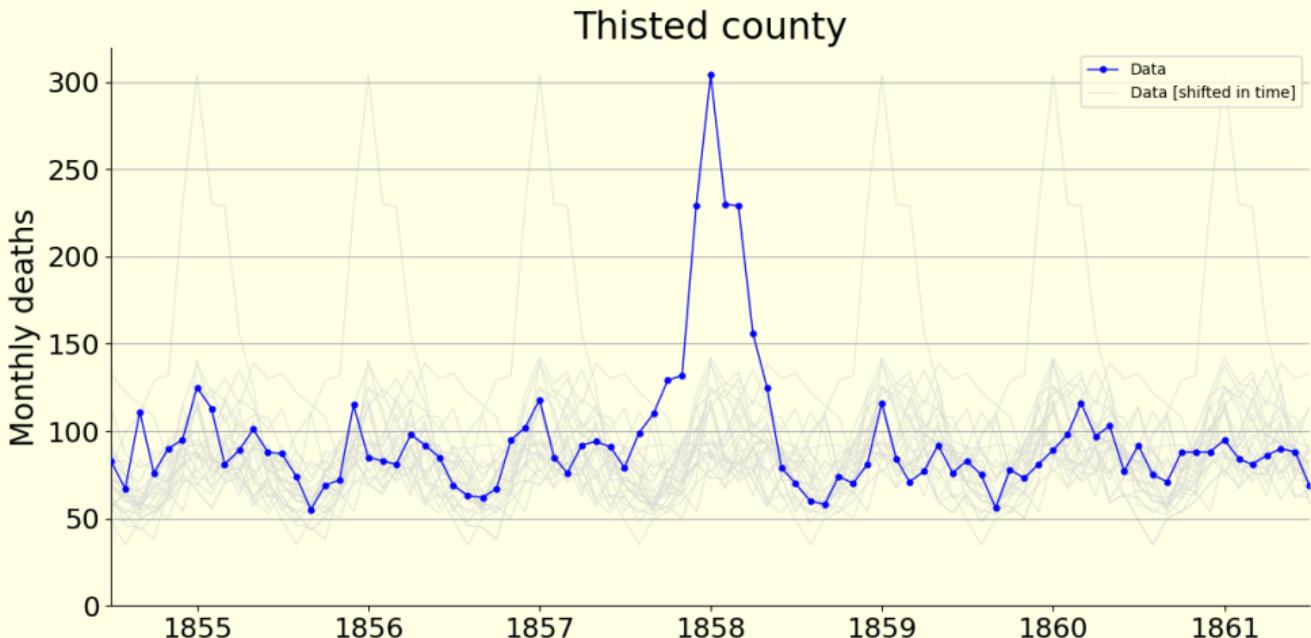
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

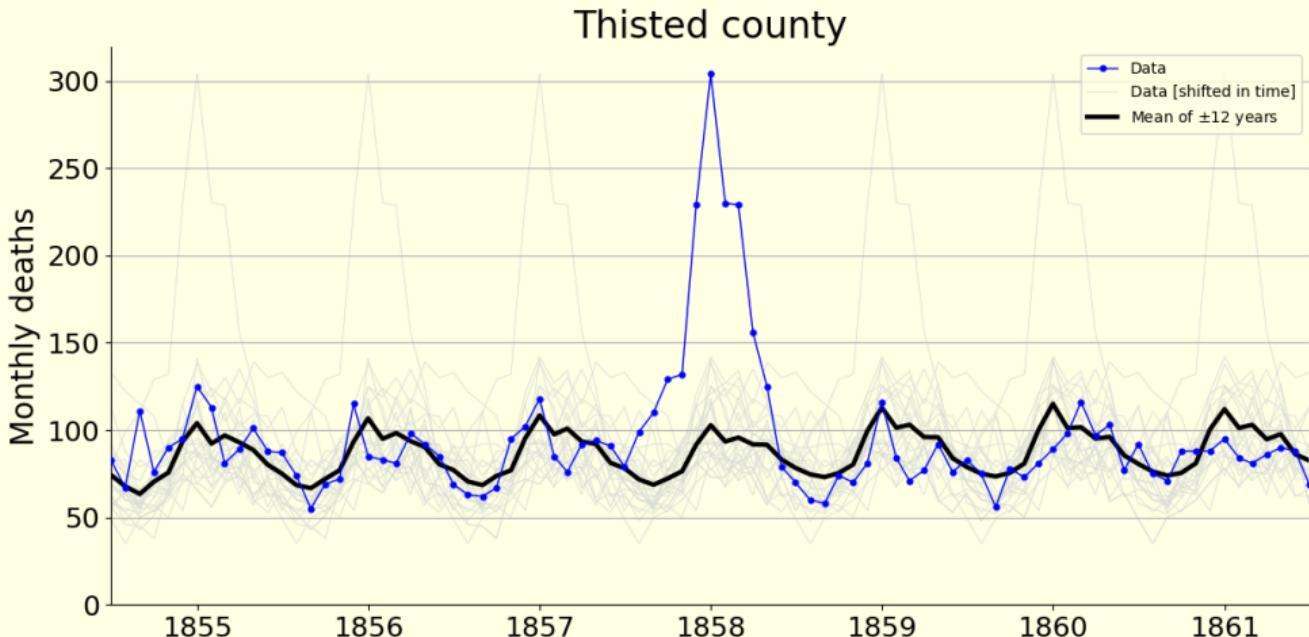
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

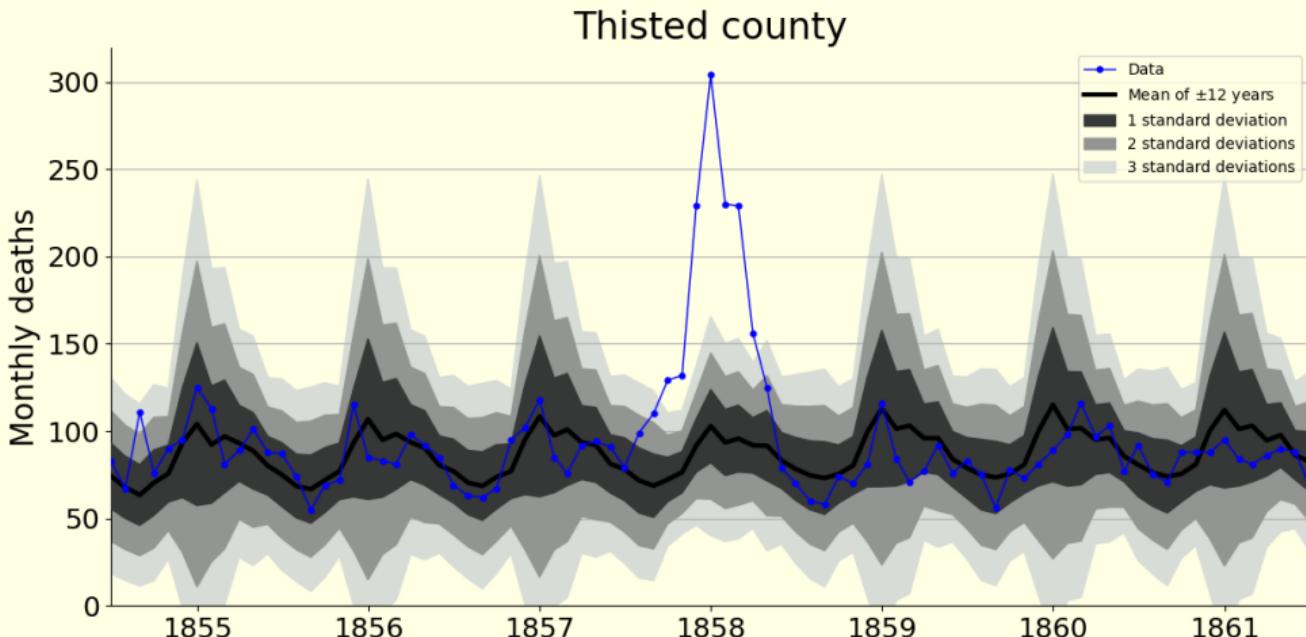
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

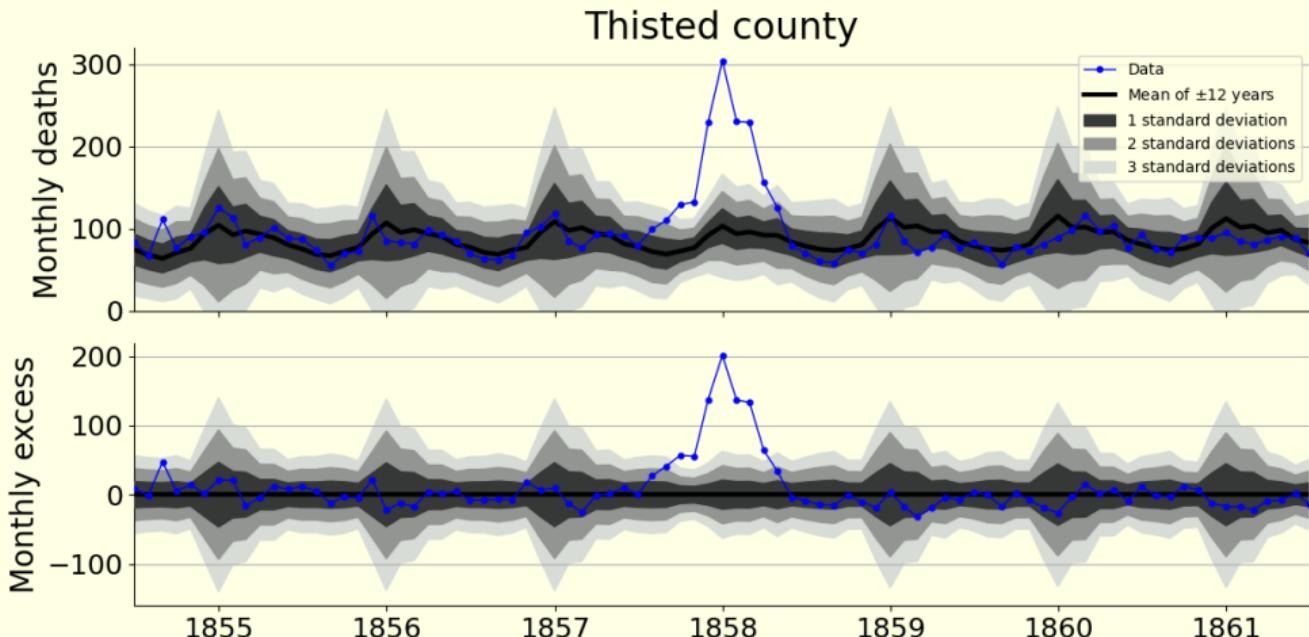
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

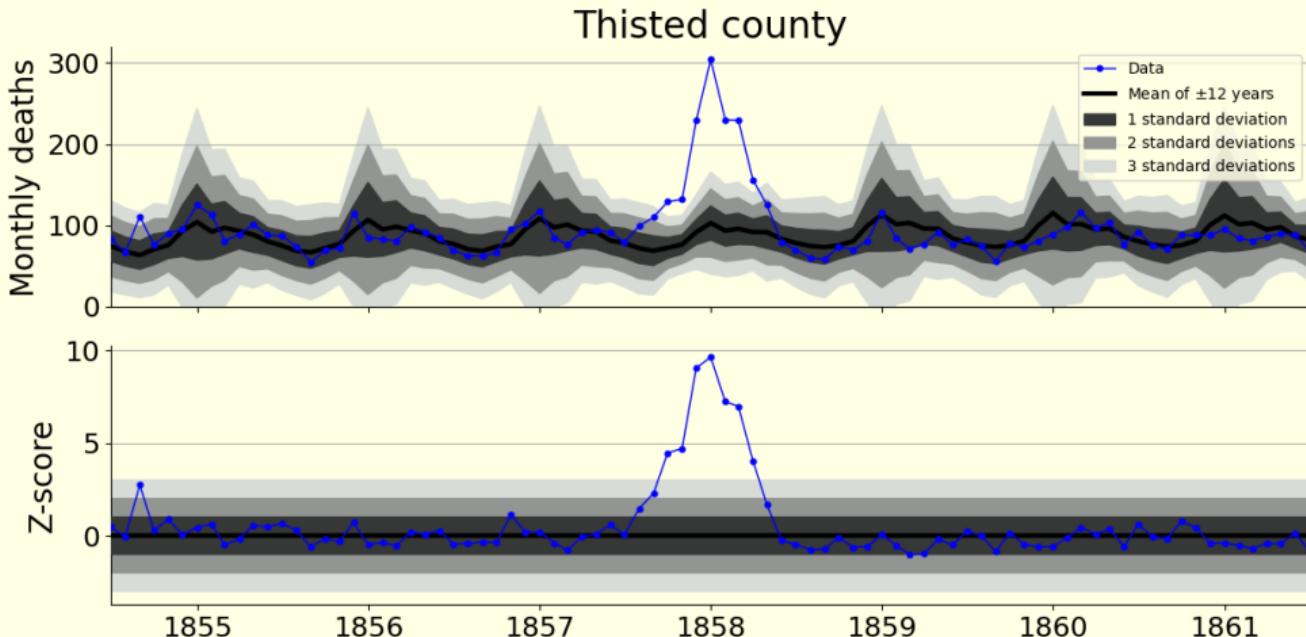
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

Results and discussion

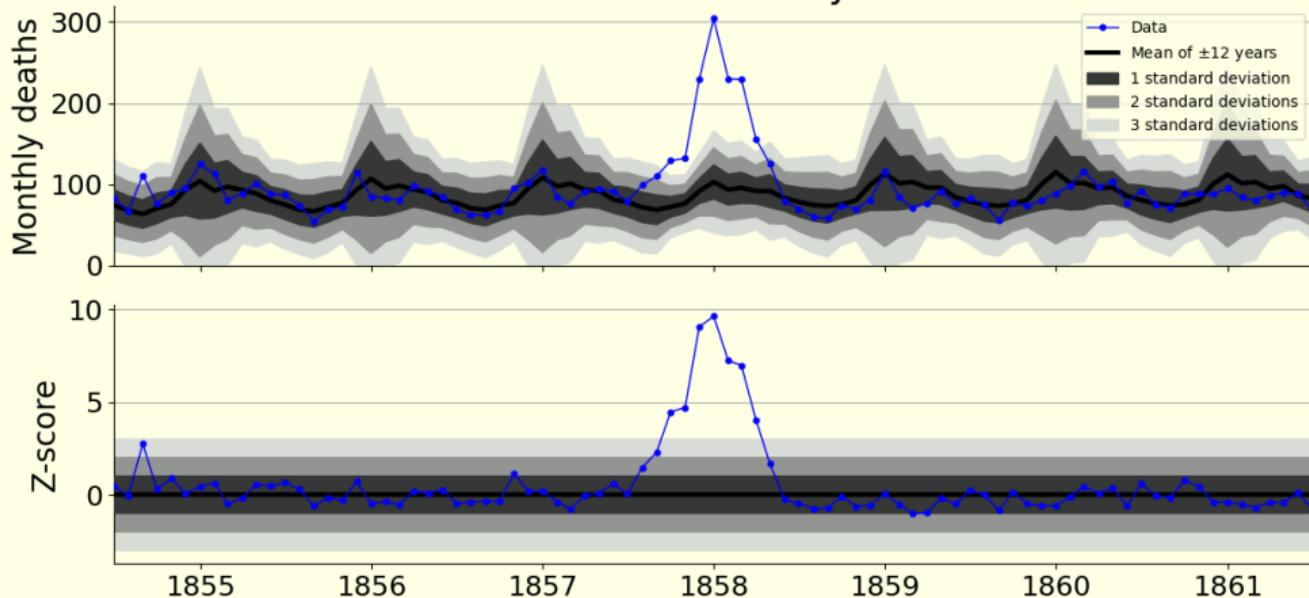
Representative signature features

Grouping crises

Summary & discussion

Calculating the mortality baseline

Thisted county



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

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

Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

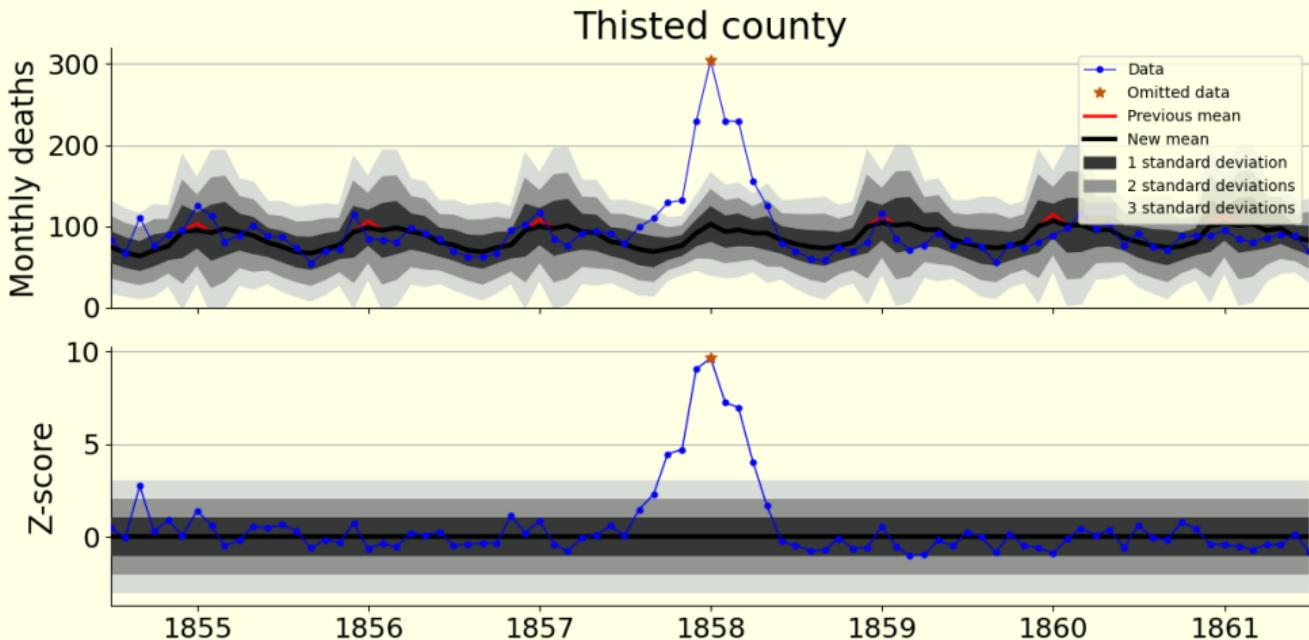
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

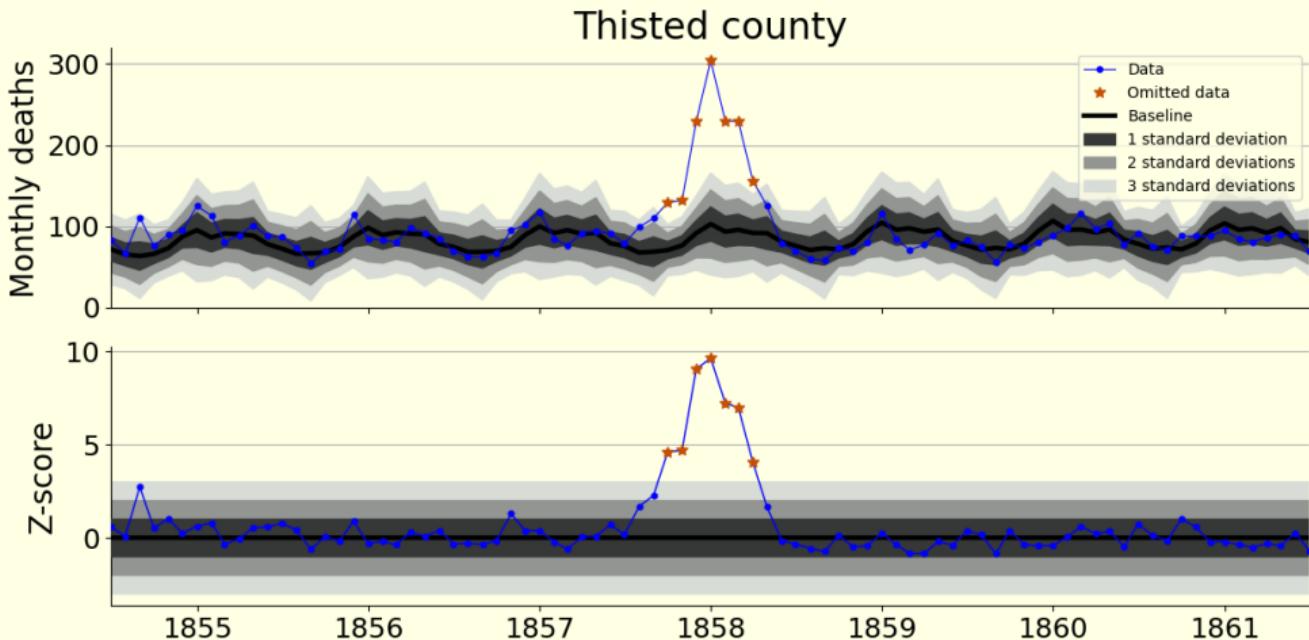
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Calculating the mortality baseline

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

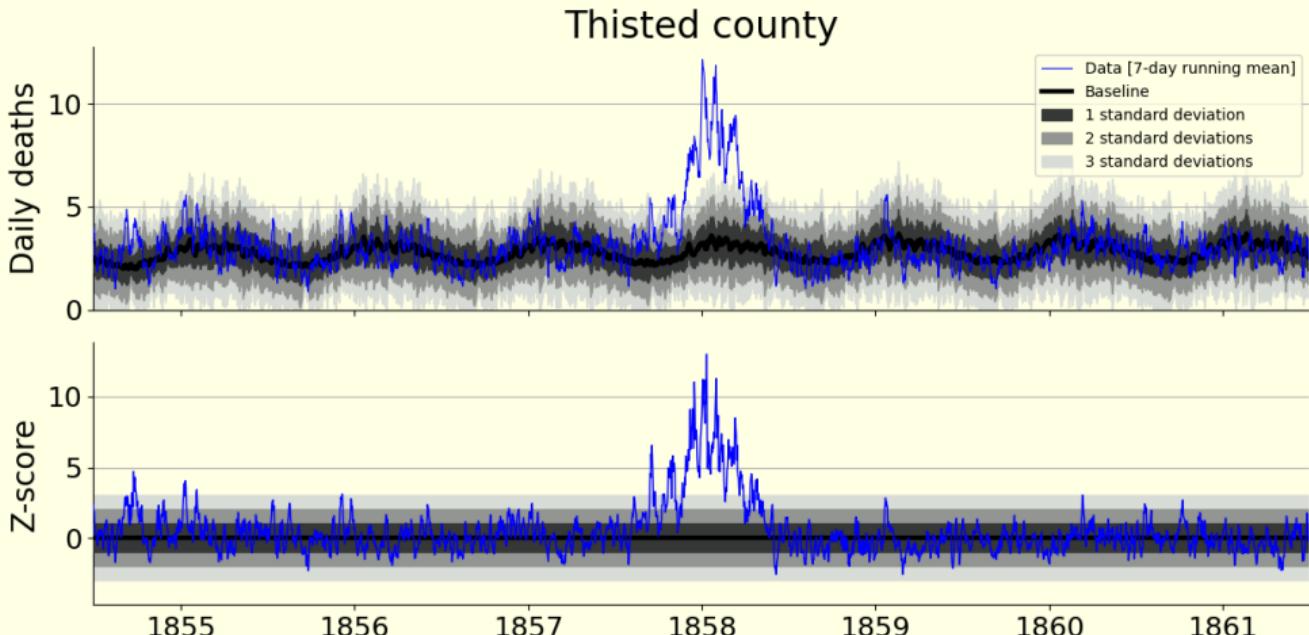
Comparing age patterns

Results and discussion

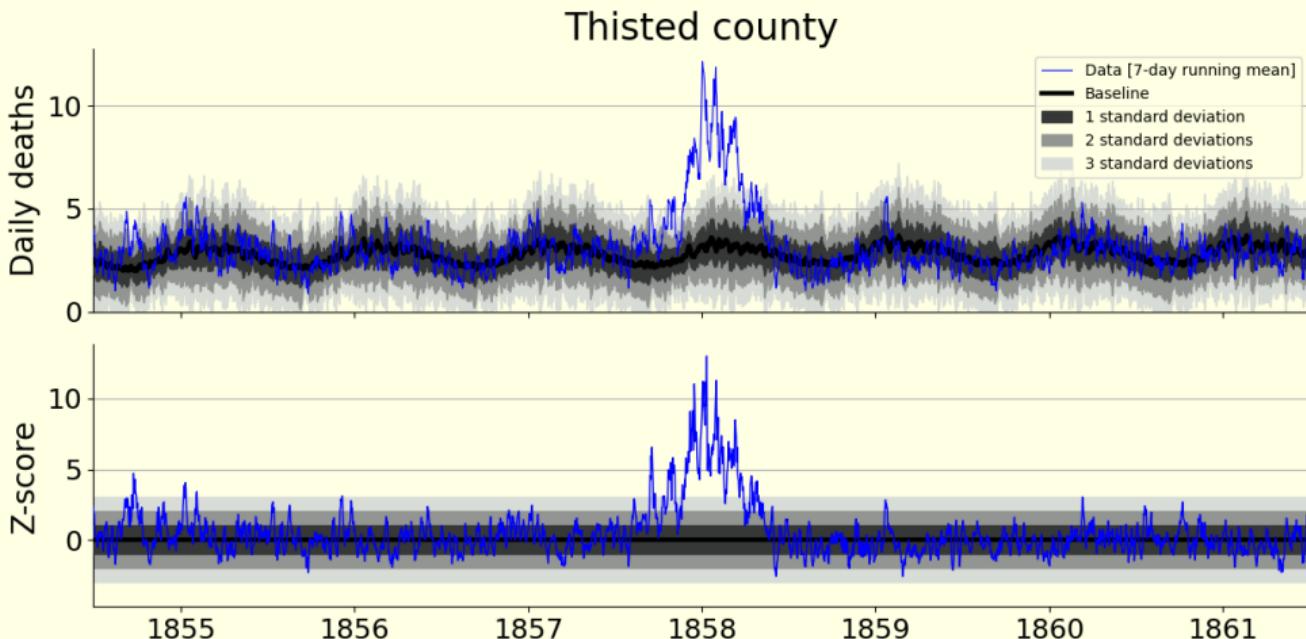
Representative signature features

Grouping crises

Summary & discussion



Identification of “mortality crises”



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 discussion

Representative signature features

Grouping crises

Summary & discussion

Identification of “mortality crises”

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

“Mortality crisis”

Age-specific mortality

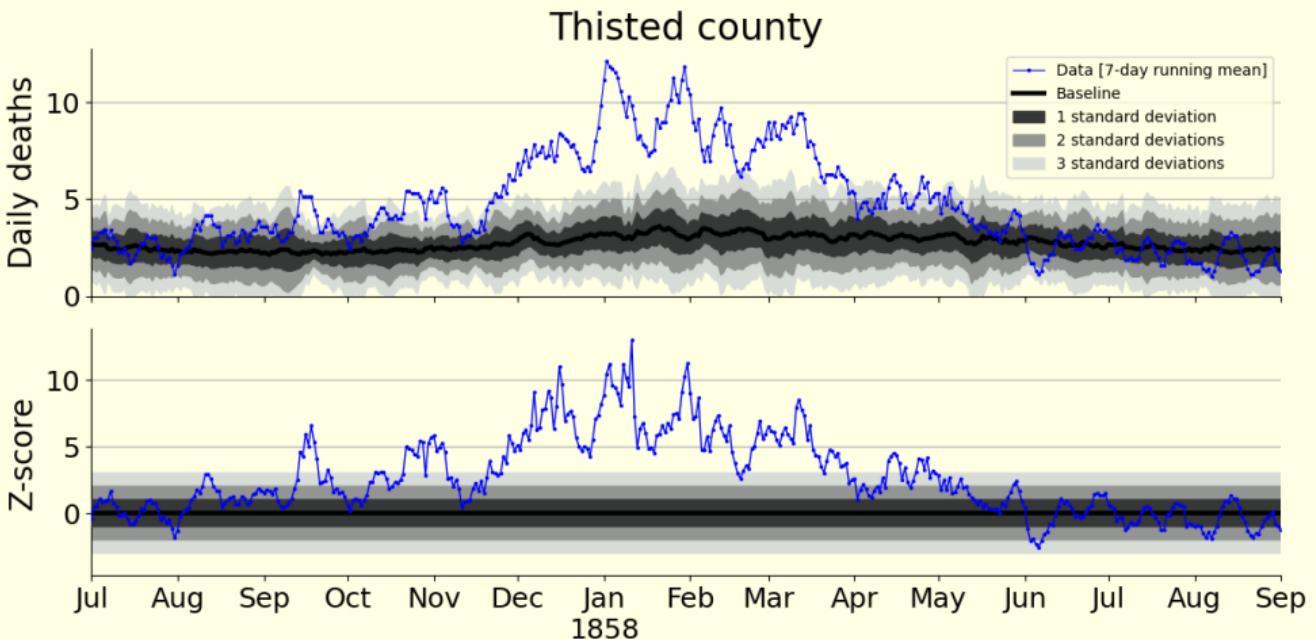
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Zooming in...

Identification of “mortality crises”

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

“Mortality crisis”

Age-specific mortality

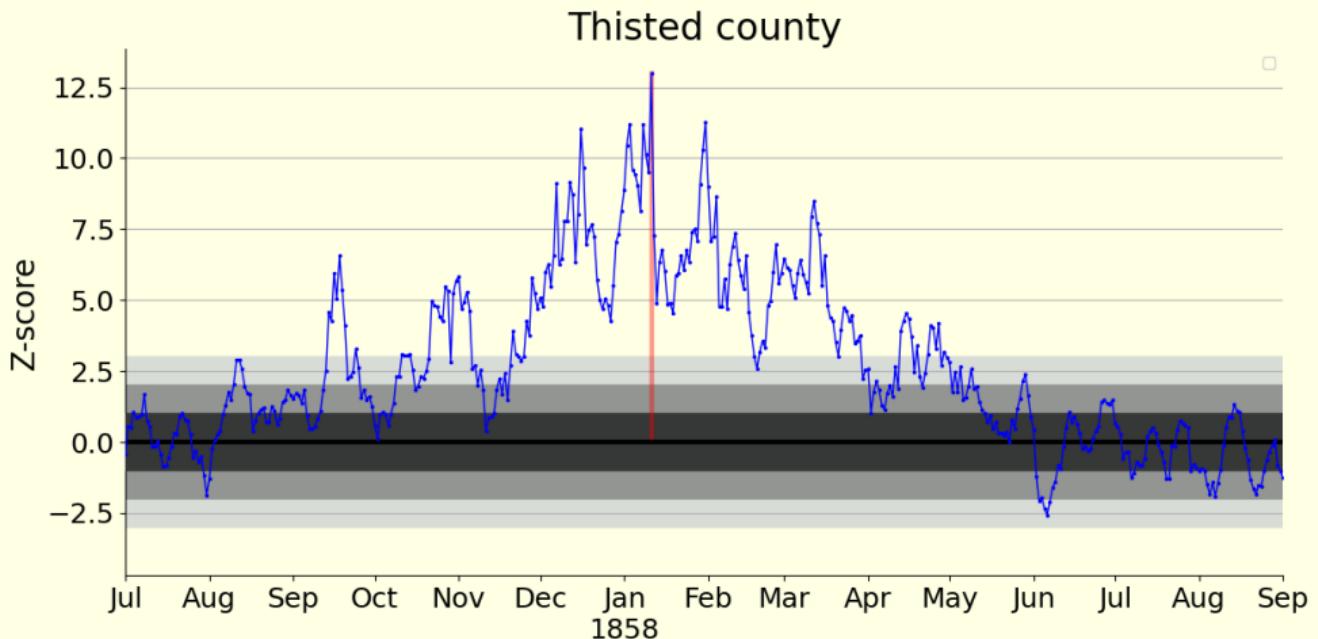
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



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

Identification of “mortality crises”

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

“Mortality crisis”

Age-specific mortality

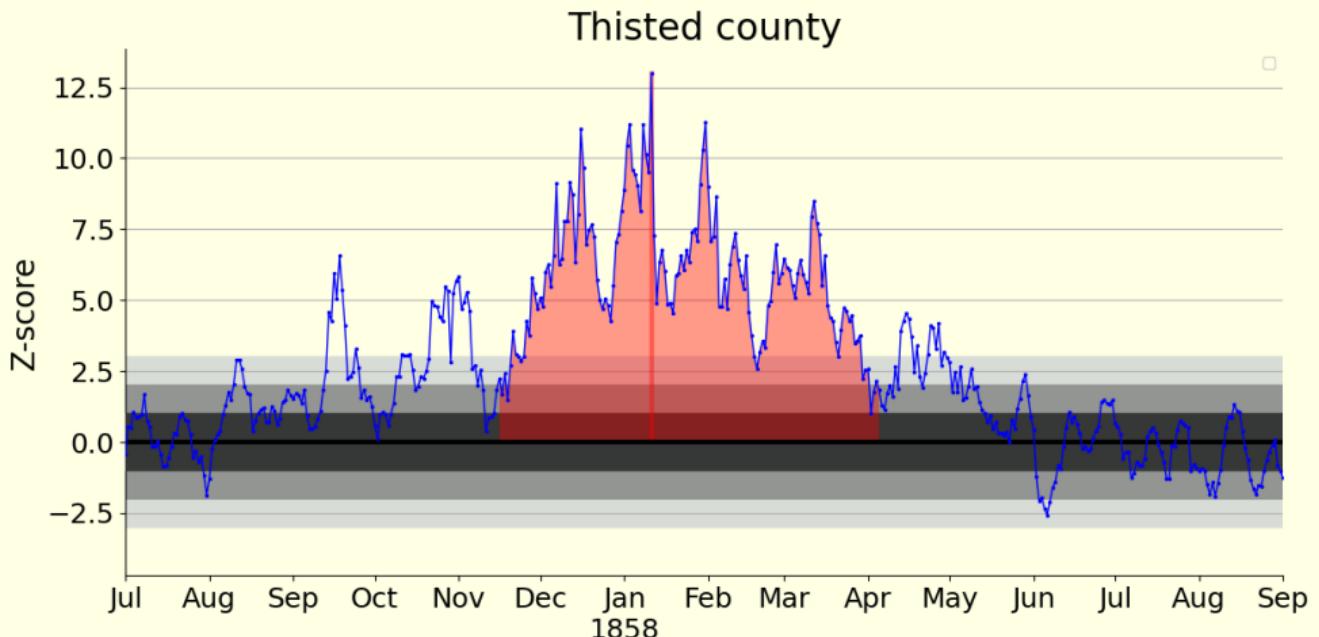
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



... 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”

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

“Mortality crisis”

Age-specific mortality

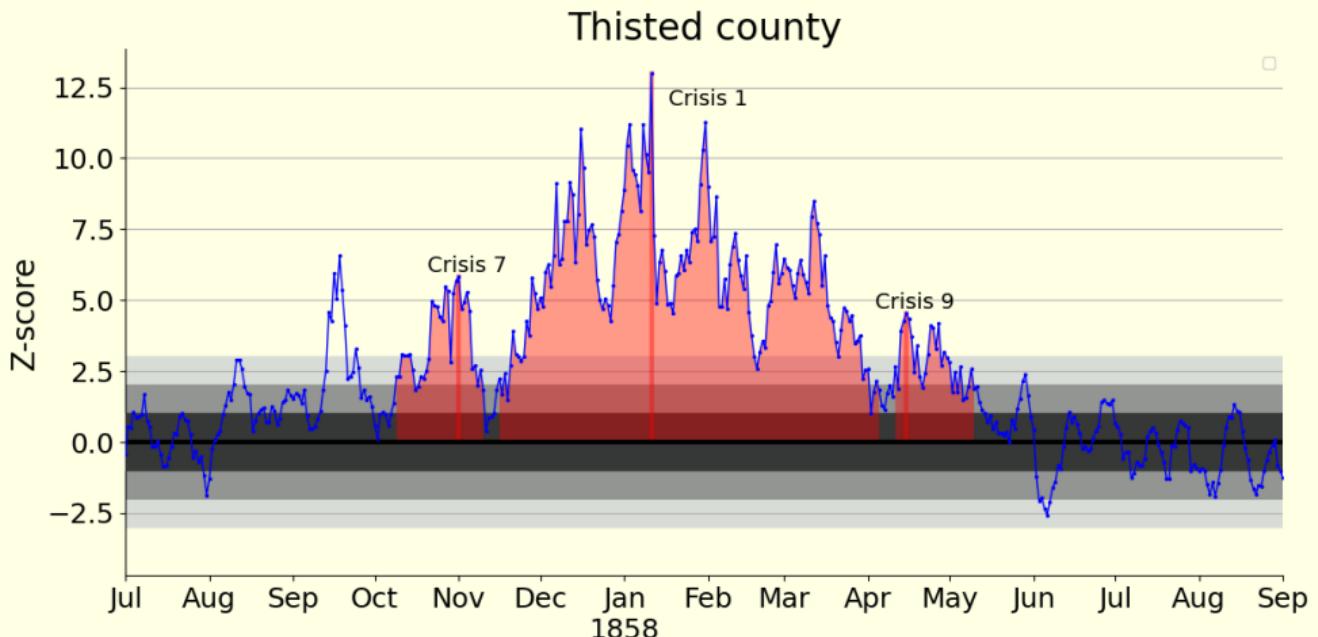
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



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 418 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 418 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”

Identifying Excess Mortality

RK Pedersen

Using this methodology, we identify 418 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		
⋮	⋮	⋮		

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

Summary & discussion

Identifying main “signature features”

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

Using this methodology, we identify 418 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 418 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 418 mortality crises.

For each crisis,

- ▶ Peak-date.
Significant on a county level
(Population-sizes $\approx 100,000$).
- ▶ Excess deaths.
- ▶ 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 418 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 discussion

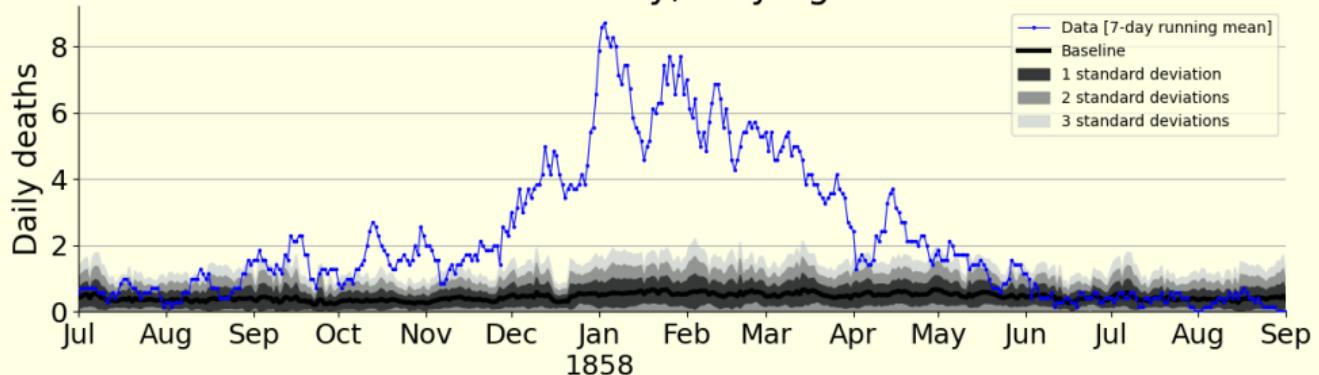
Representative signature features

Grouping crises

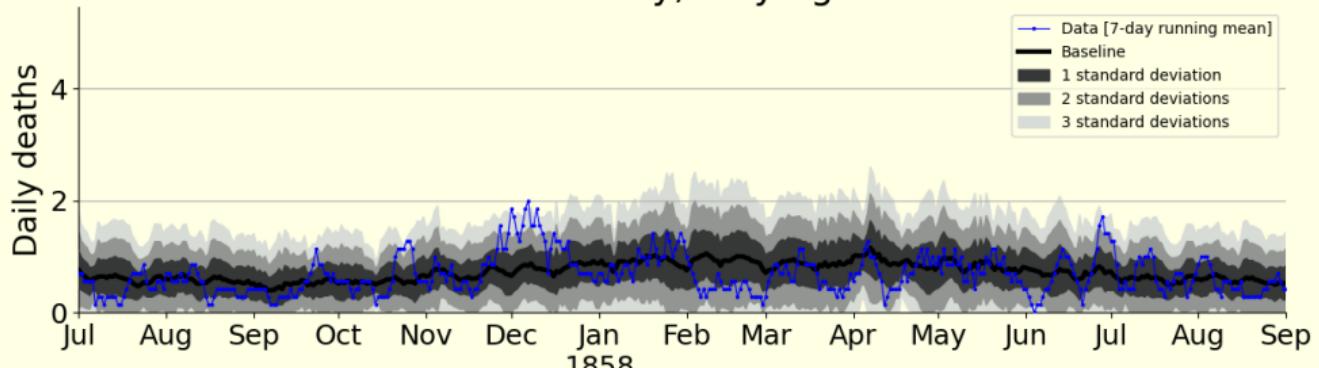
Summary & discussion

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

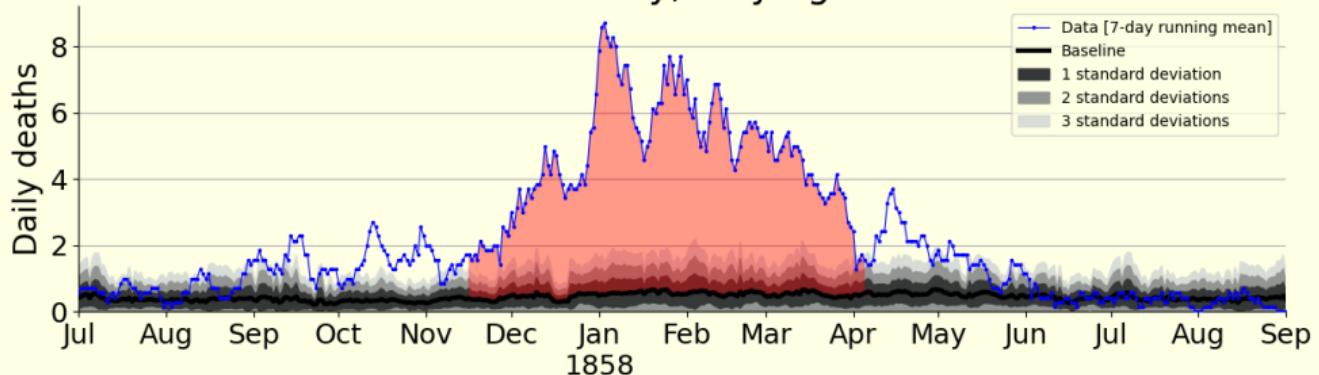
Representative signature features

Grouping crises

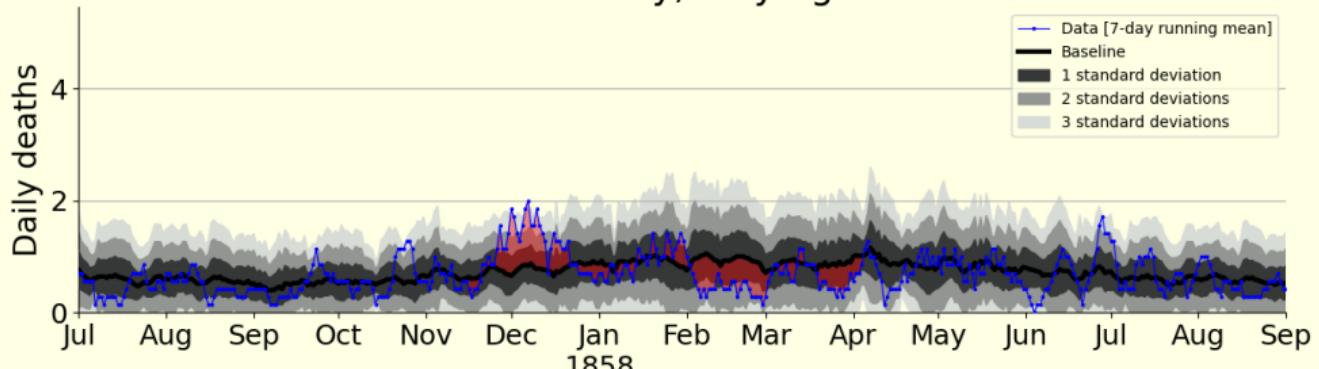
Summary & discussion

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

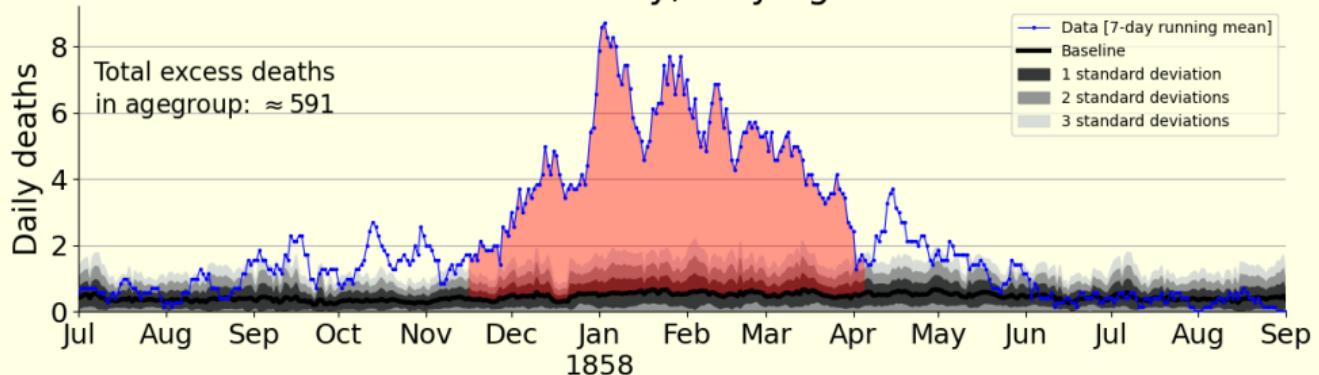
Representative signature features

Grouping crises

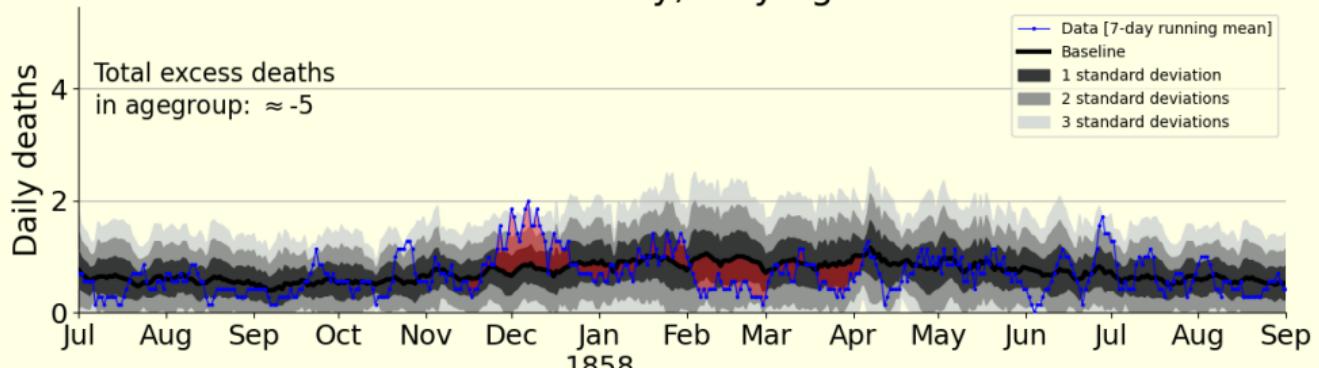
Summary & discussion

Analyzing age-patterns

Thisted county, only ages 1-14



Thisted county, only ages 60+



Analyzing age-patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

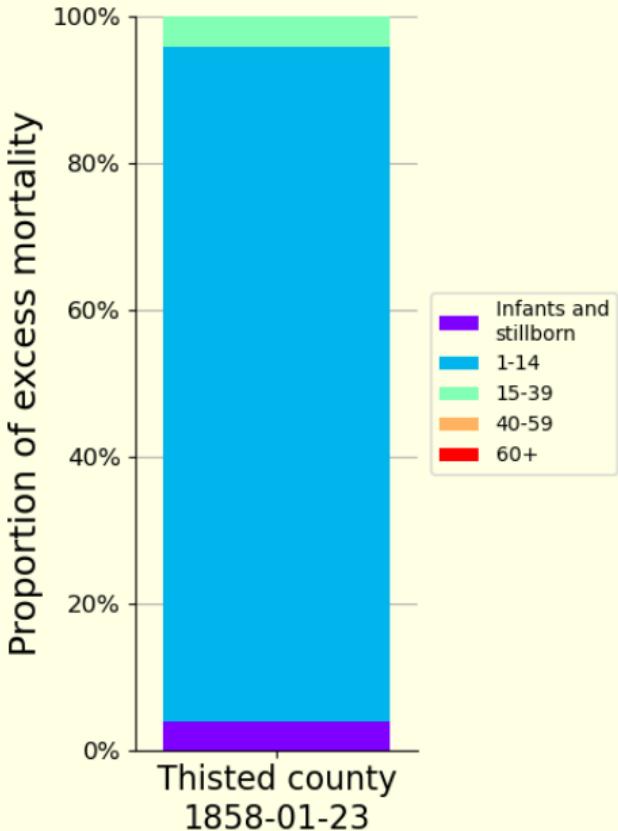
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

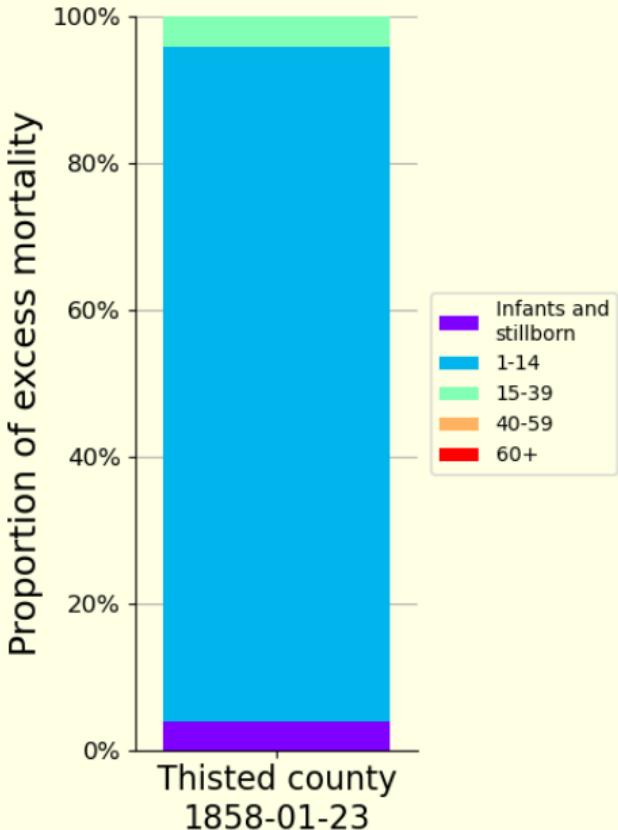
Summary & discussion



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%

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%

Consider this a five-dimensional vector:

$$(0, 0, 0.03, 0.93, 0.04)$$

Analyzing age-patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

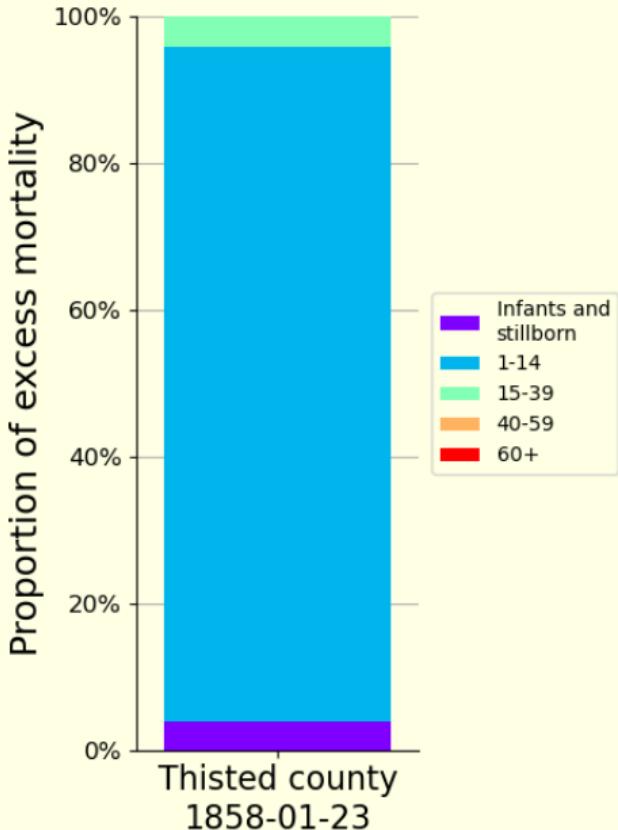
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Age-specific excess mortality in this period:

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- ▶ Age group "Below 1 year": 4%

Consider this a five-dimensional vector:

$$(0, 0, 0.03, 0.93, 0.04)$$

In terms of age groups "Below 1 year" and "1-14":

$$(0.04, 0.93)$$

In terms of age groups "40-59" and "60+":

$$(0, 0)$$

Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

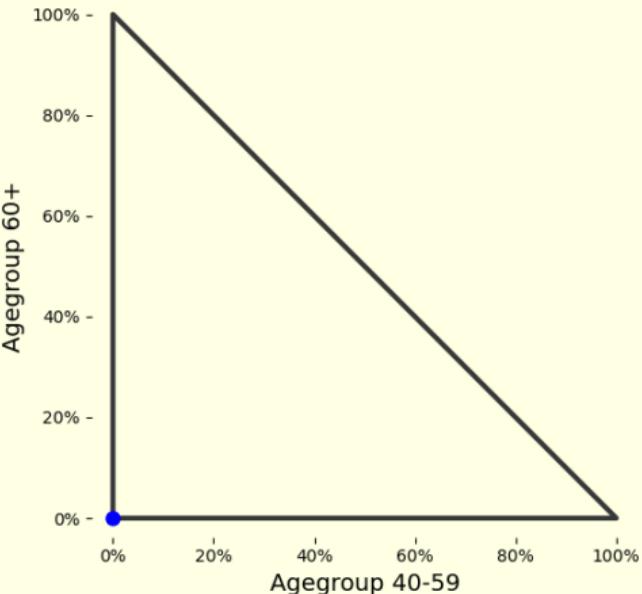
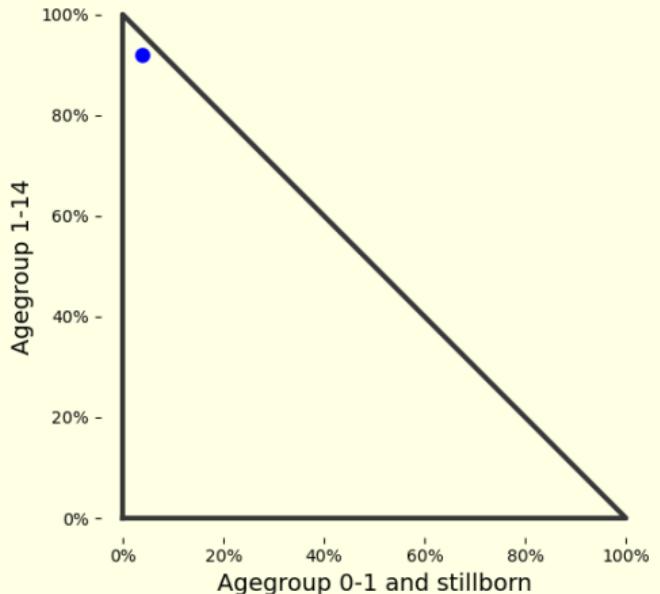
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



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

Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

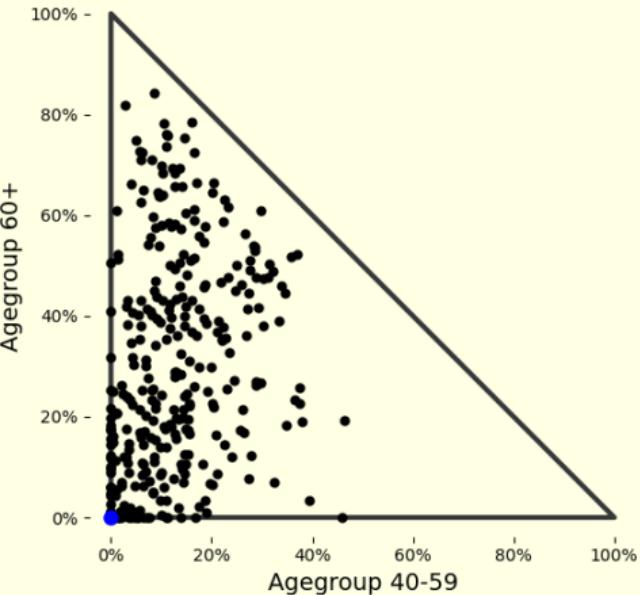
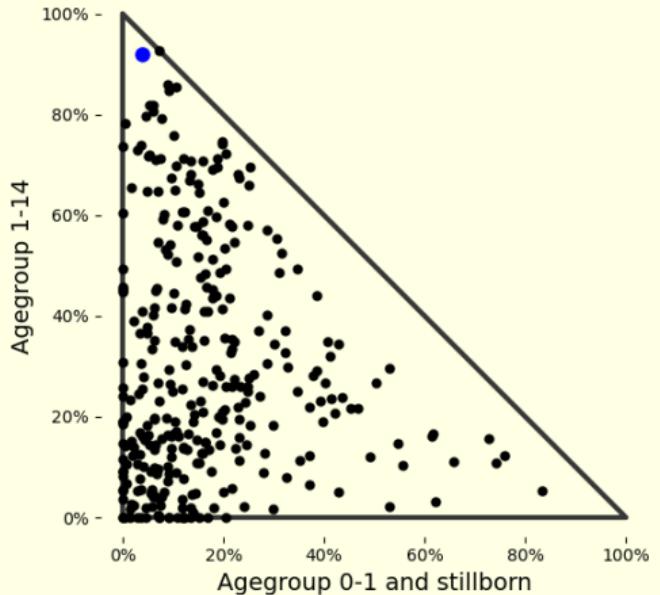
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Adding the other 417 mortality crises identified.

Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

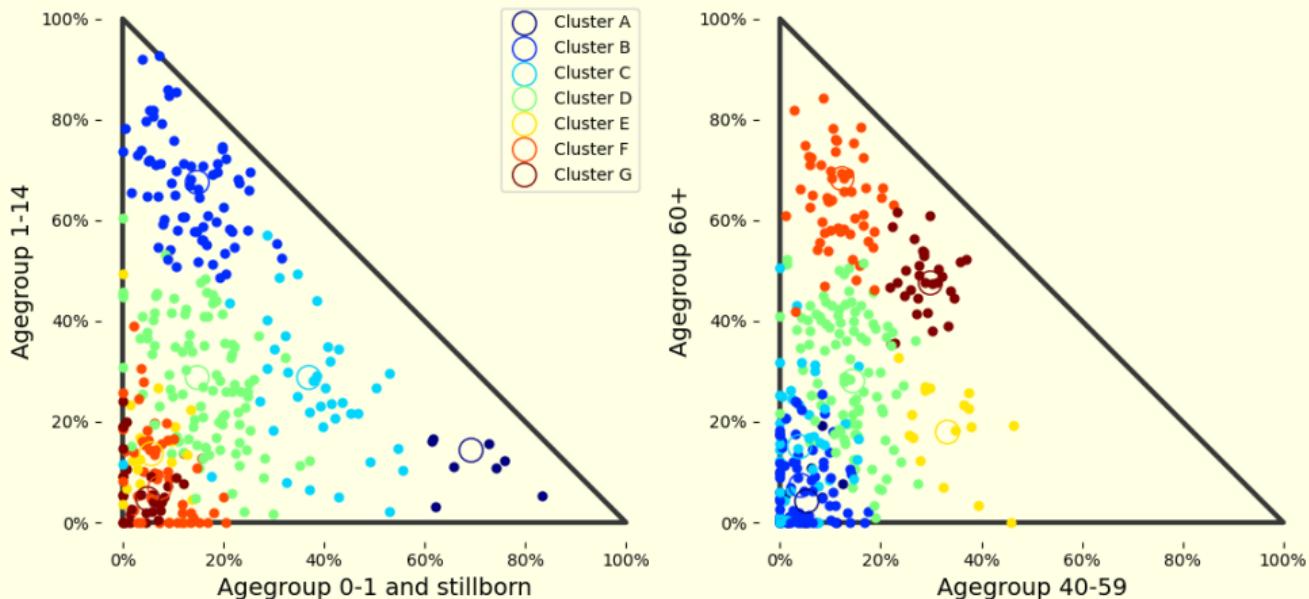
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Gaussian mixture modelling on full five-dimensional data.

Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

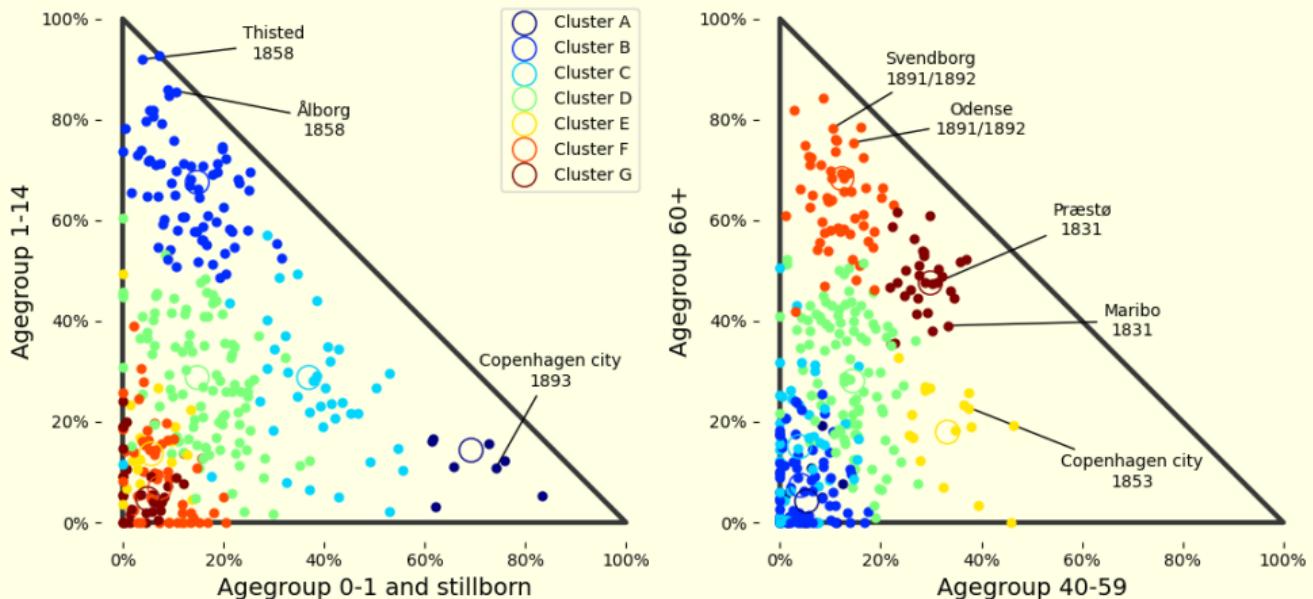
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Gaussian mixture modelling on full five-dimensional data.

Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

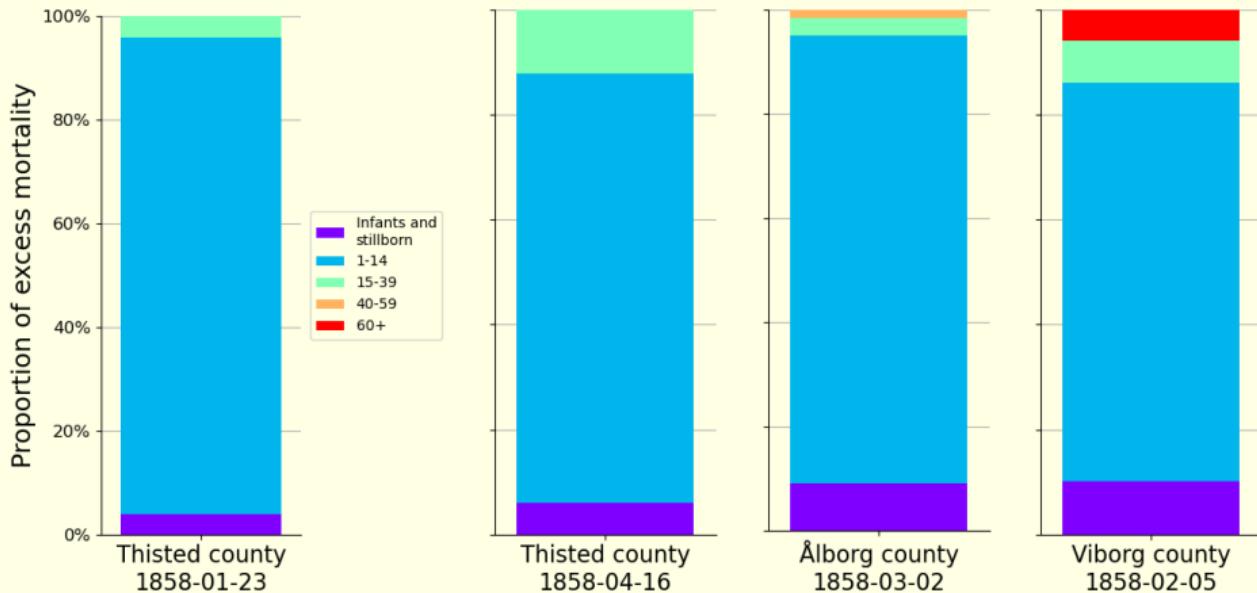
Results and discussion

Representative signature features

Grouping crises

Summary & discussion

Examples from "Cluster A"



Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

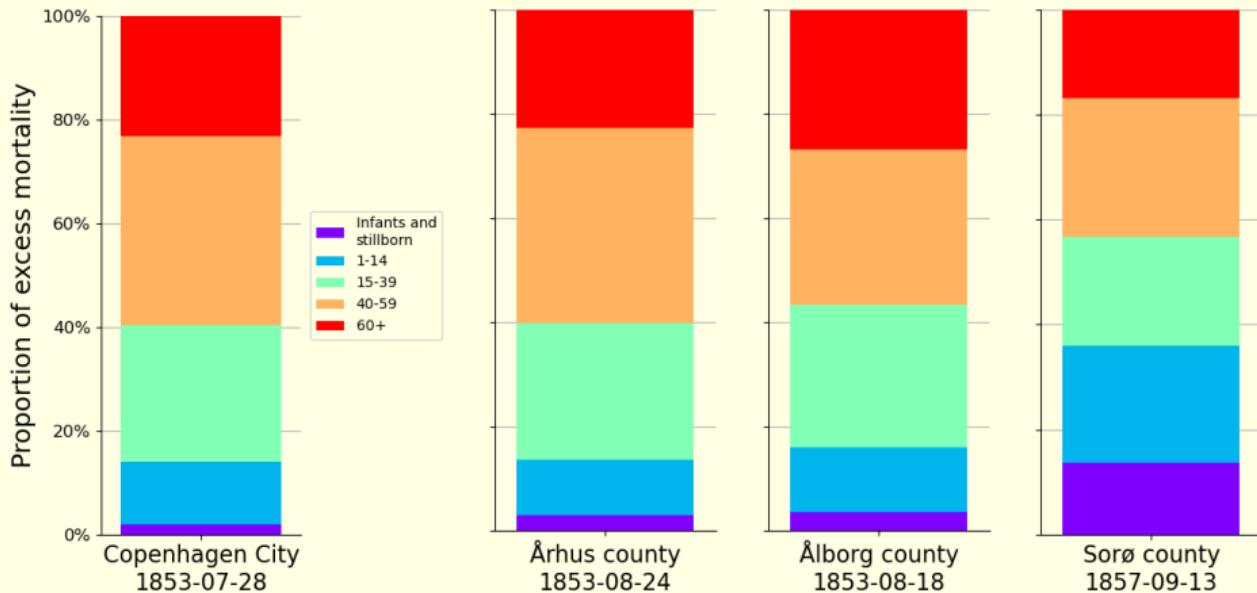
Results and discussion

Representative signature features

Grouping crises

Summary & discussion

Examples from "Cluster E"



Mortality crises with comparable age patterns

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

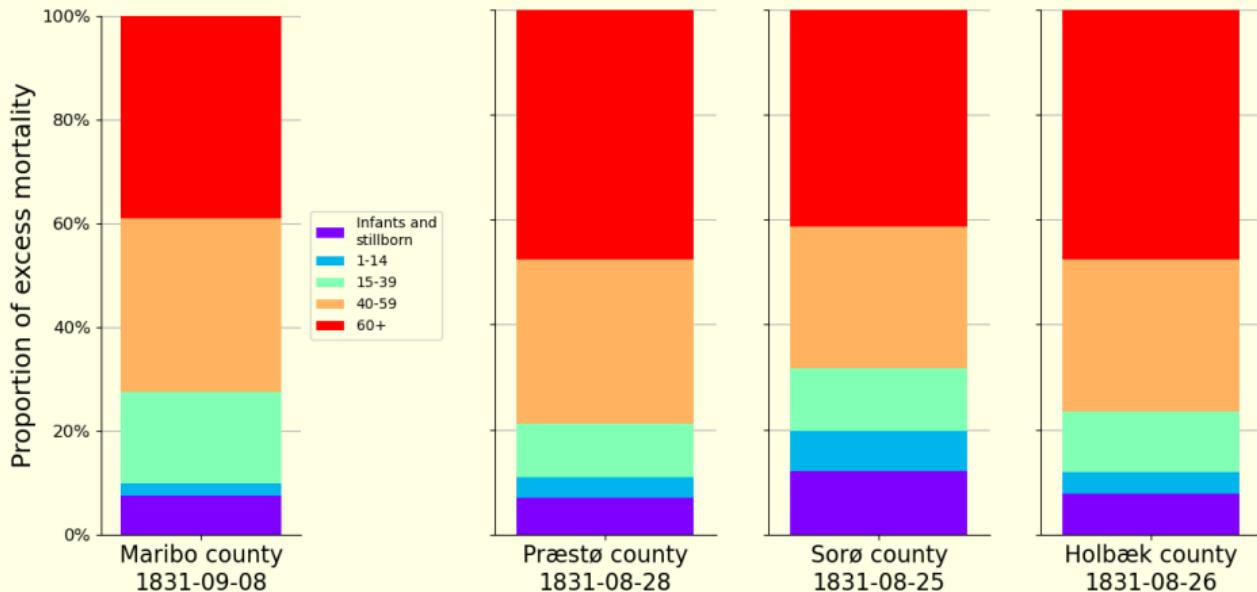
Results and discussion

Representative signature features

Grouping crises

Summary & discussion

Examples from "Cluster G"



The signature features of certain diseases

Identifying Excess Mortality

RK Pedersen

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

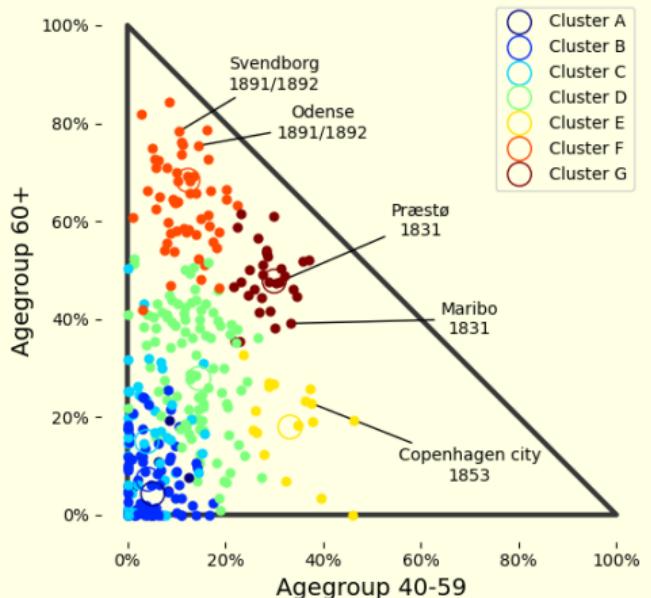
Comparing age patterns

Results and discussion

Representative signature features

Grouping crises

Summary & discussion



Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

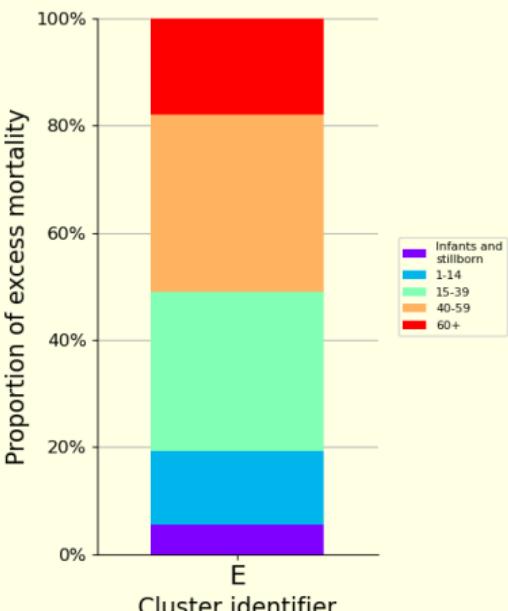
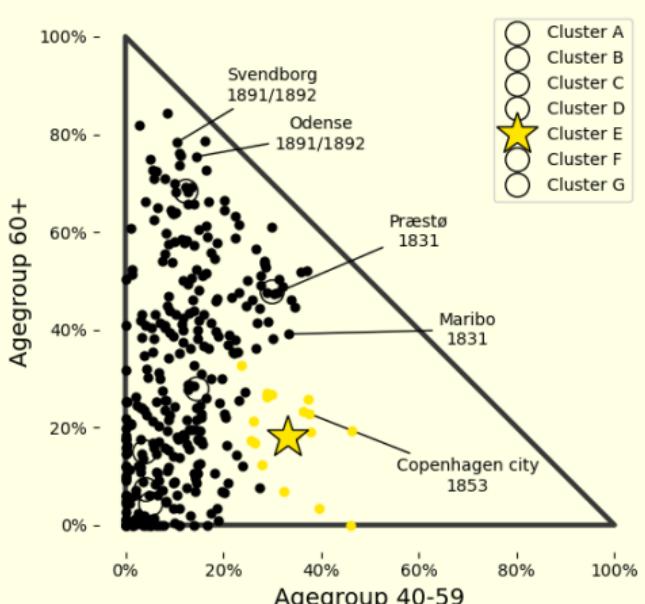
Results and discussion

Representative signature features

Grouping crises

Summary & discussion

The signature features of certain diseases



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

Introduction

Background and data handling

Data source

Data cleaning

Methodology

Mortality baseline

"Mortality crisis"

Age-specific mortality

Comparing age patterns

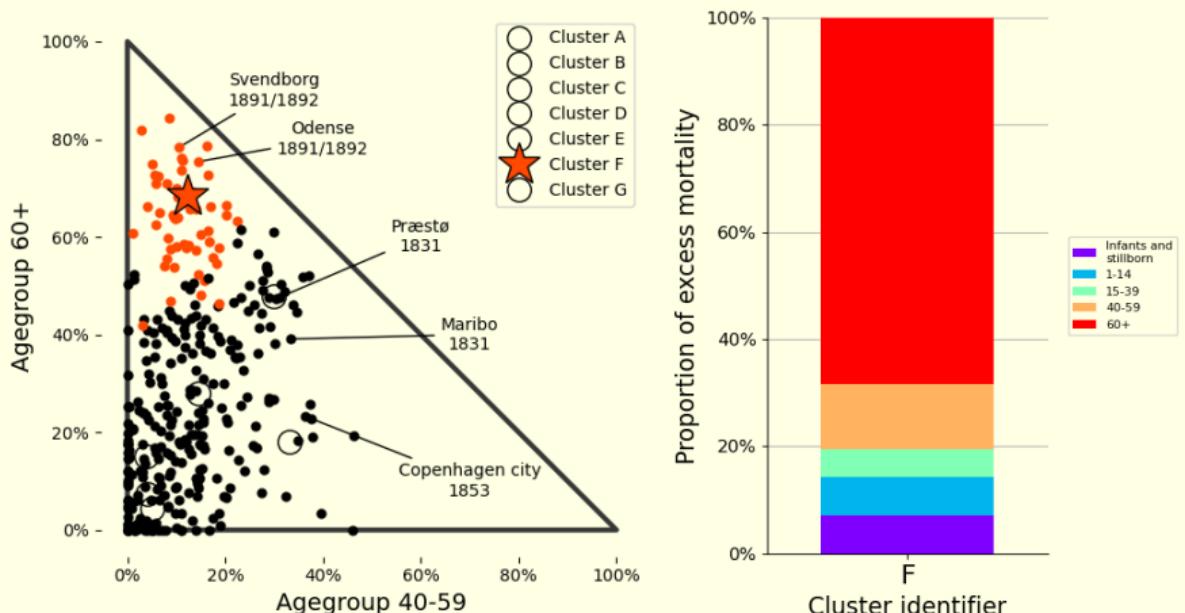
Results and discussion

Representative signature features

Grouping crises

Summary & discussion

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

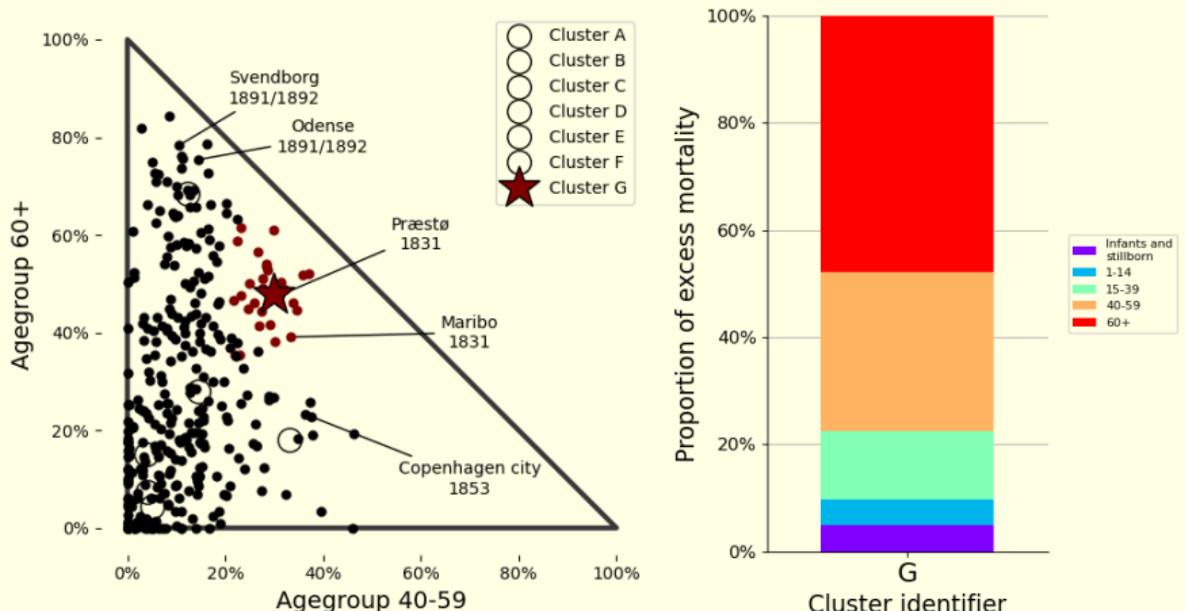
Results and discussion

Representative signature features

Grouping crises

Summary & 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

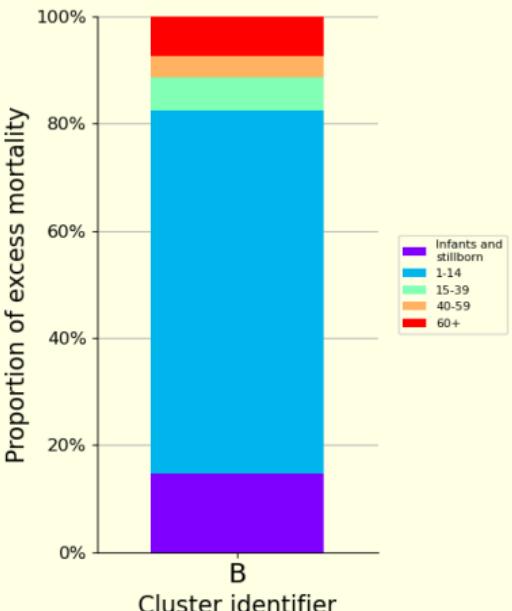
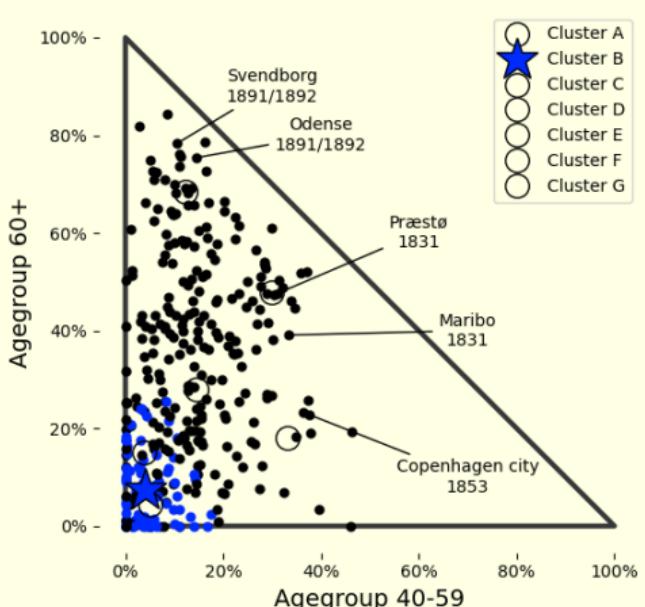
Results and discussion

Representative signature features

Grouping crises

Summary & 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

Identifying Excess Mortality

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

Representative signature features

Grouping crises

Summary & discussion

Disease	Timing	Total excess	Age structure
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, 1826-1832	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

Summary & discussion

- 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 discussion

Representative signature features

Grouping crises

Summary & discussion

- We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- We identify 418 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 discussion

Representative signature features

Grouping crises

Summary & discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 418 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 discussion

Representative signature features

Grouping crises

Summary & discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 418 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 discussion

Representative signature features

Grouping crises

Summary & discussion

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- ▶ For each crisis, we determine signature features:
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 - ▶ 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 discussion

Representative signature features

Grouping crises

Summary & discussion

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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

Summary & discussion

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 - ▶ Geography.

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

Summary & discussion

- ▶ We determine mortality baselines on county-level, using an iterative process to omit outliers and estimate excess mortality.
- ▶ We identify 418 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

Summary & 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

Summary & 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.

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

Summary & discussion

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 - ▶ 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.

Python library, available on GitHub: github.com/PandemiXCenter/ExcessMortality

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

Summary & discussion

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 - ▶ Excess mortality calculation.
Python library, available on GitHub: github.com/PandemiXCenter/ExcessMortality
- ▶ Despite demographic differences between 19th century Denmark and modern times, the age patterns in the 19th century may be similar for modern 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

Summary & discussion

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 - ▶ Excess mortality calculation.
Python library, available on GitHub: github.com/PandemiXCenter/ExcessMortality
- ▶ 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

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Email: rasmus.p@uni-muenster.de

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



This work was supported in part by funding from the Danish National Research Foundation (grant number DNRF170), the Carlsberg Foundation (grant number CF20-0046) and NordForsk (project number 104910).

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

Summary & discussion