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

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Joint work with
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Viggo Andreasen & Lone Simonsen

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Roskilde University

PANDEMIX CENTER

Danmarks Grundforskningsfond
Danish National Research Foundation

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  - SARS-CoV-2 - Experiences from influenza pandemics and SARS-CoV-1.
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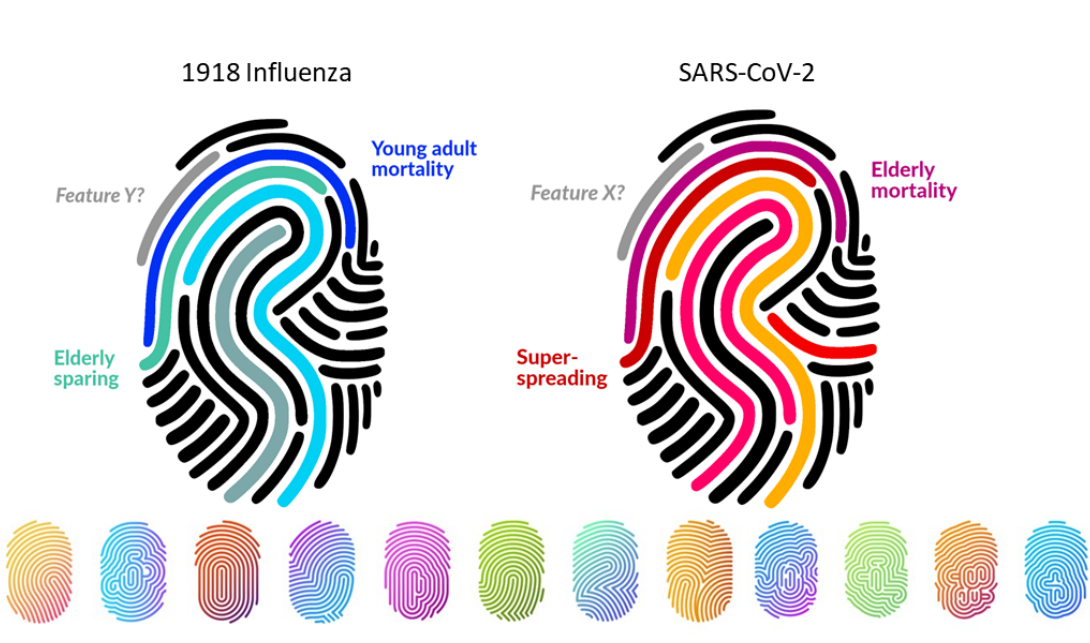
  - Scarlet fever - Experiences from historical scarlet fever.
- Analyzing historical pandemics is a way to study infectious diseases in more details than the study of modern pandemics alone allow for.


1918 Influenza
Young adult mortality
Feature Y?
Elderly sparing
SARS-CoV-2
Feature X?
Elderly mortality
Super-spreading

Overview of talk

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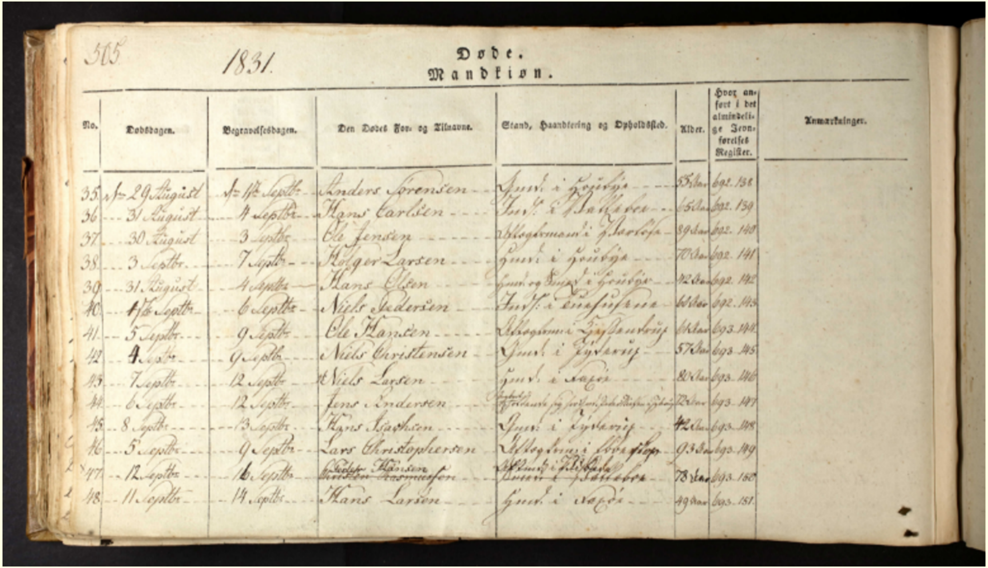
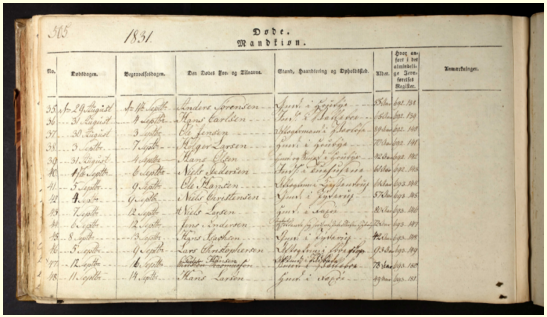
- Analyzing age patterns to classify epidemics.
- Reflect on what we can learn through historical epidemiology.

Data source



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
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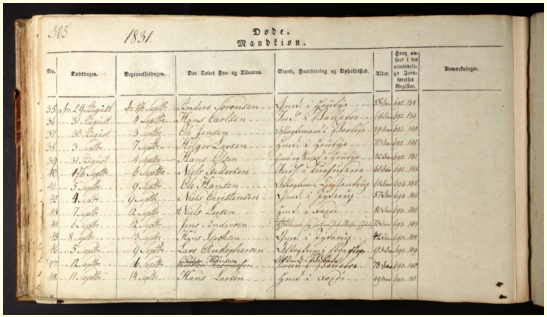
- Approximately 4 million burials



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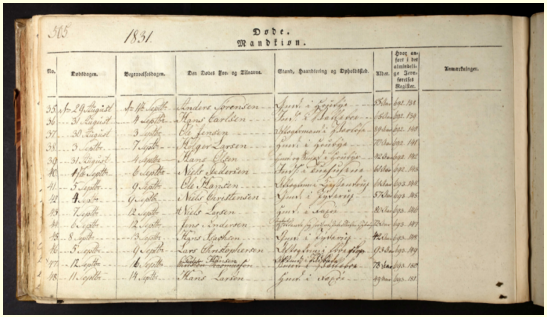

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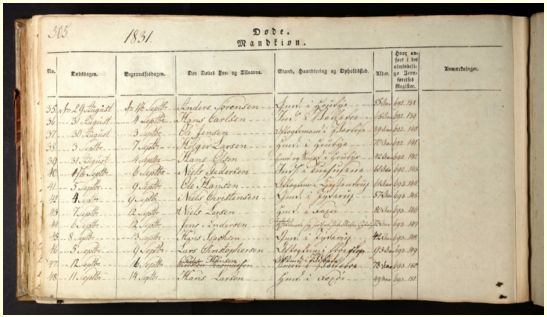

Scan of parish register for "Fakse" parish.

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 Tüylfang	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)

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- Geographical resolution:
  - Individual parishes
  - Shire (groups of 5 to 10 parishes)
  - Counties (groups of 5 to 10 shires)
- Temporal resolution:
  - Daily
  - Weekly
  - Monthly
  - Yearly

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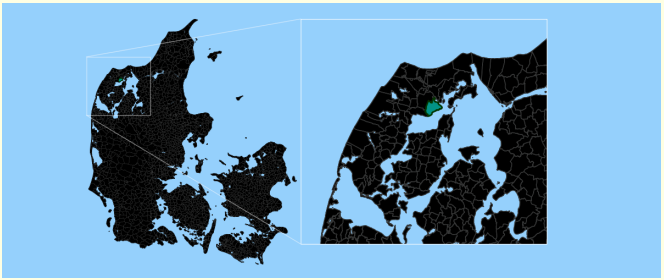

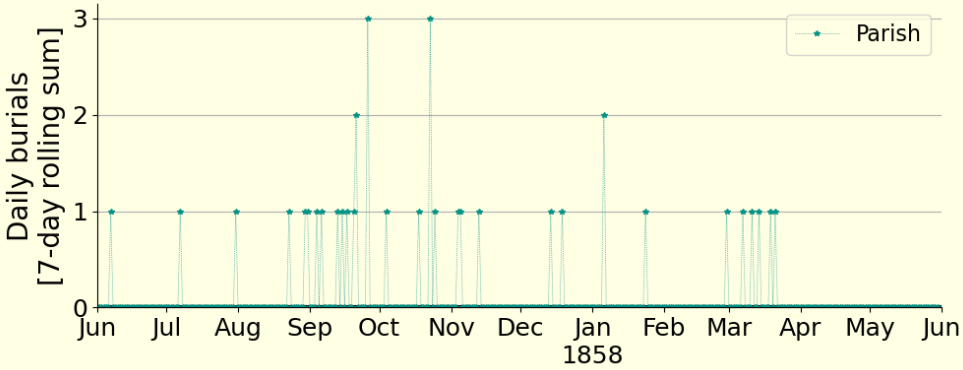

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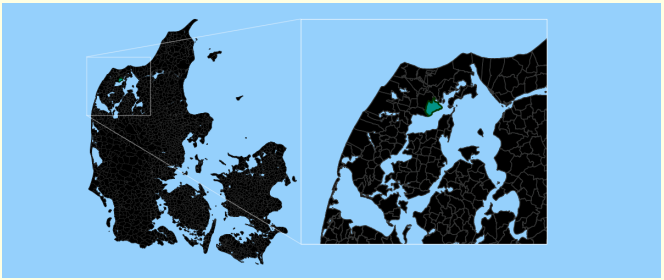

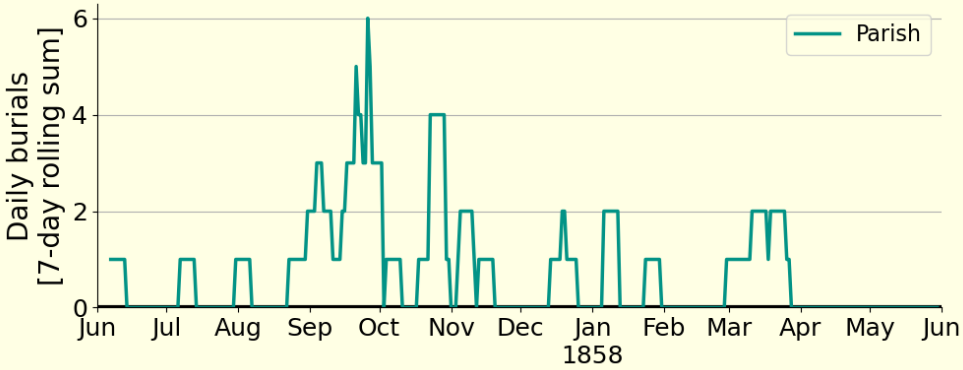

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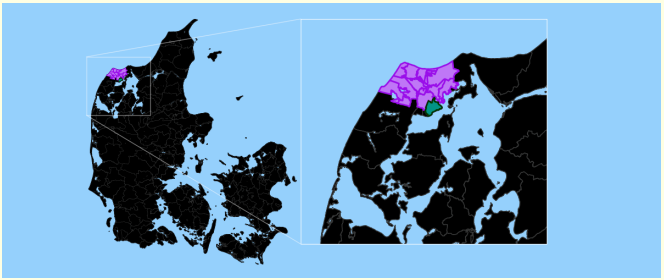

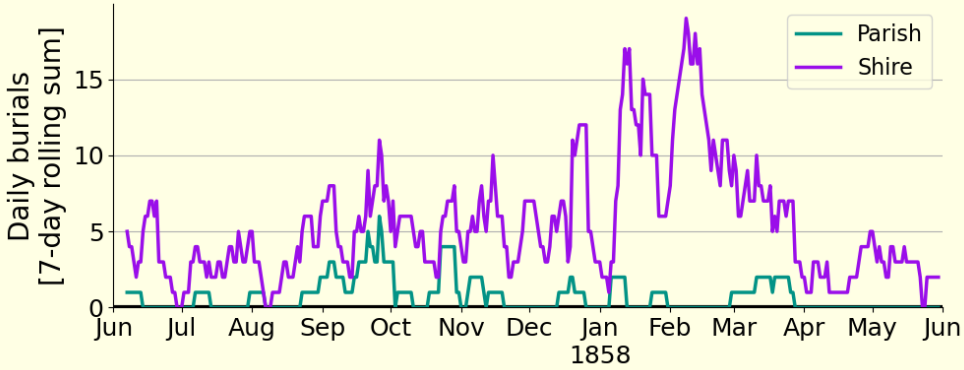

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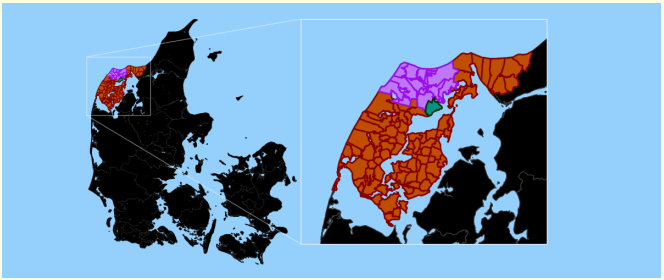

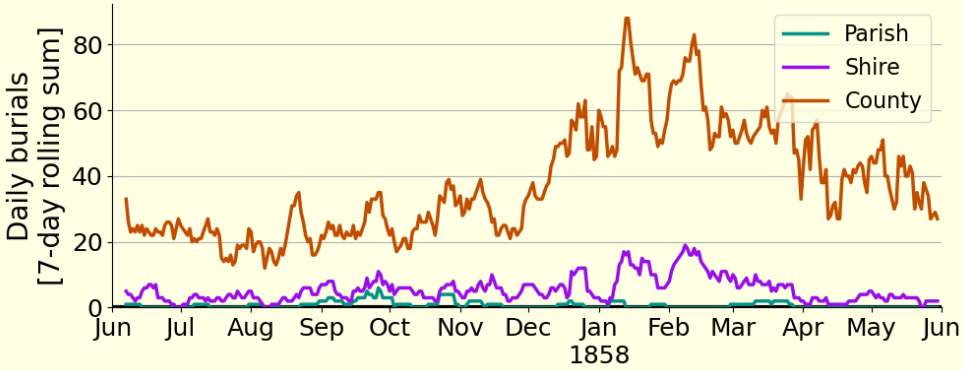

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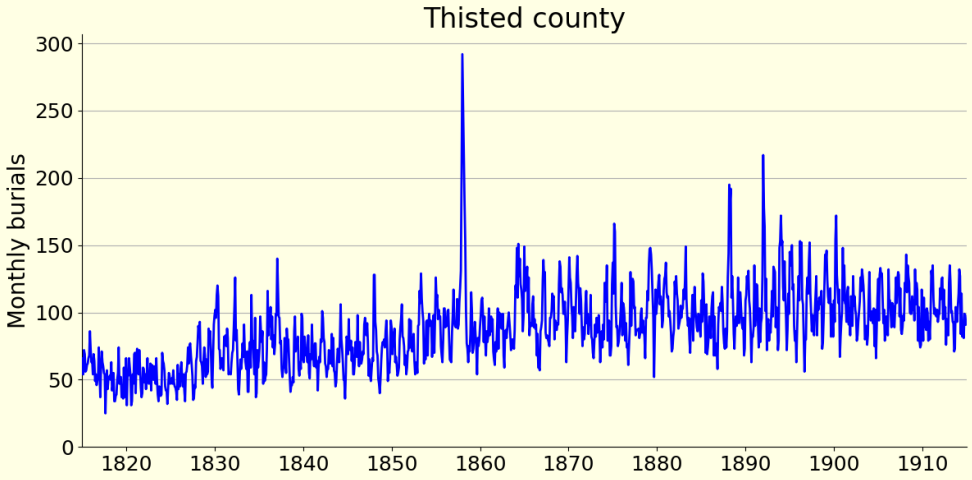
Calculating the mortality baseline



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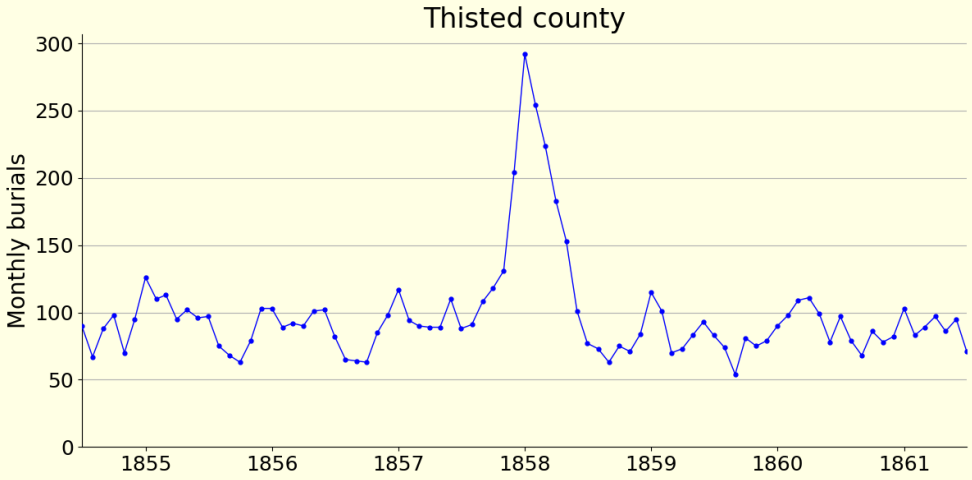

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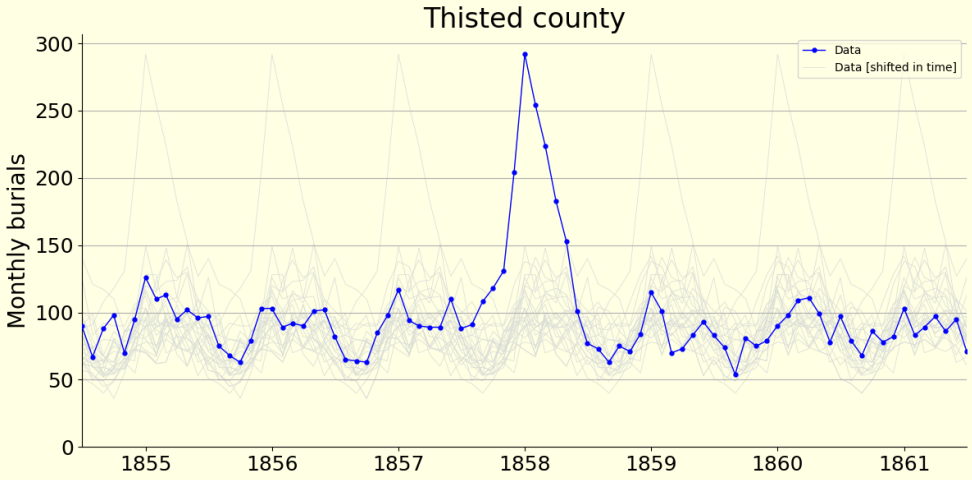

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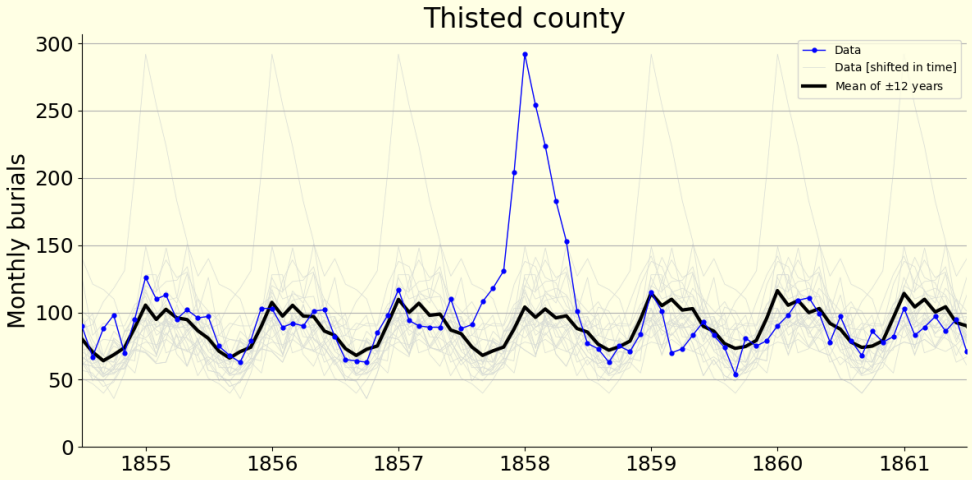

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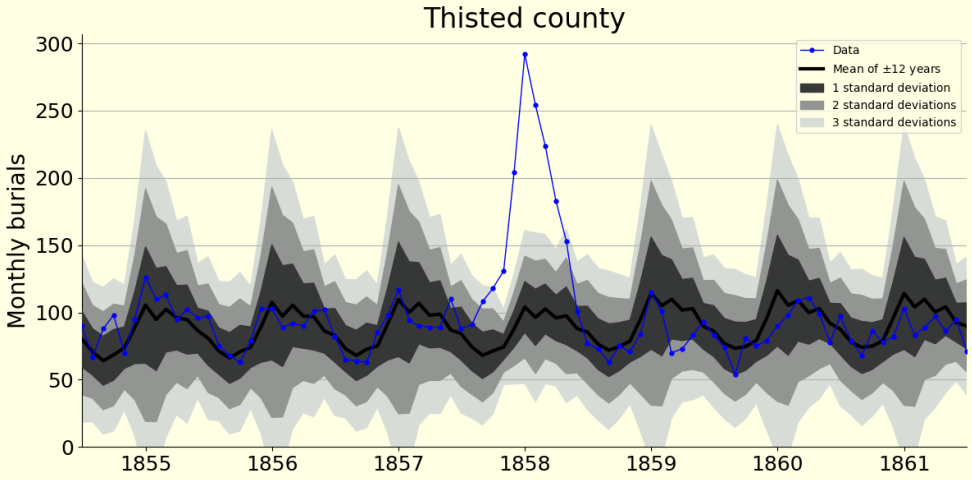

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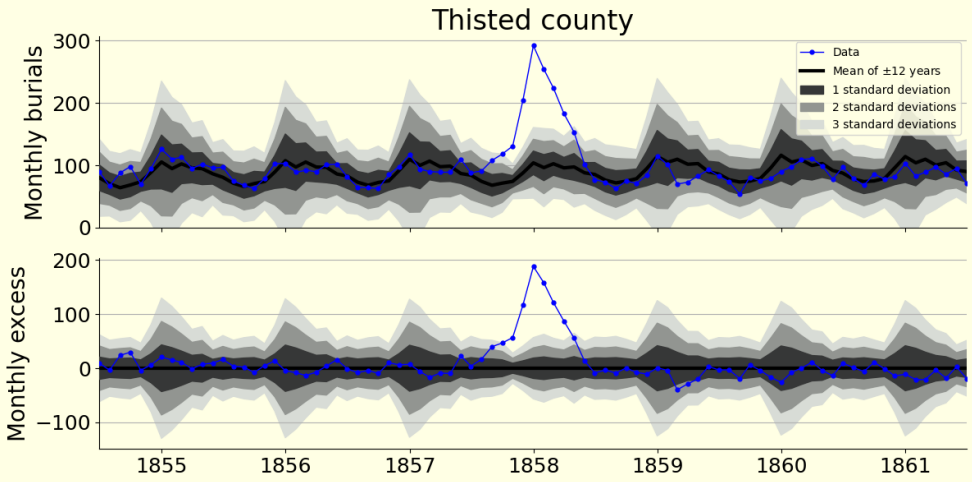

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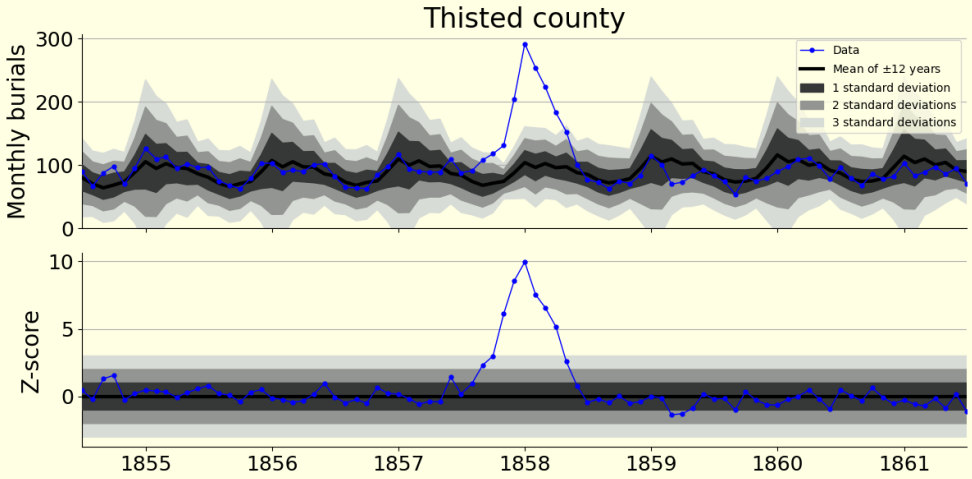

Hinde[1] uses the definition of months with a Z-score above two and three as "mortality crisis" and "severe mortality crisis", respectively

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

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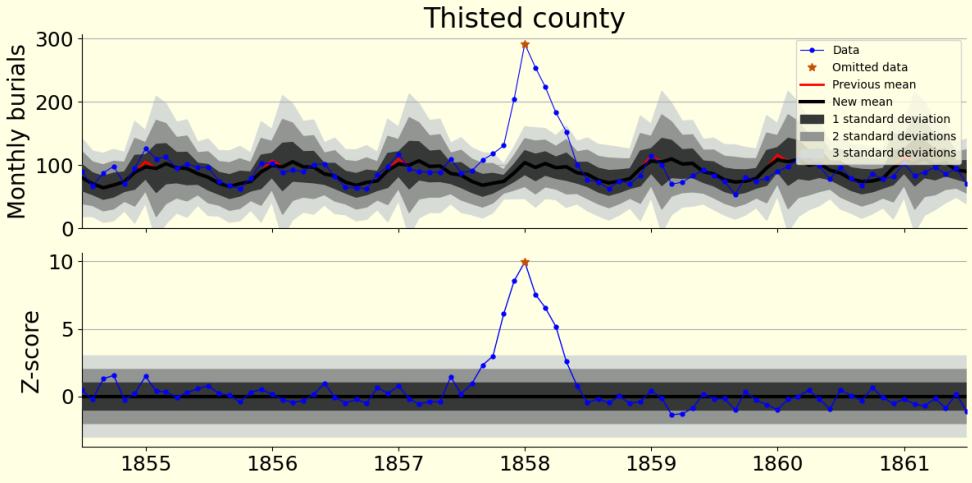

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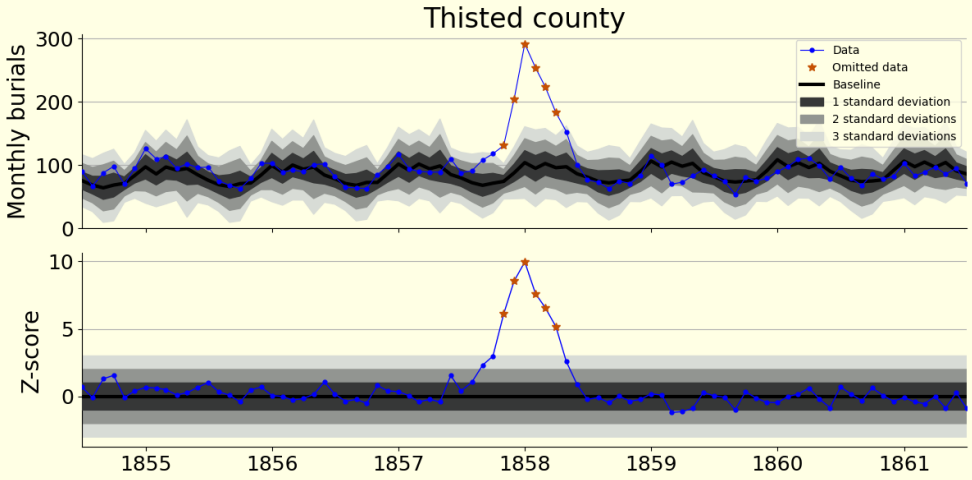

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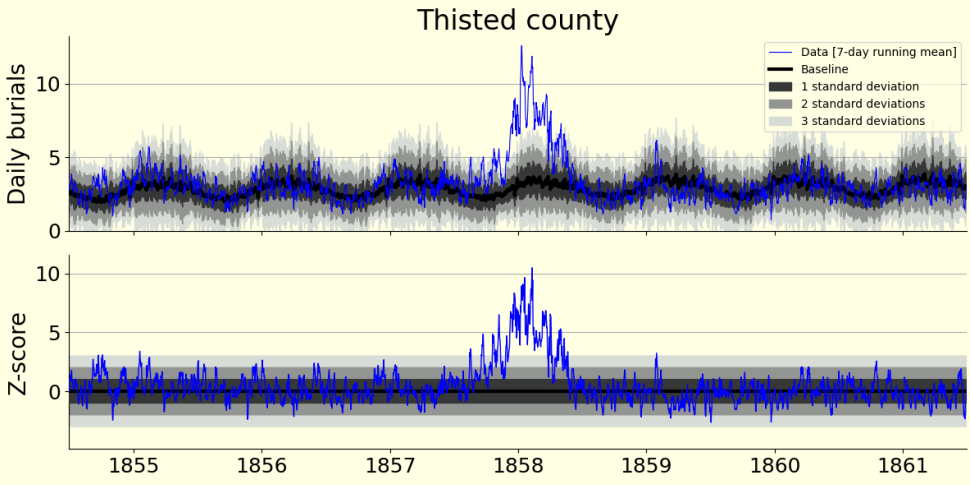

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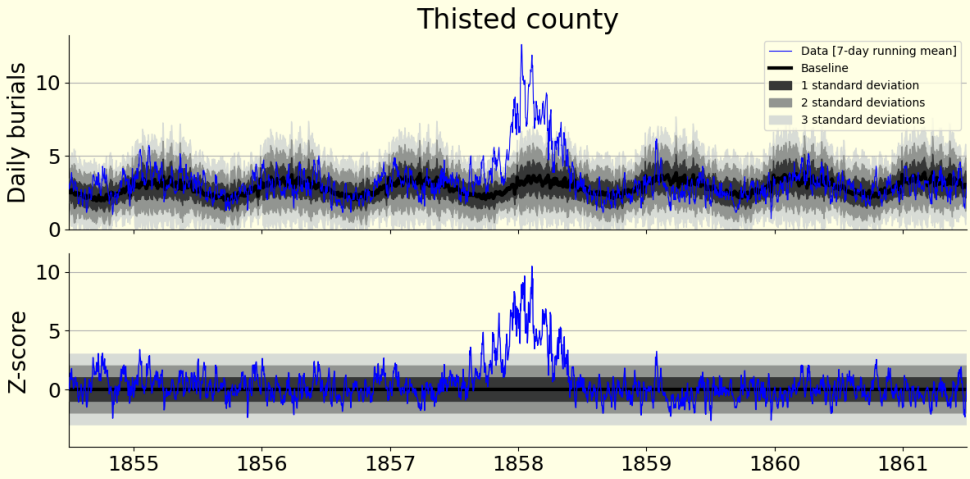
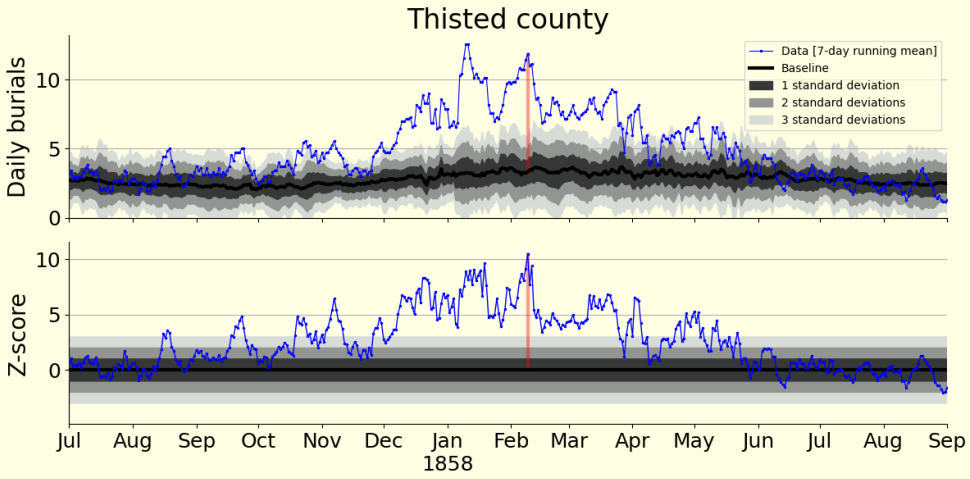
Identification of “mortality crises”



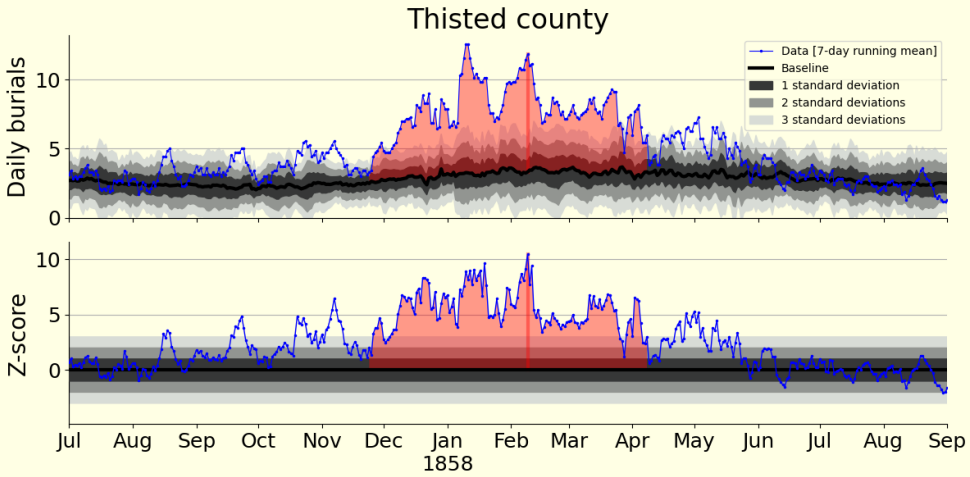
We wish to identify periods continuous excess mortality.

Identification of “mortality crises”



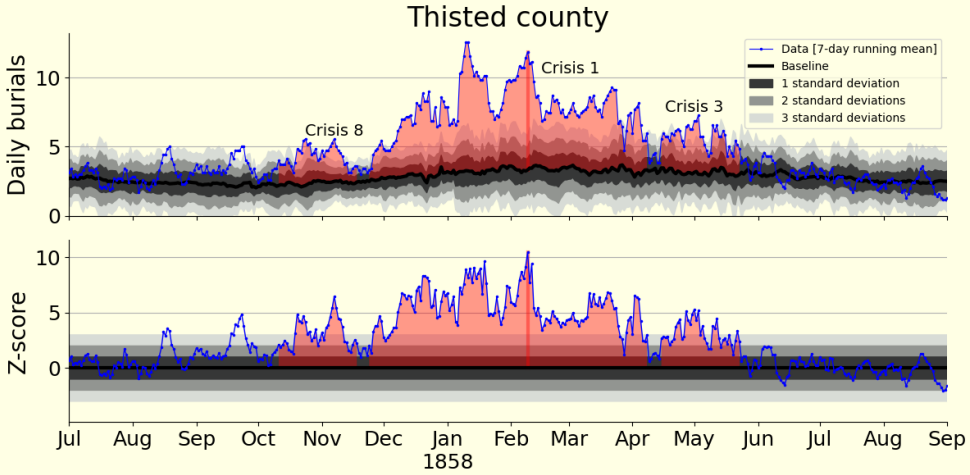
Starting from the date with most burials...

Identification of “mortality crises”



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

Identification of “mortality crises”



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

Brief return to the "signature features"

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

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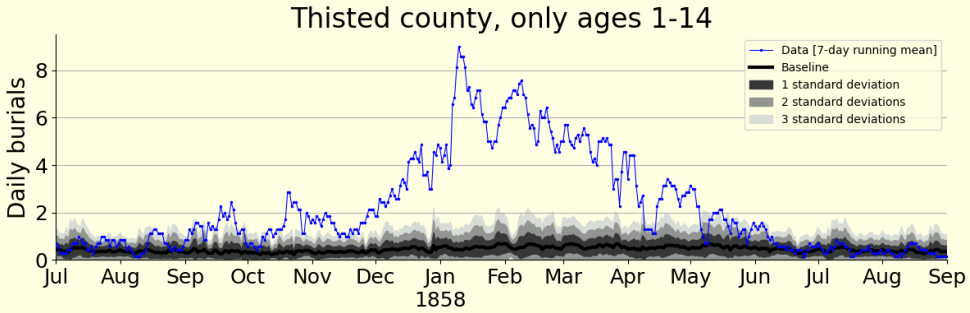
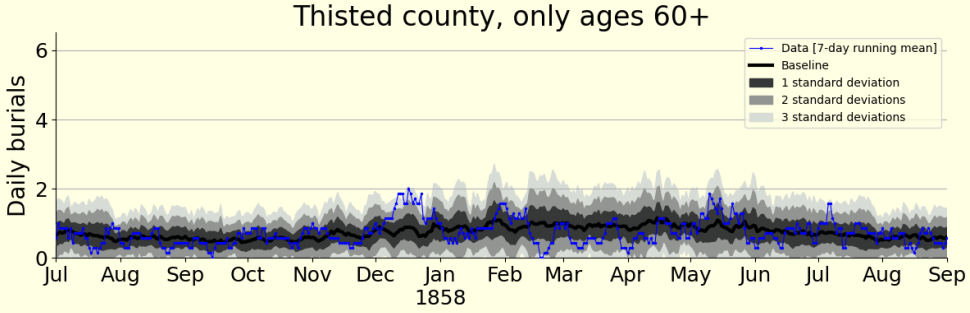
  e.g. "lasting two months"

But we also have data on age.

Analyzing age-patterns





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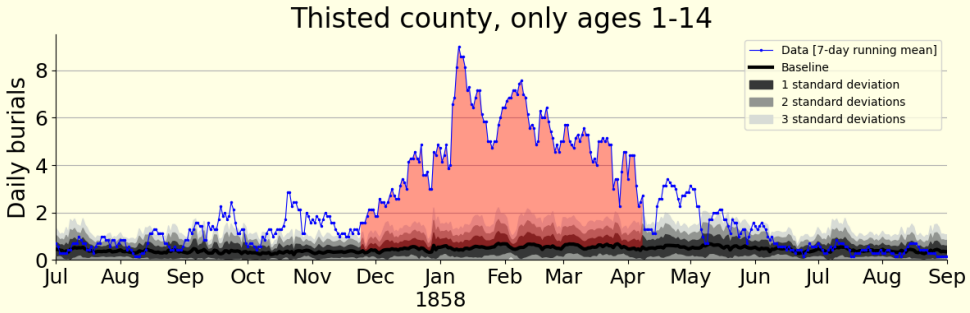

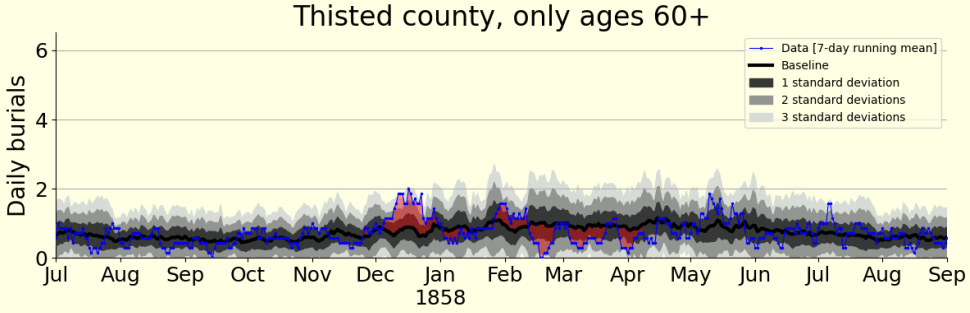

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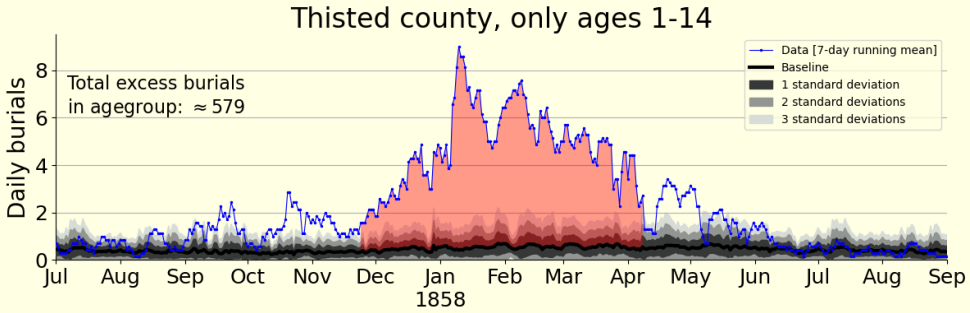

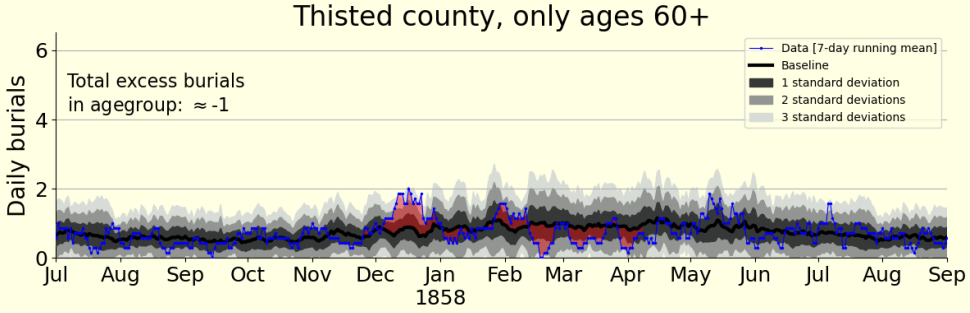

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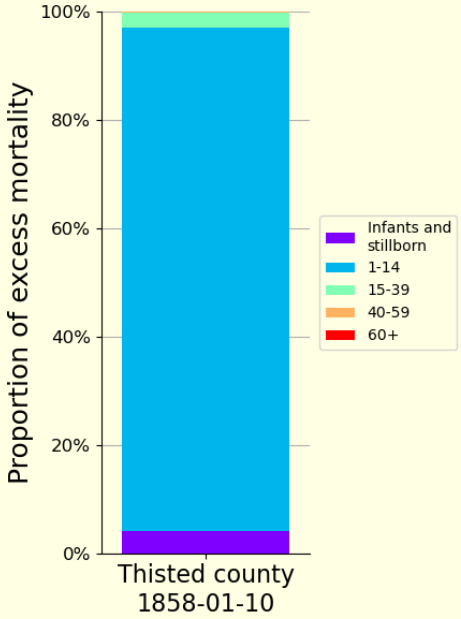
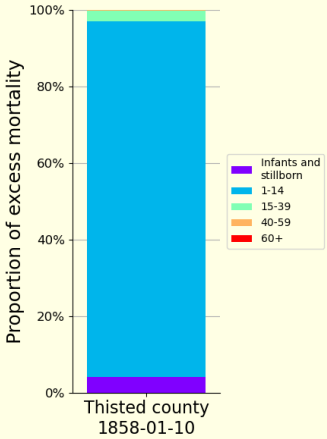


Age-specific excess mortality in this period:

- 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%

Mortality crises with comparable age patterns



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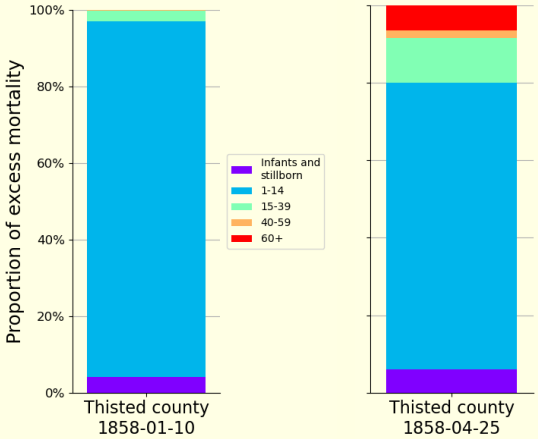

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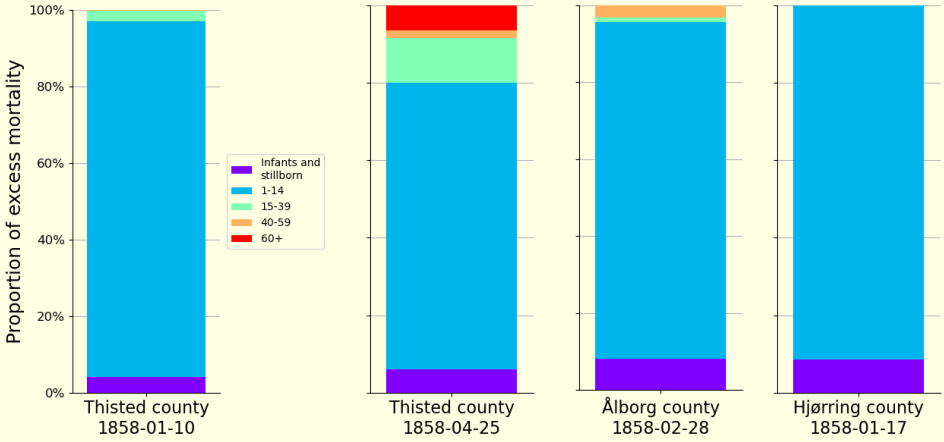
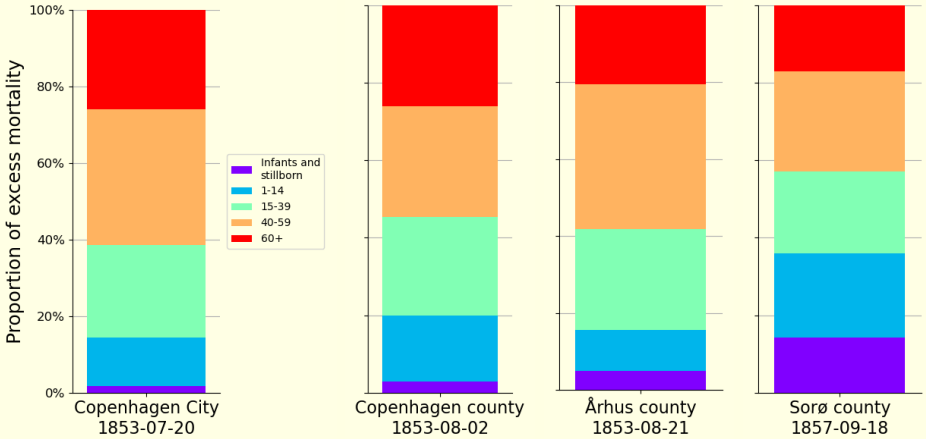


Mortality crises with comparable age patterns



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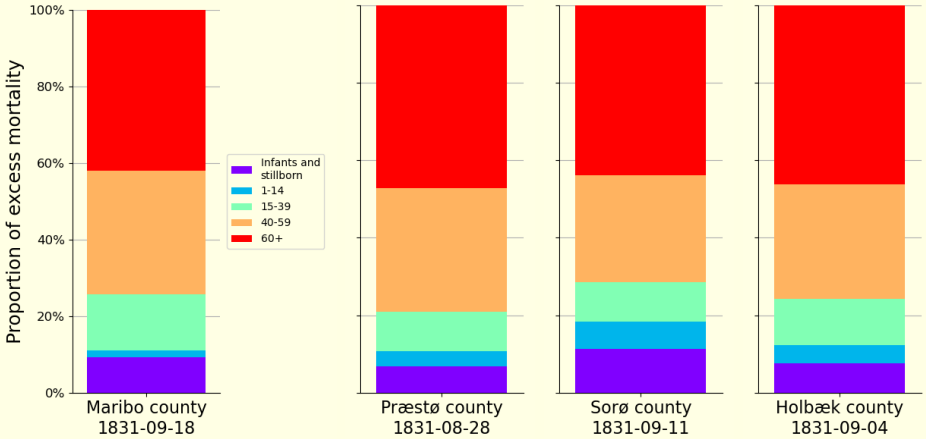

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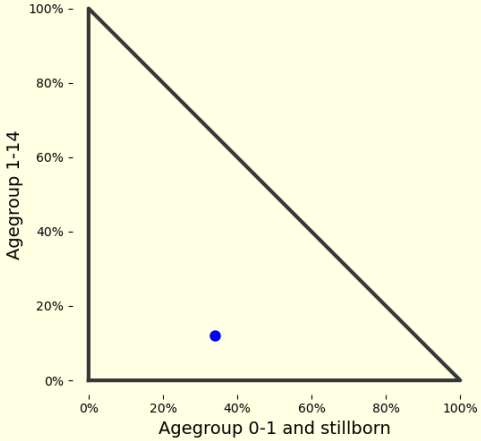
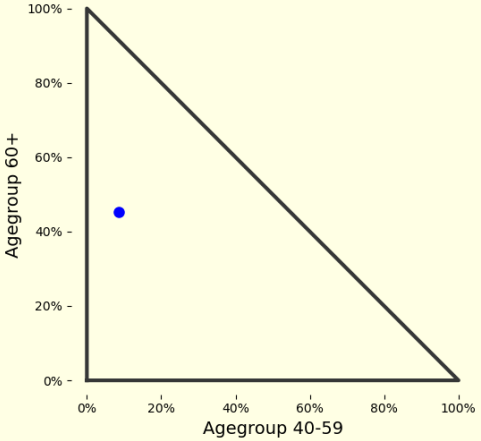
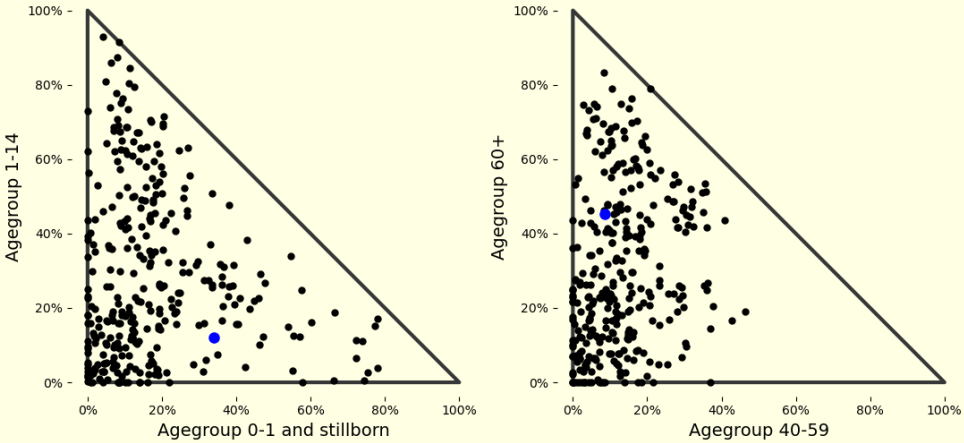




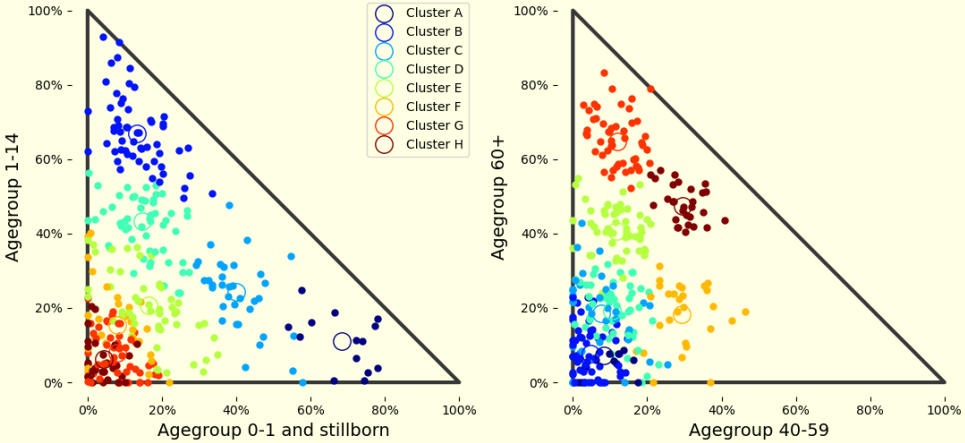
(Age group "15-39" not shown here)

Mortality crises with comparable age patterns



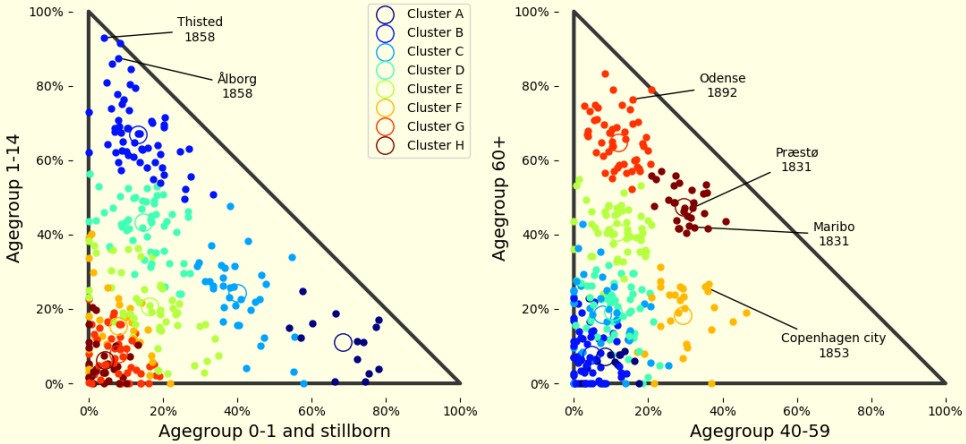
Adding the other 319 mortality crises identified.

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.

All epidemics and pandemics in 19th century Denmark

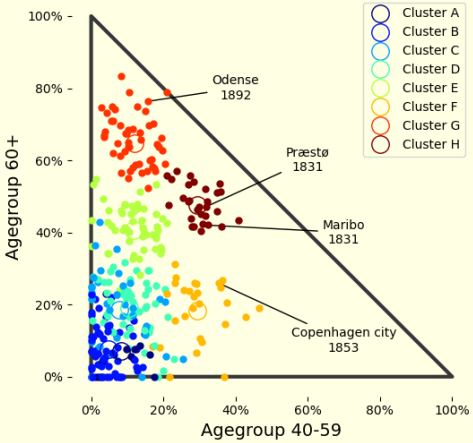
Going through all major mortality crises, and crossreferencing with historical records of epidemics:

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" epidemic[1]	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*

The signature features of certain diseases



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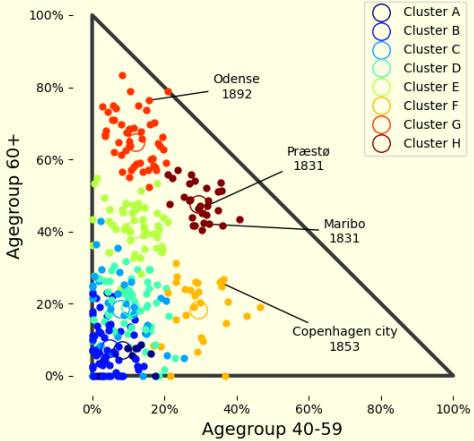

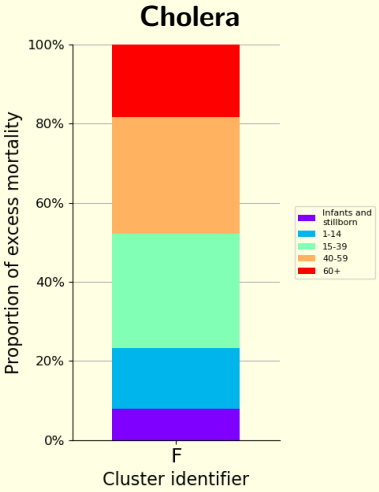

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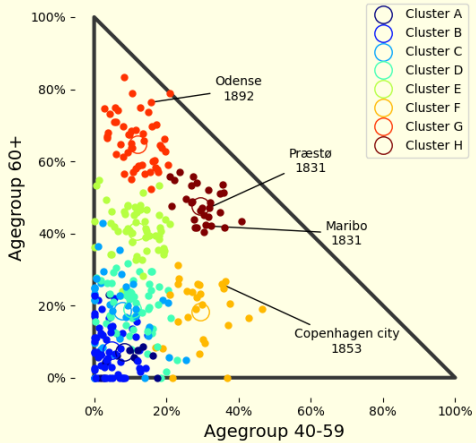

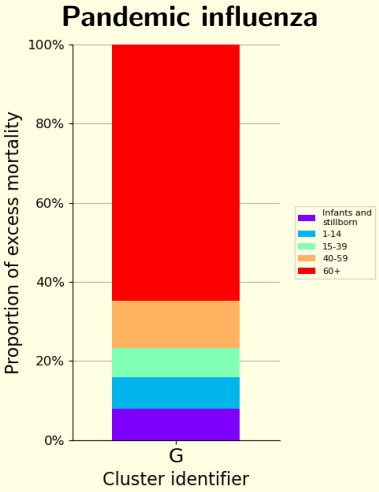

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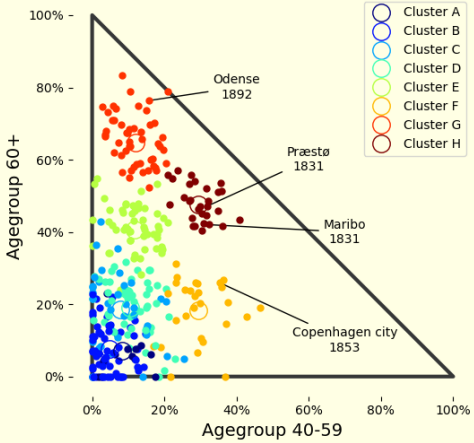

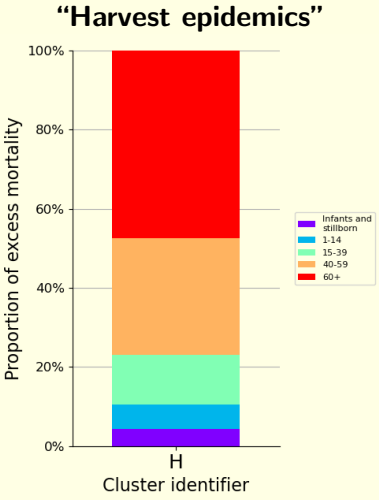

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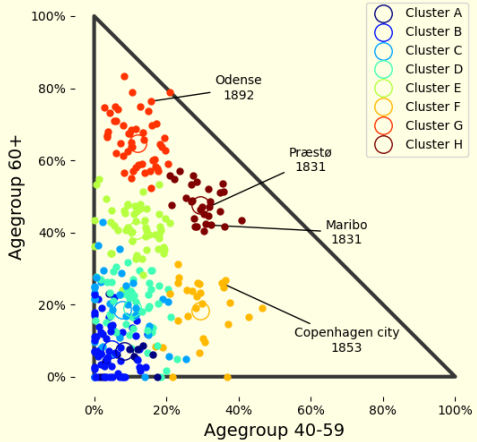

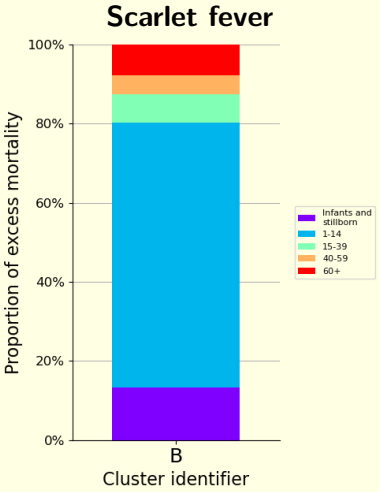

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  - Age-pattern.
- By comparing these features and validating with historical sources, we are able to determine groups of mortality crises with the same etiology, and estimate the total number of excess deaths during specific epidemics.

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- 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

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