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# Epidemiological Description of Unmitigated Cholera Epidemics in 19th Century Denmark



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## 1. Context

- **Mathematical models** are used to evaluate potential interventions in endemic and epidemics settings and need **empirical parameterizations**[1].
- **Historical outbreak data** are underutilized as a source of empirical data for **model parameterization**.
- In **1853 & 1857** singular cholera outbreaks occurred across Denmark in populations with **no previous exposure** and **no effective interventions** were implemented.

## 2. Objectives

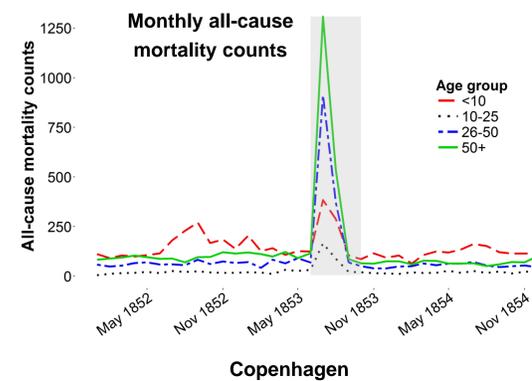
- Describe **unmitigated** cholera outbreaks in **immunological naïve populations**.
- To infer key parameters such as the **serial interval** and the **reproductive number ( $R_0$ )** from the data.
- To compare key metrics of the Danish outbreaks with **Haitian 2010** outbreak.

## 3. Data & methods

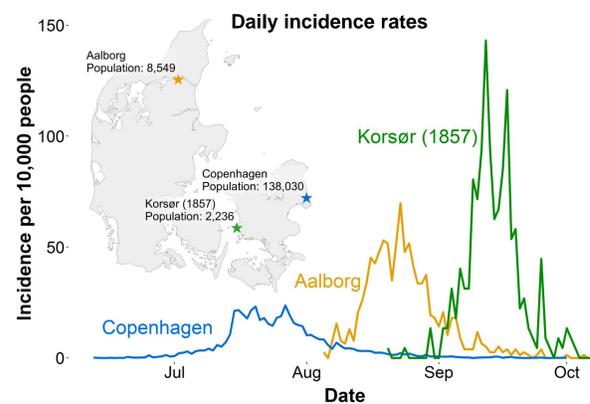
- Daily cholera morbidity & mortality data from three cities digitized from municipal cholera commission reports.
- All-cause monthly mortality data for Copenhagen, 1852 – 1854 digitized from the “Statistisk Tabelværk”.
- Transmission chains reconstructed from physician narratives of index cases.

## 4. Results

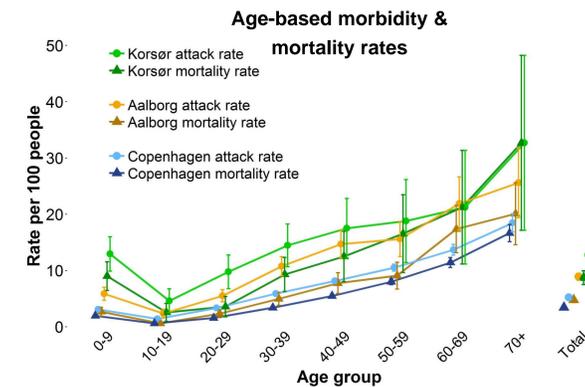
- The outbreak was severe for all age groups.
- A 14-fold increase in monthly all-cause mortality was seen among those aged 50+ in Copenhagen.



- Outbreaks all occurred in late summer / autumn.
- Copenhagen's outbreak was likely an amalgamation of multiple outbreaks in sub-populations resulting in a flatter epidemic curve.



- Adults were at highest risk of infections and death in all three locations.

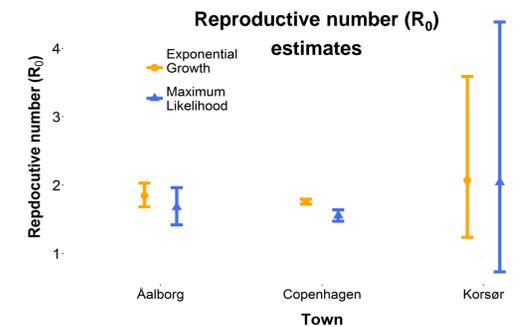


- Copenhagen and Haiti outbreaks have comparable reported attack rates & reproductive numbers ( $R_0$ ).
- Improvement in case-management and interventions likely lowered the CFR and excess mortality in Haiti.

Location	Copenhagen 1853	Haiti 2010-11
$R_0$	(1.5 – 1.8)	(2.1 – 1.6)* [2]
Reported attack rate (95% CI)	5.2% (5.1% – 5.4%)	6%*† [3]
Adjusted attack rate using $R_0$	58% - 69%	NA
Excess mortality as % of population (95% CI)	2.4%	0.4% (0.3% - 0.7%)* [4]
Reported CFR	66%	~2%† [3]
Adjusted CFR using $R_0$	5% - 6%	>2%†
% of cases in patients <5 years	8.4%	15.5%*‡ [3]

\*Port-au-Prince; \*\*Gonaives; †first 4 months; ‡first 2 years

- The reproductive numbers were comparable across the locations despite dissimilar water supply infrastructure.



- The serial interval was estimate to be **3.1 days** (95% CI: 1.9 – 4.5) and is the first estimate from an outbreak setting to our knowledge.

## 5. Conclusions

- **Severe unmitigated cholera** epidemics in **entirely susceptible populations** provide a unique opportunity to describe the **natural course** of a cholera outbreak.
- Despite a focus on water supply interventions in cholera outbreak response, the role of **non-waterborne transmission routes** in **epidemic settings** merits further consideration.
- In spite of **dissimilar water infrastructure** in the three towns, the reproductive numbers ( $R_0$ ) and age distribution of cases/deaths were **comparable**, suggesting **non-waterborne** transmission routes were **important**.
- The serial interval estimate of 3.1 days is the **first** to our knowledge from an **outbreak setting**
- **High** morbidity & mortality in **adults** and **low** among the **young** is the **inverse** of **endemic** settings. This is likely due to the **lack of acquired immunity** and **under-reporting** of moderate cases in the young due to the **strict case-definition** used at the time.

## Literature cited

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