Historical Infectious Disease Data Digitization

A Case Study in Whooping Cough

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Data Digitization

Weekly infectious disease incidence data is instrumental for analyzing outbreak patterns, but weekly data are challenging to access. Our lab has digitized and compiled over one million incidence records for Canada, by province and territory, creating a comprehensive digital archive of all notifiable diseases, from 1924–2000.

Whooping Cough in the 20th Century

Pertussis, commonly known as Whooping Cough, is a highly contagious respiratory tract infection caused by the bacterium *Bordetella pertussis* [5].

- Resurgences are common despite mandated childhood immunization programs; it is one of the **most commonly reported vaccine preventable diseases in Canada** [4].
- Primarily a concern for infants, who are too young to be vaccinated and account for the majority of cases.

Vaccine History

Vaccination efforts began in 1943 and have encountered several unique complexities.

- **1943:** Whole cell vaccine, first vaccine and widely effective.
- **1980–1985:** Absorbed whole cell vaccine, introduced in various provinces at different times, controversy about effectiveness and side effects [5].
- **1997–1998:** Acellular vaccine, more effective in clinical trials and less reactive than previous whole cell vaccines [5].

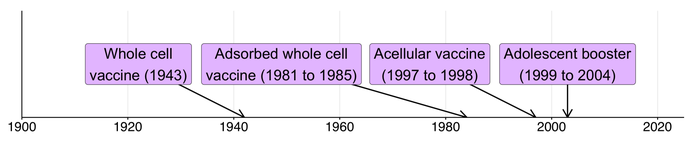

Figure 1: Historical Timeline of Vaccination for Whooping Cough

1990s Resurgence

Several researchers proposed that this resurgence was caused by a combination of the inadequate protection from the absorbed whole cell vaccine and improvement of testing and surveillance practices. **Nonetheless, the magnitude, prevalence and extent of the resurgence is still a topic of ongoing research and discussion.**

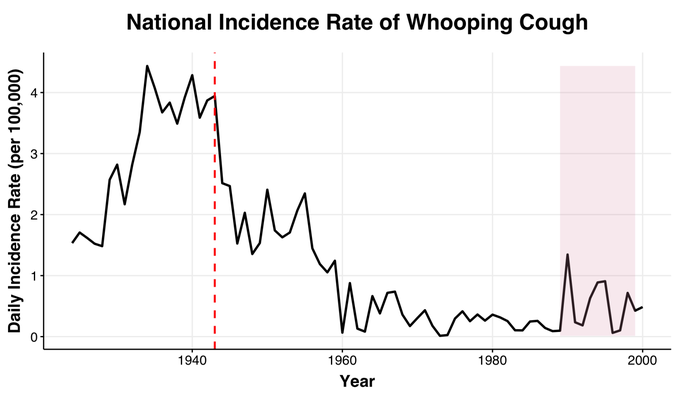

Figure 2: Annual Whooping Cough Incidence Rates in Canada, from 1924–2000, shaded region is 1989–1999 to highlight the 1990s resurgence

Periodic Trends

- **Inter-Epidemic Period:** time period between epidemics.
- Known inter-epidemic period of 2-5 years [1].
- Theory predicts that longer inter-epidemic periods are associated with lower transmission [4].

Main Objectives

1. Illustrate the usefulness of provincial and weekly data.
2. Use provincial data to analyze spatial variations across provinces to determine if the differences in the timing of the resurgence are linked to the varying time of introduction of the absorbed whole cell vaccine as previously hypothesized [5].
3. Use weekly data to evaluate the impact of vaccination on the inter-epidemic period.

Methods

- Daily incidence rates per 100,000 people is used to ensure fair comparisons across varying population sizes and consistency over time scales.

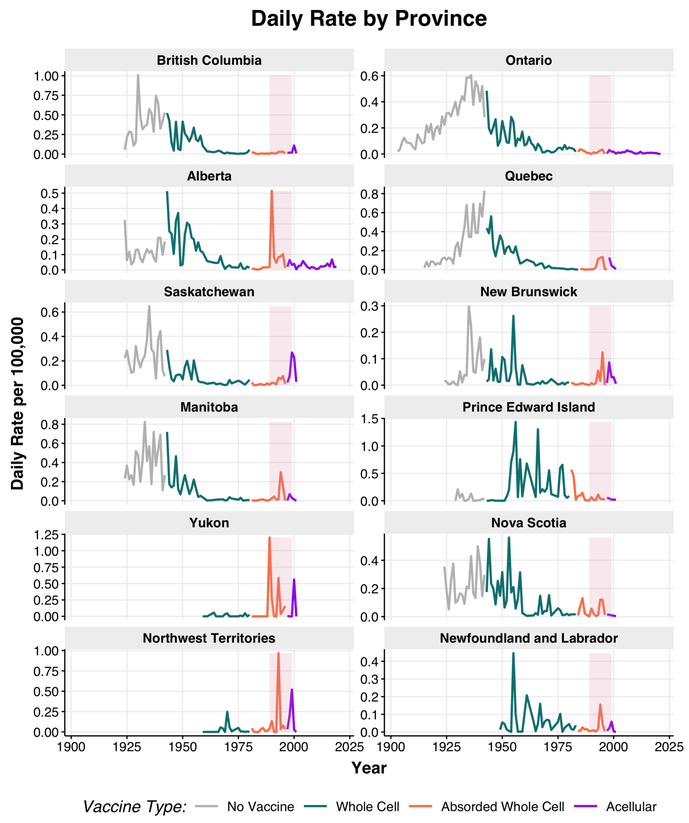

Figure 3: Overview of all provincial vaccine and incidence data, shaded region is 1989–1999 to highlight the 1990s resurgence, lines colored by vaccine type

Timing and Vaccine Impact: 10/12 of provinces saw an uptick in cases before the switch to the acellular vaccine in 1997, and the introduction of the acellular vaccine did not immediately curb outbreak levels.
Regional Variations in Resurgence: All provinces, except Ontario, had an outbreak sometime between 1989 and 2000, with British Columbia, Quebec, and Prince Edward Island having milder resurgences.

Periodic Analysis

- **Periodogram:** a tool to identify the dominant periods of a time series to determine which cycles are most prevalent.
- **Power:** on the y-axis, indicates how much of the variation in the time series can be explained by cycles of different periods.

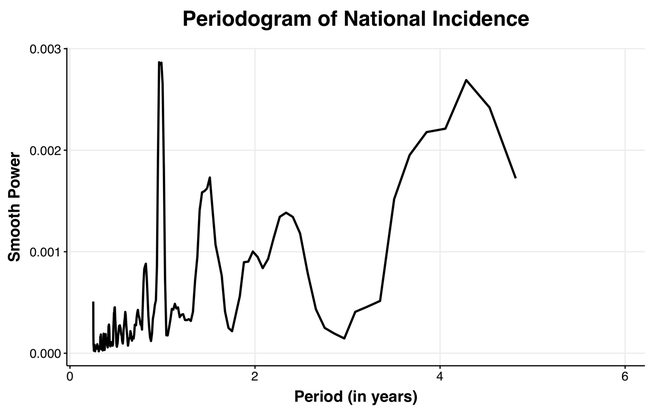

Figure 4: Lomb-Scargle periodogram using national data from 1924–2000

- Dominant peak occurs at 1 year and the second most dominant peak occurs around 4.2 years, consistent with previous studies [1, 4].

Results

Synchrony: time series that have concurrent peaks and troughs.

Resurgence in Western Canada

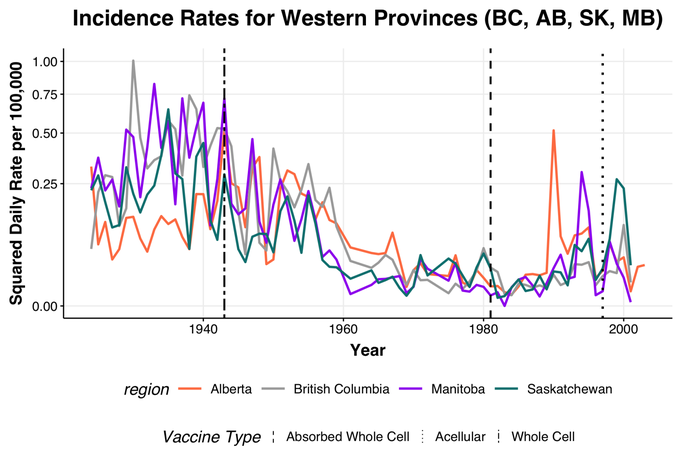

Figure 5: Comparison of western provinces from 1924–2000

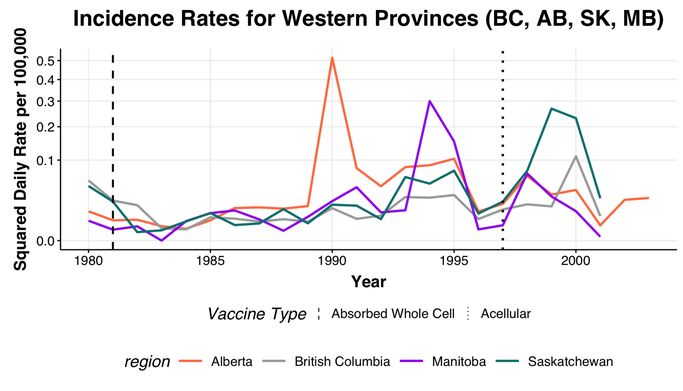

Figure 6: Comparison of western provinces from 1980–2000

- **Common Vaccine Timeline:** All four provinces adopted the absorbed whole cell vaccine in 1981 and acellular vaccine in 1997 [2] ; yet the time series are quite asynchronous with multiple years between the relative peaks for each province.
- **BC's Different Pattern:** British Columbia was relatively unaffected by the resurgence until a peak in 2000. This may be attributed to the early adoption of PCR testing in 1998, leading to more accurate case detection [3].

Effects of Vaccination on Periodicity

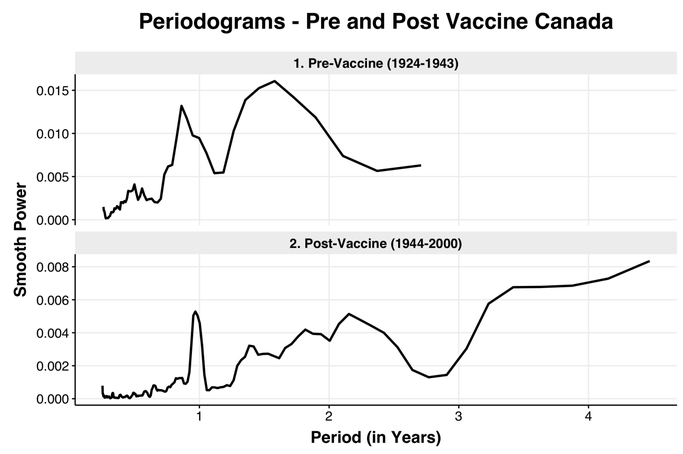

Figure 7: Comparison of periodograms before and after immunization programs

Mass vaccination efforts are associated here with an increase in the dominant period; moving from 1.6 years before vaccination to some period greater than 4 years after vaccination. This indicates a potential lengthening of the inter-epidemic period as a result of vaccination efforts.

Conclusions

- The provincial difference in the timing of the resurgence in 1990s cannot straightforwardly be explained by differing vaccine timelines.
- The magnitude of the resurgence in the 1990s varied from negligible in Ontario to near pre-vaccination levels in Alberta.
- The use of a whole cell vaccine from 1943-1997 was associated with an increased inter-epidemic period suggesting that the whole-cell vaccine was effective at reducing transmission.

Next Steps

- Formal statistical tests of the observed differences in provincial dynamics.
- Apply techniques (e.g., wavelet analysis) to evaluate potential synchrony amongst provinces.
- Generate periodograms of de-trended time series to confirm the assumption of a lengthening inter-epidemic period.

References

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[2] National Advisory Committee on Immunization et al. Prevention of pertussis in adolescents and adults. *Canada communicable disease report= Releve des maladies transmissibles au Canada*, 29:1–9, 2003.

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