Changing patterns of epidemic polio mortality in New Zealand

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COMPASS seminar 18 July 2018
Outline

1. Intro to polio and broad research questions
2. Summary of previous project (Ontario)
3. Overview of NZ project results to date (1916-1949)
   • Brief closer look at 1916 epidemic (*topic for tomorrow’s seminar!*)
4. Next steps
ENTEROVIRUS PATHOGENESIS

Entry via aerosol or ingestion

Replication
Oro-pharynx tonsils

Replication
Peyer's patches

Secondary viremia
Target tissue
Primary viremia circulation

Polio Cox
Polio Cox
Brain
Meninges
Meningitis

Echo, Cox
Echo, Cox
Hep A
Liver
Hand foot mouth disease
Rash Herpangina

Echo Cox A
Skin

Echo Cox A B
Muscle

Myocarditis
Pericarditis
Pleurodynia

Virus in feces
Paralysis: The New Epidemic

By Helen MacMurchy, M.D.

Infantile Paralysis is epidemic in some parts of Canada. The germ attacks rich as well as poor, adults as well as children. In Ontario last month half the cases were fatal. Dr. MacMurchy is able to give our readers the latest developments concerning this dread disease direct from the great specialists, having recently attended a medical congress where the question was discussed. It is now thought that the germ is carried mainly by the stable fly. Dr. MacMurchy says, Never let a fly rest on an infant.
Background

• Traditional model based on **hygiene hypothesis**
  • Higher SES, smaller families

• **Intensive Exposure (IE) hypothesis** (Nielsen et al.)
  • Crowding

• Use of mortality data for testing predictions of hypotheses, informing understanding of epidemiological transition

- Pre-20th C.
- Poor sanitation
- Endemic polio

- 20th C.
- Good sanitation
- Epidemic polio
Questions

1) What groups were the most vulnerable?

2) Emergence of, or increase in, excess male mortality over time?

3) How were the epidemics shaped by their social, political, and economic structures and contexts – and vice versa?

Ontario Project Overview

• Wentworth and York Counties
• Major epidemics in 1910, 1922, 1929/30, 1937
• 337 deaths (1900-1937)
• Mapping with ArcGIS
Data

• Age
• Sex
• Illness duration
• Seasonality
• Nativity
• Birthplace
• Ethnicity
• Religion
• Family size
• Birth order
• Occupation (SES)
• Residence
Challenges

• Data availability
  • Birth records only to 1914
  • Absence of 1921 Census data (until 2013)

• Mobility of population
  • Multiple moves between countries, cities
  • Migration from rural farms to cities
  • Frequent change of residence within city
Predictions of Nielsen et al.

• Intensive-exposure:
  • Polio deaths will increase with family size
  • U-shaped age curve in polio deaths

• Cross-sex transmission:
  • Higher sex ratio in smaller families

Predictions of traditional hygiene model

• Mortality by SES:
  • Greater mortality at higher SES
Figure. Number of acute polio deaths by age in Wentworth and York Counties, ages 0-19.
# SES by status scores

<table>
<thead>
<tr>
<th>Status score</th>
<th>Category</th>
<th>Example occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Professional</td>
<td>Dentist, Lawyer</td>
</tr>
<tr>
<td>2</td>
<td>Entrepreneurial/Clerical</td>
<td>Clerk, Farmer, Sales manager</td>
</tr>
<tr>
<td>3</td>
<td>Skilled labour</td>
<td>Carpenter, Stonemason</td>
</tr>
<tr>
<td>4</td>
<td>Semi-skilled labour</td>
<td>Porkpacker, Teamster</td>
</tr>
<tr>
<td>5</td>
<td>Unskilled labour</td>
<td>Farm labourer, Travellers</td>
</tr>
</tbody>
</table>

## Polio deaths by status score

### TABLE 5. Proportions of acute polio deaths by status score over time

<table>
<thead>
<tr>
<th>Status score</th>
<th>1900–29</th>
<th></th>
<th>1930–37</th>
<th></th>
<th>1900–37</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>2.54</td>
<td>5</td>
<td>6.76</td>
<td>8</td>
<td>4.17</td>
</tr>
<tr>
<td>2</td>
<td>39</td>
<td>33.05</td>
<td>28</td>
<td>37.84</td>
<td>67</td>
<td>34.90</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
<td>43.22</td>
<td>29</td>
<td>39.19</td>
<td>80</td>
<td>41.67</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>14.41</td>
<td>9</td>
<td>12.16</td>
<td>26</td>
<td>13.54</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>6.78</td>
<td>3</td>
<td>4.05</td>
<td>11</td>
<td>5.73</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>100.0</td>
<td>74</td>
<td>100.0</td>
<td>192</td>
<td>100.0</td>
</tr>
</tbody>
</table>

A chi-square test found no evidence of a real difference between the proportions of deaths by status score for the 1930–37 period compared to those of the 1900–29 period ($\chi^2 (4, n = 74) = 7.04, p = .13, V = .15$).
Proportion of population vs polio deaths by status score

<table>
<thead>
<tr>
<th>Status score</th>
<th>Census %(^a)</th>
<th>Polio %(^b)</th>
<th>Polio (n) expected(^c)</th>
<th>Polio (n) observed(^b, d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.46</td>
<td>3.33</td>
<td>2.18</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>28.08</td>
<td>23.33</td>
<td>42.13</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>40.77</td>
<td>52.00</td>
<td>61.15</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>10.98</td>
<td>14.00</td>
<td>16.47</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>18.71</td>
<td>7.33</td>
<td>28.06</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: Census of Canada 1921 (Canada, Dominion Bureau of Statistics 1925, Table 41).

\(^a\) A chi square test found evidence of a real difference between the observed polio deaths versus the expected number of deaths based on the Census distribution for status scores two through five. \(\chi^2(3, n = 145) = 17.75, p < .001, \phi = .22\).

\(^b\) This status score versus sum of remaining status scores. Two-tailed \(p\) values reported. Status score one not tested itself due to its small sample size.
Pre-Depression (1900-29) vs Depression (1930-37)

Table 10 Median and untransformed mean ages by status score for acute polio deaths in the pre-Depression (1900–1929) and Depression (1930–1937) periods

<table>
<thead>
<tr>
<th>Status score</th>
<th>1900-29&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1930-37&lt;sup&gt;b&lt;/sup&gt;</th>
<th>1900-29</th>
<th>1930-37</th>
<th>1900-29</th>
<th>1930-37</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18.66</td>
<td>16.50</td>
<td>18.23 (0.79)</td>
<td>13.97 (8.15)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>14.21</td>
<td>11.22</td>
<td>16.65 (14.40)</td>
<td>14.11 (8.88)</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>4.95</td>
<td>10.89</td>
<td>8.60 (9.70)</td>
<td>12.60 (6.23)</td>
<td>51</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>2.44</td>
<td>11.04</td>
<td>5.26 (7.39)</td>
<td>12.59 (9.12)</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>3.05</td>
<td>18.26</td>
<td>7.62 (9.78)</td>
<td>14.38 (10.13)</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>All status scores</td>
<td>5.87</td>
<td>10.97</td>
<td>10.95 (11.87)</td>
<td>13.14 (7.88)</td>
<td>118</td>
<td>74</td>
</tr>
</tbody>
</table>

<sup>a</sup> A Kruskal-Wallis test rejected the null hypothesis that age at death was the same across the status scores for the 1900–1929 period. $H(4) = 19.89, p < .001$. Jonckheere’s test demonstrated a trend of decreasing median age over the status scores, $J = 1498, z = -4.28, p = .000, r = -.39$.

<sup>b</sup> A Kruskal-Wallis test found no difference in age at death across the status scores for the 1930-1937 period. $H(4) = .30, p = .99$. 

(Battles 2017)
Working class plague

- Working classes (skilled/semi-skilled labourers) hardest hit
- Fits with findings of the *Report on Poliomyelitis in Ontario, 1937*
  - Households with epidemic polio cases had more persons per household and fewer rooms per person
- Mixed high and low risk?
  - "In poor and unhygienic households you were more likely to be protected against the virus but you were also more likely to meet it" (Cockburn 2005)

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**Battles, H.T. (2017)**
Overview of Findings

- 2-stage pattern for Wentworth/York:
  - 1910-1927 vs. 1928-1937
- Changes in polio deaths, socio-ecology
- Consistent with predictions of Nielsen et al.

<table>
<thead>
<tr>
<th></th>
<th>Stage 1 (1910-1927)</th>
<th>Stage 2 (1928-1937)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age at death</strong></td>
<td>Majority &lt;5</td>
<td>Majority &gt;5</td>
</tr>
<tr>
<td><strong>U-shaped age curve</strong></td>
<td>Absent</td>
<td>Present (dip at ages 7-8)</td>
</tr>
<tr>
<td><strong>Sex ratio (ages 0-19)</strong></td>
<td>1.0 (equal)</td>
<td>1.5 (excess males)</td>
</tr>
<tr>
<td><strong>Family size</strong></td>
<td>Median = 4</td>
<td>Median = 2</td>
</tr>
<tr>
<td><strong>Age gradient by SES</strong></td>
<td>Present</td>
<td>Absent</td>
</tr>
</tbody>
</table>
Conclusions

Quantitative results + Social/economic context of southern Ontario pre-SWW (esp. during Depression)

= polio more accurately characterized as a ‘working-class plague’

Polio’s patterns were not static – they changed as the environment changed.
Bio-eco-cultural approach to the study of emerging disease
NZ Project Overview

• Non-Māori death registrations

• Four major epidemics:
  • 1916
  • 1924/25
  • 1936/37
  • 1947-49
Materials and Methods

• Death registrations – infantile paralysis/ poliomyelitis
• 20th C. reports and research papers (e.g. in NZMJ)
• Census (esp. 1916)
• Newspapers (via Papers Past)
• Autobiographic accounts (published and unpublished)
Results

• 415 deaths identified
• 1916: 125 deaths
• 1924/25: 181 deaths
• 1936/37: 44 deaths
• 1947-49: 65 deaths
• December – April (i.e., summer/early autumn)
Deaths by age: *Which groups were most vulnerable?*
Polio and war

• Gear (1952:6): “In the second world war, as in the first, poliomyelitis was more prevalent than in more normal times.”

• Blamed the South African epidemics of 1918 and 1944/45 on troops returning from Middle East

‘The Homecoming from Gallipoli’ (Wellington, NZ, 15 July 1915) by Walter Armiger Bowring
<table>
<thead>
<tr>
<th>Country</th>
<th>Region</th>
<th>Death Rate (per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US (regions)</td>
<td>New England (6 states)</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>Middle Atlantic (3 states)</td>
<td>24.1</td>
</tr>
<tr>
<td></td>
<td>South Atlantic (4 states)</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>Atlantic regions combined</td>
<td>17.3</td>
</tr>
<tr>
<td>NZ (Prov. Districts)</td>
<td>Auckland</td>
<td>20.1</td>
</tr>
<tr>
<td></td>
<td>Taranaki</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>Hawke’s Bay</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>Wellington</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>Marlborough</td>
<td>24.1</td>
</tr>
<tr>
<td></td>
<td>Nelson</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Westland</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Canterbury</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Otago – Otago Portion</td>
<td>0.0</td>
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<tr>
<td></td>
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</tr>
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<td>Wellington</td>
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<td>Marlborough</td>
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<td></td>
<td>Nelson</td>
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</tr>
<tr>
<td></td>
<td>Westland</td>
<td>0.0</td>
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<tr>
<td></td>
<td>Canterbury</td>
<td>2.7</td>
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<tr>
<td></td>
<td>Otago – Otago Portion</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Otago – Southland Portion</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td><em>North Island</em></td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td><em>South Island</em></td>
<td>4.0</td>
</tr>
</tbody>
</table>
1916 Results: Age and sex

χ² = 4.393, df = 4, p = 0.36
Did the sex ratio in polio mortality increase over time?

<table>
<thead>
<tr>
<th>Epidemic</th>
<th>Median age at death (years)</th>
<th>Sex ratio (M:F)</th>
<th>Chi square test results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1916</strong></td>
<td>M: 8, F: 7.5</td>
<td>1.7 (79:46)</td>
<td>χ² (1,125) = 8.712, p = .003, φ = .26</td>
</tr>
<tr>
<td><strong>1924/25</strong></td>
<td>M: 6, F: 5</td>
<td>1.1 (95:86)</td>
<td>χ² (1, 306) = .448, p = .50</td>
</tr>
<tr>
<td><strong>1936/37</strong></td>
<td>M: 19, F: 16</td>
<td>2.4 (31:13)</td>
<td>χ² (1,44) = 7.364, p = .007, φ = .41</td>
</tr>
<tr>
<td><strong>1947-49</strong></td>
<td>M: 21, F: 21</td>
<td>1.0 (33:32)</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Questions from first results

• Can we say there are general patterns for polio?
  • How variable?
  • Did they vary according to certain rules/conditions, as Nielsen et al. suggest?
• How to address the problem of small sample sizes?
Results so far

• **Preliminary** results show partial fit with expectations of traditional model
• No evidence of polio among NZ troops in FWW
• Excess male mortality - but sex ratio fluctuates
• Polio pandemics? (1916? 1937?)
Next steps

• SES analysis - *Was there differential mortality during New Zealand’s polio epidemics?*
  • Status scores and/or HISCLASS
  • Compare to Ontario pattern
  • Compare to Rice and Bryder’s finding re: 1918 influenza in NZ

• The 1916 epidemic and the First World War
  • How they were linked biologically and socially
  • Why was this epidemic ‘forgotten’?
  • How was the epidemic linked to imperialist anxiety (including fears of disability/impairment)?
ANTHROPOLOGY SEMINAR
To be held on Thursday, 19th July 2018
4.00 to 5.30 pm in Room HSB 802 (Social Sciences Staff Room)

Heather Battles
(University of Auckland)

The First World War and the ‘forgotten’ 1916 polio epidemic in New Zealand

This presentation examines New Zealand’s 1916 polio epidemic, which resulted in over 1,000 notified cases and 125 deaths among Pakeha alone, in addition to an unknown number cases and deaths among Maori. Despite the proportionately heavy toll of this epidemic, it has been largely forgotten’, subsumed in historical and public memory by the upheaval and impact of the Great War as well as the subsequent mass mortality of the 1918 Flu.

Scholarship on the once-forgotten 1918 influenza pandemic has illuminated not only many factors which contributed to this ‘forgetting’ but also how intimately linked that disease was to the War – both biologically and socially. Are similar links to be found in the case of polio in 1916?

I present the results of quantitative and qualitative research of the non-Maori death registrations, contemporary newspapers, and other historical sources. I find little evidence of a direct biological link between wartime conditions and the spread and severity of the disease. Much clearer are the ways in which the epidemic articulated socially and politically with the War. I examine the negative and positive repercussions of these connections for the treatment of polio patients and how these connections to the War contribute to our understanding of collective forgetting versus remembering.

Dr. Heather Battles completed her BA in Anthropology and History at the University of Victoria in BC, Canada, in 2005, before moving to Ontario for graduate studies. She completed her Masters in the Anthropology of Health and her PhD in Biological Anthropology, both at McMaster University. Her doctoral dissertation used historical records to examine the shifting social, geographic, and demographic patterns of polio mortality in southern Ontario in the early 20th century. She took up her current position in Biological Anthropology at the University of Auckland in 2014, beginning her ongoing research into polio mortality in New Zealand. She takes an inter/multi-disciplinary approach to the study of epidemics, combining historical demography, infectious disease ecology, medical anthropology, and social history.
Acknowledgments

• University of Auckland Faculty of Arts New Staff FRDF grant
• New Zealand Department of Internal Affairs Births, Deaths and Marriages and the Registrar General
• Previous research on polio in NZ by Jean Ross and Deborah Simpson
References (partial list)


