Changing Mortality Rates of Three Vaccine Preventable Diseases in Historic Rochester

Kayla Carlin, State University of New York at Geneseo

Introduction

Public health is an interdisciplinary field that encompasses a range of focuses from treatment efficacy to outbreak control. Public health initiatives are especially important in preventing the outbreak and spread of disease. Naturally, these initiatives have changed over the past two centuries due to health improvements. Cutler, Deaton, and Lleras-Muney (2006) describe a three-stage health transition model which outlines the shift in public health focuses since the mid-18th century. As these public health focuses shifted, the common causes of death also changed. Figure 1 applies the Health Transition Model to the changing public health initiatives in Rochester, New York and includes some common causes of death in Rochester during those times.

While there are records of major public health initiatives in Rochester, the influence of these initiatives on diphtheria, whooping cough, and pneumonia rates is not well understood. These diseases were among leading causes of death during the 20th century, especially in children. The purpose of this study is to explore and compare the mortality rates these diseases in Rochester, New York from the mid-19th century until the early-20th century using the context of public health campaigns both nationally and in Rochester. The prediction for the study is that diphtheria, whooping cough, and pneumonia mortality rates decreased as immunization initiatives grew. This study also seeks to inform current vaccination prevention efforts.

Time Period	Health Transition Model Phase	Rochester Initiatives	Common Causes of Death
1850 – 1900	Phase #2 Improve Water and Sewage	• **1853** – Rochester officials begin improving the sewage system • **1876** – Water Works Commission reroutes water from Hemlock Lake • **1897** – Dr. George Goler (the Director of the Board of Health at the time) develops the first free summer milk station to prevent diphtheria and pneumonia	• Cholera • Dysentery • Smallpox • Typhoid Fever • Malaria • Summer Complaint • Diarrhea
1900 – 1950	Phase #3 Prevent infectious diseases through vaccinations and antibiotics	• **1909** – Three nurses were appointed by the Health Bureau to work in schools to monitor child disease • **1911** – patients admitted to the municipal hospital were vaccinated against diphtheria and smallpox • **1915** – milk stations become "welfare stations" which emphasize immunization	• Tuberculosis • Influenza • Diphtheria • Pneumonia • Pertussis • Tetanus • Polio • Measles

Figure 1. Application of the Health Transition Model to Rochester, NY public health initiatives and common causes of death between 1850 and 1950.

Methods

Data was collected by transcribing Mount Hope Cemetery death records. The records were retrieved from the University of Rochester Rare Books, Special Collections, and Preservation (RBSCP) library. Each record contains a list of names, dates of internment, ages of death, causes of death, and places of residence for individuals who were buried in Mount Hope Cemetery. Records between 1893 and 1935 were transcribed and filtered to only include diphtheria, pneumonia, and pertussis. There were multiple names that were included in analyses because the names for diseases were not consistent. Many causes of death were also comorbid diseases, especially with pneumonia. Names that were used in the analysis included pneumonia, diphtheria, pertussis, whooping cough, Broncho-pneumonia, and bronchitis and pneumonia.

Results

Figure 2 outlines the proportion of deaths from diphtheria, pertussis, and pneumonia between 1850 and 1935. The figure shows that counter to hypotheses, pertussis rates remained constant over time. Diphtheria rates gradually decreased over time, and pneumonia rates continued to fluctuate, with a decrease in spikes around 1930. Initial analyses showed the age of death from all recorded causes steadily increased between 1850 and 1934 from 23 years old to 66 years old. The average age of death for pneumonia was the highest ($M = 44.1$, $SD = 30.4$), followed by diphtheria ($M = 6.1$, $SD = 7.5$), and pertussis ($M = 3.2$, $SD = 7.9$). There were no significant differences in age of death between sexes for pertussis, $t(5) = 1.14$, $p = 0.30$, diphtheria, $t(21) = 0.63$, $p = .53$, and pneumonia, $t(110) = 1.9$, $p = 0.06$. Pneumonia was the most prevalent cause of death with 405 cases total. Diphtheria was the second highest with 170 cases, and pertussis had 32.

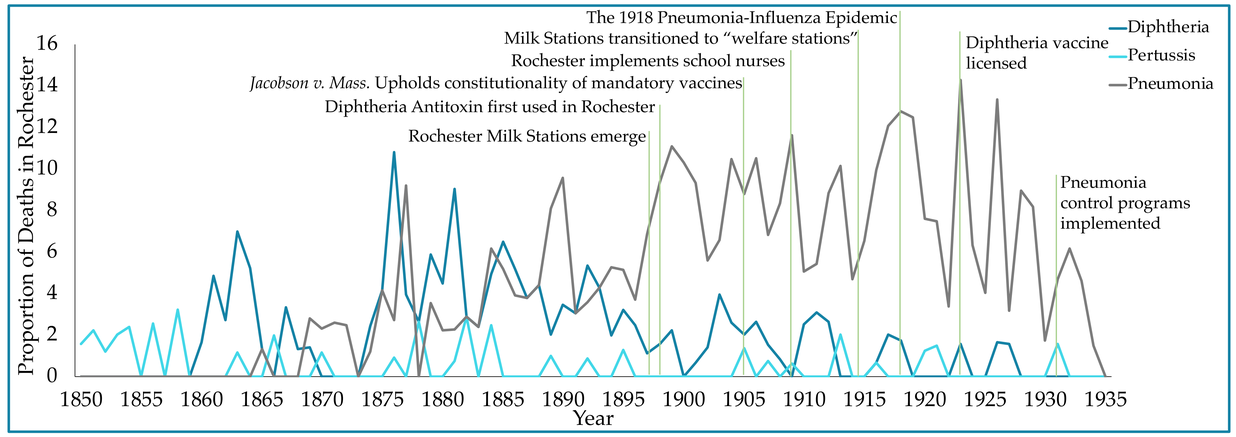

Figure 2. Proportion of deaths from diphtheria, pertussis, and pneumonia between 1850 and 1935, with major public health advancements indicated. Number of deaths was calculated based on Mount Hope Cemetery death record data.

Influence	Diphtheria Example	Pertussis Example	Pneumococcal Example	Why does this matter?
Cultural Beliefs	Businesses resisted diphtheria vaccination advertisements in 1923 because they believed that they were causing "bad business"(Goler, 1944).	The initial focus was on vaccinating children and reducing school transmission (Guiso, 2013; Rodman & Bradford, 1946). However, as children were vaccinated, adult transmission became more common. Public health efforts shifted to include adults, including licensing an adult pertussis vaccine in 1953 (IAC, 2020).	Pneumonia was initially seen as an inevitable disease, which limited research on a vaccine (Mulholland, 2007). The success of the first vaccine was overshadowed by the discovery of penicillin in the 1940s (Kazanjian, 2004). The emergence of antibiotic-resistant strains of pneumococcal pushed acceptance for the new pneumococcal vaccine licensed in 1977 (IAC, 2020).	Cultural beliefs about the diseases can impact how receptive the public is to accepting initiatives. If the public or clinicians do not think the diseases or prevention efforts are important, then the initiatives will be more difficult to implement. Control efforts may be difficult if the beliefs about transmission are not complete, such as pertussis.
Nature of Vaccines	The diphtheria and pertussis vaccines have been combined since 1948 (IAC, 2020). The recommended schedule is first five doses of the DTap to children over the course of six years (CDC, 2019). Then, adolescents are given a variation of the vaccine called Tdap, which is a "booster" every ten years (NCIRD, 2020).	Same as diphtheria!	The pneumococcal vaccine is recommended to infants in a series of four doses over 15 months. After the infant receives the vaccination, there is usually no need to continue to be immunized until the individual is 65 years old (NCIRD, 2020).	More complicated vaccine schedules may allow for more opportunities to miss a vaccination, in turn increasing rates of infection.
Nature of Disease	Diphtheria is less infectious, where only 85% of the population needs to be vaccinated to protect against the disease.	Pertussis has one of the highest infectious rates, where between 90%-95% of the population needs to be vaccinated to protect against the disease (Guiso, 2013; Vally, 2019).	While the actual infectious rate is hard to determine, pneumonia is often a complication of other diseases which in making prevalence increase.	A smaller proportion of the population needs to stop vaccinating in order to potentially contract pertussis compared to diphtheria. Having pneumonia as a complication increases the chance of death from each disease.

Figure 3. Potential influences on diphtheria, pertussis, and pneumonia mortality statistics in Rochester, NY with examples and explanations.

Discussion

In line with hypotheses, diphtheria rates decreased as more initiatives were implemented. However, the the proportion of deaths from pertussis and pneumonia fluctuated even after public health initiatives grew. Figure 3 outlines multiple factors that may have contributed to the different trends which were not measurable in this present study.

There are limitations to the study that may influence the death rates. First, the study is based on transcribed death records during a time where these diseases were not fully understood, leading to potentially inaccurate causes of death. This limitation may explain why pertussis had a lower sample size despite being particularly deadly to children. Although Mount Hope Cemetery is the largest cemetery in Rochester, there are other cemeteries that contain a different population of people which may change the prevalence of disease. Additionally, sex was inferred based on name. While the researchers were diligent in assessing the connotated gender for names, generational biases may have persisted. Finally, the data did not cover past 1935, which missed advancements in medicine such as the discovery of penicillin and licensing the DTP vaccine. More research should be conducted with a wider historical scope and in multiple cemeteries to increase the scope of the research covered here.

Future vaccine coverage efforts can be informed by the current research. Since the development of vaccines, policies have been implemented in order to monitor the effectiveness and safety of the vaccines. The rise of the internet may contribute to an increase in misinformation about vaccines (Laharyia, 2016). Educational initiatives may be important with the increased access to misinformation. Finally, having educated may increase utilization of public health measures. Public health remains an important discipline to help decrease the spread of disease, and initiatives can continue to be developed using this research to create a healthier community.

References

Centers for Disease Control and Prevention. (2019). Manual for the surveillance of vaccine-preventable diseases.

Cutler David M, Deaton Angus, Lleras-Muney Adriana. (2006). The Determinants of Mortality. *Journal of Economic Perspectives*, *20*(3), 97–120.

[Goler, G. W.]. [ca. 1944]. *Occasional Addresses*. Unpublished notes from the former Director of the Rochester Board of Health. Central Library of Rochester and Monroe County, Rochester, NY.

Guiso, N. (2013). How to fight pertussis?. *Therapeutic Advances in Vaccines*, *1*(2), 59-66.

Rodman, A., Bradford, W., & Berry, G. (1946). An epidemiological study of an outbreak of pertussis in a public school. *American Journal of Public Health*, *36*, 1156-1162.

Immunization Action Coalition. (2020). Vaccine timeline: historic dates and events related to vaccines and immunization.

Kazanjian, P. (2004). Changing interest among physicians toward pneumococcal vaccination throughout the twentieth century. *Journal of the History of Medicine and Allied Sciences*, *59*(4), 55-587.

Mulholland, K. (2006). Perspectives on the burden of pneumonia in children. *Vaccine*, *25*(1), 2394- 2397.

National Center or Immunization and Respiratory Disease (2020). Vaccines and p reventable diseases: diphtheria. *Centers for Disease Control and Prevention.*

Vally, H. (2019). What is herd immunity and how many people need to be vaccinated to protect a community?. *The Conversation*.