ARTICLE

The Impact of the 1918 Influenza Pandemic on the Demography of the Island of Newfoundland in the First Half of the Twentieth Century

Lisa Sattenspiel, Taylor P. van Doren, and Jessica Dimka

Abstract

The early twentieth century was a time of dramatic social, economic, political, demographic, and health-related change in Newfoundland and Labrador. One of the major upheavals at this time was the 1918 influenza pandemic, which led to the deaths of nearly 2,000 residents of the Dominion. In this paper we examine the short- and long-term demographic consequences of this catastrophic event. We focus on changes in the overall age and sex distribution, fertility levels, and cause-specific (for selected causes) and overall mortality before, during, and after the 1918 pandemic. Data on these demographic processes and the prevalent social conditions have been collected at The Rooms, the Digital Archives at Memorial University of Newfoundland, and other archives in the province and online. Results indicate that, although the 1918 pandemic had major impacts over the short term on fertility, mortality, and the age and sex structure, both on the island as a whole and in every region analyzed, these effects were of short duration. Long-term demographic changes occurring on the island during the first half of the twentieth century appear to be more related to the

large-scale socio-economic changes that occurred through the long process of moving from an independent Dominion to Confederation with Canada.

Introduction

The 1918–20 influenza pandemic (hereafter referred to as the 1918 influenza pandemic) was one of the most momentous infectious disease events in recorded history. The death toll from the pandemic has been estimated at 50–100 million deaths worldwide (Johnson and Mueller 2002) in a population of 1.8 billion, meaning that 2.5–5 per cent of the world's population died from influenza and related causes during the pandemic. This mortality rate is substantially above that seen during the COVID-19 pandemic, during which, as of mid-August 2023, 6.95 million deaths out of a population of 7.8 billion (~0.09 per cent) had been reported (http://covid19.who.int).

Although investigation of the 1918 pandemic was neglected for many decades, much research has been conducted on this event in the last 35 years, and it has been known throughout this time that it was a true worldwide pandemic that reached even some of the most remote locations on earth (see, e.g., Crosby 1989; Johnson and Mueller 2002; Patterson and Pyle 1991; Phillips and Killingray 2003 for early reviews). The COVID-19 pandemic has stimulated additional research on the 1918 influenza pandemic throughout the world, which is filling out our knowledge of this major event in many previously understudied regions. Studies from 2021and 2022 alone examined the pandemic, in many instances for the first time, in locations as diverse as Michigan (Chandra et al. 2021), Switzerland (Staub et al. 2021), Argentina (González et al. 2021), South Africa (Fourie and Jayes 2021), India (Sharma et al. 2021), Greece (Raftakis 2022), and Tahiti (Cavert 2022).

The authors of this paper and other colleagues have studied the 1918 pandemic in Newfoundland and Labrador since the early 2000s. At the time of the pandemic, Newfoundland and Labrador was a Dominion of the British Empire and was linked to Europe and the rest of North America by regular shipping across the North Atlantic (Cadigan 2009). It had significant economic and military ties, not only with Great Britain but also with the United States and Canada. During the early twentieth century, however, the Dominion was economically impoverished and possessed few of the advantages in health and welfare that were beginning to become evident elsewhere in Western Europe and North America (Schmidt and Sattenspiel 2017). Largely as a consequence of this, Newfoundland and Labrador was hit hard by the 1918 pandemic and recorded the deaths of over 2,000 residents from influenza and pneumonia.

We have discussed the experiences of Newfoundland and Labrador in depth in previous publications (e.g., Dimka and Sattenspiel 2022; Mamelund et al. 2013; Palmer et al. 2007; Paskoff and Sattenspiel 2019; Sattenspiel 2011; Sattenspiel and Mamelund 2013; Schmidt and Sattenspiel 2017; van Doren and Kelmelis 2022; van Doren and Sattenspiel 2021). Here, we will first present a brief overview of the general characteristics of the pandemic in the Dominion, but the primary focus of this paper is on what the long-term demographic and epidemiological consequences of the pandemic may have been. We emphasize the island of Newfoundland and address three specific characteristics of its demography: (a) changes in the age and sex distribution of the population between 1900 and 1935, both on the island of Newfoundland as a whole and among different regions of the island; (b) general trends in births and deaths in different regions; and (c) patterns in the distribution of deaths by different causes in different regions. We conclude with a discussion of the potential impact of the 1918 influenza pandemic on these demographic characteristics, as well as implications of the findings for understanding the demographic history of Newfoundland in the twentieth century.

A variety of resources have been used in our research. The major source of data on deaths during the 1918 influenza pandemic is death records recorded directly from microfilm sources at the Provincial Archives of Newfoundland and Labrador (The Rooms) in St. John's, with supplementation and verification using data provided on the

Newfoundland's Grand Banks (ngb.chebucto.org) and Family Search (familysearch.org) websites. Additional sources of data used in this paper include data from the 1901, 1911, 1921, and 1935 Censuses of Newfoundland and Labrador, vital statistics reports published between 1910 and 1931 in the *Journal of the House of Assembly of Newfoundland*, and assorted documents relating to the pandemic available at The Rooms, the Memorial University of Newfoundland Centre for Newfoundland Studies, and the Memorial University of Newfoundland Digital Archives.

In this paper, we focus on data aggregated at the district level, of which there were 17 on the island in the early twentieth century. However, some of the districts were small, and there was some shifting of political boundaries in the 1930s that resulted in the creation of new districts and splitting of others (for example, St. Barbe was split into two separate districts towards the end of our study period, Trinity became Trinity North and Trinity South, and a portion of the southeastern corner of St. Barbe became Humber). Consequently, we have limited the analyses reported here to the island as a whole and the regional level, with district groupings based primarily on geography, but also variation in cultural and social attributes. This regional level of analysis is also consistent with previous research on the 1918 influenza pandemic and health in early twentieth-century Newfoundland, allowing for integration with the existing body of knowledge (e.g., Paskoff and Sattenspiel 2019; Sattenspiel 2011; van Doren and Kelmelis 2022; van Doren and Sattenspiel 2021).The four regions are (a) the Avalon Peninsula, (b) the North, (c) the West, and (d) the South. Table 1 gives the division of the island's districts into these four regions. Labrador is considered independently from these regions, and will be discussed only in the next section, which gives an overview of the pandemic throughout the Dominion. The analyses discussed in the remainder of the paper will centre solely on the island of Newfoundland.

Table 1. Newfoundland and Labrador Districts* (1910–1930) and Their Assigned Regions.

Avalon	North	South	West
Bay de Verde	Bonavista	Burin	Burgeo/La Poile
Carbonear	Fogo	Fortune Bay	St. Barbe
Ferryland	Trinity	Placentia/St. Mary's	St. George
Harbour Grace	Twillingate		
Harbour Main			
Port de Grave			
St. John's			

*Labrador is not included in this categorization.

A Brief Overview of the 1918 Influenza Pandemic in Newfoundland and Labrador

Like most other locations throughout the world, the 1918 influenza pandemic in Newfoundland and Labrador occurred as a series of three waves. The first two waves, a small and relatively mild wave in the summer of 1918 and a major and deadly wave in the fall and winter of 1918–19, have been recognized in the majority of locations where the pandemic has been studied, although the outbreaks were somewhat delayed in the Dominion compared to other parts of Western Europe and North America. Researchers often have identified a third wave in these regions that occurred in the spring of 1919, but there is little evidence of this wave in Newfoundland and Labrador's epidemic curve (Figure 1). Instead, the Dominion's third wave occurred as a small echo wave in the early spring of 1920. It is not clear how common influenza was globally in 1920, but a growing number of studies are beginning to uncover evidence of major outbreaks at this time (e.g., Chandra et al. 2021; Cilek et al. 2018; Dahal et al. 2018; Grabowski et al. 2017; Hsieh 2009; Richard et al. 2009; Sattenspiel et al. 2023).

Because of its severity, much of the work on the 1918 influenza pandemic in Newfoundland and Labrador (and elsewhere) has focused on the second wave of the pandemic. The date of introduction of this wave into Newfoundland and Labrador is not known exactly. Parsons

(1992) suggested that it began at the very end of September and Figure 1 does show a substantial rise in deaths beginning around that time. It is important to note, however, that deaths from flu and pneumonia occurred in many districts in mid- to late September 1918, suggesting that the flu virus may have been circulating at low levels on the island well before the date noted by Parsons (Palmer et al. 2007). The second Newfoundland wave was clearly bimodal, with the largest peak occurring in early November 1918 and a secondary peak occurring shortly after the turn of the year in 1919 (Figure 1).

Mortality from the flu varied significantly across Newfoundland without any clear spatial patterns (Palmer et al. 2007; Sattenspiel 2011). Almost all districts exhibited the typical age distribution of deaths, with unusually high mortality among individuals aged 15–44 (Paskoff and Sattenspiel 2019). This "signature" age pattern of mortality — unprecedented excess in adults aged 15–44 and lower than

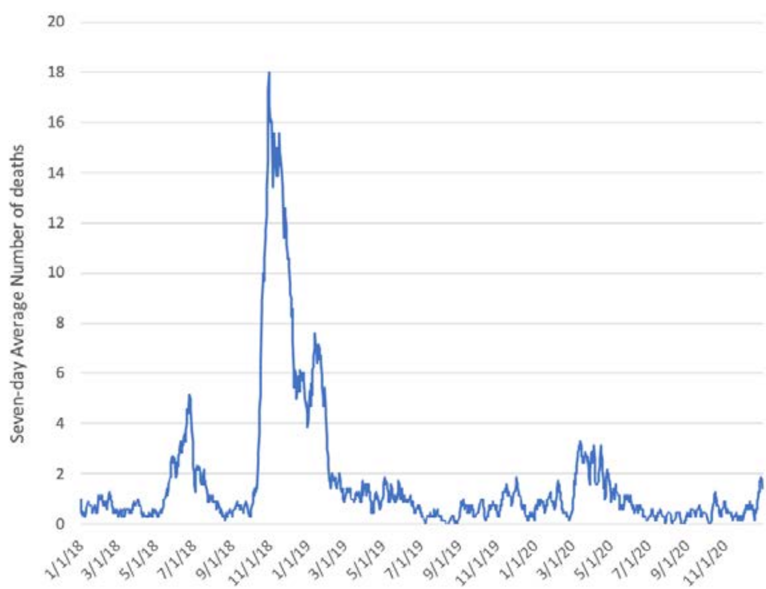

Figure 1. Epidemic curve showing seven-day averages of the daily numbers of deaths from influenza and pneumonia on the island of Newfoundland, 1 January 1918 and 31 December 1920.

expected mortality in the youngest and oldest age classes — has been observed globally (e.g., Andreasen et al. 2008; Erkoreka 2010; Mamelund 2006, 2011; Saglanmak et al. 2011).

Population-level mortality rates were highest in the South and in the middle Western region (St. George district and the southern half of the St. Barbe district) (Palmer et al. 2007; Sattenspiel 2011). However, survivorship, or the probability of experiencing death from influenza during the pandemic at any given age, did not show signs of inequality among regions (van Doren and Kelmelis 2022). This result may speak to the severity of the pandemic influenza virus on the younger adult age classes (15–44), since no matter their location on the island, the probability of surviving beyond this age group during the pandemic declined dramatically in all regions.

Sex-based differences in mortality were also highly variable across the island with no obvious patterns, although there was a slightly stronger probability of female death compared to male death in the South (Paskoff and Sattenspiel 2019). Paskoff and Sattenspiel suggested that these sex-based differences may have been an outcome of differing gender roles that differentially affected men's and women's risks of exposure to and ultimately mortality from the disease.

Additionally, tuberculosis was a common disease in early twentieth-century Newfoundland (House 1981), and the South had the highest mortality from tuberculosis for most of the century (van Doren and Sattenspiel 2021). The combination of influenza and tuberculosis is a well-understood co-morbidity, during and outside of the 1918 influenza pandemic (Noymer 2009, 2011; Walaza et al. 2015; Zürcher et al. 2016), so the severity of the 1918 pandemic in the South was also likely affected by the co-circulation of the tuberculosis pathogen. Chronic poor nutrition may have played a role as well (van Doren and Sattenspiel 2021).

Specific reasons for observed patterns in other regions of the island could not be easily or definitively determined. Palmer et al. (2007) suggested that both shipping and more informal boat travel, exposure to the disease during the mild first wave and consequent immunity, and/or railroad traffic may have influenced the severity of the pandemic across districts and how and when it spread from place to place.

Some regions of Labrador were devastated by the 1918 pandemic, while other parts were barely touched (Mamelund et al. 2013; Sattenspiel and Mamelund 2013). The northern communities of Okak and Hebron experienced some of the most severe mortality observed anywhere in the world (79 per cent and 68 per cent mortality, respectively). The southernmost regions of Labrador, however, had very low mortality, with almost all occurring during the first, mild summer 1918 wave. Mamelund et al. (2013) and Sattenspiel and Mamelund (2013) have linked the patterns in Labrador to a combination of factors, including, for example, the timing of fur-trapping and fishing activities, exposure to the disease when infected ships arrived with winter supplies, and presence of medical facilities and resources. According to researcher Anne Budgell, the disastrous outbreaks at the Moravian Mission stations of Okak and Hebron in northern Labrador, introduced by an infected sailor aboard the Mission supply ship *Harmony*, were exacerbated by the remote locale, poor communication with the outside world, and somewhat racist attitudes from the government in St. John's (Budgell 2018).

Previous research illustrates that Newfoundland experienced severe disruptions to life during the pandemic, but it is not clear whether there were long-term consequences of the pandemic on the population and how long such consequences may have lasted. In the remainder of this paper, we address this question specifically with respect to the long-term effects on fertility, mortality, and the age structure of the population on the island of Newfoundland.

Potential Demographic Impacts of Pandemics: General Considerations

Populations are unlikely to simply reset "back to normal" after crisis events such as pandemics, although predicting the duration, direction, and degree of disruption is not always straightforward. For example, baby busts or booms may occur in response to effects of illness on fertility, loss of spouses and subsequent remarriages, or the desire or need to replace lost children, as well as other factors that favour or limit the opportunity or ability to have children (e.g., Bloom-Feshbach et al. 2011; Boberg-Fazlic et al. 2021; Chandra et al. 2018; Gaddy and Ingholt 2023; Mamelund 2004). The pattern of causes of death from diseases such as tuberculosis or cancers may change as individuals prematurely die relative to when they would have been expected to, while suicide rates may increase or decrease for a variety of reasons (e.g., social isolation or, alternatively, social cohesion) (Bastiampillai et al. 2021; Chang et al. 2020; Stack and Rockett 2021; Wasserman 1992). Beyond direct health effects, social and economic consequences related to societal disruption, such as job losses, also could significantly impact various demographic measures (Velde 2022).

Further, from a broader historical perspective, potential changes should be considered in the context of overall trends before and after the event. Previous research on other pandemics, especially the Black Death (the second pandemic of plague in the fourteenth century), indicates that the high mortality had a strong impact on the demography of affected populations. For example, studies have shown that there were improvements in health in the aftermath of the Black Death in England (i.e., higher survivorship and lower mortality risk) that accompanied ambient improvements in the standard of living (DeWitte 2014). Similar results were found for post-pandemic skeletal populations in Denmark (Kelmelis and DeWitte 2021). Additionally, changes in biological markers of stress such as reductions in height and increases in stress markers in teeth occurred during the Black Death, after which height increased and stress markers decreased, which can also be understood in the context of improving post-pandemic social conditions (DeWitte 2018). The loss of an estimated one-third of the population of Europe eventually led to a large number of dependants due to the deaths of many young, working adults (Herlihy 1997) and a stronger economy via competition among landowners for labor (Hybel and Poulsen 2007; Kelmelis and DeWitte 2021). While geographically limited in scope, these results indicate the value of further investigation into how population structure and human biology are impacted by acute pandemic events.

Very little work has been done on how the 1918 influenza pandemic impacted the demography of disparate populations, although a recent review (DeWitte and Wissler 2022) has outlined the value of this line of inquiry. Given the high levels of mortality associated with the pandemic, this is a puzzling gap in the literature, which needs to be addressed for better understanding of how populations experience pandemic events. The characteristics of the 1918 influenza pandemic in particular beg pressing questions about long-term experiences. For example, since those who exhibited the highest mortality were aged 15–44, i.e., the age class that makes up most working and care-giving adults, how did both young and elderly dependants fare after the loss of probable caretakers? Similarly, given the substantial impact in this age group, did the pandemic affect fertility, and if so, to what extent? These and other questions about long-term impacts are rarely asked in pandemic studies.

In this paper, we consider the nature of the pandemic and its potential long-term demographic effects on the entire island of Newfoundland as well as the experiences of regions that vary geographically and socially. Contextual factors such as political instability and the growing recognition of the importance of sanitation and available health-care resources also help explain patterns over time and across space. We attempt to broadly describe how the 1918 influenza pandemic may have influenced demographic change in Newfoundland through the 1930s. This discussion contributes to knowledge of how a pre-industrial and heterogeneous population was impacted by the pandemic using a broader lens than is typical for 1918 influenza research, which often only investigates the pandemic years themselves (e.g., Chowell et al. 2014; Curson and McCracken 2006; Mamelund et al. 2016; Viboud et al. 2013). Since the data from historical pandemics cover a completed event and historical perspective, their study provides valuable opportunities to reflect upon the multiple dimensions of pandemic consequences. With this historical knowledge, not only will we be able to more fully understand the impacts of past pandemics (DeWitte 2016; Noymer 2010), but we can better prepare for the consistent threat of emerging infectious diseases and present pandemics (DeWitte and Wissler 2022).

Changes in the Demography of the Island of Newfoundland in the Early Twentieth Century

In the following sections, we investigate demographic changes from a variety of angles, including age and sex distributions at the broad population level, overall birth and death rates, and cause-specific death rates. Age and sex structure were analyzed at both the total island and regional levels, while the analyses of birth rates, aggregate death rates, and cause-specific death rates were analyzed only at the regional level. This choice was made in the interest of brevity and to avoid unnecessary repetition in reporting similarities between aggregate island- and regional-level results. For each approach below, we briefly describe the specific data sources and methods used and present and interpret the results. Our interpretations in this section focus on the specific factors we are considering with each approach (i.e., age and sex structure, fertility, and mortality). In the discussion section, we take up the question of whether the 1918 pandemic had any long-term consequences for these demographic characteristics and address the overall changes in demography when all three characteristics are considered simultaneously.

Changes in the Overall Age and Sex Structure of the Population

One of the simplest and most effective ways to visualize changes in a population's demography over time is to observe the structure of histograms of the age and sex distribution in a population. Figure 2 gives age–sex histograms for the entire island of Newfoundland using data from the 1901, 1911, 1921, and 1935 censuses. The horizontal bars represent age classes, in this case consisting of five-year age groups, with the youngest at the bottom and the oldest at the top. Males and

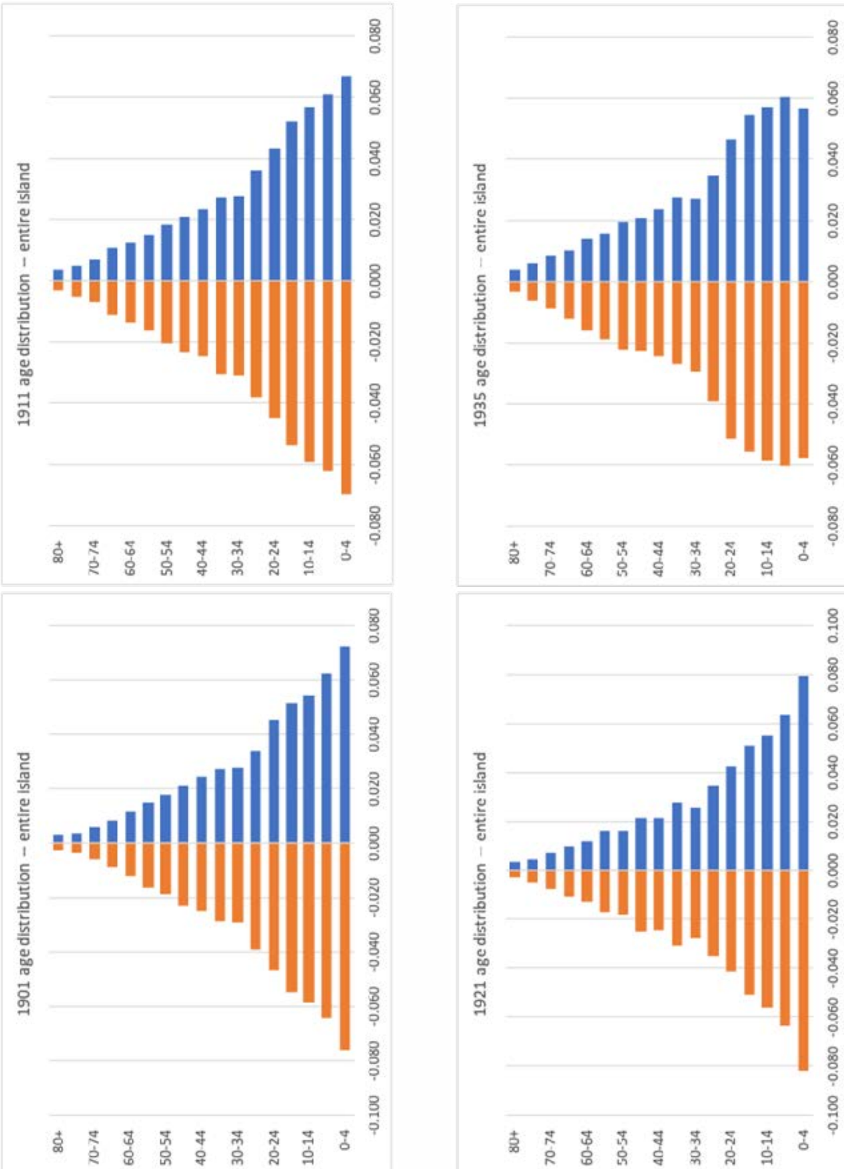

Figure 2. Age–sex histograms for the island of Newfoundland, 1901, 1911, 1921, and 1935. Note: Bars on the left show the proportions of the population who are male; bars on the right show the female population proportions.

females are separated, usually with males on the left side and females on the right; the length of a particular bar gives the proportion within the population of the age class represented by that bar. For example, in 1901, the proportion of males aged 0–4 was 0.076; in 1935, the proportion of this same group was 0.058.

In many developing countries today and in the past, age–sex histograms tend to have a very wide base that narrows sharply until the proportions at the oldest ages are small (call this *Type 1*). This shape reflects a population that has high fertility (the primary cause of the wide base) and high mortality (the underlying reason for the steep incline). Typically, with increased levels of economic development, fertility and mortality both begin to decline, and the resulting shape has a narrower base and gradual slope to older ages (leading to a more rectangular shape; call this *Type 2*). When a population shifts from *Type 1* to *Type 2*, the first thing usually observed is a decline in the birth rate, which shows up as a constriction at the youngest ages relative to those born just before them when fertility rates were higher. This pattern of declining birth rates and subsequent aging population structure, hallmark characteristics of a situation called the "demographic transition," has formed the basis of a broad demographic theory to describe how vital rates, population size, and life expectancy change in response to changes in the socio-cultural milieu (Davis 1945; Kirk 1996). The pattern was first identified in nineteenth-century populations of Western Europe and North America (Thompson, 1929); subsequent research has demonstrated significant variation in this pattern in different populations and at different times (Davis 1945), indicating that a more sophisticated model is needed to fully understand how demographic patterns change when major shifts in the socio-cultural environment occur.

Like other regions in Western Europe and North America, the shift from a *Type 1* to a *Type 2* age and sex structure is exactly what is observed in Newfoundland's age–sex histograms, although this shift occurred much later in Newfoundland. From the beginning of the twentieth century through at least the early 1920s, the age–sex histograms

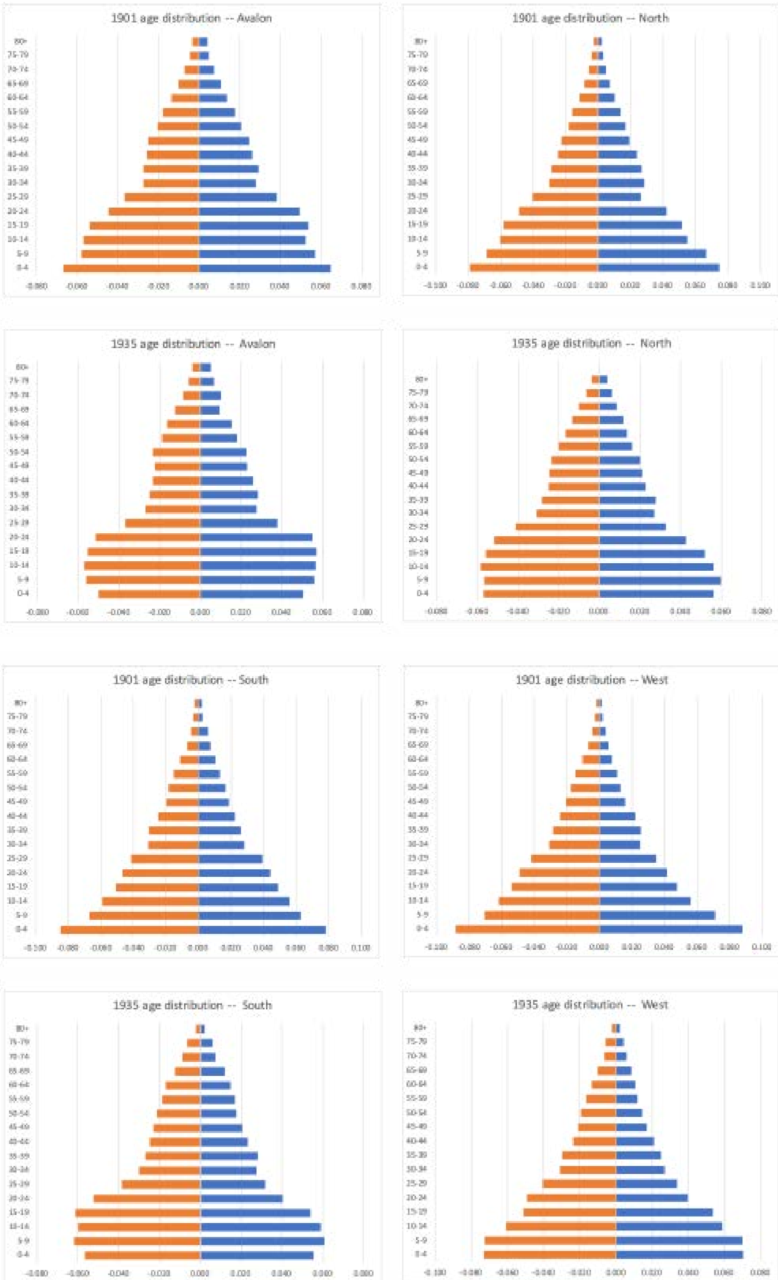

Figure 3. Age–sex histograms for the four geographic regions in 1901 and 1935.
Note: Bars on the left show the proportions of the population who are male; bars on the right show the female population proportions.

clearly illustrate that, in terms of its demography, Newfoundland exhibited the characteristics of a developing country, with high fertility (a wide base) and high mortality (rapid reductions in the proportions as age increases). However, the histogram based on data in the 1935 census (Figure 2) suggests strongly that Newfoundland was beginning to transition to a situation of significantly lower fertility, although the mortality appears to have remained high.

To see if there was any regional variability in these patterns, age–sex histograms were also drawn for each of the four regions on the island (Avalon, North, South, and West) and for each of the four sets of census data. Figure 3 shows these histograms for 1901 and 1935 — in every region the histograms for 1911 and 1921 were similar in overall shape to those for 1901. As can be seen clearly in this figure, the histograms for the Avalon, North, and South regions mirrored the pattern observed for the island as a whole, with high fertility and mortality through the first three censuses and declining fertility by 1935. The histograms for the West, however, give little indication of the significant declines in fertility seen elsewhere by 1935, although the equal proportions of the 0–4 and 5–9 age classes in the 1935 West histogram do suggest some nascent change in fertility.

Although all age–sex histograms suggest that fertility began to decline significantly in the 1930s, while mortality was still high, alone they tell us very little about the specific changes in fertility and mortality that may be underlying these broad population-level patterns. Thus, by themselves, they cannot inform much about the specific changes that may have occurred as a result of the 1918 influenza pandemic and how long those changes may have influenced the population's demography. To investigate this situation in more detail, additional analyses focus more directly on both overall birth and mortality patterns and cause-specific mortality patterns among the island's four regions.

Trends in Birth Rates between 1909 and 1930

Birth data were collected from the Annual Report of the Registrar General of Births, Marriages, and Deaths that were published in the yearly *Journal of the House of Assembly of Newfoundland*. The numbers of births were collected for the calendar years 1909–30, which correspond to the journal publication years 1910–31 (Provincial Archives of Newfoundland and Labrador [PANL], 1910–31). Rates were calculated as the number of births reported divided by the estimated population and multiplied by 10,000. The yearly populations of the total island of Newfoundland and its four regions were calculated using linear interpolation between the data reported in the 1911, 1921, and 1935 statistical censuses. Population structure data were collected and interpolated on the district level, and then aggregated into their respective regions and for the total island population.

One of the primary goals of this paper is to investigate changes in vital rates during the early twentieth century, keeping the 1918 influenza pandemic in mind as a potential point where the trajectories of these rates might have changed. A significant change in birth rates or mortality rates from a specific cause can be visualized as an inflection or "joinpoint" over a time series where two linear segments change slope significantly. Joinpoint regression, a method described by Kim et al. (2001) to analyze significant changes in cancer incidence trends, is an ideal statistical modelling approach to identify these inflection points. We have used the Joinpoint Regression Program (2022) developed by the United States National Institutes of Health National Cancer Institute to model both the trends in fertility rates discussed in this section and in mortality rates as described later.

There are some major strengths to this statistical modelling method. First, the researcher has well-informed hypotheses about how rates may change in response to a contextual, known event, but does not force the model to fit linear trends around this point. Instead, the researcher provides the program with a range of points to be identified over an iteration of models; for example, the program may fit a series of models with zero joinpoints (a straight line) through three joinpoints (three inflections) but will identify those points statistically and systematically. Therefore, the modeller has control over determining how many joinpoints to fit, but does not place the points themselves, and the results may either confirm or fail to support the well-established hypotheses.

The second major strength to this method is that the estimated coefficients of each segment are reported in the form of annual percentage change between estimated joinpoints (Kim et al. 2001; Rea et al. 2017), which is a relatively intuitive way to interpret how rates change over a time series. For example, van Doren and Sattenspiel (2021) used joinpoint regression to show that there was a peak in tuberculosis mortality rates in Newfoundland in 1906, which is supported by historical documents and was likely the impetus for developing centralized control of tuberculosis on the island. They found that between 1900 and 1906 there was a 1.36 per cent year increase in mortality, followed by a rapid decline of –2.47 per cent per year until levelling off in 1909 and subsequently declining gradually at –0.42 per cent per year until 1939.

For the years 1909–30 and for each of the designated regions, we fit models with zero through three joinpoints. The results of the birth rate analyses can be found in Figure 4; detailed results of the statistical models can be found in tables in the Appendix. There are four lines displayed for each region, each of which represents a model fit with a different number of joinpoints (zero through three). The statistically significant points are marked with an asterisk (*) on the figure itself. The results illustrated in Figure 4 show compelling general trends: birth rates consistently decreased after 1920 in the Avalon Peninsula, North, and South regions. In the Avalon Peninsula and South regions, all joinpoints estimated for the 1920–30 segment were significant for models that were not straight lines (zero joinpoints), while for the North, this decline was estimated to begin in 1922 and was only significant for the one-joinpoint model. For the Avalon Peninsula and the South, the observed birth rates (black circles on the plots) also

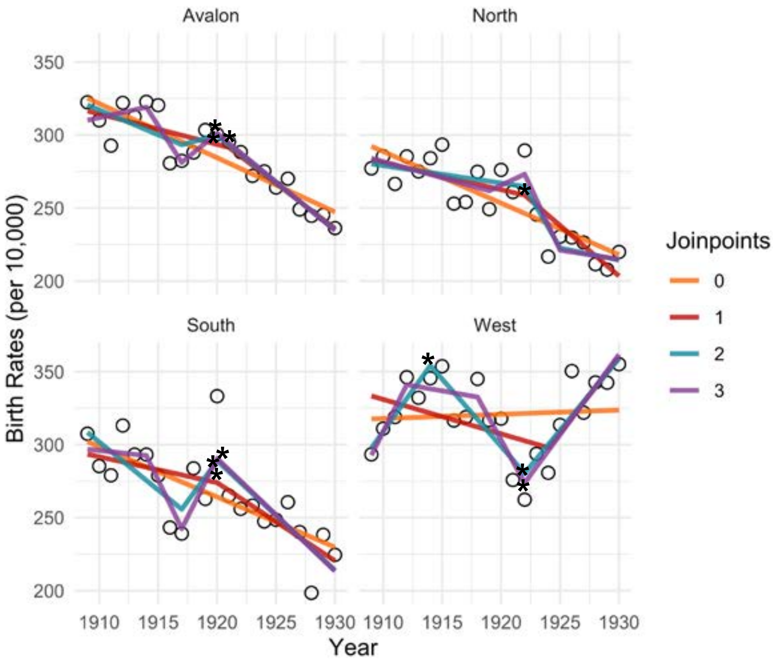

Figure 4. Results from the joinpoint models for birth rates.
Note: Asterisks denote statistically significant points of change.

peak in 1919 and 1920, respectively. Meanwhile, for the West, there was an opposing pattern: there was a significant *increase* in birth rates estimated beginning in 1922 for the two- and three-joinpoint models.

In 1909, every region had a birth rate at or around 300 births per 10,000 individuals, and rates through the study period (1909–30) were similar to those reported for the United States during the same time period (National Office of Vital Statistics 1950). While the rates did decline markedly in Newfoundland over the course of the early twentieth century in three of the four regions, they did not dip below 200 births per 10,000 individuals before the end of the study period (1930). As we discuss further in the next section on changes in mortality rates, Newfoundland birth rates were substantially higher than aggregate mortality rates on the island during this time period.

Changes in Mortality Rates for Various Causes between 1909 and 1930

Data on causes of death used in these analyses were collected from the Annual Reports of the Registrar General of Births, Marriages, and Deaths that were published annually in the *Journal of the House of Assembly of Newfoundland*. The number of deaths attributed to selected specific causes were collected for the calendar years 1909–30 (journal publication years of 1910–31) (PANL 1910–31). Data from the 1925 volume (the 1924 calendar year) were excluded because death counts were not provided in the Vital Statistics report from that year.

The causes of death include a wide range of specific causes that are grouped in the reports into categories such as "Epidemic Diseases," "Nervous System," "Circulatory System," "Locomotor System," and "Ill-Defined Diseases." In this paper, we focus on multiple causes of death, which can be broadly categorized as either infectious diseases or chronic conditions, including old age and suicide. Table 2 provides the breakdown of the specific causes of death that contributed death counts to these two broad categories for the entire study period.

These causes of death were chosen for several reasons. First, they were consistently the top causes of death in Newfoundland throughout the early twentieth century, particularly tuberculosis and its extrapulmonary forms (House 1981). To understand the changing diseasescape in early twentieth-century Newfoundland, we must understand the dynamics of these primary causes of death. Second, to investigate the role of the 1918 influenza pandemic in infectious and non-infectious disease mortality dynamics, we need to closely observe how diseases or causes of death that are known or may be suspected to closely interact with the pandemic influenza virus (e.g., tuberculosis, pneumonia, or heart disease) influenced post-pandemic mortality patterns. Finally, as described above, Newfoundland was in a period of demographic and epidemiological transition throughout the early twentieth century, especially in the Avalon Peninsula where the capital city of St. John's is located (Schmidt and Sattenspiel 2017), with implications for broad changes in patterns of chronic and infectious

Table 2. Specific causes of death collected from the Annual Report of the Registrar General for the study period (1909–30) and the aggregate number of deaths attributed to each cause in each region.

		Region			
Cause of Death*	Total (%)	Avalon	North	South	West
Infectious Diseases					
Tuberculosis of lungs	10,836 (36.4)	4,142	3,540	1,991	1,163
Pneumonia & influenza	6,248 (21.0)	2,530	1,888	1,060	770
Tuberculosis (excluding pulmonary)	2,773 (9.3)	969	925	494	385
Digestive (excluding diarrhea & enteritis)	2,043 (6.9)	898	633	293	219
Bronchitis	2,025 (6.8)	1144	655	135	91
Diarrhea & enteritis (<2 years)	1,589 (5.3)	1084	313	107	85
Whooping cough	1,280 (4.3)	405	406	246	223
Measles	909 (3.1)	374	267	149	119
Diphtheria & croup	849 (2.9)	288	254	147	160
Dysentery, diarrhea, & enteritis (2+ years)	548 (1.8)	200	218	78	52
Typhoid	493 (1.7)	160	214	54	65
Scarlet Fever	183 (0.6)	61	49	35	38
Total	**29,776**	**12,255**	**9,362**	**4,789**	**3,370**

		Region			
Cause of Death*	Total (%)	Avalon	North	South	West
Chronic Conditions					
Nervous system	10,871 (40.1)	4,943	3,441	1,430	1,057
Old age	9,089 (33.6)	4,425	2,380	1,385	899
Circulatory system	3617 (13.4)	2,462	691	283	181
Cancer	3439 (12.7)	1,725	949	454	311
Suicide	62 (0.2)	28	19	9	6
Total	**27,078**	**13,583**	**7,480**	**3,561**	**2,454**

* Causes of death are listed in descending order by the total number of deaths for each cause for the entire island. The percentage attribution of each cause to the total number of deaths in the "Infectious Diseases" or "Chronic Conditions" category is also included.

diseases. These broader trends provide important context for better understanding the role of the 1918 flu pandemic, including whether this event produced any significant observable changes in demographic rates.

In this section, we discuss results from calculating the yearly mortality rates, again using the interpolated population estimates, for (1) the aggregate causes of death, (2) infectious causes of death, and (3) chronic conditions from 1909 through 1930 for each of the four major regions. For aggregate mortality and for the infectious and chronic disease cause of death categories, we have fit joinpoint models with zero to three joinpoints to identify up to three points over the course of the study period in which there were significant changes in mortality rates from these causes. Finally, the rate ratio of the total infectious disease mortality to the total mortality from chronic conditions was calculated for every year during the study period, allowing visualization of how mortality in these two categories shifted in relation to each other over the course of the early twentieth century. Of specific interest is whether or when infectious disease mortality began to decline and whether mortality from chronic conditions increased. This dynamic is predicted by the epidemiological transition model (Omran 1971), which describes mortality changes and factors affecting the change over the course of the demographic transition discussed above.

Results are presented here in a similar fashion to the previous section, with the significant points denoted by an asterisk (Figures 5, 6, and 7), and detailed results of the model fits are provided in the Appendix. In Figure 5, results are relatively mixed by region. As the number of joinpoints per model fit increases, a peak around 1918 becomes clear in each region, although this is to be expected for two reasons: (1) influenza, pneumonia, and tuberculosis deaths dominated the total number of deaths for that year, so this was the likely outcome

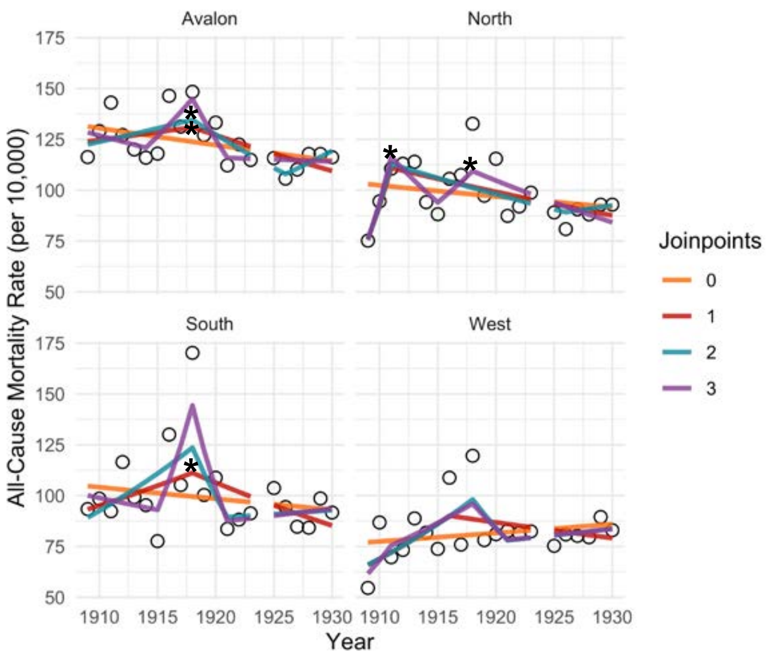

Figure 5. Results from the joinpoint models for all causes of death.
Note: Asterisks denote statistically significant points of change.

given how high the total mortality was that year; and (2) the model will fit as many joinpoints as we ask it to, so occasionally three points will force the model to overfit to the data. We cannot exclude overfitting as a possibility as the number of joinpoints fit increases.

Despite these two expectations and observations, there is no clear post-pandemic pattern for the aggregate causes of death. The Avalon Peninsula region appears to experience steady declines (anywhere between –0.66 per cent and –1.49 per cent per year), as does the North (–1.25 per cent per year). The South and West exhibit mixed results, with few significant values. There is no clear indication as to whether the aggregate mortality rates are increasing or decreasing per year after 1920. The only significant joinpoint around or after the 1918 influenza pandemic is the single point in Model 2 in the South that initiates the 1918–30 segment; the results suggest an annual decrease in mortality of –2.21 per cent per year.

For infectious diseases only (Figure 6), there are some clearer patterns. The high mortality rates experienced during the 1918 influenza pandemic in every region are prominent, most so in the South, which aligns with what has already been described about the district and regional level variation in mortality during the pandemic (Paskoff and Sattenspiel 2019; Sattenspiel 2011). In the Avalon Peninsula, Model 2 predicts a significant joinpoint in 1918, which indicates that infectious disease mortality declined significantly between 1918 and 1930 (–1.95 per cent per year); Model 2 for the North also reveals significant mortality declines between 1918 and 1930 (–2.47 per cent per year). Again, there were few significant post-pandemic declines in infectious disease mortality rates in the South or West; the only significant estimated point is for Model 2 in the South, which estimates a –2.80 per cent per year change between 1918 and 1930. Aside from this, all other significant points are for pre-pandemic periods, and all non-significant joinpoint estimates show relatively mixed results. Ultimately, visualizing the data and the trends in mortality lead towards a conclusion that, at least in the Avalon Peninsula and the North, infectious disease mortality was beginning to decline overall in the early twentieth century after the 1918 influenza pandemic. No general declines are clear for the more remote regions.

For chronic conditions (including old age and suicide), there is little variation in the general patterns of the joinpoint results (Figure 7). Unlike the aggregate and infectious disease mortality results, there are no clear peaks around the 1918 influenza pandemic. There are, again, few statistically significant estimates through all iterations of these joinpoint models for all regions. Two exceptions, both for the West, illustrate significant increases in mortality from chronic conditions around or after the 1918 influenza pandemic. First, Model 2 estimates a significant increase of 0.776 per cent per year for 1918–30; second, Model 3 estimates a significant increase of 0.982 per cent per year for 1917–30. Although the latter estimate does not technically

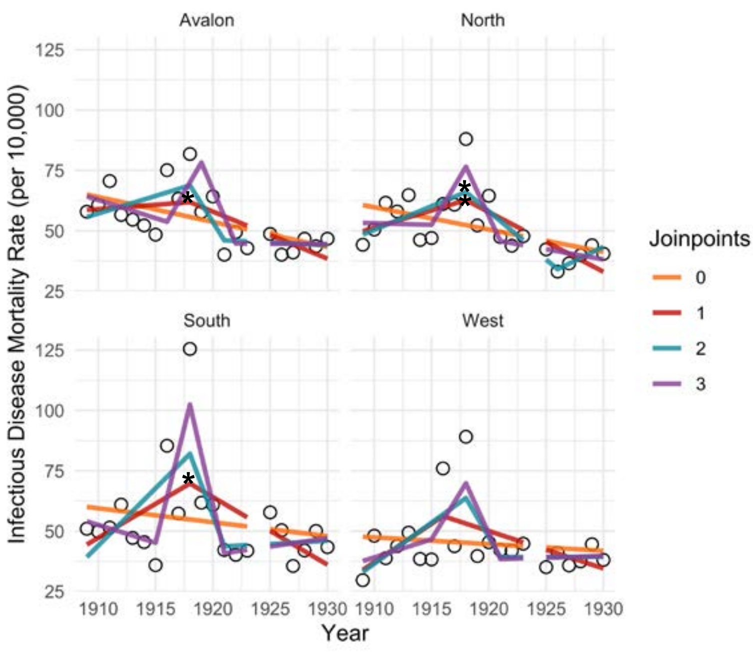

Figure 6. Results from the joinpoint models for infectious cause of death by region.
Note: Asterisks denote statistically significant points of change.

begin during or after the 1918 influenza pandemic, the 14 years of mortality rates after this point clearly indicate increases in these causes of death. There are no other significant post-pandemic joinpoint estimations.

Another important observation for the progression of mortality from chronic conditions throughout this period is that there is much less volatility in the mortality rates compared to the aggregate and infectious disease patterns. Regardless of the number of joinpoints fit to the data in any region, almost all of the inflection points occur in the pre-pandemic period, after which there is little variation in the estimated mortality rates over time. For the Avalon Peninsula and the South, the result is a set of mortality rate trends that are virtually unchanging. For the North and the West, however, a set of trends is

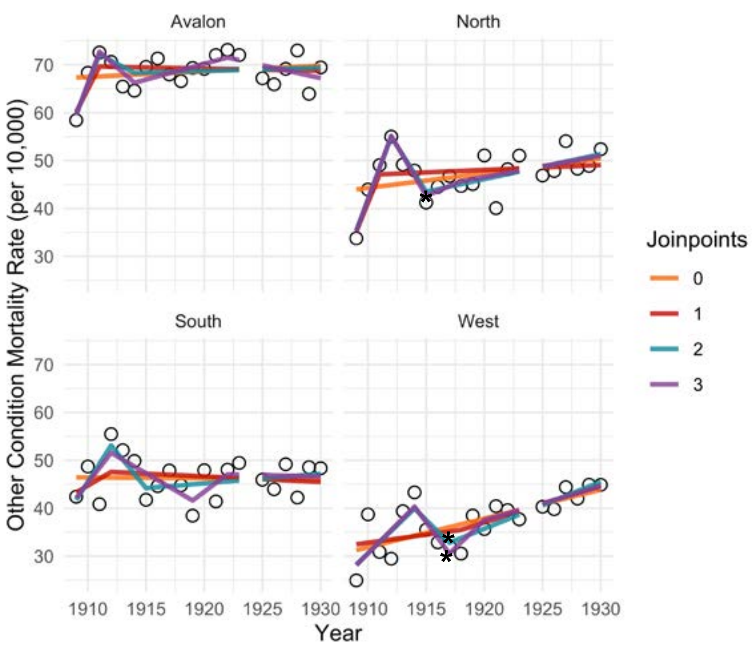

Figure 7. Results from the joinpoint models for non-infectious causes of death by region.
Note: Asterisks denote statistically significant points of change.

clearly increasing throughout the early twentieth century, whether or not the estimated joinpoints were statistically significant.

The relationship between the different cause-specific death rates over the course of the early twentieth century can also be illustrated by the rate ratio of infectious disease mortality relative to chronic disease mortality. Figure 8 shows these rate ratios for each year of the study period; trend lines were added to show the progression of the ratios more clearly over time. A solid black line at $y = 1$ represents a scenario where the two rates are exactly equal. The Avalon Peninsula is the only region in Newfoundland that had higher chronic disease mortality than infectious disease mortality for most of study period. All other regions had much higher infectious disease mortality — sometimes two to three times higher, especially during the 1918 influenza pandemic — until the early 1920s. After that point, almost all the rate ratios are below one, indicating a major shift away from higher infectious disease

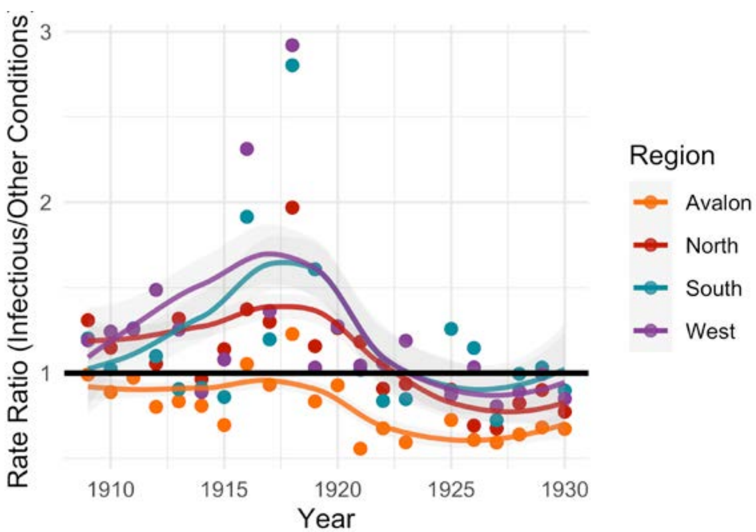

Figure 8. Rate ratios of observed infectious disease mortality rates divided by observed mortality rates of other aggregate non-infectious conditions.
Note: The black horizontal line represents a rate ratio of 1; points above this line indicate higher infectious disease mortality, and points below indicate higher other non-infectious mortality.

mortality. Although the joinpoint results do not return many points at which changes in the mortality rate were statistically significant, general observations of trends combined with the rate ratio analysis suggest that epidemiological shifts occurred in the years following the 1918 influenza pandemic. Whether these changes can be confidently associated with the effects of the 1918 influenza pandemic is less certain. We discuss this question in more detail in the following section.

Discussion

Overall, the different demographic measures show that the island of Newfoundland was actively undergoing its demographic transition from a state of high fertility/high mortality to one of lower fertility/lower mortality, characteristic of populations experiencing social and economic development. The changes predicted from demographic transition theory as it applies to Western Europe and North America include declining mortality, with epidemiological shifts towards chronic conditions rather than infectious diseases, and reductions in fertility as people begin to live longer. All three analyses of the Newfoundland data support the predictions of declining fertility and mortality, although fertility changes were more pronounced than mortality changes and, in general, were not subsequent to mortality changes. Analyses of cause-specific mortality rates and the rate ratios suggest that observed trends in relative cause of mortality were driven more by steep declines in infectious disease-related deaths rather than general increases in deaths caused by chronic conditions, thus supporting the epidemiological transition model.

Regional differences are apparent for both birth rates and mortality rates (aggregate-cause and cause-specific). Birth rates experienced overall declines from 1909 through 1930 in three of the four regions of Newfoundland (Avalon, North, and South), while the West was the only region to experience significant increases in birth rates during this time period. It is possible this reflects delays in timing of major social shifts across the island, with a gradient from east (earliest) to west (latest). In terms of mortality, the Avalon and North regions both showed significant declines in all-cause and infectious disease mortality, while the South and West both exhibited no clear post-pandemic patterns in these measures. With regard to chronic disease mortality, both Avalon and the South have relatively unchanging patterns throughout the study period, while the North and West both appear to have had increasing, albeit insignificant, trends. Only the Avalon region had higher chronic than infectious disease mortality for most of the study period, which is likely a consequence of an earlier decline in infectious disease mortality in the St. John's region than in other parts of the island (Schmidt and Sattenspiel 2017).

The factors underlying the mortality decline, both in the St. John's region and throughout the island, are numerous, and a full discussion of them is beyond the scope of this paper. However, Schmidt and Sattenspiel (2017) suggested that they were likely a consequence of complex interactions between the availability of health and social services, relatively low socio-economic status, chronic nutritional problems, and high levels of tuberculosis. As the capital, St. John's struggled less than outlying parts of the island, especially with regard to access to health and social services and securing adequate amounts and types of food, and this is probably a large part of the explanation for earlier declines in mortality in the capital. Nonetheless, Newfoundland lagged behind most other parts of the Western world until the latter decades of the twentieth century.

The age–sex histograms indicate that the regional and island-level patterns are largely similar throughout most of the period covered by this study. This may reflect the smoothing effects of aggregating several distinct districts into larger regions or important health-related social and political actions that were implemented in all parts of the island relatively equally (e.g., active attempts at tuberculosis control or improving child nutrition), but resolution of the underlying reasons must await future research.

Did the 1918 influenza pandemic have any observable impact on the demography of early twentieth-century Newfoundland? Since the

1918 influenza pandemic worldwide led to differentially higher mortality for individuals aged 15–45, one would expect to see a constriction in the 1921 age–sex histogram at these ages. For the island as a whole and in all of the regions there does appear to be a constriction, primarily among those aged 30–34 in comparison to other age categories. This constriction does not appear among those aged 45–49 in 1935 (the age category that would contain most of those aged 30–34 in 1921), however, indicating that any effects of the flu pandemic on the age and sex distribution of the population were short-lived.

Analyses of mortality and fertility patterns lead to similar conclusions. For example, although all regions show clear peaks in mortality during the pandemic, infectious disease-related mortality either declines or shows no significant post-pandemic changes following this disruptive peak. With fertility, the potential peaks around 1920 for the Avalon Peninsula and South, and in 1922 for the North, may reflect effects of the pandemic on fertility and births, but they also raise questions about the role of World War I and post-war demographic changes. That is, while these birth rates may in fact be driven by the phenomenon of increased birth rates following crises in some populations, the "crisis" here is not singular; there are likely integrated effects driven by both the 1918 influenza pandemic and the war.

Another consideration for population dynamics over the course of the study period is the contribution of migration to, from, and throughout the island. Influxes of immigration or emigration could have impacted fertility rates, and thus the population structures of the island over time, especially if there were strong biases towards excess male or female migration. Alexander (1976) noted that the crude birth rate exceeded the crude death rate throughout the early part of the twentieth century, but the labour force was relatively stable or declining in size. He concluded that this situation could have occurred only if there had been substantial out-migration of working-age residents. Crawley (1988) observed that much of this movement occurred between Newfoundland and Cape Breton, Nova Scotia, with very high rates between 1908 and 1914 but lower rates subsequently. Although this migration primarily affected males, the low rates after the mid-1910s minimized its effect on fertility and mortality following the 1918 influenza pandemic.

Significant rates of gender-based migration within Newfoundland did occur in the years following the 1918 pandemic. Forestell (1989) described in detail the nature of outport women's migration to St. John's for more diverse and higher paid domestic work, an observation also made by Botting (2000) and Kealey (2014). These women usually stayed in the paid workforce only until they married, however (Botting 2000; Forestell 1989). Thus, the effects on this type of movement on island-wide patterns of fertility were probably not substantial, but it is possible they influenced the regional patterns we observed as many women may have married and stayed in the larger towns and cities. Assessment of this issue must await further research.

The results of the demographic consequences of the 1918 influenza pandemic in Newfoundland — relatively short-lived (≤20 years) impacts and general improvements in health — are consistent with previous research on the 1918 flu in other areas. This contrasts with the relatively severe post-Black Death demographic consequences observed in European skeletal samples. One of the primary takeaways from these analyses may be that the impacts of the 1918 influenza pandemic were not as severe as those of the Black Death. However, especially considering the inconsistency in findings across regions, it is possible the observations reflect longer demographic trends of improving health and declining mortality and fertility temporarily disrupted by a crisis event rather than any causal effects of the flu on the post-pandemic measures. Further research is needed in both Newfoundland and other areas, including populations that had already completed or were farther along in demographic and epidemiological transitions, which would help distinguish pandemic effects from volatility caused by other social and economic factors.

Acknowledgements

This work was supported by the Government of Canada-Canada Studies Faculty Research Grant Program, the University of Missouri Research Board, the University of Missouri Research Council, National Science Foundation Doctoral Dissertation Research Improvement Grant #1919515, and the University of Missouri Department of Anthropology H. Clyde Wilson Opportunities for Excellence in Cultural Anthropology.

Works Cited

Alexander, D. 1976. "Newfoundland's Traditional Economy and Development to 1934." *Acadiensis* 5, no. 2: 56–78.

Andreasen, V., C. Viboud, and L. Simonsen. 2008. "Epidemiologic Characterization of the 1918 Influenza Pandemic Summer wave in Copenhagen: Implications for pandemic control strategies." *Journal of Infectious Diseases* 197: 270–78. https://doi.org/10.1086/524065.

Bastiampillai, T., S. Allison, J. Brailey, M. Ma, S.K.W. Chan, and J.C.L. Looi. 2021. "Pandemics and Social Cohesion: 1918–1920 Influenza Pandemic and the Reduction in US Suicide Rates." *Primary Care Companion for CNS Disorders* 23, no. 3: 20com02882. https://doi.org/10.4088/PCC.20com02882.

Bloom-Feshbach, K., L. Simonsen, C. Viboud, K. Mølbak, M.A. Miller, M. Gottfredsson, and V. Andreasen. 2011. "Natality Decline and Miscarriages Associated with the 1918 Influenza Pandemic: The Scandinavian and United States Experience." *Journal of Infectious Diseases* 204, no. 8: 1157–64. https://doi.org/10.1093/infdis.jir510.

Boberg-Fazlic, N., M. Ivets, M. Karlsson, and T. Nilsson. 2021. "Disease and Fertility: Evidence from the 1918–19 Influenza Pandemic in Sweden." *Economics & Human Biology* 43: 101020. https://doi.org/10.1016/j.ehb.2021.101020.

Botting, I. 2000. "'Getting a Grand Falls Job': Migration, Labour Markets, and Paid Domestic Work in the Pulp and Paper Mill Town of Grand Falls, Newfoundland, 1905–1939." PhD diss., Memorial University of Newfoundland.

Budgell, Anne. 2018. *We All Expected to Die: Spanish Influenza in Labrador, 1918–1919*. St. John's: ISER Books.

Cadigan, S.T. 2009. *Newfoundland and Labrador: A History*. Toronto: University of Toronto Press.

Cavert, W.M. 2022. "In the Grip of Calamity: Tahiti and the 1918 Spanish Influenza Pandemic." *Journal of Pacific History* 57, no. 1: 1–20. https://doi.org/10.1080/00223344.2021.2013724.

Chandra, S., J. Christensen, M. Chandra, and N. Paneth. 2021. "Pandemic Reemergence and Four Waves of Excess Mortality Coinciding with the 1918 Influenza Pandemic in Michigan: Insights for COVID-19." *American Journal of Public Health* 111: 430–37. https://doi.org/10.2105/AJPH.2020.305969.

Chandra, S., J. Christensen, S.-E. Mamelund, and N. Paneth. 2018. "Short-term Birth Sequelae of the 1918–1920 Influenza Pandemic in the United States: State-level Analysis." *American Journal of Epidemiology* 187, no. 12: 2585–95. https://doi.org/10.1093/aje/kwy153.

Chang, Y.-H., S.-S. Chang, C.-Y. Hsu, and D. Gunnell. 2020. "Impact of Pandemic on Suicide: Excess Suicides in Taiwan during the 1918–1920 Influenza Pandemic." *Journal of Clinical Psychiatry* 81, no. 6: 20l13454. https://doi.org/10.4088/JCP.20l13454.

Chowell, G., L. Simonsen, J. Flores, M.A. Miller, and C. Viboud. 2014. "Death Patterns during the 1918 Influenza Pandemic in Chile." *Emerging Infectious Diseases* 20, no. 11: 1803–11. https://doi.org/10.3201/eid2011.130632.

Cilek, L., G. Chowell, and D. Ramiro Fariñas. 2018. "Age-Specific Excess Mortality Patterns during the 1918-1920 Influenza Pandemic in Madrid, Spain." *American Journal of Epidemiology* 187, no. 12: 2511–23. https://doi.org/10.1093/aje/kwy171.

Crawley, R. 1988. "Off to Sydney: Newfoundlanders Emigrate to Industrial Cape Breton: 1890–1914." *Acadiensis* 17, no. 2: 27–51.

Crosby, A.W. 1989. *America's Forgotten Pandemic: The Influenza of 1918*, 2nd ed. New York: Cambridge University Press.

Curson, P., and K. McCracken. 2006. "An Australian Perspective of the 1918–1919 Influenza Pandemic." *New South Wales Public Health Bulletin* 17, nos. 7–8: 103–07. https://10.1071/nb06025.

Dahal, S., M. Jenner, L. Dinh, K. Mizumoto, C. Viboud, and G. Chowell. 2018. "Excess Mortality Patterns during 1918–1921 Influenza Pandemic in the State of Arizona, USA." *Annals of Epidemiology* 28, no. 5: 273–80. https://doi.org/10.1016/j.annepidem.2017.12.005.

Davis, K. 1945. "The World Demographic Transition." *Annals of the American Academy of Political and Social Science* 273: 1–11. https://doi.org/10.1177/000271624523700102.

DeWitte, S.N. 2014. "Mortality Risk and Survival in the Aftermath of the Medieval Black Death." *PLoS ONE* 9, no. 5: e96513. https://doi.org/10.1371/journal.pone.0096513.

DeWitte, S.N. 2016. "Archaeological Evidence of Epidemics Can Inform Future Epidemics." *Annual Review of Anthropology* 45: 63–77. https://doi.org/10.1146/annurev.anthro-102215-095929.

DeWitte, S.N. 2018. "Stress, Sex, and Plague: Patterns of Developmental Stress and Survival in Pre- and Post-Black Death London." *American Journal of Human Biology* 30, no. 1: e23073. https://doi.org/10.1002/ajhb.23073.

DeWitte, S.N., and A. Wissler. 2022. "Demographic and Evolutionary Consequences of Pandemic Diseases." *Bioarchaeology International* 6, nos. 1–2. https://doi.org/10.5744/bi.2020.0024.

Dimka, J., and L. Sattenspiel. 2021. "'We didn't get much schooling because we were fishing all the time': Potential impacts of irregular school attendance on the spread of epidemics." *American Journal of Human Biology* 34: e23578. https://doi.org/10.1002/ajhb.23578.

Erkoreka, A. 2010. "The Spanish Influenza Pandemic in Occidental Europe (1918–1920) and Victim Age." *Influenza and Other Respiratory Diseases* 4, no. 2: 81–89. https://doi.org/10.1111/j.1750-2659.2009.00125.x.

Forestell, N.M. 1989. "Times Were Hard: The Pattern of Women's Paid Labour in St. John's between the Two World Wars." *Labour/Le Travailleur* 24: 147–66.

Fourie, J., and J. Jayes. 2021. "Health Inequality and the 1918 Influenza in South Africa." *World Development* 141: 105407. https://doi.org/10.1016/j.worlddev.2021.105407.

Gaddy, H., and M.M. Ingholt. 2023. "Did the 1918 Influenza Pandemic Cause a 1920 Baby Boom? Demographic Evidence from Neutral Europe." *Population Studies*. https://doi.org/10.1080/00324728.2023.2192041.

González, F.A.I., J.A. Dip, and S. London. 2021. "Long-lasting Effects of Pandemics: The Case of the 1918 Influenza Pandemic in Argentina." *Spatial and Spatio-Temporal Epidemiology* 37: 100509. https://doi.org/10.1016/j.sste.2021.100409.

Grabowski, M.L., B. Kosińska, J.P. Knap, and L.B. Brydak. 2017. "The Lethal Spanish Influenza Pandemic in Poland." *Medical Science Monitor : International Medical Journal of Experimental and Clinical Research* 23: 4880–84. DOI: 10.12659/MSM.906280.

Herlihy, D. 1997. *The Black Death and the Transformation of the West.* Cambridge, MA: Harvard University Press.

House, E. 1981. *Light at Last: Triumph over Tuberculosis 1900–1975, Newfoundland and Labrador.* St. John's: Jesperson Press.

Hsieh, Y.H. 2009. "Excess Deaths and Immunoprotection during 1918–1920 Influenza Pandemic, Taiwan." *Emerging Infectious Diseases* 15, no. 10: 1617–19. https://doi.org/10.3201/eid1510.080811.

Hybel, N., and B. Poulsen. 2007. *The Danish Resources c. 1000–1550: Growth and Recession.* Leiden: Brill.

Johnson, N.P.A.S., and J. Mueller. 2002. "Updating the Accounts: Global Mortality of the 1918–1920 'Spanish' Influenza Pandemic." *Bulletin of the History of Medicine* 76, no. 1: 105–15.

Joinpoint Regression Program, Version 4.9.1.0. 2022. Statistical Methodology and Applications Branch, Surveillances Research Program, National Cancer Institute.

Kealey, L. 2014. "Outport 'Girls in Service': Newfoundland in the 1920s and 1930s." *Acadiensis* 43, no. 2: 79–98.

Kelmelis, S., and S.N. DeWitte. 2021. "Urban and Rural Survivorship in Pre- and Post-Black Death Denmark." *Journal of Archaeological Sciences: Reports* 38: 103089. https://doi.org/10.1016/j.jasrep.2021.103089.

Kim, H.-Y., M.P. Fay, E.J. Feuer, and D.N. Midthune. 2001. "Permutation Tests for Joinpoint Regression with Applications to Cancer Rates." *Statistics in Medicine* 20: 655. https://doi.org/10.1002/(SICI)1097-2058(20000215)19:3<335::AID-SIM336>3.0.CO;2-Z.

Kirk, D. 1996. "Demographic Transition Theory." *Population Studies* 50, no. 3: 361–87. https://doi.org/10.1080/0032472031000149536.

Mamelund, S.-E. 2004. "Was the 1918 Spanish Flu Responsible for the 1920

Baby Boom in Norway? The Case of a Neutral Country." *Population* 59: 269–302. https://doi.org/10.3917/popu.402.0269.

Mamelund, S.-E. 2006. "A Socially Neutral Disease? Individual Social Class, Household Wealth and Mortality from Spanish Influenza in Two Socially Contrasting Parishes in Kristiania 1918–19." *Social Science & Medicine* 62: 923–40. https://doi.org/10.1016/j.socscimed.2005.06.051.

Mamelund, S.-E. 2011. "Geography May Explain Adult Mortality from the 1918–20 Influenza Pandemic." *Epidemics* 3, no. 1: 46–60. https://doi.org/10.1016/j.epidem.2011/02.001.

Mamelund, S.-E., Haneberg, B., and S. Mjaaland. 2016. "A Missed Summer Wave of the 1918–1919 Influenza Pandemic: Evidence from Household Surveys in the United States and Norway." *Open Forum Infectious Diseases* 3, no. 1: 1–6. https://doi.org/10.1093/ofid/ofw040.

Mamelund, S.-E., L. Sattenspiel, and J. Dimka. 2013. "Influenza-associated Mortality during the 1918–1919 Influenza Pandemic in Alaska and Labrador: A Comparison." *Social Science History* 2: 177–229.

National Office of Vital Statistics. 1950. "Births and Birth Rates in the Entire United States 1909–1948: Vital Statistics — Special Reports Selected Studies." *Federal Security Agency, Public Health Service* 33, no. 8: 134–62.

Noymer, A. 2009. "Testing the Influenza–Tuberculosis Selective Mortality Hypothesis with Union Army Data." *Social Science & Medicine* 68, no. 9: 1599–1608. https://doi.org/10.1016/j.socscimed.2009.02.021.

Noymer, A. 2010. "Epidemics and Time: Influenza and Tuberculosis after the 1918–1919 Pandemic." In *Plagues and Epidemics: Infected Spaces Past and Present*, edited by A. Herring and A.C. Swedlund, 137–52. Oxford, UK: Berg.

Noymer, A. 2011. "The 1918 Influenza Pandemic Hastened the Decline of Tuberculosis in the United States: An Age, Period, and Cohort Analysis." *Vaccine* 29, suppl. 2: B38–B41. https://doi.org/10.1016/j.vaccine.2011.02.053.

Omran, A.R. 1971. "The Epidemiological Transition: A Theory of the Epidemiology of Population Change." *Millbank Memorial Fund Quarterly* 49: 509–38.

Palmer, C., L. Sattenspiel, and C. Cassidy. 2007. "Boats, Trains, and Immunity: The Spread of the Spanish Flu on the Island of Newfoundland." *Newfoundland and Labrador Studies* 2: 1719–26.

Parsons, W.D. 1992. "The Spanish Lady and the Newfoundland Regiment." Paper presented to the St. John's Medical History Society, May. http://www.vlib.us/medical/parsons.htm, updated 1 May 2006, accessed 21 Aug. 2022.

Paskoff, T., L. Sattenspiel. 2019. "Sex- and Age-based Differences in Mortality during the 1918 Influenza Pandemic on the Island of Newfoundland." *American Journal of Human Biology* 31, no. 1: e23198. https://doi.org/10.1002/ajhb.23198.

Patterson, K.D., and G.F. Pyle. 1991. "The Geography and Mortality of the 1918 Influenza Pandemic." *Bulletin of the History of Medicine* 65: 4–21.

Phillips, H., and D. Killingray, eds. 2003. *The Spanish Influenza Pandemic of 1918–19*. London: Routledge.

Provincial Archives of Newfoundland and Labrador [PANL]. 1910–1931. "Annual Report of the Registrar General of Births, Marriages and Deaths." *Journal of the House Assembly of Newfoundland 1910–31*. J125 K1910 through J125 K1931.

Raftakis, M. 2022. "A 'Silent' Pandemic? 1918–1919 Influenza Pandemic in Greece: Evidence from Hermoupolis, Syros." *Social History of Medicine* hkac020. https://doi.org/10.1093/shm/hkac020.

Rea, F., E. Pagan, M.M. Compagnoni, A. Cantarutti, P. Pugni, V. Bagnardi, and G. Corrao. 2017. "Joinpoint Regression Analysis with Time-On-Study as Time-Scale. Application to Three Italian Population-based Cohort Studies." *Epidemiology Biostatistics and Public Health* 14, no. 3: e12616. https://doi.org/10.2427/12616.

Richard, S.A., N. Sugaya, L. Simonsen, M.A. Miller, and C. Viboud. 2009. "A Comparative Study of the 1918–1920 Influenza Pandemic in Japan, USA and UK: Mortality Impact and Implications for Pandemic Planning." *Epidemiology and Infection* 137, no. 8:, 1062. https://doi.org/10.1017/S0950268809002088.

Saglanmak, N., V. Andreasen, L. Simonsen, K. Mølbak, M. Miller, and C. Viboud. 2011. "Gradual Changes in the Age Distribution of Excess Deaths in the Years Following the 1918 Influenza Pandemic in Copenhagen: Using Epidemiological Evidence to Detect Antigenic

Drift." *Vaccine* 29: B42–B48. https://doi.org/10.1016/j.vaccine.2011.02.065.

Sattenspiel, L. 2011. "Regional Patterns of Mortality during the 1918 Influenza Pandemic in Newfoundland." *Vaccine* 29, suppl. 2: B33–B37. https://doi.org/10.1016/j.vaccine.2011.02.046.

Sattenspiel, L., S.E. Mamelund. 2013. "Cocirculating Epidemics, Chronic Health Problems, and Social Conditions in Early 20th Century Labrador and Alaska." *Annals of Anthropological Practice* 36, no. 2: 402–21.

Sattenspiel, L., C. Orbann, A. Bogan, H. Ramirez, S. Pirrone, S. Dahal, J.A. McElroy, and C.K. Wikle. 2023. "Associations between Rurality and Regional Differences in Sociodemographic Factors and the 1918–20 Influenza and 2020–21 COVID-19 Pandemics in Missouri Counties: An Ecological Study." *PLoS ONE* 18, no. 8: e0290294. https://doi.org/10.1371/journal.pone.0290294.

Schmidt, D.M., and L. Sattenspiel. 2017. "The Second Epidemiologic Transition on the Brink: What We Can Learn from the Island of Newfoundland during the Early 20th Century." *American Journal of Human Biology* 29, no. 5: e22997. https://doi.org/10.1002/ajhb.22997.

Sharma, A., D. Ghosh, N. Divekar, M. Gore, S. Gochhait, and S.S. Shireshi. 2021. "Comparing the Socio-economic Implications of the 1918 Spanish Flu and the COVID-19 Pandemic in India: A Systematic Review of Literature." *International Social Science* 71, special issue S1: 23–36. https://doi.org/10.1111/issj.12266.

Stack, S., and R.H. Rockett. 2021. "Social Distancing Predicts Suicide Rates: Analysis of the 1918 Flu Pandemic in 43 Large Cities." *Suicide and Life-Threatening Behavior* 51: 833–35. https://doi.org/10.1111/sltb.12729.

Staub, K., P. Jüni, M. Urner, K.L. Matthes, C. Leuch, G. Gemperle, N. Bender, S.I. Fabrikant, M. Puhan, F. Rühli, O. Gruebner, and J. Floris. 2021. "Public Health Interventions, Epidemic Growth, and Regional Variation of the 1918 Influenza Pandemic Outbreak in a Swiss Canton and Its Greater Regions." *Annals of Internal Medicine.* doi:10.7326/M20-6231.

Thompson, W. 1929. "Population." *American Journal of Sociology* 34, no. 6: 959–75.

van Doren, T.P., and S. Kelmelis. 2022. "Contextualizing Pandemics: Respiratory Survivorship before, during, and after the 1918 Influenza Pandemic in Newfoundland." *American Journal of Biological Anthropology* 181, no. 1: 70–84. https://doi.org/10.1002/ajpa.24678.

van Doren, T.P., and L. Sattenspiel. 2021. "The 1918 Influenza Pandemic Did Not Accelerate Tuberculosis Mortality Decline in Early 20th Century Newfoundland: Investigating Historical and Social Explanations." *American Journal of Physical Anthropology* 176, no. 2: 179–91. https://doi.org/10.1002/ajpa.24332.

Velde, F.R. 2022. "What Happened to the U.S. Economy during the 1918 Influenza Pandemic? A View through High-frequency Data." *Journal of Economic History* 82, no. 1: 284–326. https://doi.org/10.1017/S0022050722000055.

Viboud, C., J. Eisenstein, A.H. Reid, T.A. Janczewski, A.M. Morens, and J. Taubenberger. 2013. "Age- and Sex-specific Mortality Associated with the 1918–1919 Influenza Pandemic in Kentucky." *Journal of Infectious Diseases* 207, no. 5: 721–29. https://doi.org/10.1093/infdis/jis745.

Walaza, S., C. Cohen, A. Nanoo, A.L. Cohen, J. McAnerney, C. von Mollendorf, J. Moyes, and S. Tempia. 2015. "Excess Mortality Associated with Influenza among Tuberculosis Deaths in South Africa, 1999–2009." *PLoS ONE* 10, no. 6: e0129173. https://doi.org/10.1371/journal.pone.0129173.

Wasserman, I.M. 1992. "The Impact of Epidemic, War, Prohibition and Media on Suicide: United States, 1910–1920." *Suicide and Life-Threatening Behavior* 22, no. 2: 240–54. https://doi.org/10.1111/j.1943-278X.1992.tb00231.x.

Zürcher, K., M. Zwahlen, M. Ballif, H.L. Rieder, M. Egger, and L. Fenner. 2016. "Influenza Pandemics and Tuberculosis Mortality in 1889 and 1918: Analysis of Historical Data from Switzerland." *PLoS ONE* 11, no. 10: e0162575. https://doi.org/10.1371/journal.pone.0162575.

Appendix

Supplementary Table 1. Joinpoint regression results for the analysis of change in birth rates. Results are broken down by region and by the number of joinpoints that were fit per model.

Avalon			**North**		
Slope (year range)	**APC (SE)**	***p*-value**	**Slope (year range)**	**APC (SE)**	***p*-value**
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−3.71 (0.426)	<0.001 ***	1909–1930	−3.53 (0.542)	<0.001 ***
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1921	−2.08 (0.976)	0.048 *	1909–1922	−1.84 (0.876)	0.050 .
1921–1930	−6.17 (1.51)	<0.001 ***	1922–1930	−6.93 (1.82)	0.001 **
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1917	−3.41 (1.75)	0.072 .	1909–1922	−1.19 (0.892)	0.205
1917–1920	2.13 (16.1)	0.896	1922–1925	−14.0 (17.0)	0.423
1920–1930	−6.46 (1.25)	<0.001 ***	1925–1930	−1.66 (3.81)	0.669
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1914	1.80 (2.71)	0.521	1909–1919	−2.23 (1.33)	0.123
1914–1917	−12.6 (12.1)	0.320	1919–1922	3.78 (17.1)	0.829
1917–1920	6.65 (12.1)	0.593	1922–1925	−17.3 (17.1)	0.333
1920–1930	−6.67 (0.942)	<0.001 ***	1925–1930	−1.25 (3.83)	0.750

South			West		
Slope (year range)	APC (SE)	*p*-value	Slope (year range)	APC (SE)	*p*-value
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	–3.44 (0.762)	<0.001 * * *	1909–1930	0.290 (0.912)	0.754
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1920	–1.77 (1.62)	0.291	1909–1924	–2.36 (1.36)	0.102
1920–1930	–5.36 (1.88)	0.011 *	1924–1930	10.3 (5.45)	0.076.
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1917	–6.58 (2.49)	0.019*	1909–1914	11.3 (5.08)	0.044*
1917–1920	11.1 (22.8)	0.635	1914–1922	–9.22 (3.04)	0.009* *
1920–1930	–7.49 (1.78)	<0.001 * * *	1922–1930	9.83 (2.48)	0.001 * *
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1914	–0.859 (4.77)	0.860	1909–1912	16.1 (10.7)	0.162
1914–1917	–16.7 (21.3)	0.451	1912–1918	–1.41 (4.81)	0.774
1917–1920	16.0 (21.3)	0.468	1918–1922	–14.7 (10.7)	0.199
1920–1930	–7.72 (1.66)	<0.001 * * *	1922–1930	10.9 (2.35)	<0.001 * * *

Supplementary Table 2. Joinpoint regression results for the analysis of change in the aggregate causes of death rates (both infectious and chronic/other conditions combined). Results are broken down by region and by the number of joinpoints that were fit per model.

Avalon			**North**		
Slope (year range)	**APC (SE)**	***p*-value**	**Slope (year range)**	**APC (SE)**	***p*-value**
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−0.657 (0.286)	0.0329*	1909–1930	−0.554 (0.45)	0.234
Model 2: One joinpoint			Model 2: One joinpoint		
1909–1918	0.606 (0.961)	0.537	1909–1911	18.8 (15.4)	0.241
1918–1930	−1.49 (0.623)	0.0296*	1911–1930	−1.25 (0.461)	0.0157*
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1918	1.04 (0.968)	0.299*	1909–1911	19.8 (16.1)	0.240
1918–1926	−2.76 (1.55)	0.099	1911–1926	−1.57 (0.82)	0.0759*
1926–1930	2.50 (3.35)	0.468	1926–1930	0.924 (5.09)	0.859
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1914	1.21 (2.38)	0.620	1909–1911	21.7 (11.9)	0.0992
1914–1918	4.54 (5.32)	0.414	1911–1915	−5.34 (5.96)	0.391
1918–1921	−7.45 (10.6)	0.500	1915–1918	5.06 (11.9)	0.579
1921–1930	−0.171 (1.01)	0.869	1918–1930	−2.18 (0.705)	0.0114*

South			West		
Slope (year range)	APC (SE)	*p*-value	Slope (year range)	APC (SE)	*p*-value
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−0.559 (0.583)	0.349	1909–1930	0.524 (0.52)	0.329
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1918	0.195 (0.157)	0.231	1909–1916	4.49 (2.52)	0.0948
1918–1930	−2.21 (1.02)	0.045*	1916–1930	−0.930 (0.887)	0.309
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1918	3.62 (1.59)	0.0413*	1909–1918	4.39 (1.68)	0.0215*
1918–1921	−10.8 (17.5)	0.549	1918–1921	−7.66 (18.4)	0.685
1921–1930	0.416 (1.66)	0.806	1921–1930	0.783 (1.75)	0.662
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1915	−1.22 (2.01)	0.557	1909–1911	10.1 (15.7)	0.533
1915–1918	14.6 (11.9)	0.246	1911–1918	3.44 (2.65)	0.223
1918–1921	−16.7 (11.9)	0.191	1918–1921	−6.83 (15.7)	0.673
1921–1930	7.48 (1.13)	0.523	1921–1930	0.736 (1.49)	0.632

Supplementary Table 3. Joinpoint regression results for the analysis of change in rates of death due to infectious causes. Results are broken down by region and by the number of joinpoints that were fit per model.

Avalon			**North**		
Slope (year range)	**APC (SE)**	***p*-value**	**Slope (year range)**	**APC (SE)**	***p*-value**
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−1.03 (0.333)	<0.01 **	1909–1930	−0.925 (0.383)	0.0260*
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1918	0.359 (1.02)	0.729	1909–1918	1.429 (0.916)	0.138
1918–1930	−1.95 (0.662)	<0.01 **	1918–1930	−2.47 (0.594)	<0.001 ***
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1918	1.46 (0.927)	0.141	1909–1918	1.96 (0.901)	0.0487*
1918–1921	−7.58 (10.2)	0.468	1918–1926	−3.99 (1.44)	0.0159*
1921–1930	−0.222 (0.964)	0.821	1926–1930	2.32 (3.12)	0.471
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1915	−1.59 (1.17)	0.299	1909–1915	−0.126 (1.61)	0.939
1915–1918	8.18 (6.92)	0.265	1915–1918	8.01 (9.53)	0.420
1918–1921	−11.2 (6.92)	0.137	1918–1921	−10.3 (9.53)	0.307
1921–1930	−0.0198 (0.657)	0.977	1921–1930	−0.842 (0.905)	0.374

South			West		
Slope (year range)	APC (SE)	*p*-value	Slope (year range)	APC (SE)	*p*-value
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−0.576 (0.679)	0.407	1909–1930	−0.279 (0.457)	0.558
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1918	2.81 (1.47)	0.0732	1909–1916	3.18 (2.14)	0.157
1918–1930	−2.80 (0.950)	<0.01 **	1916–1930	−1.55 (0.751)	0.0560
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1918	4.75 (1.50)	<0.01 **	1909–1918	3.40 (1.21)	0.0149*
1918–1921	−12.8 (16.4)	0.450	1918–1921	−8.13 (13.3)	0.551
1921–1930	0.257 (1.56)	0.871	1921–1930	0.00593 (1.26)	0.996
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1915	−1.48 (1.67)	0.395	1909–1915	1.51 (1.35)	0.291
1915–1918	18.9 (9.87)	0.0838	1915–1918	7.72 (8.00)	0.357
1918–1921	−20.4 (9.86)	0.0658	1918–1921	−10.4 (8.00)	0.221
1921–1930	0.685 (0.937)	0.482	1921–1930	0.136 (0.759)	0.861

Supplementary Table 4. Joinpoint regression results for the analysis of change in chronic/other causes of death rates. Results are broken down by region and by the number of joinpoints that were fit per model.

Avalon			**North**		
Slope (year range)	**APC (SE)**	***p*-value**	**Slope (year range)**	**APC (SE)**	***p*-value**
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	0.119 (0.122)	0.342	1909–1930	0.305 (0.155)	0.0631
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1911	4.74 (4.13)	0.267	1909–1911	5.98 (5.64)	0.305
1911–1930	−0.0461 (0.123)	0.713	1911–1930	0.102 (0.168)	0.552
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1911	6.29 (3.88)	0.129	1909–1912	6.54 (2.15)	<0.01**
1911–1914	−1.30 (3.88)	0.743	1912–1915	−3.82 (4.31)	0.392
1914–1930	0.0705 (0.149)	0.645	1915–1930	0.523 (0.182)	0.0133*
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1911	6.60 (3.99)	0.129	1909–1912	6.62 (2.42)	0.0210*
1911–1914	−2.15 (3.99)	0.601	1912–1915	−4.18 (4.84)	0.408
1914–1922	0.658 (0.533)	0.245	1915–1918	1.02 (4.84)	0.838
1922–1930	−0.538 (0.478)	0.236	1918–1930	0.445 (0.286)	0.151

South			West		
Slope (year range)	APC (SE)	*p*-value	Slope (year range)	APC (SE)	*p*-value
Model 1: Zero joinpoints			*Model 1: Zero joinpoints*		
1909–1930	−0.0134 (0.146)	0.928	1909–1930	0.600 (1.36)	<0.001 * * *
Model 2: One joinpoint			*Model 2: One joinpoint*		
1909–1912	1.43 (2.79)	0.616	1909–1918	0.333 (0.524)	0.535
1912–1930	0.117 (0.180)	0.528	1918–1930	0.776 (0.340)	0.0363*
Model 3: Two joinpoints			*Model 3: Two joinpoints*		
1909–1912	3.80 (2.54)	0.158	1909–1914	2.34 (1.13)	0.0593
1912–1915	−2.97 (5.07)	0.568	1914–1917	−2.38 (5.06)	0.645
1915–1930	0.198 (0.215)	0.373	1917–1930	0.982 (0.265)	<0.01 * *
Model 4: Three Joinpoints			*Model 4: Three Joinpoints*		
1909–1912	3.14 (2.57)	0.249	1909–1914	2.45 (1.17)	0.0622
1912–1919	−1.42 (0.868)	0.132	1914–1917	−3.27 (5.22)	0.545
1919–1922	1.82 (5.13)	0.729	1917–1920	2.34 (5.22)	0.664
1922–1930	−0.0586 (0.615)	0.926	1920–1930	0.701 (0.413)	0.121