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This study contributes to our understanding of health in late nineteenth-century communities in Ontario and the major factors contributing to the high mortality of the period. The focus of the study is Belleville, Ontario, from 1876 to 1885. Life expectancies at birth in the low forties characterized the community with infant mortality rates in the very high range, 160 per 1000 live-births. Major contributors to the observed pattern of mortality included tuberculosis, weanling diarrhea, and scarlet fever. Significant differences in the likelihood of dying from these three major causes varied by gender and religious affiliation. It is possible that more extended patterns of breast-feeding among Catholics led to lower levels of weanling diarrhea mortality in their infants.

Résumé

Cette étude permet de mieux comprendre la santé dans les communautés ontariennes à la fin du dix-neuvième siècle ainsi que les principaux facteurs responsables du fort taux de mortalité durant cette période. L'étude porte sur Belleville en Ontario, entre 1876 et 1885. Cette communauté se caractérisait par une espérance de vie à la naissance d'une quarantaine d'années et un taux de mortalité infantile très élevé, soit 160 décès pour 1000 naissances vivantes. Les principaux facteurs agissant sur le taux de mortalité observé incluaient la tuberculose, la diarrhée post-sevrage et la scarlatine. Les probabilités de décès liées à ces trois grandes causes variaient beaucoup selon le sexe et l'appartenance religieuse. La durée plus longue de l'allaitement au sein chez les mères catholiques contribuait peut-être à abaisser le taux de mortalité causé par la diarrhée post-sevrage chez leurs nourrissons.

Introduction

According to Pelletier and co-workers,[1] "knowledge of nineteenth-century mortality levels in Canada and Québec is limited," so limited, in fact, that they refer to this period as the "dark ages for the study of mortality." Our understanding of mortality in early American populations, on the other hand, while still far from complete, is more satisfactory.[2] The overall progress in tracing the demographic evolution of communities in early Ontario[3] has been regrettably slow. To date, most attention has focused on fertility and household structure,[4] while comparatively less has been done in addressing mortality.[5] The paucity of information on mortality in Ontario is related to a host of problems inherent in undertaking a study of this nature. Perhaps the single most serious deterrent to mortality research in Canada is the lack of reliable multi-source demographic information for settlements located outside of Quebec.[6]

For the current study, we draw upon the nominal registers of vital events held at the Provincial Archives of Ontario to reconstruct the mortality experience of one such community in the late nineteenth century, the city of Belleville, Ontario, from 1876

to 1885. While a ten-year study period may seem limited in scope, there are distinct advantages offered by this micro-level investigation. First, the selected period represents an ideal time frame in which to use mortality estimates based on government registers, since 1876 was a watershed year for civil registration in Ontario. According to Emery,[7] legislation that came into effect on the 1 January 1876 "required householders to register a death prior to interment (rather than within 10 days) in return for which they were issued a certificate of death." Reviews for the decade 1871–80 showed birth registrations up to 70 per cent from 50 per cent and death registrations almost doubled from 32 per cent to 60 per cent.[8] The onset of our study period also coincides with the year that Belleville petitioned to change its status from that of a town to a city and, accordingly, captures some of the problems inherent in the early transition to urban living. Furthermore, the study period reflects a time of relative demographic stability in Belleville, as a world depression in the 1870s reduced the volume of migration to the area.[9] The study period is also notable as it predates the development of most modern public health measures and sanitary reforms, as well as the general acceptance of the modern germ-based theory of medicine. Finally, our study period also predates the existence of a hospital in Belleville, therefore reducing the possibility of attracting the sick and dying from outlying rural areas and artificially inflating the burden of mortality. The mortality rates for this period are presumably a good reflection of the hazards of urban living in early Belleville.

Before proceeding, two caveats are worth noting. First, we acknowledge that our findings are not necessarily representative of other early communities in Ontario. Individual towns and cities often differed in the level of mortality they experienced and the timing of their decline in accordance with changes in public health, sanitation, and the environment, as well as with respect to regional economic and cultural differences.[10] Second, we echo the statement of Pelletier et al.[11] that the figures reported here are not precise indicators of mortality, but rather establish a pattern or general level. This research is part of a major study where a rare opportunity was granted to compare nineteenth-century human skeletal remains and demographic records for the Saint Thomas Anglican Church in Belleville.[12]

The Population and Its Setting

The Founding of Belleville

United Empire Loyalists settled Belleville in the late eighteenth century. Known first as Meyer's Creek, Belleville prospered and grew quickly alongside the Bay of Quinte, a small inlet off Lake Ontario. Compared to many of the contemporary urban centres in the northeastern United States, Belleville was considerably smaller, less densely populated, and culturally distinct.[13] A comprehensive treatment of the historical development of Belleville can be found elsewhere,[14] though a few themes will be expanded upon here, given that overall socio-demographic and economic properties can typically influence the relative health of a community.

Unlike the classic colonial settlements of Kingston and Toronto, Belleville was neither planned nor developed for strategic purposes, but rather grew into its purpose and attracted settlers because of an advantageous geographic and economic location.[15] While the lumber industry was the mainstay of Belleville's economy, the establishment of the Grand Trunk Railway line (1856) and the northern Ontario mining boom of the 1860s stimulated further growth. The success of Belleville's local economy becomes evident in one inventory taken in the early 1850s:

> Belleville contains three grist mills . . . there are also four saw mills, a cloth factory, blind factory, three axe and edge tool factories, three foundries, a paper factory, shingle factory, four breweries, two distilleries, a tannery, morocco leather factory, ashery, patent pail factory, three soap and candle factories, a nursery, &c. &c. The public buildings consist of a court house and jail, built of stone, a brick market-house, a grammar school of stone, and six churches.[16]

With industry continually expanding, Belleville came to be viewed as a "flourishing little town" acting as an important centre in a catchment area that was still fundamentally rural. Like many of the smaller urban settlements that existed in nineteenth-century Ontario, Belleville served as a collection and distribution centre for produce of the surrounding countryside and drew much of its import through its economic and transportation links with the major industrial cities such as Toronto, Kingston, and Montreal.[17]

Belleville's early demographic growth (figure 1) was fuelled largely by overseas immigration. Much of this movement of peoples was stimulated by the severe economic distress in the British Isles during the 1840s.[18] The bulk of newcomers from Ireland, Scotland, England, and Wales found work in any number of occupations; the majority of young unmarried immigrant women worked as household servants and seamstresses, while men found employment in the fields, forest industry, mines, and commerce. In the years leading up to our study period, however, the population of Belleville was increasingly made up of those born locally.[19]

Public Health

Our study period coincides with the beginning of the movement of public health legislation in Ontario.[20] In 1873, Ontario enacted the First Public Health Act which provided for the appointment of temporary provincial and local boards of health to deal with health emergencies. In 1882, the Second Act established a permanent central board of health, which was to have advisory powers over local boards. Two years later, the Third Public Health Act made local boards mandatory and placed them under the supervision of the provincial board. Under this legislation local boards were able to appoint medical health officers and sanitary officers.[21] Changes at the legislative level, however, typically took time to influence communities directly. A case in point is the United States where reforms began somewhat earlier, though the sanitary environment for virtually all large cities in the
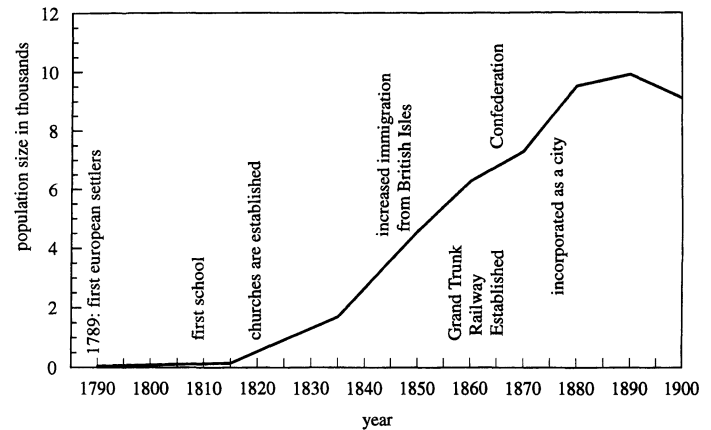

Figure 1: Growth of Belleville, and selected landmark events

American east and midwest prior to 1881 remained dismal. Cities were typically characterized by a number of problems: an absence of plentiful and pure water, inadequate scavenging and primitive sewer systems, outdoor open privies normally immediately adjacent to houses and tenements, and adulterated and unsanitary food and milk supply systems.[22] There is no reason to believe that similar conditions would not have existed in Belleville during our study period.

One of the best measures by which to gauge Belleville's conditions during the study period is provided by a report published in 1876 by James Bell, former chair of Belleville's Board of Heath: "Epidemic Diseases and Their Prevention in Relation to the Water Supply."[23]

In this report we learn the dismal state of Belleville's sanitary infrastructure. The sewage system was described as consisting of "overcharged cesspools, neglected privies, and filth-laden sewers."[24] Additional sanitary problems arose from the common practice of forcing solid matter, such as "night soil, the cleanings of fish or other household refuse" down the drains.

The situation in Belleville was further aggravated by a long-standing water supply problem in the summer and fall months. Dr. Bell[25] borrowed on Coleridge's Ancient Mariner to describe the situation in the city, "Water, water, everywhere—But not a drop to drink." There were, in fact, three possible sources of water for the inhabitants of Belleville: the springs and wells within the city, the River Moira, and the Bay of Quinte. The wells and springs presented problems associated with the high population density in the city, for

> The more wells that are dug, the smaller seems to the quantity obtainable from each, and many which used ten or fifteen years ago to afford a constant and copious supply, now run dry for a considerable portion of the year. Several springs too, which, when I came to this place, seventeen years ago, used to emit a good volume of water, are now either dried up, or have diminished in their flow, in

consequence of the indiscriminate destruction of trees that formerly covered the ground, and of the general adoption and extension of land-drainage.[26]

The groundwater was also found to be "strongly impregnated with mineral matter" such as sodium chloride, calcium chloride, iron and sulphuric acid, leading to water that tasted and smelled like rotten eggs. Large amounts of chlorides and sulphates in the drinking water were likely to produce adverse health effects with dyspeptic symptoms and bowel infections. In September 1881, the local newspaper reported that a third of the city's population was forced to use public wells that were "muddy and unsavory."[27] Well water was easily contaminated by the common practice of disposing of sewage and refuse in pits dug into the earth that was directly adjacent to the wells. As groundwater filtered through the polluted soil, wells simply became reservoirs for unclean water. The porosity of the soil, the pattern of high-density residential living, and the practice of keeping animals and poultry in close proximity to living quarters all further enhanced the risk of groundwater contamination.

As the well water supply diminished, the people of Belleville turned to less favourable sources of water, such as the River Moira. According to Bell, however, this source "dwindles down to a scanty rill in the summer and autumn," besides the fact that he felt this water was completely unfit for domestic use owning to the peaty colour of the water.[28] Bell quickly discounted the possibility of using the Bay of Quinte, explaining that due to the bay's connections with marshes, the warm season brought with it a profusion of animal and vegetable life, to the degree that "large tracts of [the bay's] surface resemble a lawn rather than a lake."[29] He felt that the only option open to the people of Belleville was to access a nearby natural reservoir known as Oak Hill Pond. Despite the expense associated with this more distant source, Bell felt that people would be willing to pay a reasonable price for having "a constant supply of pure, soft, wholesome water on their premises."[30]

The absence of a hospital in Belleville was another contentious issue for sanitary reformers, as it reflected poorly on the state of health-care delivery in this community. Bell, in particular, felt that diseased individuals should be isolated, lest they spread their sickness to others in their household, and he proposed that a hospital should be established to serve that function. Earlier calls for a hospital in Belleville had been centred on a major train crash along the outskirts of Belleville in 1872.[31] Seventy-five people were rescued from the wreck, approximately sixty alive but injured. Medical practitioners were available but ineffective, as Belleville had neither a hospital, an emergency facility, nor trained nurses. Despite these and Bell's appeals, many people in Belleville felt that a hospital was unnecessary, since people were quite accustomed to the home serving as the place for both births and deaths.[32] There was, in fact, quite a controversy not only about the need for a hospital but also the real fear felt by some of Belleville's inhabitants that a hospital would actually spread disease more readily than if the sick were simply kept in their homes.[33] Gagan[34] argues that there was

general distrust of hospitals in Ontario prior to the advent of Listerism (antisepsis), standardized nursing care, and modern diagnostic and surgical techniques. In fact, hospitals prior to the end of the Victorian period were seen less as institutions for healing and more as "essentially custodial facilities maintained as secular charities by wealthy patrons who in turn determined who should be admitted for care."[35] More pessimistic views in England saw hospitals as "hotbeds of infections" or where patients passed though "gateways to death."[36] One year following the close of our study period, in 1886, a hospital was, in fact, established in Belleville.

Some degree of public welfare was encouraged through women's groups in Belleville. The establishment of charitable institutions and welfare organizations, such as the Ladies' Domestic Mission, provided clothing to the poor and addressed issues of illiteracy and life survival skills.[37] Reorganizing themselves under the auspices of the Women's Christian Association in 1879, these women would eventually own and operate the hospital and the home for the aged as well as administering the city funds for the poor and indigent.[38] This was not an easy progression, however, as these women were blamed for attracting the poor of the countryside to Belleville, since it was increasingly becoming a place where the unfortunate could find financial and material support.[39]

Assessing Health in Nineteenth-Century Belleville

Methodology

This study uses estimates of infant mortality, life expectancy, and cause-specific mortality as the framework to assess the health of Belleville in the late nineteenth century. The ten-year study interval ensures that results are reasonably stable and not subject to annual minor fluctuations. Nominal census rolls for 1881, which have been computerized for this population, provided the raw material for estimating the population at risk of dying.

The overall mortality profile of the community was based on period life-expectancy estimates and their respective standard errors following the methodology of Chiang.[40] Under this approach, the individual is subjected, mathematically speaking, to one undifferentiated hazard of death. The Chiang methodology of life table calculations is particularly suited to small communities as it provides standard error estimates of both life expectancy and the probability of death for given ages. These, in turn, permit the investigator to assess the magnitude of sampling error implicit within these life table functions.

The multiple decrement life table extends this approach by subjecting an individual to a number of mutually exclusive hazards such as tuberculosis or cancer. The concept of the multiple decrement approach thereby allows for the empirical assessment of the impact of specific diseases or disease clusters exerted on overall mortality.[41] To gauge the relative impact of a disease or cluster, one can look to the number of potential years that would be added to overall life expectancy if

that particular disease or disease cluster was removed. Given the comparatively small number of deaths in Belleville, it is imperative that the results reported herein should be viewed cautiously and with an emphasis on trends rather than absolute values. To ensure an interpretable minimum, each application of the multiple-decrement life table is restricted to disease categories represented by at least 100 deaths. As a result, deaths due to "accidents and violence"[42] and "childbearing" were not included in the study.

Not unexpected in the nineteenth century, infectious diseases were responsible for the majority of deaths in the community and, as a result, become the focal point of this study. Owing to the significance of the infectious diseases, this category has been further subdivided to assess the effects of respiratory tuberculosis, weaning diarrhea, scarlet fever, and other infectious diseases. With the exception of weaning diarrhea, the disease classification used here follows that established by Preston et al.[43] Problems that emerge in this type of analysis are those of under-reporting or misclassification (e.g., of those diseases that carried with them some social disgrace) and vague (e.g., "old age") or symptomatic (e.g., "colic") causes of death. Nonetheless, carefully considered, the analysis of cause-specific data can provide insight into prevailing health conditions.[44]

Infant Mortality

The magnitude of infant mortality, measured as an infant mortality rate (IMR) and defined as the number of deaths under one year of age per 1000 live births, is an important component in the overall life expectancy of a population and therefore warrants special consideration in and of itself before proceeding. Infant mortality has traditionally been used as a proxy measure of the social and sanitary state of a community and there is further evidence to suggest that infant mortality, rather than childhood mortality, is the most sensitive indicator of the effects of malnutrition.[45] Variation in infant mortality rates is also influenced by culturally rooted practices such as breast-feeding, age and season of weaning, and family planning. An advantage in using infant mortality as an indicator of overall mortality is the fact that its level is calculated independent of the age-structure of a population,[46] thereby providing a means to compare communities that have not established a stationary population structure (i.e., those that are expanding or diminishing).

Given all the advantages in infant mortality assessments, it is unfortunate that "infant deaths are among the most consistently underreported vital events in the past."[47] An additional problem in measuring infant mortality is the need for complete registration of infant births, since they serve as the denominator in calculating infant mortality rates. Carpenter[48] observed that "in the country districts of Upper-Canada, doubtless a large number of infants are born and corpses interred without any other record than a family bible, if indeed that." As late as 1872, the registrar general of Ontario remarked that "the death returns exhibit their bad pre-eminence in unsatisfactoriness."[49] In the case of

Belleville, we know that there were registration difficulties as the city registrar complained about the underreporting of births in the local newspaper in 1881 and proposed a $20 fine for those failing to report a new addition to their family.[50] Working to our advantage, however, is the fact that while Belleville reported the highest rate of measles in Ontario in 1880, the local newspaper argued that this was because deaths were more consistently reported in Belleville than elsewhere.[51]

Over the study period, the infant mortality rate averaged about 159 deaths per 1000 live-births.

Consistent with a population experiencing high mortality under a regime of infectious diseases,[52] there was considerable yearly variation in infant mortality (table 1). During epidemics of scarlet fever and diphtheria, it was common for the infant mortality rate to exceed 180 per 1000 live-births. Overall, there were no significant differences in infant mortality by sex, despite a slightly higher rate among females (159.6) as opposed to males (158.4). The slight excess of female infant deaths was apparent in both endogenous and exogenous mortality where the ratio of female to male mortality was 1.09 and 1.13 respectively.

These infant mortality rates are, statistically speaking, point estimates and subject to normal sampling error resulting from the limited number of vital events (that is, births and/or deaths) inherent to small settlements. An approximation of the true magnitude of IMR may be obtained by examining the range of variation in IMR as set within the parameters of the 95 percent confidence interval. In the case of males, for example, when allowing for 5 per cent error, we can be 95 per cent confident that the average infant mortality in Belleville during this period fell anywhere between 140.5 and 179.1 (table 2).

Before accepting estimates of IMR, even when framed within their 95 per cent confidence limits, it is also important to question the quality of the database, as it has direct implications for the accurate measurement of infant mortality. In this regard, we used the biometric technique of Bourgeois-Pichat as a

Table 1: Infant Mortality by Year, Belleville, Ontario, 1876–85

Year	IMR
1876	162.2
1877	182.1
1878	141.3
1879	133.6
1880	121.3
1881	140.1
1882	173.4
1883	190.8
1884	175.8
1885	185.4
Average	**159.0**

Table 2: Infant Mortality Rates by Sex, Belleville, Ontario, 1876–85

		95% confidence estimate		
	Average	Lower	Higher	Critical ratio[a]
Male[b]	158.4	140.5	179.1	$Z = 0.28$
Female[c]	159.6	139.5	182.7	

a. Critical ratio = the difference in IMR between males and females divided by the standard error of the difference, as defined in Chiang 1984.

b. Total male infant deaths = 186, total male births = 1174.

c. Total female infant deaths = 170, total female births = 1055.

Table 3: Infant Mortality in Belleville and Other Selected North American Communities

Community	Year	IMR
Belleville, Ontario[a]	1876–85	159 males, 161 females
Montreal, Quebec[b]	1859	
French		224
Irish Catholic		170
Protestants		170
Baltimore, Maryland[c]	1870	278
Montreal, Quebec[d]	1879	
French		188
Irish Catholic		135
Protestants		131
Ingersoll, Ontario[e]	1881	130 males, 115 females
Lowell, Massachusetts[f]	1881–90	223
Schnectady, New York[g]	1883–85	184.5
Ontario[h]	1891	115
Hamilton, Ontario[i]	1891	155
Kingston, Ontario[j]	1891	168
London, Ontario[k]	1891	150
Ottawa, Ontario[l]	1891	185
Toronto, Ontario[m]	1891	199

a. Present study. Number of male deaths = 186, number of male births = 1169. The 95% confidence interval for male IMR (138.1–181.1). Number of female deaths = 170, number of female births = 1055. The 95% confidence interval for female IMR (139–183.3).

b. Thornton et al. 1987.

c. Howard 1924.

d. Thornton et al. 1987.

e. Emery and McQuillan 1988.

f. Tetrault 1993.

g. Wells 1995.

h–m. McInnis 1997.

quantitative check on the question of underreporting of infant mortality.[53] This technique is built on the premise that the age structure of infant mortality after one month of age occurs independent of the overall level of mortality. The application of this technique is based on three assumptions: "(1) the age structure of deaths between 1 and 11 months of age remains constant across time and location and is independent of the prevailing level of mortality; (2) no endogenous deaths occur after the first month; and (3) the exogenous deaths in the first month of life follow the same pattern as those at ages 1 to 11 months."[54] After successive trials, Bourgeois-Pichat demonstrated that the accumulation of infant mortality after the first month of life can be linearly related to age in days *(n)* when age is transformed by the function $(\log (n+1))^3$. Based on this finding, it is possible to calculate the level of endogenous deaths, or those deaths of infants under one month of age, by simple extrapolation of the straight line formed by the cumulative mortality after one month to birth. Subtracting the estimated from the assumed number of deaths provides the means to gauge the extent of under-reported deaths and, in turn, a better estimate of overall mortality. According to Pressat, the line-fitting procedure can also be approximated by the understanding that "the exogenous deaths of the first thirty days are about 25 per cent of the deaths from the 31st through the 365th day of the first year of life."[55] Our endogenous mortality rate of 42.17 per 1000 live-births constitutes 34.8 per cent of the exogenous mortality or 26.3 per cent of all infant deaths under one year. The excess of endogenous mortality may be the result of under-reporting of exogenous mortality or, more likely, a transfer of prenatal deaths (for example, stillbirths) to the group of live born infants who died shortly after birth (i.e., perinatal deaths). There has been some suggestion that Roman Catholics were more predisposed to this type of misclassification since only live-born infants, regardless of a perinatal death, were entitled to the rights of baptism, which stillbirths were not. While the issue of registration of infant deaths in Belleville awaits further study, the estimates of infant mortality derived for this community are well within the range of IMR values observed for most towns and urban centres in North America during the mid-nineteenth century (table 3).

Overall Health

During the period from 1876 to 1885, life expectancy at birth stood at about forty-two years, a value comparable to other communities in North America at roughly the same time (table 4). A comparison of male and female life expectancies at birth showed no statistical difference as the observed critical ratio of .704 fell far short of the critical value of $Z=2.33$ (alpha level of .01 level of significance) (table 5). The similarity in male and female life expectancy suggests the predominance of infectious diseases.[56] Under regimes of infectious disease, both sexes are typically at equal risk of infection with relatively little difference in overall life expectancy measures. Confirmation of the heavy burden of infectious diseases carried by the residents of Belleville is indicated by the fact that a total gain of 15.3 and 16.2 years for males and females could have been added to life expectancy through the elimination of these diseases. Given the

Table 4: Estimates of Life Expectancy at Birth for Belleville and Selected Towns and Cities in North America

Location	Year	Male	Female
Massachusetts[a]	1860		
(size of towns)			
Under 1000		46.2	45.6
1000–2499		48.2	48.4
2500–4999		46.6	47.9
5000–9999		46.8	47.3
10,000+		37.2	41.0
Boston[b]	1864–6	32.3	35.6
Philadelphia[c]	1870	39.6	39.6
Chicago[d]	1880	39.3	39.3
New York[e]	1879–80	33.3	36.8
Manti, Utah[f]	1880	49.9	54.2
Belleville[g]	1876–85		
Protestants		45.6	48.1
Roman Catholics		36.0	38.3
Total		**41.7**	**42.4**

a. Vinovskis 1972

b. Haines 1994

c. Condron and Cheney 1979

d. Mayer 1995

e. Billings quoted by Haines 1994

f. Levison et al. 1981

g. Present study. For males, 95% confidence interval at birth was 39.9–43.4 and at age 10 46.0–49.2. For females, 95% confidence interval at birth was 40.7–44.2 and at age 10 47.3–49.8

Table 5: Life Expectancy at Birth

		95% confidence estimate		
	Average	Lower	Higher	Critical ratio[a]
Male[b]	41.7	39.9	43.4	Z = 0.70
Female[c]	42.6	40.7	44.4	

a. Critical ratio = the difference in life expectancy at birth between males and females divided by the standard error of the difference, as defined in Chiang 1984.

b. Total male deaths = 898

c. Total female deaths = 895

Table 6: Life Expectancy at Birth by Religious Affiliation[a]

		95% confidence estimate		
	Average	Lower	Higher	Critical ratio[b]
Male				Z = 4.35
Prot.	45.6	43.1	48.1	
RC	36.0	32.4	39.6	
Female				Z = 3.76
Prot.	48.1	45.6	50.6	
RC	38.3	33.0	43.5	

a. Total Protestant deaths = 865, total Roman Catholic deaths = 341

b. Critical ratio = the difference in life expectancy at birth between males and females divided by the standard error of the difference, as defined in Chiang 1984.

predominance of infectious diseases, chronic non-infectious diseases were relatively unimportant during this period. These diseases become much more significant in the epidemiological transition of the twentieth century as life expectancy into older age groups gradually increased.

An analysis of mortality by religion revealed a substantial disparity between Protestants and Roman Catholics (table 6). Life expectancy at birth among Protestants was significantly higher for both sexes as the calculated Z score values for both males (Z=4.35) and females (Z=3.76) exceeded the critical level of 2.33. While a comprehensive explanation of the underlying reason(s) for this marked disparity is beyond the scope of the present study, one possible answer may lie in known differences in the socio-economic structure of Protestants and Roman Catholics. Assessing the significance of socio-economic status (SES) on mortality patterns in Ontario during this period is problematic, since death registers did not specify any occupational information. To approximate the economic structure of each religious group, therefore, we relied on the 1881 census for this community to compare the occupational profile for males in each religious group who were fifteen years of age and older. Katz's occupational classification was used to characterize individuals in terms of socio-economic status.[57] The five SES groups (the individuals placed in the sixth "unclassifiable" group were treated as missing) were further collapsed into three broader groups for analytical purposes (designated here as high, middle, and low SES). Based on the 1881 census, a comparison of these two major religious groups revealed a significant excess of low SES occupations among male Catholics relative to their Protestant counterparts (=143.1, 2df, p<.001). These results suggest a greater burden of poverty among the Roman Catholics.

Poverty-related risks are typically multifaceted, embracing a wide set of synergistic factors that collectively dampen the quality of life, contribute to malnutrition, and increase susceptibility to infectious disease. Poor housing, inadequate and

polluted water supplies, deficient sewage and scavenging systems, improper and insufficient diets, and poor public health education are but some of the many factors that may arise from the poverty complex. Poverty may also act upon several culturally influenced behaviours, such as the care and nursing of infants, breast-feeding practices, and the age and season of weaning.[58] Poverty and culture may also interact at the level of fertility-related decisions, concerning, for example, family size, age at first pregnancy, and age at last pregnancy.

Infectious Diseases

Respiratory Tuberculosis

Of the diseases identified here as infectious, tuberculosis[59] was the single most important disease affecting mortality. Over the study period, a total of 110 males and 160 females died of tuberculosis. Local newspaper accounts of the time also targeted tuberculosis as the leading cause of death, and estimated its responsibility in 26 of every 1000 deaths in 1879.[60] Since death by tuberculosis in the nineteenth century carried with it a lingering stigma or social disgrace for remaining family members, it is very likely that the number of deaths was under-reported[61] in our sample. Accordingly, our reported figures do not necessarily reflect the total burden of tuberculosis carried by the inhabitants of Belleville. While there is considerable evidence pointing to the important relationship between poverty and tuberculosis mortality,[62] there has been some debate about the universality of this statement, particularly in historical populations where tuberculosis was in high general incidence.[63]

Our results do indicate that tuberculosis was particularly burdensome for women. Analysis revealed that a potential gain of 4.7 years would have been added to their total life expectancy after eliminating deaths due to respiratory tuberculosis (table 7). Among women in England and Wales, with a comparable life expectancy at birth of 42 in 1871, the potential total years gained after removing tuberculosis was only 3.3,[64] almost a year and a half less than the women in Belleville. Among males, elimination of tuberculosis only led to an increase of 3.4 years added to life expectancy. The male pattern in Belleville was more comparable to that found in England and Wales in 1871, where a potential total of 3.0 years could be gained after removing respiratory tuberculosis.[65] The high rate of tuberculosis mortality in Belleville is not unexpected, given that conditions conducive to the spread of tuberculosis,[66] such as poor personal and domestic hygiene, poor ventilation, overcrowding and under-nutrition were commonplace in late nineteenth-century North American cities, particularly among the poor. It is noteworthy that our findings of sex differences in tuberculosis mortality run counter to the findings of Elman and Myers[67] for the United States. Their work identified minimal sex differentials with respect to gender differences in respiratory tuberculosis mortality and, where differences did emerge, males were typically disfavoured over females.

Table 7: Total Years Gained[a] through Elimination of Certain Diseases among Belleville Residents According to Sex

	Male	Female
Total years added after removal of:		
Total infectious diseases	15.3	16.2
Respiratory tuberculosis	3.4	4.7
Weanling diarrhea	2.3	2.4
Scarlet fever	2.3	2.1
Pneumonia, bronchitis	1.1	1.3
Life expectancy at birth	41.7	42.4

a. The multiple decrement life table was employed to asses the impact that specific diseases or disease clusters exerted on overall mortality. Results are expressed in terms of total years added to total life expectancy after elimination of each disease. Following the methodology of Preston et al. 1972.

Native-Born Patterns in Tuberculosis Mortality

A closer examination of age-specific probabilities of dying from tuberculosis from birth to age fifty was undertaken to assess the nature of this disease in late nineteenth-century Belleville. Analysis of age-specific probabilities of tuberculosis mortality was truncated at age fifty in order to minimize haphazard irregularities associated with small numbers of deaths and individuals at risk in the older age categories. Further, to minimize the contribution of older migrants to the pattern of tuberculosis mortality, the analysis was restricted to the data set that included only Canadian- and American-born residents.[68] This line of reasoning is based on the premise that shifts in migratory patterns may have distorted the community's mortality profile over time. From an epidemiological perspective, migrants represent a group that may be more susceptible to increased risks of mortality in their new environment or, on the other hand, may carry greater immunological resistance by virtue of prior exposure to disease in their native countries.[69] Migrants are also to some extent self-selected, and we cannot rule out the possibility that those who were poor and more likely to have tuberculosis were also more likely to migrate in search of new opportunities. This possibility is supported by Wherett's[70] finding that though Canada had hoped to attract European farmers to settle its underused farm lands, "Europe by this time had become highly industrialized and it was the poor urban worker who often made the journey." On arrival to Belleville, migrants may have been more susceptible to economic disadvantage as they adjusted to their new environs and, as a result, harder hit by many of the effects of poverty-related problems, such as malnutrition and under-nutrition.[71] Consequently, as the number of newcomers to Belleville decreased over time, and an increasingly larger proportion of the population was represented by those native born, there was a greater
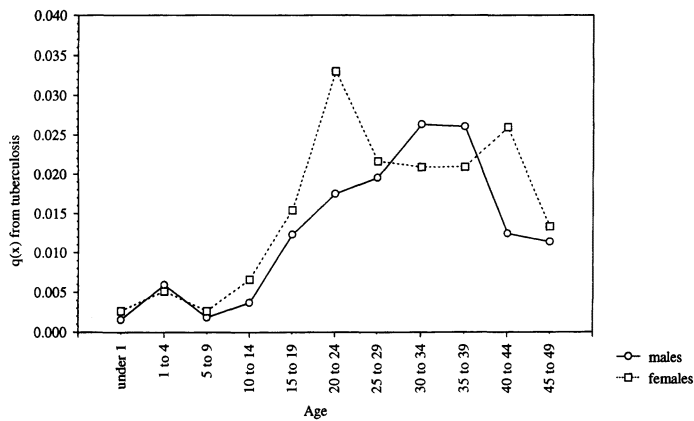
Figure 2: Age-specific probability of dying from tuberculosis among Canadian/American-born residents of Belleville, 1876–85

Figure 3: Age-specific probability of dying from tuberculosis among Canadian/American-born females of Belleville by religion, 1876–85

opportunity for a more local mortality profile to develop. Higgs's[72] analysis of cycles and trends in mortality in large American cities from 1871 to 1900 indicated that short-term variations in the rate of immigration were closely associated with corresponding variations in the rate of mortality. Howard's[73] earlier analysis of changing mortality patterns in Baltimore astutely concluded that the shifting origins of immigrants could influence the long-term decline of certain diseases.

Our analysis of North American–born female residents of Belleville revealed the classic pattern of tuberculosis mortality as the probability of death rose sharply through the teenage years and reached a peak risk of over three per cent at twenty to twenty-four years of age (figure 3). A slightly lower rate was observed for males, with the notable difference of the peak mortality occurring later at thirty to thirty-four years of age. This finding is consistent with other studies which have found that young women develop disease sooner after infection than men.[74] This pattern suggests a community with a high annual rate of infection, where virtually everyone has been infected with the bacilli by the age of twenty. According to the "golden age" hypothesis, children between five and fifteen years of age are believed more likely than those in other age groups to present a tuberculosis infection as a minor illness, only to be ravaged by delayed onset of the disease in their adult years.[75]

Gender Bias and Tuberculosis

Explanations for why females experienced higher rates of tuberculosis mortality than males remain controversial, especially in considering the possible effects of pregnancy. Smith[76] cites the work of 1930s researchers who felt that "weak, malnourished pregnant consumptives already had a bad prognosis" and that the imposed burdens of pregnancy, the strain of labour, and the sudden fall of the diaphragm after birth might act as an increased risk for reactivation and death among females. Others suggest that there is no convincing evidence to support this relationship.[77] Mitchinson[78] argues that male/
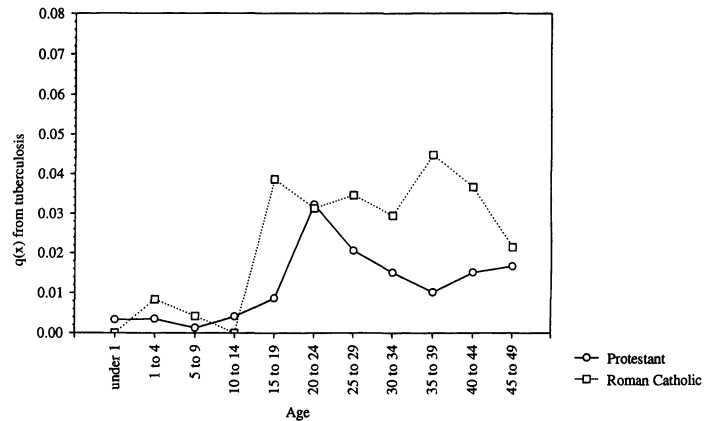
female differences in tuberculosis mortality may be best addressed in terms of gender influences. She reasons that it was the social position of women and the toil of their daily lives that made them more susceptible to tuberculosis than men, not their sex in itself. Others maintain that there is no known reason for the sex difference in tuberculosis mortality.[79] Agricultural communities tended to have the highest female/male differentials in tuberculosis mortality relative to industrial towns and cities, and this is attributed to the possibility of improved nutrition for women in industrial areas and their changed lifestyles as they joined men in factory work.[80] Murray[81] believes that in the case of American Shaker communities, differences in workplace crowding were responsible for the elevated rates observed among women relative to that of men, "whereas men were more likely to work in the fields or in small groups in shops, women's work tended to require groups of women to work together to work together on textile production or herb processing."

Given data limitations, our examination is confined to an exploration of the possibility that childbearing was an additional risk factor in female tuberculosis mortality in Belleville, using what is known about fertility differentials among the city's religious groups. Using census returns for 1881, Vanderlinden demonstrates that Roman Catholic fertility was substantially higher than that of Protestants.[82] It should follow, then, that the relative impact of tuberculosis on survival during the childbearing years posed a higher risk among Roman Catholic women. Examination of figure 4 shows that age-specific mortality does, in fact, remain consistently higher throughout the reproductive period among Roman Catholic as compared to Protestant women, a pattern that suggests an additional risk associated with a longer and more intense childbearing period.

Given the general SES differences between these religious groups outlined earlier, however, we cannot dismiss the possibility that the differential experiences of Protestant and Roman
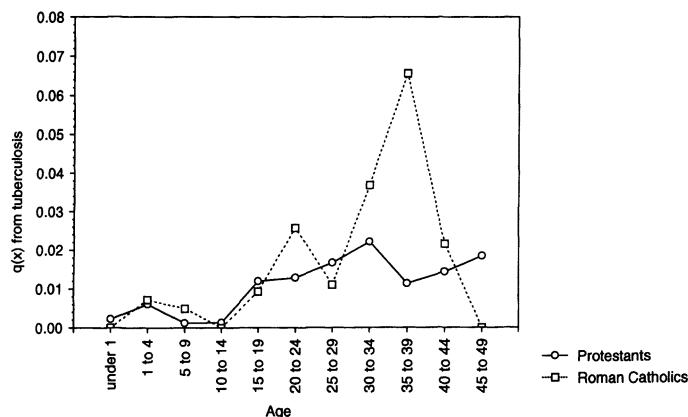
Figure 4: Age-specific probability of dying from tuberculosis among Canadian/American-born males of Belleville by religion, 1876–85

	Protestants		Catholics	
	Males	**Females**	**Males**	**Females**
Life expectancy at birth	45.6	48.1	36.0	38.3
Gain after eliminating tuberculosis	3.4	4.6	3.0	5.7
Relative gain[b]	6.7%	8.6%	9.8%	13.0%
Relative gain[b] ratio of females to males	1.3		1.3	

Table 8: Total Years Gained[a] after the Elimination of Tuberculosis as a Cause of Death among Residents of Belleville According to Religious Affiliation

a. The multiple decrement life table was employed to assess the impact of tuberculosis on overall mortality. Results are expressed in terms of total years added to total life expectancy after elimination of each disease. Following the methodology of Preston et al. 1972.

b. Relative gain was computed as the per cent of total gain in life expectancy at birth after eliminating tuberculosis over the new total life expectancy.

Catholic women are due to factors other than childbearing. This possibility finds support in the findings outlined in table 8. After eliminating tuberculosis deaths, both male and female Roman Catholics experience greater gains to life expectancy than their Protestant counterparts. In other words, the Catholic probability of dying from tuberculosis is set at a higher level, regardless of sex. If a more involved pace of childbearing were responsible for Protestant and Catholic women's experience, then we would expect that, with tuberculosis removed, Catholic women would show an improved ratio to their male counterparts, relative to the Protestant sex ratio gains. This is clearly not the case, with both religious groups showing a relative gain ratio of 1.3, thus reducing the plausibility of a childbearing effect on tuberculosis mortality.

Weanling Diarrhea

After tuberculosis, weanling diarrhea constituted the next most important factor affecting mortality, adding about three years to the total life expectancy at birth after eliminating this cause of death (table 7). Undifferentiated acute diarrhea diseases associated with infancy and early childhood are often referred to collectively as weanling diarrhea.[83] For purposes of this study, weanling diarrhea subsumed deaths attributable to diarrhea, difficult dentition or teething, marasmus, and convulsions. A total of 158 weanling deaths were recorded.

The combined effects of enteric infections, malnutrition, dehydration, and exposure to infectious disease during the course of weaning mark this event as a very risky period in an infant's life, both historically for Western countries and currently in developing countries. Enteric infections result from ingesting contaminated matter, either by direct contact, usually through unclean hands, or indirectly through contaminated food, milk, or water. The impact of epidemic diarrhea was considerable, because even infants who survived an attack would have compromised their nutritional status, thereby increasing the risk of morbidity from other infectious diseases.[84] The osteological work of

Saunders et al.[85] for this population adds direct support to the perceived dangers of weaning. Patterns of skeletal growth showed that acute infections, and not chronic undernutrition or infection, were the most serious environmental problems faced by Belleville's infants and children.

Quarterly infant mortality ratios for Belleville confirmed a summer-dominated mortality pattern (QM=1.52) with a low during the winter months (QM=0.67).[86] Deaths due to weanling diarrhea appeared yearly and were concentrated during the late summer months (July, August, and September), accounting in large measure for the overall increase in infant deaths in these months. This seasonal distribution of weanling diarrhea was a common phenomenon in other areas of North America. A similar pattern of excessive infant mortality was observed in July and August in mid-nineteenth-century Lowell, Massachusetts.[87] In Montreal, infant deaths did not rise above a standard level until the temperature exceeded 55 degrees Fahrenheit.[88] Belleville's residents experienced a temperate climate, with average temperatures rising to some 67 degrees Fahrenheit in the summer months.[89] It was during these hottest and driest months, when the water table was presumably at its lowest, wells most contaminated, and street dirt not flushed away by rain, that infant mortality rates peaked. The lack of a pure and plentiful water supply coupled with an unsanitary municipal environment with its lack of paved streets, refuse collection, and inefficient sewage system produced optimal conditions for the transmission of water- and food-borne infectious diseases. Infants, in particular, with their underdeveloped immune system were highly vulnerable to a variety of water- and food-borne enteropathogens during the hot summer months.[90]

The peak of infant diarrheal deaths and its relation to the water supply and municipal environment has typically been tied to

infant feeding practices. The process of weaning and supplementing breast-feeding with impure water during the summer months was a dangerous practice and often led to outbreaks of epidemic diarrhea.[91] The increase in weanling diarrhea in the summer months in Belleville was aggravated by the long-standing water supply problem that the community endured and that would have been worse in the dry summer and fall months. Exposure to impure water decreased substantially in the cool months. In Montreal, local doctors attributed the source of summer-dominated infant mortality to early weaning and the use of inappropriate solid foods. The Report of the Board of Health (Philadelphia 1874), as cited in Cheney,[92] provides insight into the advice given by public-health and medical-care workers, who recognized the dangers implicit in infant feeding and weaning:

> [They] advised that a child should be breastfed until after its second summer and never weaned just before or during the summer months. If cow's milk were to be used, it should be fresh, boiled during the summer months, and kept on ice if that could be afforded. Diapers should be cleaned after every use and the child bathed daily and kept cool.

According to Mirza and co-workers,[93] extending the consumption of breast milk past seventeen months while supplementing with other foods protects against the occurrence of prolonged diarrhea. Prolonged or persistent diarrhea is associated with elevated case fatality rates as well as greater adverse effects on growth than short-duration episodes of diarrhea. Besides acting as a rehydrating fluid, the protective effect of breast milk could be facilitated through: (1) providing anti-infective properties, (2) minimizing feeding of contaminated foods, and (3) providing growth factors that accelerate intestinal mucosal renewal and recovery from enteric infection.[94] Recent work by Huck[95] on nineteenth-century English towns adds increased support to the proposition that reduced breast-feeding is a plausible explanation for the increased summer infant mortality.

Unfortunately, information on breast-feeding practices and weaning in early Belleville is sparse and limited to the personal accounts of a few women.[96] One particularly relevant article entitled "The Rearing of Children" appeared in the local newspaper in 1862. In it, mothers were admonished for improper breast-feeding since it was discovered that "mothers too often give too much milk and not enough water to their babies. Milk is a child's food and not its drink."[97] This passage makes clear that mothers were being encouraged to supplement breast-feeding with water. Given the quality of water available at the time, however, it would appear that mothers who adopted this advice would have also been increasing the probability of ill-health among their infants.

In order to gain greater insight into the nature and variation in breast-feeding practices in late nineteenth-century Belleville, we used the biometric technique of Bourgeois-Pichat[98] coupled with the findings of Knodel and Kintner,[99] who applied this method on populations with known patterns of various feeding

practices. In populations where breast-feeding was uncommon or short in duration, Knodel and Kintner found that infant mortality rises particularly steeply during the early months of the first year of life. In such cases, computation of the slope of the line determined by the cumulative infant mortality at six and twelve months relative to that in the first half of the year yields a value of less than one. The excess of mortality in early infancy is attributed to the absence of passive immunity and nutritional benefits conferred by breast milk, coupled with early exposure to poor sanitary conditions surrounding artificial feeding.[100] In populations where breast-feeding is commonplace and extended, the ratio of slopes is above one. Calculation of this ratio for the entire population of Belleville yields a value of 1.32 and suggests that in late nineteenth-century Belleville breast-feeding was both commonplace and extended in duration. Using the biometric model, a recent study by Herring et al.[101] on the Anglican community of Belleville for the period 1821–74 reported values ranging from 1.19 to 1.29, once again suggesting a pattern of extended nursing. Based on stable nitrogen isotope analysis of the skeletal remains of 149 infants, they concluded that by about fourteen months of age most infants had stopped receiving significant amounts of protein from breast milk.

Once again, we employed religious affiliation as a proxy for relative wealth to investigate the possibility of SES differences in the impact of weanling diarrhea. Computation of deaths under five years of age due to weanling diarrhea revealed that Protestant children suffered higher mortality rates, although not statistically significantly higher, than Roman Catholics. This finding was somewhat unexpected, since deaths attributable to weanling diarrhea are generally correlated with lower standards of living,[102] given the greater number of Protestants filling high and middle SES occupations. We employed the biometric method to investigate the possibility that Roman Catholic infants enjoyed greater benefits of protection from diarrheal diseases due to more extensive or longer-term breast-feeding. Computation of the ratio of mortality slopes for these two religious groups in Belleville confirmed this suspicion, with Roman Catholics yielding a value of 2.4 and Protestants only 1.04. While there are no empirical means of testing for the significance of the difference of these two ratios, the higher ratio observed for Roman Catholics is closer to values cited by Knodel and Kintner for American cities where breast-feeding was common.[103] Support for religious differences in breast-feeding practices comes from the nearby city of Montreal. Using the birth interval following a surviving child as a proxy for breast-feeding, Thornton and Olson[104] found that the proportion of Irish Catholics breast-feeding was higher than that of Protestants. It appears that the greater susceptibility of Protestant infants in Belleville to weanling diarrhea may have been the result of their mother's more truncated breast-feeding patterns and consequently their greater consumption of impure water at younger ages during the summer months. Re-examination of the infantile quarterly mortality ratios supports our contention that Protestant infants were more susceptible to summer mortality (QM=1.74) than Catholic infants (QM=1.30).

Though relatively better positioned in terms of occupying higher SES occupations, it appears that Protestants were unable to buffer their infants from the significant dangers posed by an unsanitary environment. Belleville's general unsanitary municipal environment during the study period placed all young offspring at risk, regardless of family SES. It is possible that the scope for maximum class differentials in infant and childhood mortality attributable to water- and food-borne infections exists not when the general sanitary environment is uniformly bad, but when the poor cannot take advantage of improvements that have been made to the local sanitary environment. Under the circumstances of this study's time period, lessening infant exposure to the hazards of the urban environment was the only real option and something that Catholic mothers did, at least indirectly, by following longer breast-feeding schedules than Protestant women.

Scarlet Fever

Scarlet fever warrants separate and closer attention here, not only because it constitutes a leading cause of childhood mortality during the study period, accounting for a total of 123 deaths, but also because it affords an opportunity to examine a disease that began to rapidly wane in importance by the end of the 1800s. According to Scott and Duncan,[105] the decline in scarlet fever mortality in England fell after 1880, in parallel with a rise in the overall standard of living. Poor nutrition was an important factor increasing susceptibility and determining the final outcome of a bout of scarlet fever. Until the turn of the century, scarlatina was one of the great epidemic scourges in Westernized countries.[106] Caused by Group A hemolytic streptococci, which are responsible for a wide range of respiratory infections,[107] sporadic epidemics of scarlet fever ravaged Belleville's young during the winter and spring of 1879 and 1884. Owing to the concentration of scarlet fever during childhood, deaths that resulted from the infection made a substantial impact on overall survival, and life-table analysis revealed that about two years would have been gained through the elimination of this cause of death (table 7). Further analysis revealed that the death rate attributed to scarlatina among Roman Catholics (12.4/1000) and Protestants (6.8/1000) were significantly disparate among children under five years of age ($t=2.34$, $p<.05$).

It appears that although Catholic families, and mothers in particular, buffered the effect of weaning diarrhea upon their infants, their children were relatively more susceptible to airborne infections than Protestant children. In this instance, Catholics were unable to protect their children from the hazards of living in poorer households. Overcrowding, a common characteristic in lower SES families, fuelled the airborne transmission of diseases such as scarlet fever by offering more frequent and intense contact between susceptibles and those individuals already infected.[108] As poor nutrition further weakened the body's natural attempts at defence, the threat of infection became greatly exaggerated. Streptococci were resilient and could be carried in nose and throat discharges, as well as pus on skin

lesions, with transmission through direct contact with an infected individual or indirectly on dust, lint, and clothing.[109]

An examination of the published aggregate statistics on cause of death for all of Ontario indicates that from 1871 to 1901 the total number of scarlet fever deaths fell continuously from 808 to 215 between these two periods. A similar trend can be seen in Victorian England, where Wohl[110] attributes the drop in scarlet fever deaths to either a decline in the potency of the scarlet fever streptoccocus or to the heightened immunity of urban populations through long-term exposure. Accordingly, it is very likely that we are capturing the impact of scarlet fever in Belleville when the disease was at or near its peak and where differential mortality according to socio-economic status was still a potential feature of the disease.

Other Infectious Diseases

Compared to scarlet fever, the infectious respiratory disease cluster of pneumonia, bronchitis, and inflammation of the lungs constituted a less important disease group, contributing a potential gain of 1.1 and 1.3 years for males and females respectively after the elimination of this disease group (table 7). Deaths in this cluster were distributed throughout the year, though about two-thirds occurred in the months of January through May. This pattern is not unexpected, since a higher incidence of respiratory diseases such as chronic bronchitis, upper respiratory infection, and bronchial asthma is strongly associated with major shifts in temperature.[111] About 36 per cent of these deaths were concentrated in the first five years of life.

Conclusions

Given inherent temporal and spatial constraints, the objectives of the present study have been modest. Accordingly, the broad implications arising from the results of the inquiry are necessarily limited. At the most basic level, this study adds to our growing knowledge of early Canadian mortality experiences in the time of limited sanitary reform and public-health awareness. At another level, this study reinforces the need to pursue a number of research initiatives that continue to be more fully explored in Quebec and the United States. The first of these goals should be the investigation of mortality at the local, community, or micro level. This is essential if we are to appreciate the range of variation that was possible both spatially and temporally. The empirical results from the Belleville study are consistent with an emerging pattern of high mortality seen in a number of North American communities at this time. Second, it is apparent that the scope for mortality differentials at the intra-population level can be appreciable, even in small settlements. Culturally based practices, class differentials, and ecological factors that contribute to mortality differentials between groups all represent fertile fields for future investigation. Thornton and Olson's Montreal study represents an excellent example of the kind of research that can and should be conducted in communities outside of Quebec. Third, the role of tuberculosis needs to be more fully explored, as it represented a major force driving adult mortality throughout most of the nineteenth century. Research

on the Canadian experience with tuberculosis is vital if we are to understand the impact that this chronic, debilitating, and highly stigmatized disease had on individuals, families, and communities. Finally, the results from the Belleville study reinforce the general observation that, to a large extent, infant mortality was a significant component in shaping the overall mortality profile of communities. Given the fragile nature of the infant and early childhood years, studies into breast-feeding and other cultural practices and the implications of historic environments are clearly needed. The Belleville study suggests that while poor mothers may have been able to buffer their infants from death by weaning diarrhea through extended breast-feeding, poor families had a much harder time shielding their young children from air-borne infectious diseases.

Acknowledgements

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24. Bell (1876), 16–17.

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28. This was based in part on his observation that a local paper-making business established on the Moira could not produce white paper, only brown, owing to the colour of the water (Bell 1876).

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59. Respiratory tuberculosis was also called consumption or phthisis.

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Sanatorium Association). Shortly after, the Toronto Association for the Prevention of Consumption and Other Forms of Tuberculosis and the Ontario Association for the Prevention of Consumption and Other Forms of Tuberculosis were established in 1898 and 1900. G. J. Wherett, *The Miracle of the Empty Beds: A History of Tuberculosis in Canada* (Toronto: University of Toronto Press, 1977), 18.

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