Unravelling Belgium's mortality transition: the Role of Diffusion (1851-1915)

Background and objectives

The 19th and early 20th centuries witnessed a profound shift in Belgium's mortality landscape, as it transitioned from a pre-industrial society with high mortality rates to a more modern and industrialized one characterized by declining mortality. While this transition has been well documented at the national level, regional disparities, especially at the municipal level, have been less well understood. Our knowledge of which specific municipalities were the forerunners in the mortality transition and which lagged behind in Belgium is limited.

This paper seeks to bridge this knowledge gap and sets the stage for a comprehensive analysis of Belgium's mortality transition, focussing on the municipal level. Specifically, the paper aims to investigate the role of diffusion processes in Belgium's mortality transition between 1851 and 1915, with a particular emphasis on its role in influencing the speed and inequalities of the transition. Our hypothesis suggests that during the pre-transition stage, the process diffusion was limited to a constrained spatial range around each municipality. However, as urbanisation and industrialisation advanced diffusion expanded its reach to cover larger areas, contributing to the changing landscape of mortality.

Data

Data on municipalities are available starting from 1841 through 1950, encompassing annual records of deaths and mid-year population figures. It is important to note that several municipalities have data gaps, particularly for death records during certain years (notably from 1851 to 1856, 1858 to 1862, 1875, and 1877 to 1879). Additionally, population estimates are at times only available for specific dates, either on January 1st (as in 1857, 1861, 1865, 1874, and 1877) or on December 31st (as in 1858, 1862, 1866, 1876, and 1880).

The independent variables used in the analysis include population age groups, population density, population size, the percentage of literate individuals aged 21 or older (from 1851 to 1951) and cadastral income (in 1890). Most of these variables are accessible for some census years and have been extrapolated to cover extended periods surrounding the census years. To investigate the role of diffusion processes, we included mortality levels in neighbouring municipalities as an independent variable as well.

Methods

The methodology employed for data processing consisted of four key steps:

1. **Smoothing Observed Crude Death Rates (SmCDR)**: In this initial step, we smoothed the observed crude death rates and the associated population estimates. The aim was to create a consistent time series spanning 65 years for all municipalities, regardless of data gaps and random fluctuations due to small population sizes in certain municipalities.
2. **Standardizing Crude Death Rates from SmCDR**: The next stage involved standardizing the crude death rates derived from the smoothed data using information on age structure, segmented into three large age groups. This standardization process was applied for five large

periods. The standardization accounted for the yearly trends at the national level. The outcome of this step yielded standardized crude death rates (StCDR) that represented the expected mortality for each year and municipality, considering both the national mortality level and its trend.

3. **Modelling SmCDR and Socio-Economic Determinants**: This phase of the analysis entailed modelling the smoothed crude death rates while controlling for the level of standardized crude death rates (StCDR) and various socio-economic determinants, using a regression model. Notably, these determinants encompassed factors such as population size, population density, cadastral income, literacy and mortality levels in neighbouring municipalities.
4. **Mapping Residuals for Each Municipality**: The final step involved mapping the residuals for each municipality. These residuals represent the disparities between the predicted crude death rates (PredCDR) and the smoothed crude death rates (SmCDR). This mapping exercise served two key purposes: to evaluate the quality of the adjustment made in the data processing and to identify any potential spatial patterns that may have been missed in the earlier stages of analysis.

Preliminary results

1. Results of the standardised CDR model

The Poisson random effect model effectively captures the overall, unweighted mortality yearly trend. From the 1850s to the 1860s the mortality remained relatively stable at around roughly 22 per 1000, passed below the symbolic 20 per 1000 threshold in 1881, leading to a substantial one-third reduction in about 50 years, to reach a level below 15 per 1000 at the eve of the 1st World War.

This trend in predicted rates assumes that there are no unobserved differences between municipalities. It is based on model estimates controlling for observed differences due to population structure variables. During the period 1851 to 1880, the contribution of the under-15 age group to the CDR remained relatively stable. For every 1-percentage point increase in this age group's population, there was a 2% increase in the CDR, with peaks corresponding to events like the cholera outbreak in 1866 and the smallpox outbreak in 1871. In contrast, the contribution of the 55+ age group to the CDR transitioned from positive to negative between 1866 to the mid-1880s (with troughs during the epidemic years). This shift suggests improvements in the health of the elderly population and highlights the impact of the cholera epidemic essentially detrimental to children. The next period reveals markedly different trends. The contribution of children's mortality has been constantly declining (with the possible exception of 1906) since 1880 to less than 0.5% for each percentage point more of under-15 in the population. Meanwhile, the contribution of old-age mortality has been rising from slightly negative to positive in the 1880s, and remaining stable thereafter at below 0.5% for each percentage point increase in the 55+ age group, with a possible peak in 1903-1905 and a rising trend in the early 1910s. In sum, the CDR is much less sensitive to the age structure (as measured by the percentage of children and old age groups) from 1900 onwards compared to the 19th century.

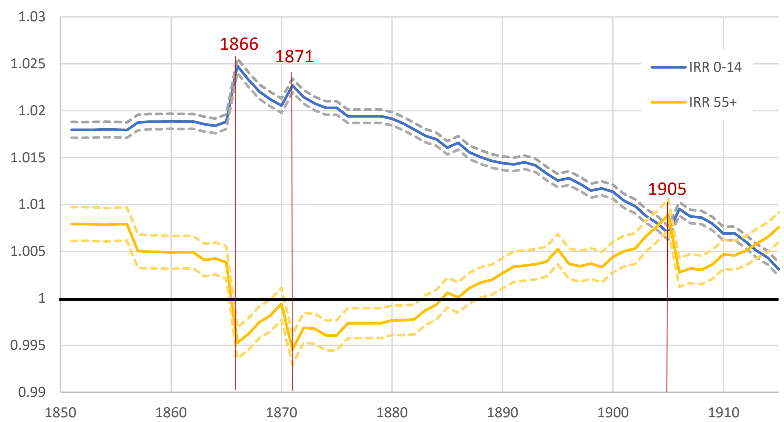

Figure 1: Contribution of children and old age groups to the variations in municipalities' Crude Death Rates

2. Summary results for the SMR model

Municipalities with greater population density and larger populations usually exhibit higher mortality than those with lower density and smaller population sizes. However, it's important to note that significant variations occurred over time and depending on the decile of population density, irrespective of the overall declining trends in mortality. Notably, the pattern commonly referred to as the 'urban penalty' saw a reversal over the second half of the century.

In the initial period 1851-1870, mortality was higher in the more densely populated municipalities (Figure). However, in later periods, mortality increased in the less densely and smaller municipalities, except for the highly densely populated ones (Figure). In the more densely and populated municipalities, mortality tended to stay stable or slightly decrease.

Municipalities located in the middle of the population density distribution, as depicted in Figure 2, and those with populations ranging between 5000 and 10000 inhabitants, as shown in Figure 3, displayed greater heterogeneity in their mortality patterns. This underscores the complex and multifaceted nature of the factors influencing mortality rates across municipalities. It suggests that a uniform approach may not fully capture the nuances of the relationship between urbanization and mortality during this specific period.

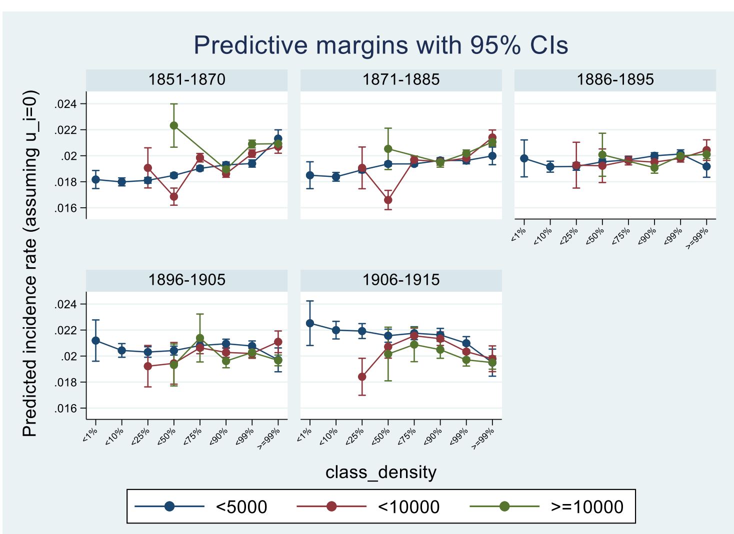

Figure 2: Predicted Crude Death Rate by population density category and period for three population sizes

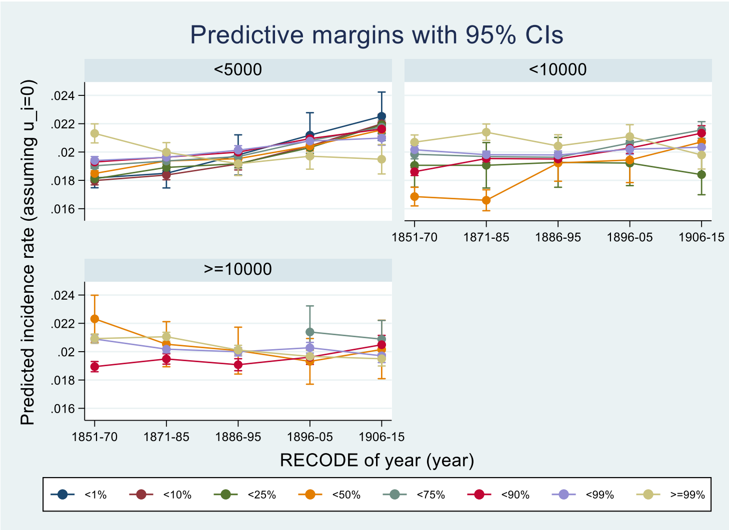

Figure 3: Predicted Crude Death Rate by population size and period for eight population density categories

Literacy, representing the capacity to read and write, emerges as a strong predictor as well. However, the results for the period 1871-1885 is counter-intuitive, as they reveal that the higher the percent literate the higher the mortality. Specifically, a 10-percentage point higher literacy leads to a reduction in the mortality rate by +0.89%. Conversely, from 1896, the results align with the expectations. In these later periods, a higher percentage of literacy in the municipality is associated with lower mortality rates. In the 1896-1905 and 1906-1915 periods, a 10-percentage point increase in literacy leads to a reduction in mortality by 1.70% and 2.09%, respectively. This latter finding suggest that literacy plays a protective role in public health during these later years. Furthermore, it's worth noting that literacy often correlates with population density and size. The interplay of these factors might have collectively cancelled out certain effects, although this is not consistent across all municipalities.

3. Further analysis on diffusion

In addition to these findings, our analysis will also delve into further examination of the effects of neighboring municipalities on the time required to cross a given mortality threshold. This aspect adds a spatial dimension to our study, shedding light on how neighboring areas may impact mortality trends.