

## Briefing Note

### Post-pandemic mortality dynamics: historical city-level evidence

COVID-19 has been the worst pandemic since the ‘Spanish flu’ of 1918-19, to which it has often been compared at the national and global level. We analysed a long time series of deaths from infectious and non-communicable diseases using detailed archival records for the City of Glasgow to construct a rich dataset of causes of mortality from 1898 to 1972. The archival records confirm that, for Glasgow, the 1918-19 influenza pandemic was the most significant outbreak since the start of the 20<sup>th</sup> century, that led to an increase in all-cause mortality that, until June 2020, exceeded that of COVID-19. They also demonstrate that the 1918-19 pandemic was followed by a period of heightened volatility in death rates from influenza and related diseases, reflecting more frequent outbreaks, before settling into a regime of smaller fluctuations post-1940. Hence, experience from 1918-19 suggests the potential for a fairly extended period of frequent outbreaks following a pandemic, at least at local scale.

#### Overview

We use public health records for one of the UK’s biggest industrial cities, Glasgow, covering the years 1898 to 1972. This allows us to contextualise the death rate associated with COVID-19 relative to those from infectious diseases during a period when outbreaks were more frequent. The long time series is critical to examine medium-run dynamics separately from the trend, and after identified outbreak periods (e.g. for the Spanish flu, after 1919).

#### Disease and mortality in Glasgow 1898 – 1972

We compiled a dataset of death rates by cause from the annual *Medical Officer for Health (MOH) Reports* over the period 1898 to 1972.<sup>i</sup> These reports were compiled by City of Glasgow officials for the purposes of monitoring public health in the city.

Over the period we investigate, there was a significant decline in overall mortality: death rates from all causes fell from around 20,000 per million per year to around 12,000 over the 75-year period. Figure 1 shows the classic pattern of the epidemiological transition, consisting of a decreasing share of deaths due to infectious diseases and an increasing share of non-communicable diseases.<sup>ii</sup>

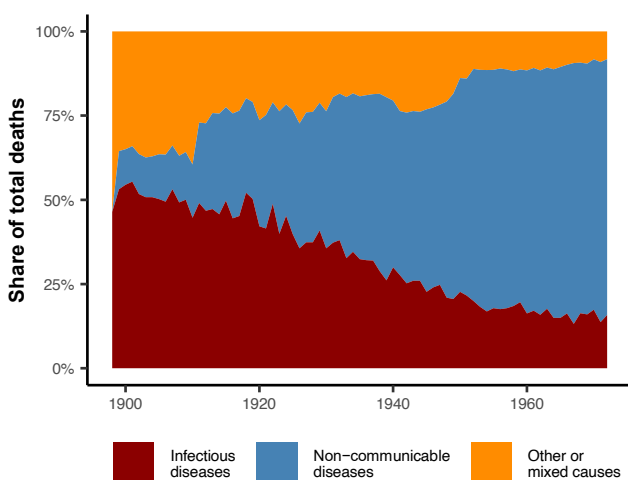


Figure 1: Proportion of deaths due to different causes, Glasgow, 1898 – 1972.

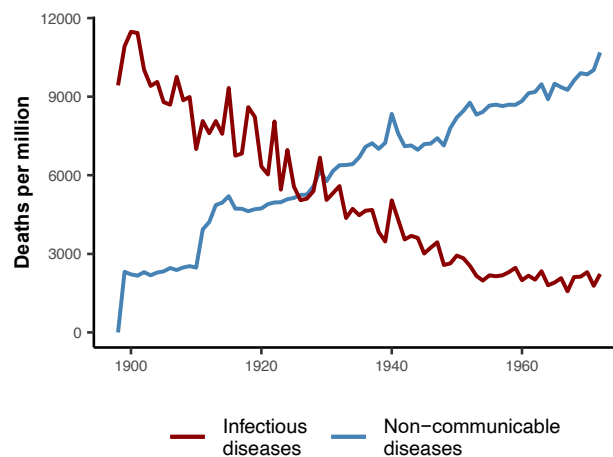


Figure 2: Deaths per million from infectious and non-communicable diseases. Shaded areas denote world wars.

Figure 2 shows that deaths from non-communicable diseases increased with a more-or-less constant slope after the First World War with limited volatility. In contrast, infectious disease death rates showed a downward trend with a slope that varied over time, and also fluctuated much more strongly year-on-year. The decline in infectious disease deaths reflects improved access to vaccines and antibiotics and better public health and sanitation. Despite the downward trend in

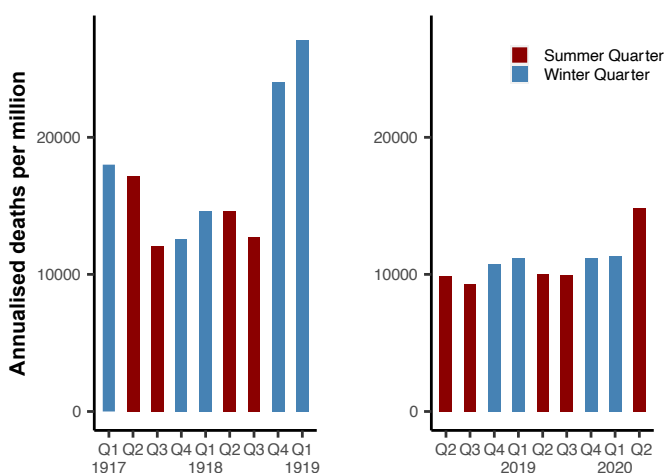
infectious disease deaths, as discussed in MOH reports, sporadic outbreaks and bad weather still contributed to spikes in certain years, especially during the first half of the 20<sup>th</sup> century.

### The 1918-19 influenza pandemic and COVID-19

The 1918-19 ‘Spanish flu’ influenza outbreak was the worst pandemic event in the 20<sup>th</sup> century, with an estimated 50 million deaths worldwide<sup>iii</sup>. In the study of the COVID-19 pandemic, comparisons with the 1918-19 pandemic are common<sup>iv</sup>.

In the spring of 1918, Glasgow was one of the first cities in the UK to record cases of a new influenza, with cases continuing throughout the spring and summer.<sup>v</sup> This first wave proved to be relatively mild compared with the second and third waves in the following winter and spring. Public health responses were limited, and despite sporadic school closures, measures such as a general quarantine were not applied.

Figure 3 shows quarterly data from the MOH reports on death rates from all causes for the years prior to and during the 1918-19 pandemic,<sup>vi</sup> and quarterly all-cause mortality rates since 2019 in the Greater Glasgow and Clyde NHS Health Board Area.<sup>vii</sup>



**Figure 3: Annualised all-cause mortality rates in Glasgow prior to and during the 1918-19 influenza pandemic, and for COVID-19 until the second quarter of 2020.**

Focusing on the four quarters immediately preceding the respective pandemics (Q4 1917 to Q3 1918 and Q1-Q4 2019) reveals that mortality reduced substantially from around 13,600 per million per year in 1918 to around 10,600 today, a reduction of around 22%. The seasonality of death rates, with higher rates in the winter quarters, is still present in the recent data, although is less pronounced than in the past. A comparison between death rates for corresponding quarters prior to and during each pandemic revealed

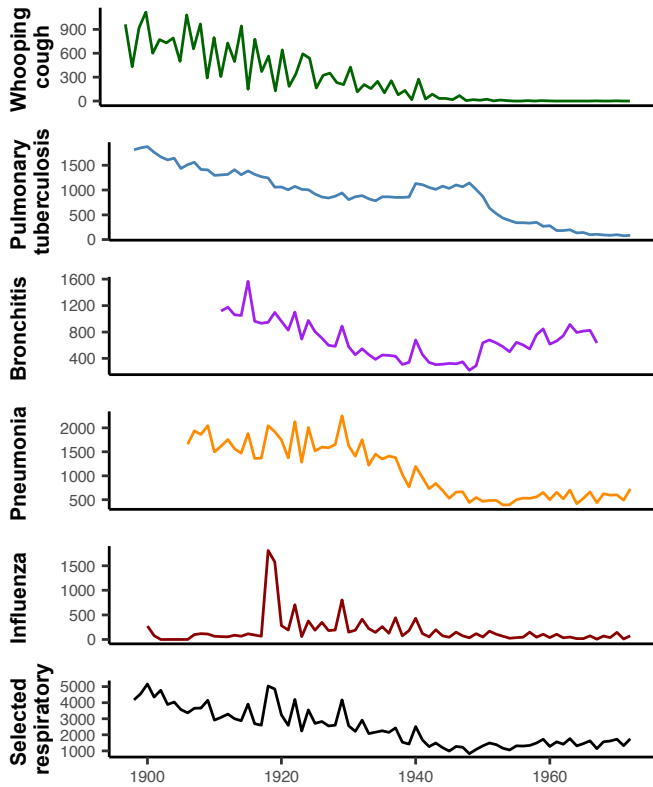
an increase in all-cause mortality of 90% for the first wave of the 1918-19 influenza pandemic (comparing 1918 Q4 with 1917 Q4), and an increase of 49% for COVID-19 (comparing 2020 Q2 with 2019 Q2).

### Infectious disease dynamics

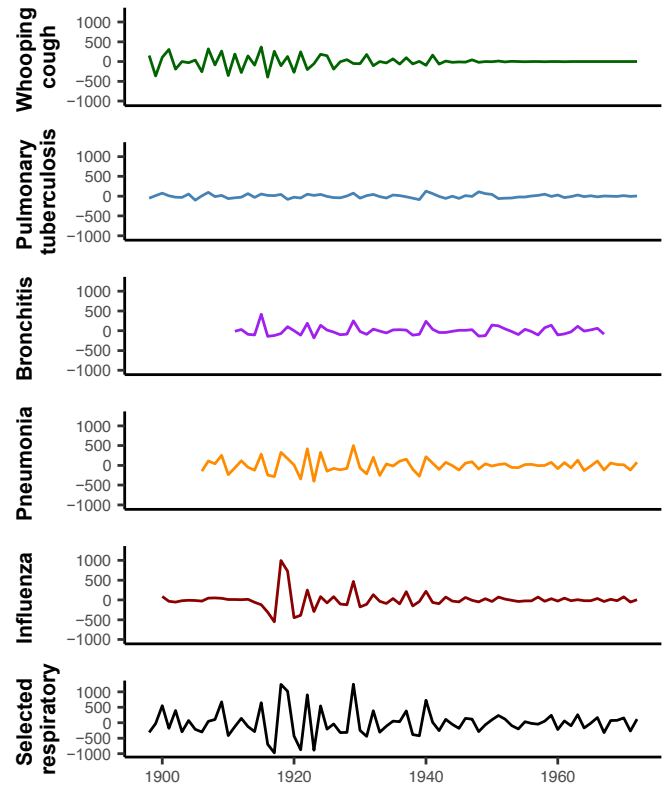
Figure 4 shows the dynamics of mortality rates associated with key respiratory diseases. Given the strong reduction in mortality rates over the 20<sup>th</sup> century, the magnitude and frequency of outbreaks are better evaluated by examining the de-trended time series. Therefore, Figure 5 shows fluctuations around the trend for each cause.<sup>viii</sup> The time series for whooping cough, pulmonary tuberculosis and pneumonia follow the general pattern of a reduction in both death rates and volatility over time<sup>ix</sup> seen in Figure 2, while bronchitis appears more erratic. In contrast, influenza shows a distinct pattern, which dominates the dynamics of the combined series of ‘selected respiratory diseases’, consisting of deaths from respiratory diseases other than whooping cough and pulmonary tuberculosis. Alongside influenza, this combined series predominantly reflects deaths from pneumonia and bronchitis<sup>x</sup>, both of which are potential outcomes of influenza (although other causes are possible).<sup>xi</sup>

The striking feature in Figures 4 and 5 are the time series of death rates from influenza (also reflected in ‘selected respiratory diseases’<sup>xii</sup>). Firstly, it is evident that the 1918-19 pandemic constitutes the largest increase in death rates above the trend since the beginning of the 20<sup>th</sup> century<sup>xiii</sup>. Secondly, the data reveal an interesting pattern in the medium-run dynamics of influenza mortality after the main 1918-19 pandemic waves. In particular, influenza kept resurfacing over the following two decades, with major outbreaks in 1922 and 1929, as also noted in the MOH reports. This effect is seen in the time series for influenza alone, as well as when combined with pneumonia and bronchitis. This volatility is in contrast to the more limited year-on-year variation in influenza mortality prior to 1918.

Increased post-pandemic volatility of influenza and the system of ‘selected respiratory diseases’ suggests that the pandemic strain (or related strains arising due to mutation) continued to circulate in the population, or influenced the dynamics of co-circulating respiratory infections that might have been recorded as influenza, and/or that survivors of the pandemic suffered chronic effects and later succumbed to related illnesses. Although a full investigation of the drivers of this dynamic pattern requires epidemiological analysis beyond the scope of this Briefing Note, the data suggest that the 1918-19 pandemic cast a long shadow.

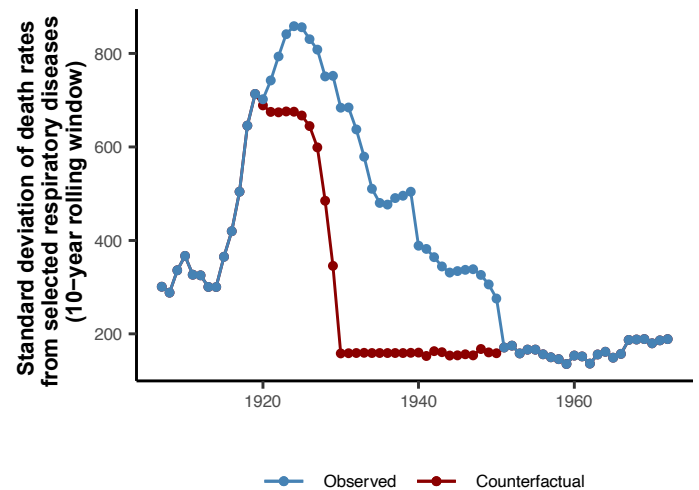


**Figure 4: Death rates per million from selected diseases.**



**Figure 5: Deviations from trend (of death rates per million) for selected diseases.**

Figure 6 shows a further analysis of the implications of the 1918-19 pandemic for the increased volatility in death rates and its persistence. Specifically, it shows the standard deviation (estimated from 10-year rolling windows) of the de-trended combined death rates from ‘selected respiratory diseases’<sup>xiv</sup>, contrasting the observed data with a counterfactual scenario in which the 1918-19 outbreak is treated as an isolated event without persistence.<sup>xv</sup> In the data, there is a clear increase in volatility that begins in 1918 and only returns to its pre-pandemic level at the beginning of the Second World War, reflecting heightened volatility throughout the 20-year period 1920-1939, not simply the 1918-19 spike. Comparing with the counterfactual scenario reveals that the increased volatility due to the direct effect of the 1918-19 outbreak would have only lasted for a much shorter period, and that volatility would have been highest around the original spike. Therefore, there was a 20-year period of increased volatility in death rates after the 1918-19 pandemic from respiratory diseases related to influenza.



**Figure 6: Standard deviation of de-trended death rates (observed and counterfactual); shaded area denotes the period of increased volatility.**

Overall, our results suggest that the 1918-19 influenza pandemic had a substantial impact on the lives of Glaswegians for over 20 years after the main 1918-19 pandemic via recurrent influenza outbreaks and co-movement with related causes of mortality, resulting in two decades of frequent outbreaks.

## Authors

Konstantinos Angelopoulos, Economics, Adam Smith Business School, University of Glasgow, UK and CESifo, Munich, Germany

Spyridon Lazarakis, Economics, Lancaster University, UK

Rebecca Mancy, Leckie Research Fellow, Social and Public Health Sciences Unit, University of Glasgow, UK

Max Schroeder, Economics, Adam Smith Business School, University of Glasgow, UK

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<sup>i</sup> The office of Medical Officer of Health was introduced in Glasgow in 1862 to monitor and improve public health in the city. For a short introduction see [here](#). For the MOH Reports visit the [Wellcome Trust website](#). Since the problem of comparability of causes of death across long time periods is well known (Alter and Carmichael, 1996), we aggregate more specific causes of death into broad categories which remain consistent over time.

<sup>ii</sup> *Infectious* diseases are those caused by a transmittable pathogen, such as a virus or bacterium. *Non-communicable* diseases are those where the main cause is probably genetic, physiological, environmental or related to lifestyle factors.

<sup>iii</sup> Potter (2001).

<sup>iv</sup> Ashton (2020).

<sup>v</sup> 1914 – 1919 MOH Report, page 55pp.

<sup>vi</sup> 1914 – 1919 MOH Report, page 7. The MOH reports provide annualised quarterly death rates, obtained by multiplying deaths in each quarter by 4 and dividing by annual population.

<sup>vii</sup> Mortality rates are compiled using Monthly Data on Births and Deaths Registered in Scotland (Table 3) from the [National Records of Scotland](#). Population data are taken from the [Scottish Government population estimates](#). We transformed the monthly data on deaths into annualised quarterly death rates by adding the monthly counts for each quarter, multiplying by 4, and dividing by population for the specific year.

<sup>viii</sup> We use a standard Hodrick-Prescott (HP) filter to isolate a flexible trend for each series (Ravn and Uhlig, 2002, Granados *et al.*, 2016). The results in Figures 4 and 5 are obtained using a penalty parameter of

6.25, but the patterns are similar if a higher parameter value, 100, is used instead.

<sup>ix</sup> An exception is the increased rate of deaths from pulmonary tuberculosis in the 1940s.

<sup>x</sup> Deaths from influenza, pneumonia and bronchitis constitute approximately 92% of the 'selected respiratory diseases' for the years where we have information on all three diseases.

<sup>xi</sup> Glezen (1996).

<sup>xii</sup> The co-movement of influenza with bronchitis and pneumonia in Figures 4 and 5 is stronger than with whooping cough and pulmonary tuberculosis (as well as measles, not shown).

<sup>xiii</sup> Another sizeable outbreak was that of measles in 1921. The deviation from trend caused by this was, however, smaller than for 1918-19 influenza.

<sup>xiv</sup> The results are similar if we only focus on influenza. For any given year, the 10-year window is defined as the 10 years prior to that year.

<sup>xv</sup> We randomly sampled (with replacement) from the post-1940 outcomes, when the mortality series is (approximately) stationary. We replaced the observations between 1920 and 1940 with these draws and re-calculated standard deviations. This procedure was repeated 1000 times and the average used as the counterfactual.