Inequalities in Regional Excess Mortality and Life Expectancy during the COVID-19 Pandemic in Europe

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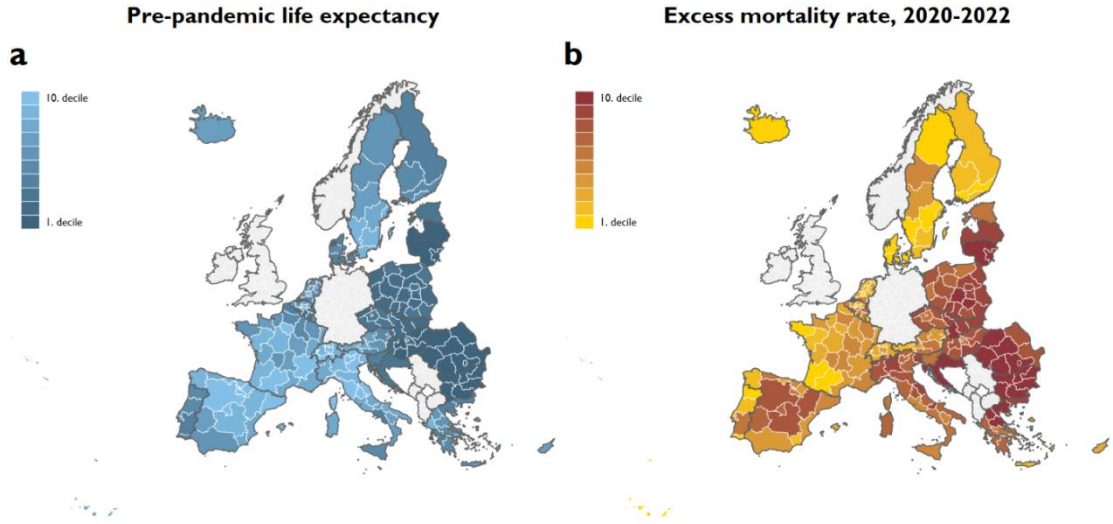
In the last few years, many empirical studies have examined the mortality burden of the COVID-19 pandemic and how it affected life expectancy. The differential impact of COVID-19 on mortality and life expectancy for disadvantaged and non-disadvantaged regions, countries, and individuals is also a popular topic in the literature. We add to this literature by examining the role of the population's health capital in the differences in excess mortality and change in life expectancy of the European regions. We consider health capital as something "that produces an output of healthy time"[1] and might make individuals more resilient to various health shocks. In the empirical analysis, we measured it by the average life expectancy in the pre-pandemic years (2015–2019) since it adequately reflects the differences in the overall health status of the European regions.

The novelty of our work is threefold. We present regional-level excess mortality for 201 NUTS 2 regions in Europe to measure the mortality burden of COVID-19 from the pandemic outbreak to the end of 2022. In addition, we analyze the regional association between health capital and COVID-19 excess mortality. Moreover, we reveal the changing inequalities in regional mortality by investigating the variance in life expectancy from 2019 to 2022.

Our empirical analysis was based on Eurostat's two publicly available datasets. The first is the number of weekly deaths by sex, five-year age group (from 0–4 to 90 years and older), and NUTS 2 region. The second is the population size by age, sex, and NUTS 2 region on January 1 each year. We used data for 2015–2022 and restricted the analysis sample to the countries of the European Union and the European Free Trade Association. Three countries (Germany, Ireland and Norway) were excluded due to technical issues. To calculate excess mortality, we used a time-series regression with fixed effects. The relationships between excess mortality and pre-pandemic life expectancy were estimated using OLS regressions.

Figure 1: Regional distribution of pre-pandemic life expectancy and excess mortality



The average pre-pandemic (2015-2019) life expectancy varied significantly between NUTS 2 regions in Europe, ranging from 73.7 to 84.6. Figure 1a highlights an East-West divide, with regions in France, Spain, Italy, and Switzerland falling into the highest decile and those in Bulgaria, Romania, Latvia, Lithuania, and Hungary the lowest decile of pre-pandemic life expectancy. The excess death toll from the COVID-19

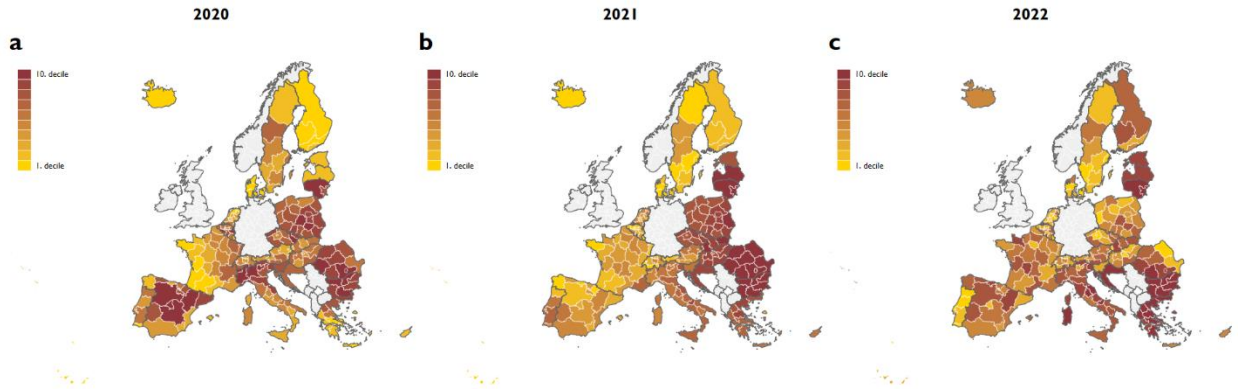
[1] Grossman, M. On the Concept of Health Capital and the Demand for Health. Journal of Political Economy 80, 223–255 (1972).

pandemic also showed significant regional variation (Figure 1b). Most regions with excess mortality rates in the top deciles were in Central and Eastern Europe. However, extremely high excess mortality rates were also observed in some Mediterranean regions.

Variation between countries accounted for 92% of the total variance in regional pre-pandemic life expectancy, indicating that country-level institutional, environmental, and behavioral factors greatly affect the expected lifespan of the population. Nevertheless, intra-country variation was also remarkable. Similarly, national factors were responsible for 81% of the overall variation in excess mortality per million population, but the role of the regional differences was noteworthy, too.

The regional pattern in excess mortality rate changed considerably throughout the different phases of the pandemic (Figure 2). The East-West divide was observed only in 2021, which accounts for 39% of total excess deaths between 2020 and 2022 in our sample of 201 European NUTS 2 regions. In 2020, high excess mortality rates were observed in several high-income regions in addition to some eastern regions. In 2022, the spatial pattern in excess mortality rate was less clustered, although many regions in Greece, Bulgaria, and the Baltic states had high excess mortality rates.

Figure 2: Excess mortality rate deciles by year.

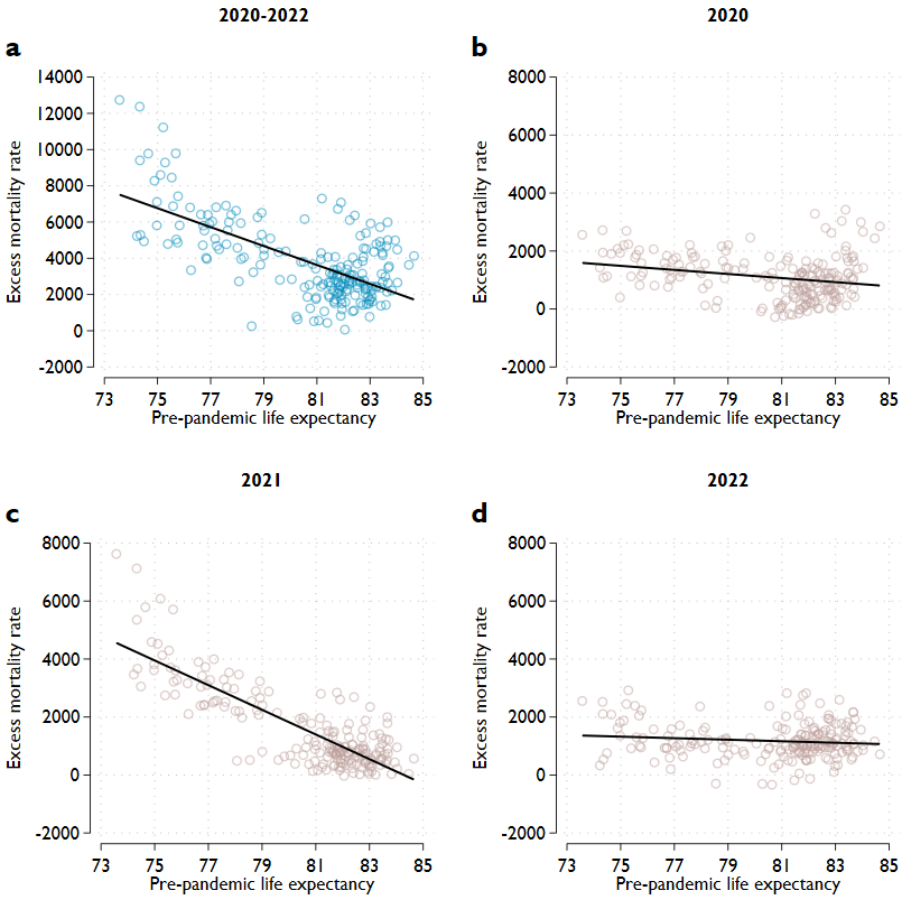


While there is a clear negative relationship between pre-pandemic regional life expectancy and excess mortality rate for the whole period (Figure 3), there are significant differences between years. Excess mortality and pre-pandemic life expectancy were slightly negatively correlated in 2020, which can be explained by the fact that the distribution of COVID-19 excess mortality in the first period was mainly driven by the spread of infection. This phase can be considered an external "random" shock. The contributions of all other factors, such as the age structure, the inhabitant's health status, the level of health services, and the efficiency of state protection, were comparatively lower.

The correlation between excess mortality and pre-pandemic life expectancy became strongly negative in 2021, indicating an increasing role of health capital after the shock. Pre-pandemic life expectancy alone explained 69% of the regional variation in excess mortality rates, and according to the result of the regression estimations, a lower one-year pre-pandemic life expectancy was associated with 425 more excess deaths per million inhabitants. This impact is considerable given that the average excess death per million population was 3,807 across regions during the pandemic. These results suggest that those factors defining health capital (pre-pandemic mortality) may have shaped the distribution of COVID-19 excess mortality. Therefore, factors such as health status, lifestyle, nutrition, health infrastructure, and access to healthcare services that shape life expectancy in a given region in "normal" times (i.e., health capital) may also have a crucial role in vulnerability to a pandemic.

However, as we move into 2022, the relationship between life expectancy and excess deaths disappears. It is worth emphasizing that these changes coincided with the moderation of the pandemic. While there were countries where excess mortality still spiked for a while afterwards, the overall intensity of the pandemic declined significantly after the first quarter of 2022. These results are robust to different calculations of the excess mortality rates, and we see similar patterns for males and females.

Figure 3: Excess mortality rates as a function of pre-pandemic life expectancy.



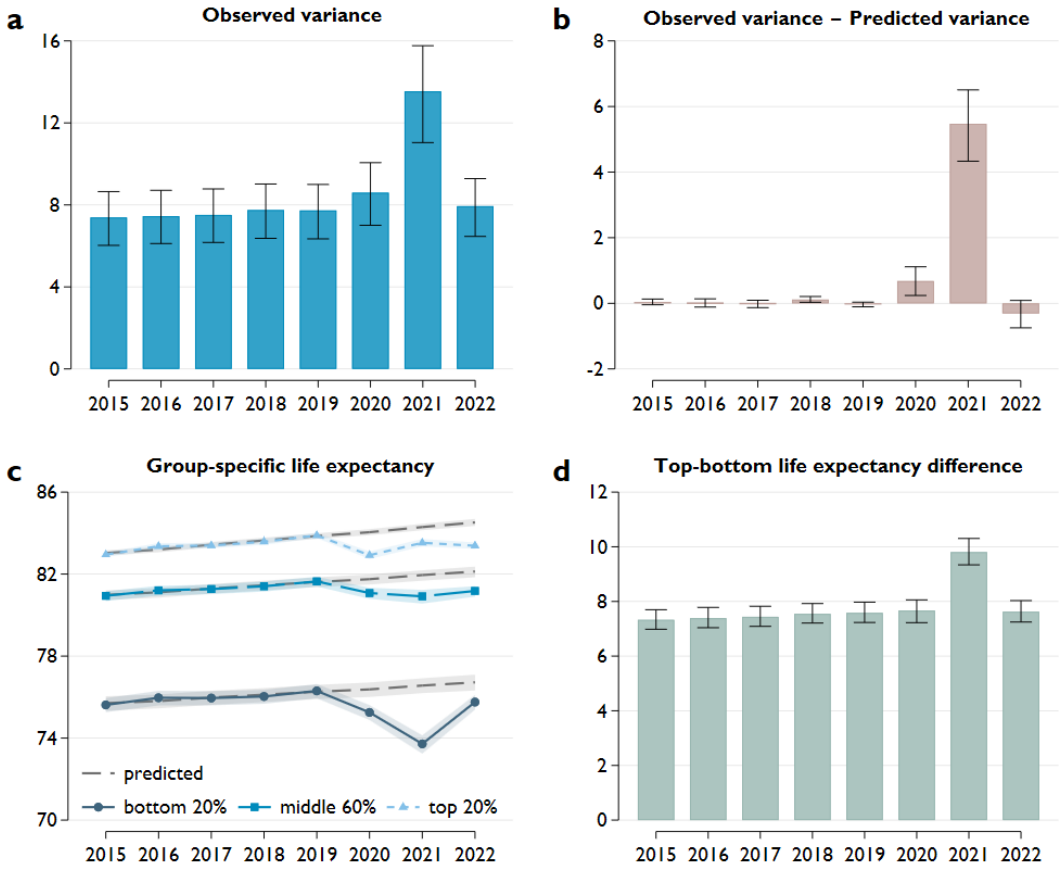
The changing relationship between pre-pandemic life expectancy and excess mortality, especially the strong negative association between them in 2021, raises the issue of changing differences in regional mortality. In the years before the pandemic, a moderate increase in life expectancy was generally observed in the surveyed regions. Average regional life expectancy slowly improved from 80.3 years in 2015 to 81.0 years in 2019. When the pandemic hit Europe, this indicator fell to 80.3 in 2020 and decreased further to 80.0 in the following years. Our data show a clear rebound in 2022 when average life expectancy almost reached 80.5 years.

However, from the perspective of regional differences, the change in the variance of life expectancy is more relevant. This indicator was relatively stable over five years before the pandemic, ranging between 7.4 and 7.7 (Figure 4a). The outbreak of the pandemic brought remarkable changes. The variance increased slightly to 8.6 in 2020 and jumped to 13.5 in 2021 but fell back to 7.9, around the pre-crisis level, in 2022. These results suggest that the pandemic significantly increased the regional differences in life expectancy in 2021 and to a smaller extent in 2020.

The difference between the observed and predicted variance was calculated to identify the contribution of the pandemic to the change in the variance of regional life expectancy. The latter was derived from a projection using mortality rates from 2015 to 2019. This calculation showed that the pandemic increased the variance in life expectancy by 5.5 in 2021 (Figure 4b), corresponding to a 68% increase over the predicted variance. It also means that the regional differences in life expectancy would have stayed around the pre-pandemic level without the emergence of COVID-19. The difference between the observed and

predicted variances indicates a significantly small positive impact of the pandemic in 2020, while its effect was effectively zero in 2022.

Figure 4: Variance in life expectancy.



It is worth breaking down the changes in the regional variance of life expectancy to determine which part of the distribution has undergone a major adjustment. The observed and predicted life expectancies are presented separately for the countries in the top 20%, bottom 20%, and middle 60% according to their position in a rank of the pre-pandemic life expectancy (Figure 4c). Focusing on 2021, when the variation in regional life expectancy jumped, there are remarkable differences between the three groups. The countries in the bottom 20% experienced a reduction in life expectancy of 2.8 years, much larger than the reductions of 0.8 and 1 year for the top 20% and middle 60%, respectively. This finding indicates that the increase in differences arose from the higher mortality of countries initially with lower life expectancy (health capital). The overall reduction in life expectancy was much lower in 2020 and 2022, with a smaller variance. A similar picture emerges if we focus on the life expectancy gap between the countries with the highest and lowest pre-pandemic life expectancies (Figure 4d). In the last step, we broke down the variance in life expectancy into between-country and within-country parts, and our results indicate that while a large part of the increase in total variance is caused by increasing between-country differences, within-country variation also contributed to it significantly.

The lesson to be learned from our results is that regions with lower health capital face greater risks in case of future global health shocks. The greater vulnerability of areas with lower life expectancy increases the inequality in health conditions. If the shock permanently reduces life expectancy, inequalities may continue to increase.