Spatial, Cause-Specific and Seasonal Effects of Excess Mortality Associated with the COVID-19 Pandemic: The Case of Germany, 2020–2022

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ABSTRACT

Since the beginning of the COVID-19 pandemic, only few studies on excess mortality have considered both cause-specific and sub-national differences. Located at the intersection of the European north-south and east-west gradients of (excess) mortality, Germany represents a fascinating context for such detailed analysis, as the German example might provide implications for the overall European pattern.

Our analyses rely on official cause-of-death statistics consisting of 7.74 million individual death records reported for the German population during 2015–2022. We conduct differential mortality analyses by age, sex, cause, month and district (N=400), using decomposition and standardisation methods, comparing each strata of the mortality level observed during 2020–2022 with its expected value.

Our results show remarkable spatial differences to the disadvantage of the south of eastern Germany in both 2020 and 2021. Excess mortality in the most affected districts is driven widely by older ages and deaths reported during the second wave, particularly from COVID-19 but also from cardiovascular and mental diseases. In 2022, however, the spatial pattern completely changed with the northwest showing the highest levels of excess mortality, while the east widely experienced a rise again in life expectancy.

Our results for 2020 and 2021 suggest that increased psychosocial stress influenced the outcome of excess mortality in the most affected areas during the second wave of the pandemic. Cause-specific and seasonal data for 2022 will become available by March 2024 and will help us understand the fundamentally changed pattern of excess mortality.

KEYWORDS

COVID-19, excess mortality, causes of death, regional differences, decomposition, life expectancy, Europe, Germany

BACKGROUND

Excess mortality has varied considerably across Europe over the course of the pandemic (EUROMOMO 2023). Despite these remarkable differences, most studies on excess mortality widely remained on the surface analysing all-cause mortality or conducting spatial regressions that do not imply causal relationships, and, thus, being rather speculative. Located at the intersection of the European north-south and east-west gradients of excess mortality, Germany represents a fascinating context for an in-depth study, as it widely mirrored the European pattern on the sub-national level (Bonnet et al. 2023). Therefore, detailed analyses of German data by region, cause of death, season, age and sex might allow conclusions beyond the German context.

Germany as a whole experienced three consecutive years of decline in life expectancy after 2019. In total, life expectancy at birth decreased from 81.3 in 2019 to 80.7 in 2022 in Germany (for both sexes combined). A decline in this magnitude had not happened in post-war Germany since the late 1960s

(Eurostat 2023). As Germany seemed to get so well through the first wave of the pandemic, the more pronounced mortality increases from the second wave onwards were unexpected and reached a lot of international attention (e.g. Van Noorden 2022).

First sub-national analyses for Germany showed that excess mortality in 2020 and 2021 was widely concentrated in regions that are in close proximity to hot spots in Czechia and Poland, particularly to the disadvantage of the south of eastern Germany (e.g. BiB 2022, 2023; Kolobova et al. 2023; Mühlichen et al. 2023). In 2022, the European pattern changed considerably, however, with the east of Europe widely showing rising levels of life expectancy again, which is also true for eastern Germany (BiB 2023).

The question as to which age groups and which causes of death determined these patterns and changes on a smaller spatial level and what we can conclude from that, is not only of great relevance for German policy makers and the German public but for an international audience as well.

DATA AND METHODS

Based on the official German population and mortality statistics, we first estimated life expectancy at birth for Germany's 16 federal states and decomposed the differences in 2020, 2021 and 2022 compared to 2015–2019 into the contributions of selected age groups. After extensively reconstructing the current administrative borders for previous years, we were able for the first time to measure mortality trends from 1992–2022 on the level of 400 harmonized spatial units ('Kreise'). We calculated life expectancy trends from 1992–2022 and standardised mortality ratios for 2020–2022. In addition, based on the German individual-level cause-of-death statistics consisting of 7.74 million individual death records reported for the German population during 2015–2022, we measured cause-specific standardised death rates (SDRs) from 1992–2021 (2022 forthcoming) for these regions (results not shown here). Using the ratios of cause-specific SDRs (each pandemic year divided by 2015–2019)[1], we identified spatial hot spots and cold spots by Getis-Ord Gi* statistic (not shown in this abstract). These analyses allow us to identify the spatial clusters of elevated mortality and disentangle the effects of age and cause contributions. We will be the first to show such detailed long-term regional and cause-specific results for Germany.

RESULTS

Figure 1 shows that the older age groups from 65 upwards contributed most to excess mortality in those regions affected by life expectancy losses, at least among men. In 2021, however, also the younger age groups – men in particular – experienced a rise of mortality in many states. For 2022, our analyses are not yet completed.

Figure 2 shows that the hot spots of excess mortality in 2020 (panel *a*) were primarily located at the southeastern border in close proximity to Czechia and Austria, whereas the coastal regions in the north of Germany were least affected. Excess mortality in the most affected regions is widely connected with increased rates in cardiovascular, mental/behavioural/nervous, respiratory and – most pronouncedly – other diseases including COVID-19. This pattern is true for both men and women.

Having a closer look on the cause-specific SDRs in 2020, the difference to 2015–2019 in the most affected counties was driven widely by the onset of COVID-19, whereas this disease was rarely diagnosed as cause of death in the 40 least affected counties (not shown in this figure). Regarding the age distribution, additional analyses reveal that 94% of all COVID-19 deaths in 2020 were recorded at ages 65 and older.

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[1] We chose the 5-year period from 2015 to 2019 as our baseline to account for annual fluctuations, which are high on a small spatial level. We declined the option to estimate artificial baselines, i.e. to project the level of mortality in 2020 and 2021 that would have occurred without the onset of the Corona pandemic, because such approaches get increasingly insecure on a smaller regional level, especially when causes of death are considered. Furthermore, we are more interested in the spatial differences than on the 'right' level of excess mortality.

While the pattern in 2020 was quite diverse spatially, with high heterogeneity even within federal states, there is a clearer geographical gradient for 2021, to the disadvantage of the east. This east-west divide in all-cause mortality is widely driven by COVID-19-related mortality (and slightly by mental/behavioural/nervous diseases). For Germany in total, the number of deaths from COVID-19 almost doubled in 2021 compared to 2020 (from approx. 40,000 to 70,000).

Figure 1: Life expectancy differences in the German federal states between a) 2020 and 2015/2019 and between b) 2021 and 2015/2019 decomposed into the contributions of selected age groups

a) 2020
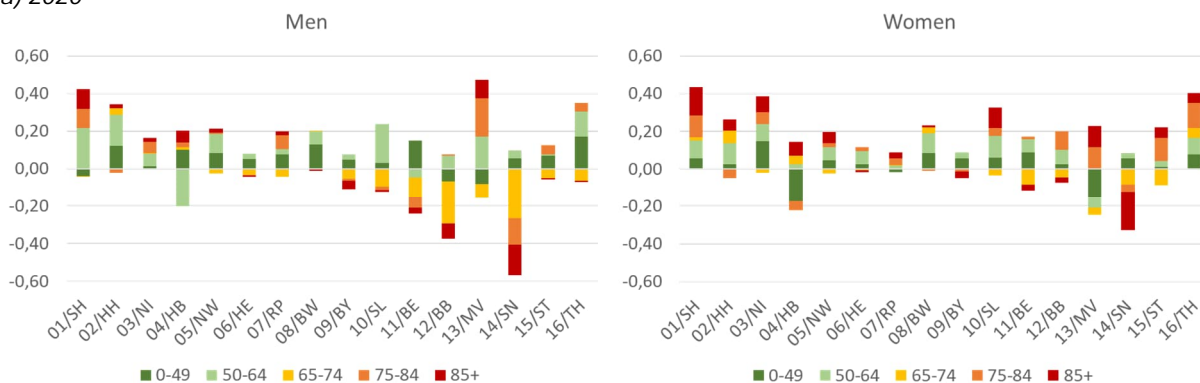
b) 2021
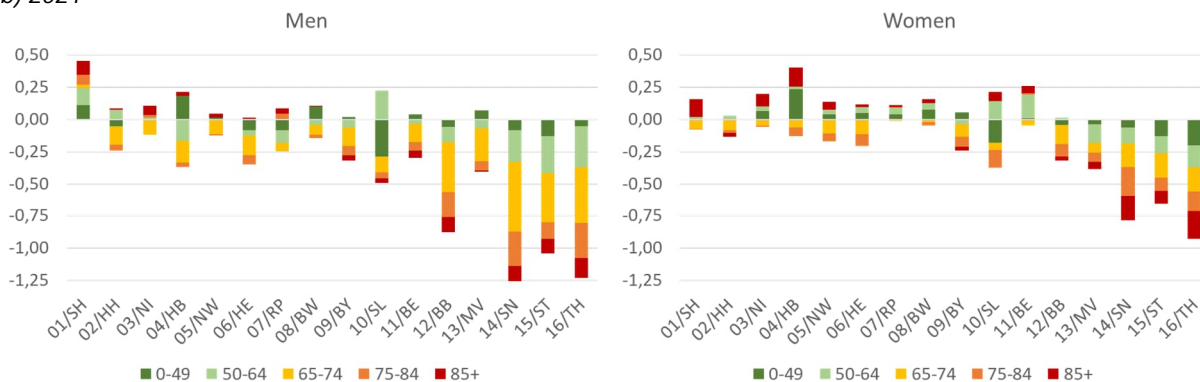
01 - Schleswig-Holstein (SH)
02 - Hamburg (HH)
03 - Niedersachsen (NI)
04 - Bremen (HB)
05 - Nordrhein-Westfalen (NW)
06 - Hessen (HE)
07 - Rheinland-Pfalz (RP)
08 - Baden-Württemberg (BW)
09 - Bayern (BY)
10 - Saarland (SL)
11 - Berlin (BE)
12 - Brandenburg (BB)
13 - Mecklenburg-Vorpommern (MV)
14 - Sachsen (SN)
15 - Sachsen-Anhalt (ST)
16 - Thüringen (TH)

Data source: Statistical offices of the German federal states; authors' calculations.

CONCLUSIONS AND OUTLOOK

Our preliminary results show that excess mortality in 2020 and 2021 was mostly concentrated in the south of eastern Germany and connected with older age groups and COVID-19. However, we also found that the most affected areas experienced elevated mortality from mental/behavioural and cardiovascular diseases in late 2020 until spring 2021, thus hinting at an increased level of psychosocial stress caused by the spread of the virus and/or the implementation of policy measures (lockdown and social distancing) to combat it. The geographical variation of population composition with regard to health-related resilience might play a role in this context.

At EPC 2024, we will also show the seasonal variations and cause-of-death patterns by age and sex as well as long-term trends from 1992 onwards. The German individual-level cause-of-death statistics for 2022 will become available by March 2024, perfectly in time for the conference. These data will help us understand the fundamentally changed pattern of excess mortality in 2022, affecting mostly the northwest of Germany, which was rather spared in previous years by comparison with other German regions. Overall, our results will allow us to draw conclusions for health policies, e.g. with regard to the handling of the COVID-19 pandemic and the collection of relevant data.

Figure 2: Spatial variation of excess mortality across 400 German districts by selected causes; SDR ratios; both sexes combined

a) 2020
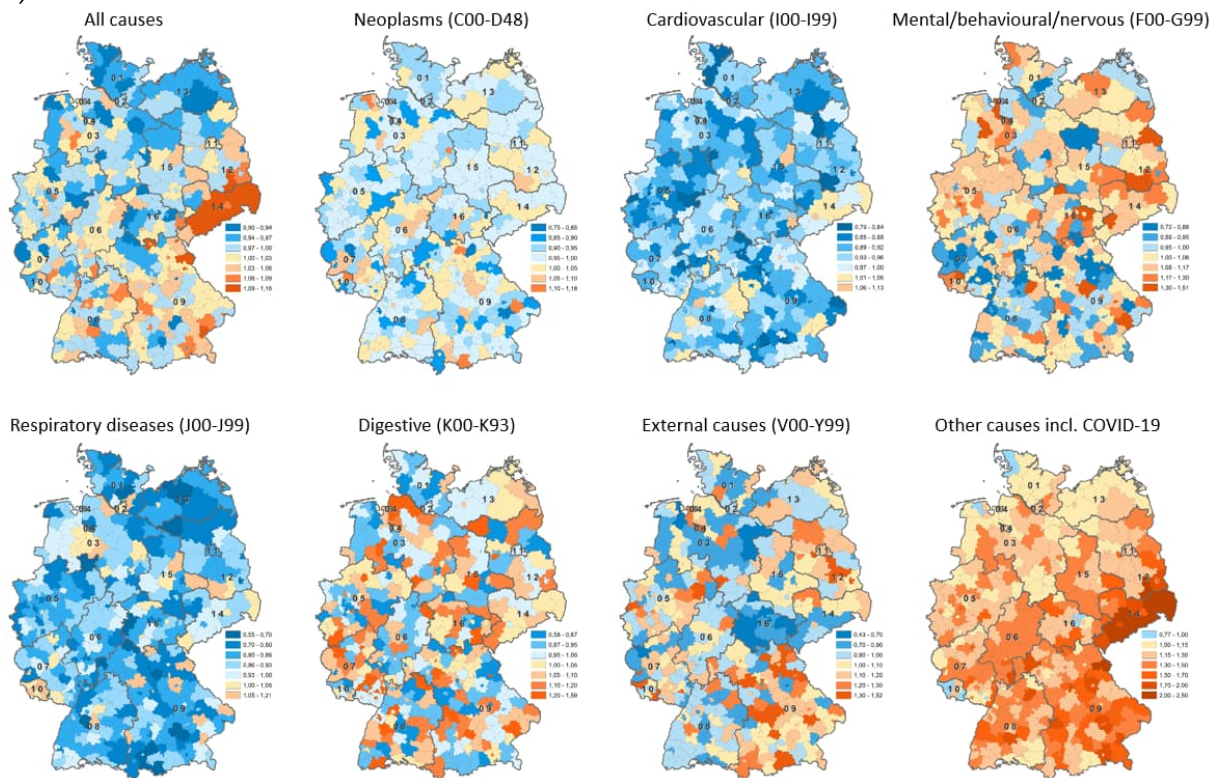
b) 2021
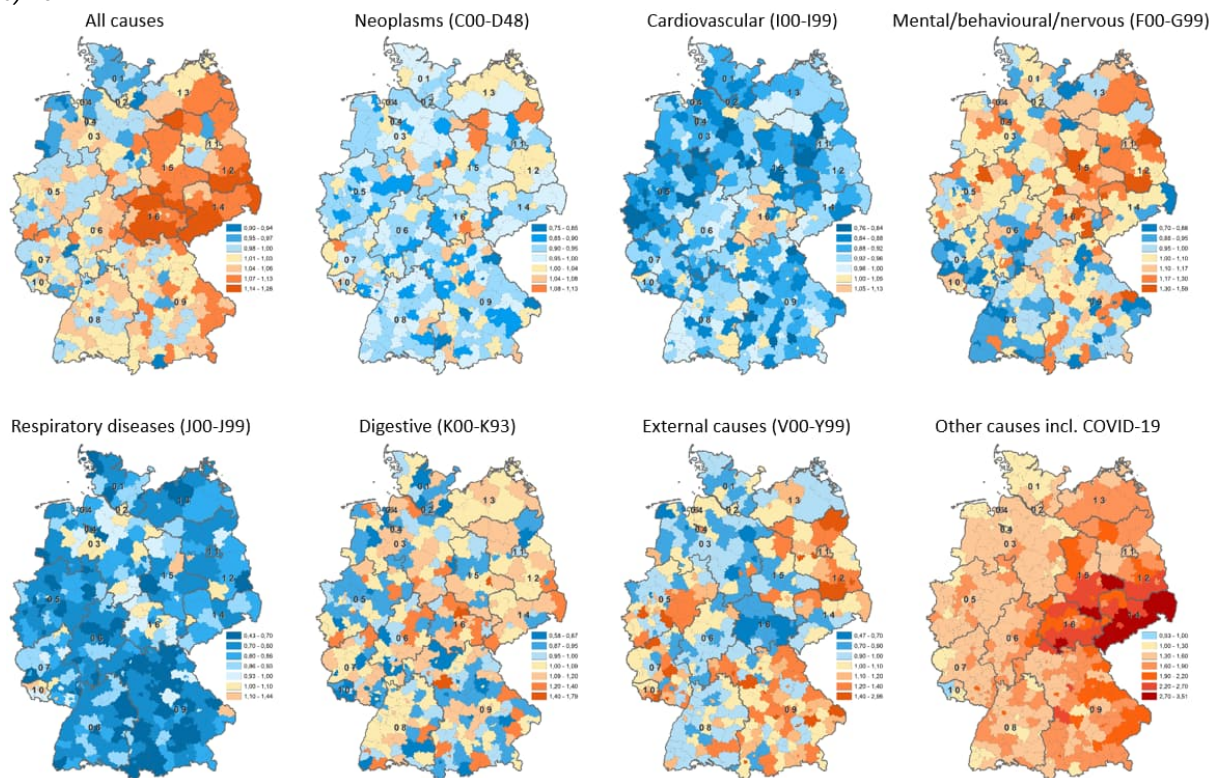
Data source: Statistical offices of the German federal states; authors' calculations; base map: © BKG.

REFERENCES

BiB (2022): [Corona pandemic: Life expectancy decreased considerably in parts of Germany]. Press Release, 17 August 2022. Wiesbaden: Federal Institute for Population Research. Available online: https://www.bib.bund.de/DE/Presse/Mitteilungen/2022/2022-08-17-Corona-Pandemie-Lebenserwartung-in-Teilen-Deutschlands-stark-gesunken.html (Accessed 31 October 2023).

BiB (2023): [Life expectancy in 2022 under pre-pandemic level in all German federal states]. Press Release, 6 September 2023. Wiesbaden: Federal Institute for Population Research. Available online: https://www.bib.bund.de/DE/Presse/Mitteilungen/2023/2023-09-06-Lebenserwartung-2022-in-allen-Bundeslaendern-unter-Vorpandemieniveau.html (Accessed 31 October 2023).

Bonnet F. et al. (2023): Spatial variation in excess mortality across Europe: A cross-sectional study of 561 regions in 21 countries. medRxiv (preprint). https://doi.org/10.1101/2023.04.04.23284990

EUROMOMO (2023): European mortality monitoring. Graphs and maps. https://www.euromomo.eu/graphs-and-maps (Accessed 31 October 2023).

Eurostat (2023): Life expectancy by age and sex (demo_mlexpec). Eurostat database of the European Commission. https://ec.europa.eu/eurostat/web/main/data/database (Accessed 31 October 2023).

Kolobova M et al. (2023): Variation in mortality burden of the COVID-19 pandemic across federal states in Germany. *European Journal of Public Health* (online first). https://doi.org/10.1093/eurpub/ckad110.

Mühlichen M, Sauerberg M, Grigoriev P (2023): Evaluating Spatial, Cause-Specific and Seasonal Effects of Excess Mortality Associated with the COVID-19 Pandemic: The Case of Germany, 2020. *Journal of Epidemiology and Global Health* (online first). https://doi.org/10.1007/s44197-023-00141-0

Van Noorden R (2022): COVID death tolls: scientists acknowledge errors in WHO estimates. Researchers with the World Health Organization explain mistakes in high-profile mortality estimates for Germany and Sweden. *Nature* 606: 242–244. https://doi.org/10.1038/d41586-022-01526-0