Area-level excess mortality in times of COVID-19 in Switzerland: geographical, socioeconomic and political determinants

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[Supplementary text S1](file:///C:\Users\maegger\Downloads\10_redistribute-model_nostrat.html#data)

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# Abstract

The COVID-19 related excess mortality in Switzerland is well documented, but no study examined mortality at the small-area level. We analysed excess mortality in 2020 for 2,141 Swiss municipalities using a Bayesian spatio-temporal model fitted to 2011-2019 data. Areas most affected included the Ticino, the Lake of Geneva region, the Jura and the Northeast. Rural areas, areas with international borders, areas of lower socioeconomic position and areas with less support for control measures in the popular vote on the COVID-19 Act had greater excess mortality. Municipalities that are particularly vulnerable require special efforts to mitigate the impact of pandemics.

# Key points

* Small-area excess mortality varied substantially in Switzerland in 2020, depending on the geographical location and type of municipality.
* Areas most affected included the Ticino, the Lake of Geneva region, the Jura and the Northeast of the country.
* Rural municipalities, municipalities of lower socioeconomic position and showing lower support for COVID-19 control measures experienced higher excess mortality.
* Public health interventions targeted at vulnerable municipalities, including testing and vaccination campaigns, could mitigate the impact in these areas in future pandemics.

# Introduction

Excess all-cause mortality is central to assessing the impact of the COVID-19 pandemic. Its estimation relies on predicting the expected number of deaths in a given population from historical data. In previous work the level of spatial granularity has varied, from country to the municipal level,1–3 with some studies exploring associations between excess mortality and area characteristics.1,4 We estimated excess mortality at the municipal level for the year 2020 in Switzerland and explored associations with characteristics of municipalities, such as level of urbanisation, vicinity of international borders, socioeconomic position and voting behavior in a referendum on COVID-19 control measures.

# Methods

We obtained data on all-cause deaths for the years 2011–2020 from the Federal Statistical Office (FSO), aggregated by week, canton (26 levels), age group (40–59, 60–69, 70–79 and 80 and older) and sex.5 Data on ambient temperature were obtained from the ERA5 reanalysis data set of the Copernicus climate data.6

We predicted the expected number of deaths for each week by canton, age group and sex using a Bayesian spatio-temporal model fitted to data from 2011-2019.7 The model accounted for long-term, seasonal and spatial trends in mortality, for ambient temperature, for public holidays and for changes in population size. Next, we aggregated the results from week to year. Last, we downscaled the expected number of deaths from the cantonal to the 2,141 Swiss municipalities by randomly sampling from a multinomial distribution with weights corresponding to the observed distribution of deaths. We then computed the yearly absolute excess mortality by age, sex and municipality by subtracting the expected from the observed number of deaths. We averaged results over 50 posterior samples of municipality-level excess mortality to ensure uncertainty propagation.

We explored associations with absolute excess mortality using a model where , the number of observed deaths during week in municipality , age group and sex group , depends on the number of expected deaths based on historical data multiplied by a log-linear predictor (with intercept , design matrix and parameter vector ). We followed an iterative approach by progressively adding complexity to (see Supplementary material). The models included intercepts for age and sex groups and the spatial autocorrelation across municipalities.8 Variables included language region (German, Italian or French), urbanisation level (rural, peri-urban, urban9), presence of an international border (yes versus no), socioeconomic position (quintiles of the median Swiss neighbourhood index, which is based on rent, household head education and occupation, and crowding10), and results from the June referendum on the COVID-19 Act11 (quintiles of yes votes supporting control measures). Models were implemented in R-INLA.12

# Results

We observed 74,776 deaths in people aged 40 and older, compared to an expected 55,676 deaths (95% credible interval: 53,865 to 57,821), for a relative increase in excess mortality of 34% (29% to 39%). The population and observed deaths in municipalities ranged from xxx to xxx, and xx to xx, respectively. Excess mortality varied across age and sex, with higher absolute excess in older age groups and men. Areas most affected included the Ticino, the Lake of Geneva region and the Jura. Cities in the German-speaking area (Zurich, Basel and Bern) and mountainous regions of the Grison were less affected than other cities and areas (Figure 1A, Supplementary material).

In univariable analysis, municipalities in Italian- (1.17; 95% CrI 1.22-1.22) and French-speaking regions (1.09; 95% CrI 1.07-1.12) had higher excess mortality than the German-speaking regions (Figure 1B). Urban (relative excess mortality 0.94; 95% CrI 0.92-0.96), and semi-urban (0.97; 95% CrI 0.94-0.99) areas had lower excess than rural areas whereas municipalities with international borders were more affected (1.04; 95% CrI 1.01-1.07). Excess mortality was higher in municipalities of lower socioeconomic position (1.07; 95% CrI 1.04-1.11 comparing first with fifth quintile) and higher in municipalities with less support for COVID-19 control measures (1.05; 95% CrI 1.01-1.08 comparing first with fifth quintile of yes votes).

A multivariable model including urbanisation, international border status, socioeconomic position and the COVID-19 referendum results was used to produce a map that adjusted for these variables (Figure 1C). In addition to the patterns seen on the crude map, the adjusted map included an area of comparatively higher excess mortality in the Northeast of the country.

# Discussion

This study mapped the 2020 COVID-19 excess mortality in Switzerland for 2,141 municipalities. We confirmed that areas in the Ticino and the Romandie had higher excess mortality than other regions. We identified regions in the Jura and the Northeast that were more affected than their surroundings and found that the cities in the German-speaking region of the country were impacted less than those in the other language regions. Several municipality-level characteristics were associated with excess mortality in univariable analyses. Urban and semi-urban municipalities were less affected than rural areas, and municipalities sharing international borders, of lower socioeconomic position and with lower support for COVID-19 control measures experienced higher excess mortality.

In Switzerland’s direct democracy, citizens can initiate referenda on various issues. During the pandemic, there were vigorous debates on COVID-19 restrictions, such as lockdowns, mask mandates, and vaccination campaigns. The COVID-19 Act,11 which came into force in September 2020 and regulates special powers of the Federal Council to combat COVID-19, was put to a referendum in June 2021. The Swiss thus became the only people in the world voting on public health measures to control COVID-19. The Act was accepted overall with a majority of 60%, but support for the COVID-19 control measures was lower in rural areas and municipalities of lower socioeconomic position.

The present study found that lower support for the COVID-19 Act was also associated with greater excess mortality in 2020. The ecological nature of the explanatory variables analysed and the collinearity between some of these variables precludes causal interpretation. Nevertheless, the higher excess mortality in municipalities of lower socioeconomic position is supported by an individual-level analysis of the COVID-19 epidemic in Switzerland 2020-2021, which showed that people living in areas of lower socioeconomic position were less likely to get tested but more likely to test positive for COVID-19, admitted to hospital and die compared with those living in areas of higher socioeconomic position. The association became stronger along the care continuum, from test positivity to hospitalisation and death.7 The greater excess mortality in areas of lower socioeconomic position and rural areas might reflect higher risks of SARS-CoV-2 infection at work and home, with more unprotected contact with others. The more negative attitude towards COVID-19 control measures may also have played a role.

The international spread of COVID-19 will have affected the geographical patterns observed in our study. The early epidemic in northern Italy and then France led to introductions in south and south-west Switzerland, which probably explains the higher excess mortality in the Italian- and French-speaking regions compared to German-speaking Switzerland. Cultural differences between the language regions, which some commentators and media outlets put forward at the time, probably played a minor role.

Strengths of this study include the national coverage and completeness of the mortality data. Another strength is using the recently updated Swiss neighbourhood index of socioeconomic position, which has criterion validity and is based on data from more than 1 million households.10 In conclusion, public health interventions targeted at vulnerable municipalities, including testing and vaccination campaigns, could mitigate the impact in these areas in future pandemics.

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# References

1 Brandily P, Brébion C, Briole S, Khoury L. A poorly understood disease? The impact of COVID-19 on the income gradient in mortality over the course of the pandemic. *Eur Econ Rev* 2021;140:103923.

2 Blangiardo M, Cameletti M, Pirani M, Corsetti G, Battaglini M, Baio G. Estimating weekly excess mortality at sub-national level in Italy during the COVID-19 pandemic. *PLoS One* 2020;15:e0240286.

3 Acosta RJ, Patnaik B, Buckee C, et al. All-cause excess mortality across 90 municipalities in Gujarat, India, during the COVID-19 pandemic (March 2020-April 2021). *PLOS Glob Public Health* 2022;2:e0000824.

4 Bertoli S, Guichard L, Marchetta F. Turnout in the Municipal Elections of March 2020 and Excess Mortality During the Covid-19 Epidemic in France. *IZA Institute of Labour Economics Discussion Papers Series* 2020;IZA DP No. 13335:1–20.

5 Konstantinoudis G, Cameletti M, Gómez-Rubio V, et al. Regional excess mortality during the 2020 COVID-19 pandemic in five European countries. *Nat Commun* 2022;13:482.

6 Hersbach H, Bell B, Berrisford P, et al. The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society* 2020;146:1999–2049.

7 Riou J, Hauser A, Fesser A, Althaus CL, Egger M, Konstantinoudis G. Direct and indirect effects of the COVID-19 pandemic on mortality in Switzerland. *Nat Commun* 2023;14:90.

8 Riebler A, Sørbye SH, Simpson D, Rue H. An intuitive Bayesian spatial model for disease mapping that accounts for scaling. *Stat Methods Med Res* 2016;25:1145–65.

9 Office FS. Spatial divisions. URL https://www.bfs.admin.ch/bfs/en/home/statistiken/querschnittsthemen/raeumliche-analysen/raeumliche-gliederungen.html Accessed 1 September 2023.

10Panczak R, Berlin C, Voorpostel M, Zwahlen M, Egger M. The Swiss neighbourhood index of socioeconomic position: update and re-validation. *Swiss Med Wkly* 2023;153:40028.

11SR 818.102 - Federal Act of 25 September 2020 on the Statutory Principles for Federal Council Ordinances on Combating the COVID-19 Epidemic (COVID-19 Act). URL https://www.fedlex.admin.ch/eli/cc/2020/711/en Accessed 15 September 2023.

12Rue H, Martino S, Chopin N. Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations. *J R Stat Soc Ser B-Stat Methodol* 2009;71:319–92.

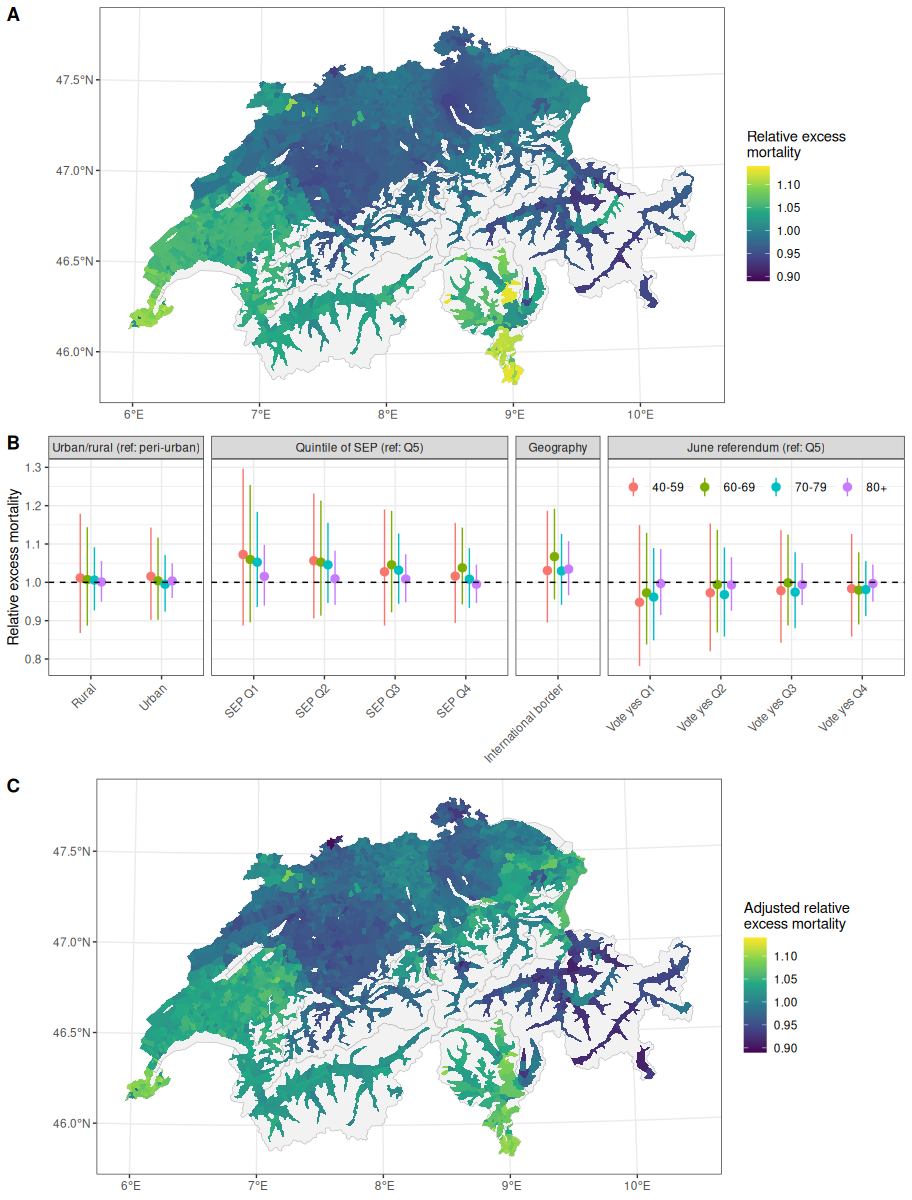


Figure 1. Municipality-specific relative excess mortality in 2020 (A). Influence of municipality-level characteristics on excess mortality (B). Municipality-specific relative excess mortality in 2020 adjusted for municipality-level characteristics.