VARIATION IN BURDEN OF COVID-19 PANDEMIC ACROSS THE FEDERAL STATES IN GERMANY: THE ROLE OF REPORTED COVID-19 MORBIDITY AND SELECTED STRUCTURAL FACTORS

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MONITORING OF COVID-19 PANDEMIC (1/5)

"Weekly excess deaths could provide the most objective and comparable way of assessing the scale of the pandemic and formulating lessons to be learned. [...] Crucially, the counts would be of deaths by all causes combined, thus side-stepping issues of what is or is not a death attributable to COVID-19."

Leon et al. 2020

Leon, D. A., Shkolnikov, V. M., Smeeth, L., Magnus, P., Pechholdová, M., & Jarvis, C. I. (2020). COVID-19: a need for real-time monitoring of weekly excess deaths. *The Lancet*, *395*(10234), e81.

MONITORING OF COVID-19 PANDEMIC (2/5)

Contributions to changes in life expectancy at birth from 2019 to 2020 attributable to official COVID-19 deaths and remaining causes of death (Aburto et al. 2022).

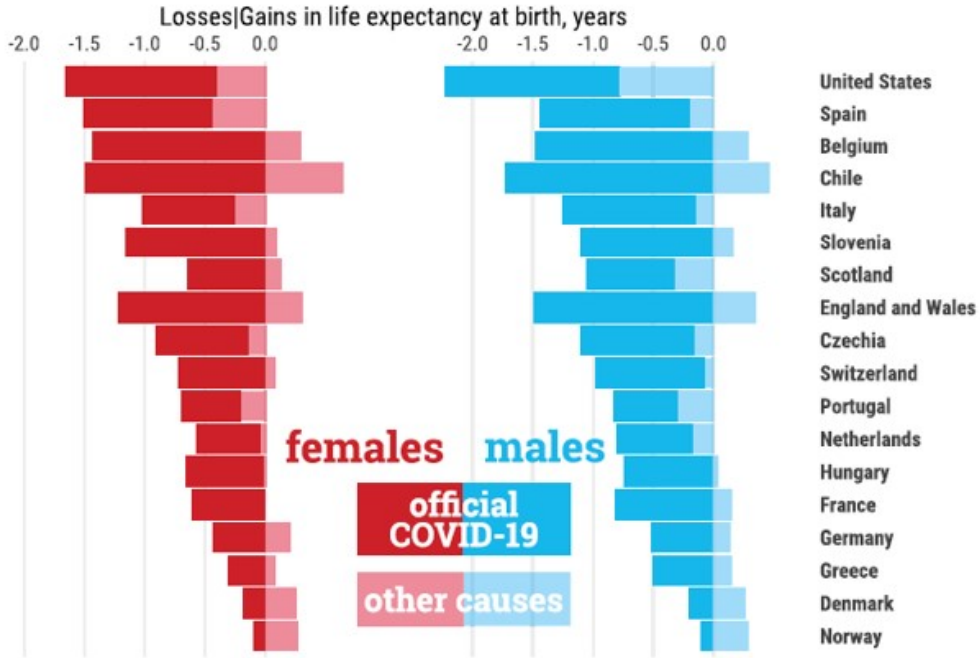
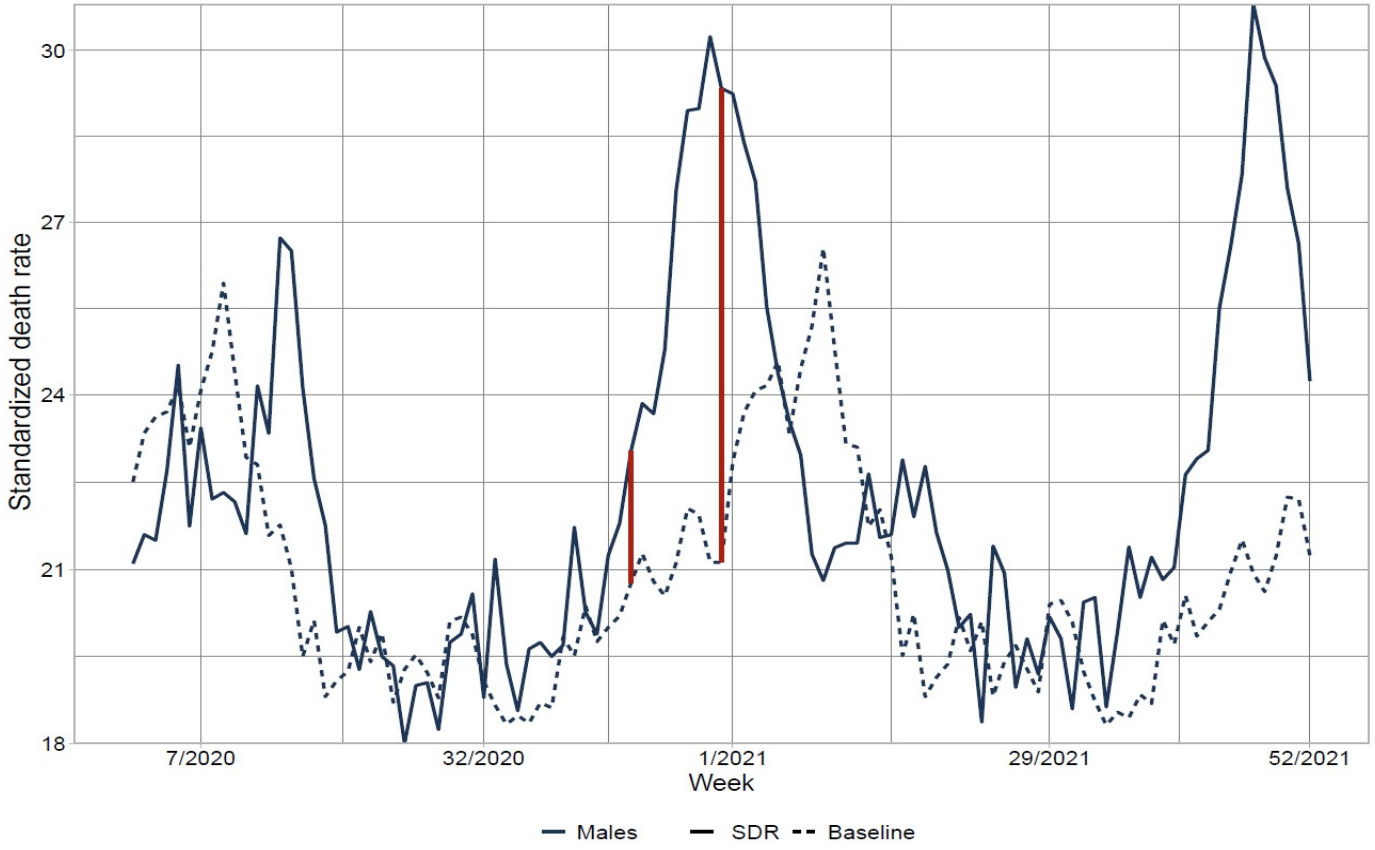


Figure 5 Contributions (in years) to changes in life expectancy at birth from 2019 to 2020 attributable to official COVID-19 deaths and remaining causes of death. Countries are sorted from largest to smallest losses. The sum of both components adds to the total change from 2019 to 2020 in a given country. All data points are provided in a table in Supplementary File 3, available as Supplementary data at *IJE* online .

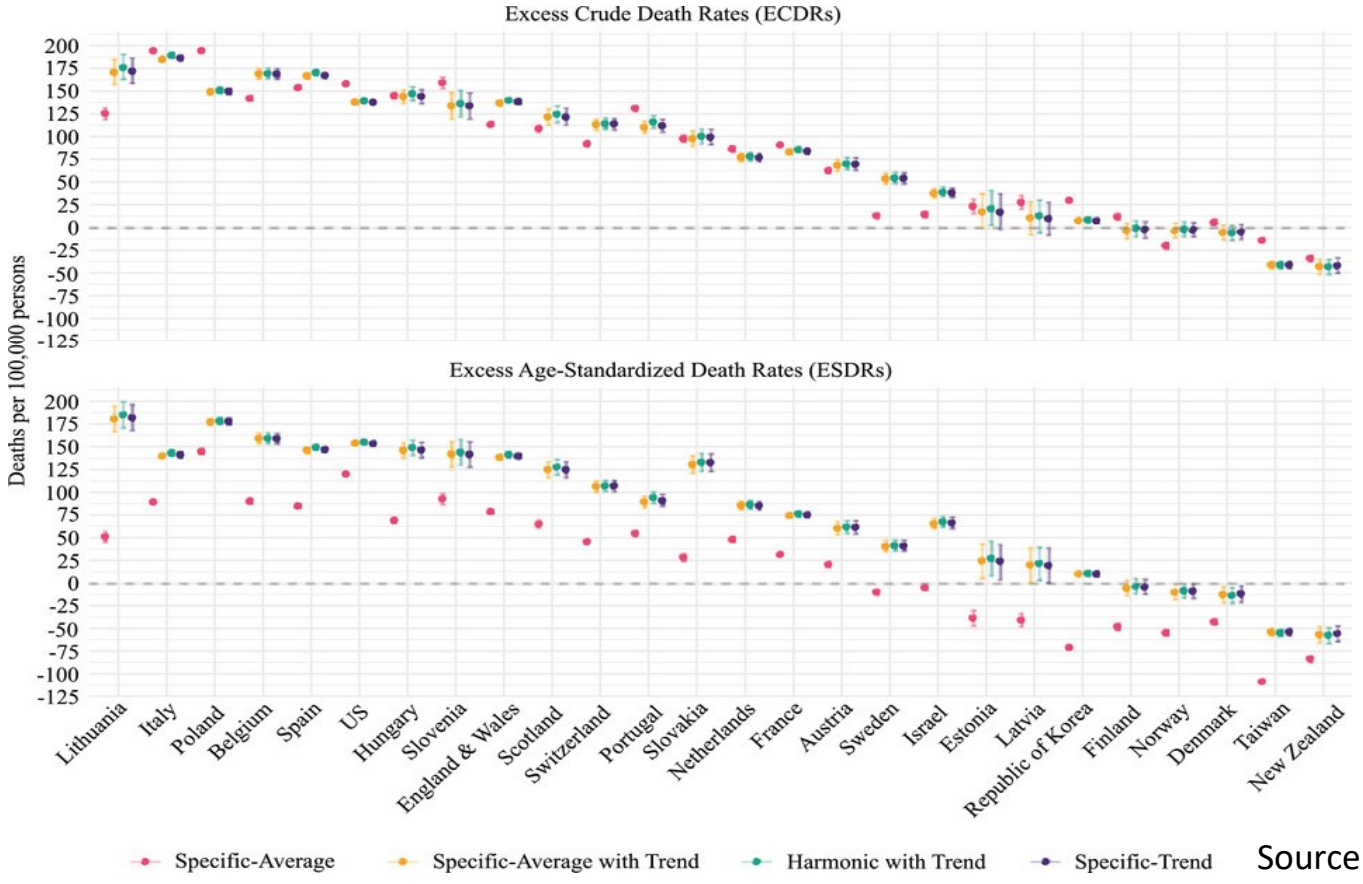
MONITORING OF COVID-19 PANDEMIC (3/5)

Estimation of excess mortality as a difference between observed and expected mortality levels.



MONITORING OF COVID-19 PANDEMIC (4/5)

Sensitivity analysis of excess mortality estimation.



Source: Nepomuceno et al. (2022)

MONITORING OF COVID-19 PANDEMIC (5/5)

HMD
Human Mortality Database
HMD Twitter: User's Guide:

Country or region
Germany

Target year
2021

Show other years

Measure
Death Rate, Total

Sex
Total Female Male

Reference period
Continuous Multi-year

Reference years
2000 2010 2019 2022

Reference level
Week-specific Trends

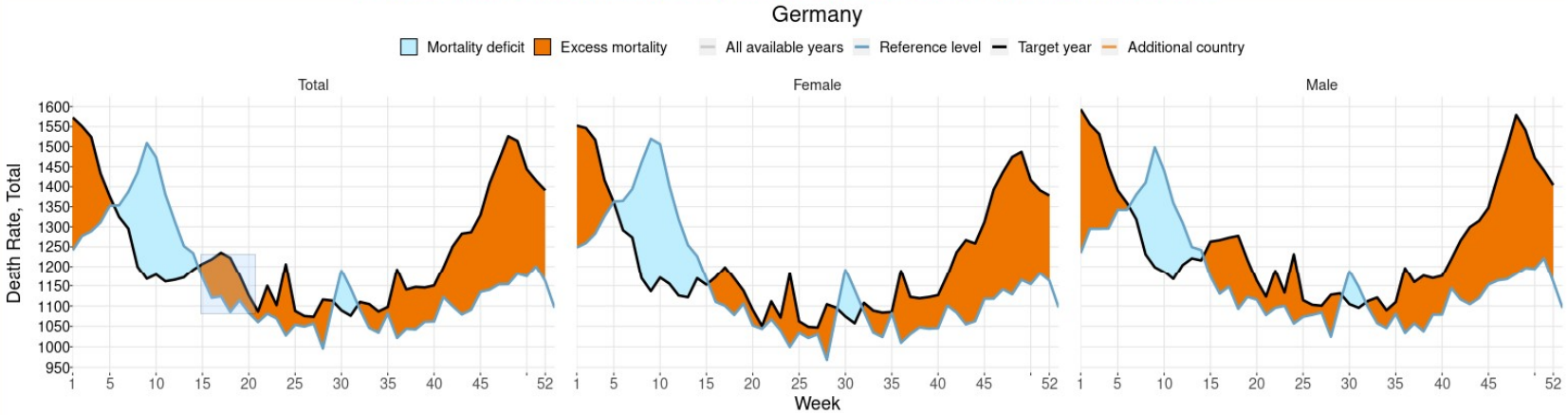
Additional country or region

Data:
XLSX CSV Note Meta

MAX PLANCK INSTITUTE FOR DEMOGRAPHIC RESEARCH Berkeley UNIVERSITY OF CALIFORNIA

Short-term Mortality Fluctuations

The most recent update is: 2022-03-28
The project's website: Human Mortality Database www.mortality.org hmd@mortality.org
This online data repository was supported by the Volkswagen Foundation (Volkswagen Stiftung) in the framework of the supported project on "Strengthening a reliable evidence base for monitoring the COVID-19 and other disasters"
Data descriptor article DOI: 10.1038/s41597-021-01019-1
Research article DOI: 10.1371/journal.pone.0246663 || UX/UI and public GitHub repository by László Németh
Data for the last available weeks is preliminary and may be incomplete, please refer to the country-specific metadata for details.



Summary statistics
The selection in Germany is between weeks 15 and 20 for the year 2021 compared to the period of 2010-2019.

Sex	Difference	Average Death Rate	Average, Target	Average, Reference	ADR/Reference (%)
Total	Excess mortality	81.54	1197.52	1115.98	7.31
Female	Mortality deficit	-15.14	1152.27	1167.41	-1.30
Female	Excess mortality	64.05	1153.20	1089.15	5.88
Male	Excess mortality	112.77	1243.09	1130.32	9.98

Clicked point information

Source: HMD 2022.
https://www.mortality.org

STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (1/6)

Estimated excess mortality at the national level (Kontis et al. 2021).

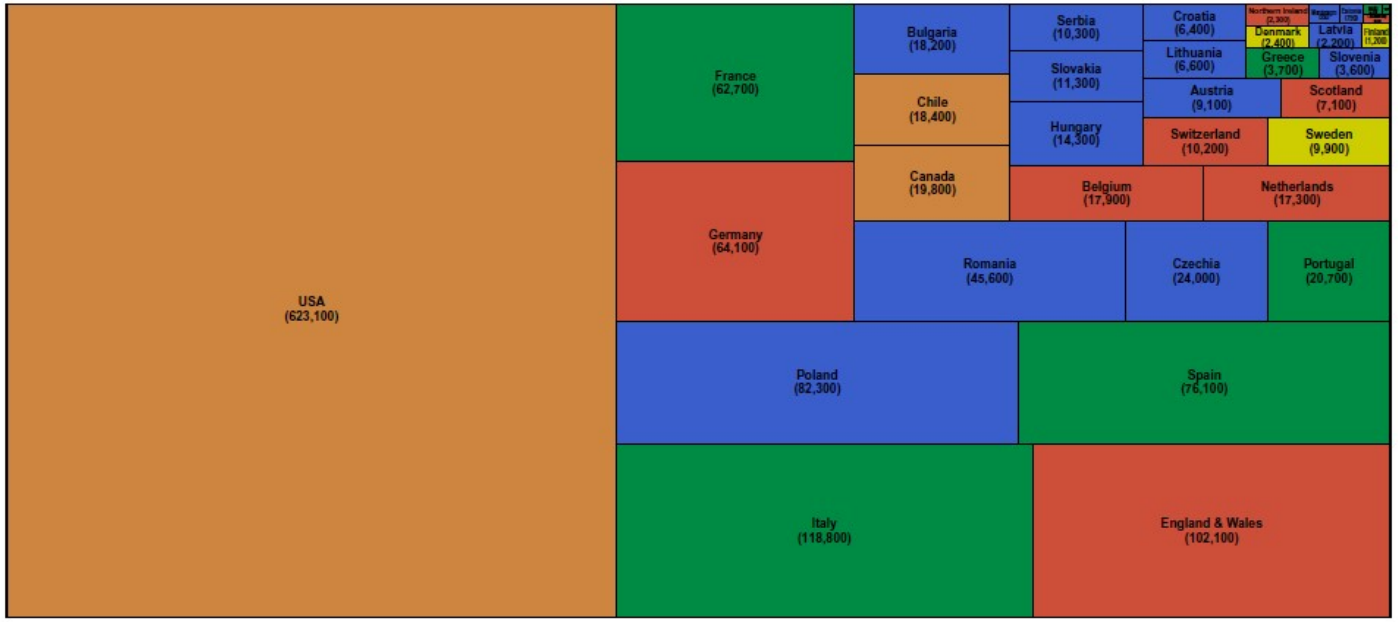


Figure 1. Number of excess deaths due to the first year of the coronavirus disease 2019 (COVID-19) pandemic by country. The size of each rectangle shows the number of deaths from all causes in excess of what would be expected if there had been no COVID-19 pandemic from mid-February 2020 through mid-February 2021 for each country. There are no segments for Australia, New Zealand, Norway, Iceland and South Korea because we estimated no detectable excess deaths or a potential reduction in mortality compared to the no-pandemic baseline. Colour for each country indicates its geographical region: the Pacific (Australia, New Zealand, South Korea), the Americas (Canada, Chile, the USA), Central and Eastern Europe (Austria, Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia), Southwestern Europe (Cyprus, France, Greece, Italy, Malta, Portugal, Spain), Northwestern Europe (Belgium, England and Wales, Germany, Luxembourg, the Netherlands, Northern Ireland, Scotland, Switzerland) and Nordic (Denmark, Finland, Iceland, Norway, Sweden).

STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (2/6)

Estimated excess mortality at the subnational level of the USA (Kontis et al. 2021)

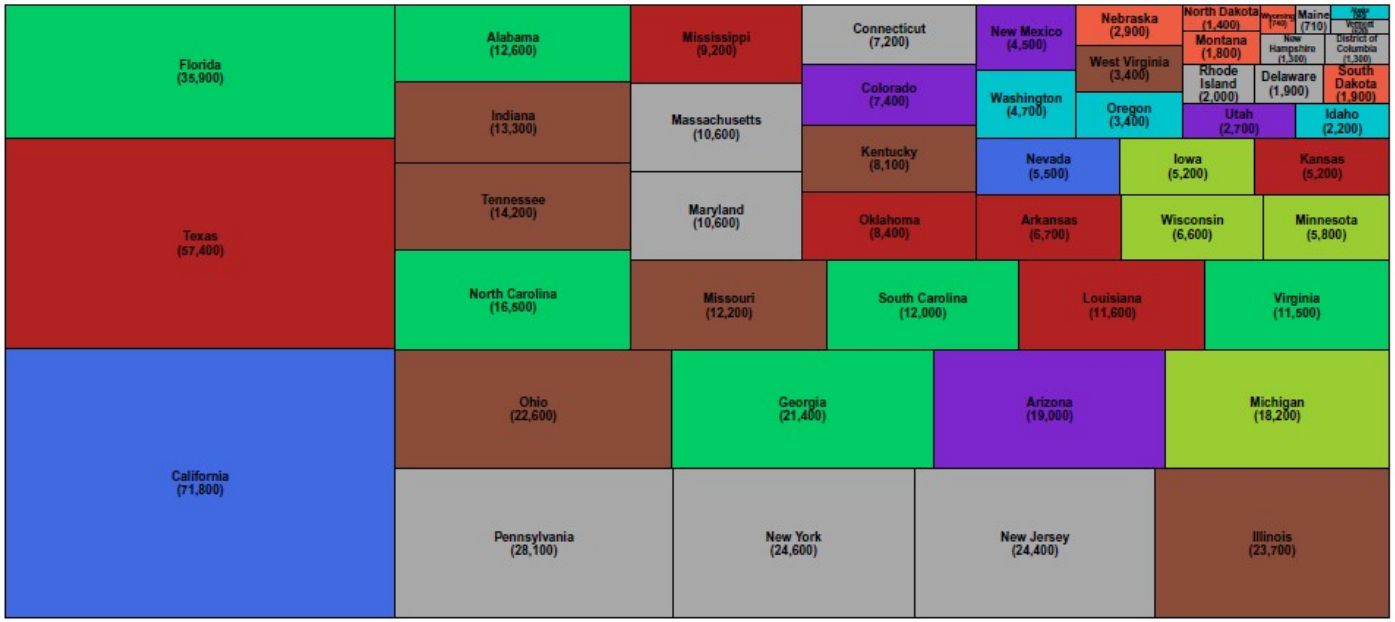
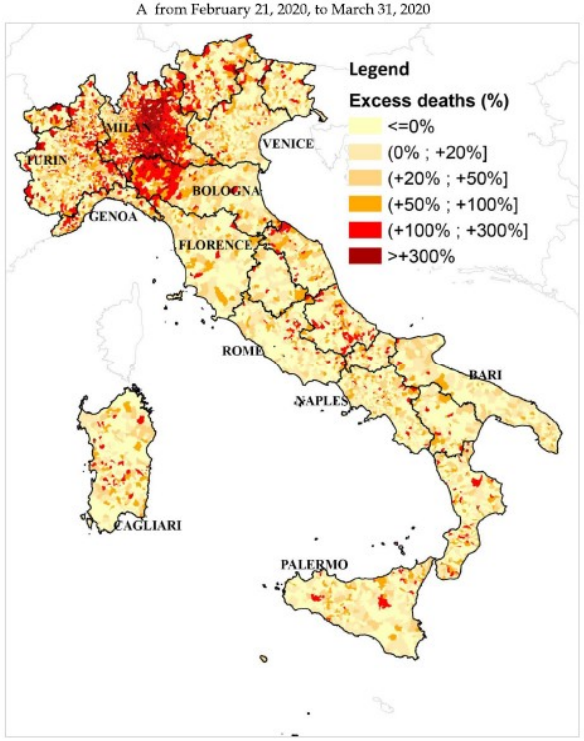


Figure 2. Number of excess deaths due to the first year of the coronavirus disease 2019 (COVID-19) pandemic by US state. The size of each rectangle shows the number of deaths from all causes in excess of what would be expected if there had been no COVID-19 pandemic from mid-February 2020 through mid-February 2021 for each state and the District of Columbia. There is no segment for Hawaii because we estimated no detectable excess deaths. The colour of each state indicates its geographical region: Southeast (Alabama, Florida, Georgia, North Carolina, South Carolina, Virginia); Northwest (Alaska, Idaho, Oregon, Washington); Southwest (Arizona, Colorado, New Mexico, Utah); South (Arkansas, Kansas, Louisiana, Mississippi, Oklahoma, Texas); West (California, Nevada); Northeast (Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont); Central (Illinois, Indiana, Kentucky, Missouri, Ohio, Tennessee, West Virginia); East North Central (Iowa, Michigan, Minnesota, Wisconsin); and West North Central (Montana, Nebraska, North Dakota, South Dakota, Wyoming).

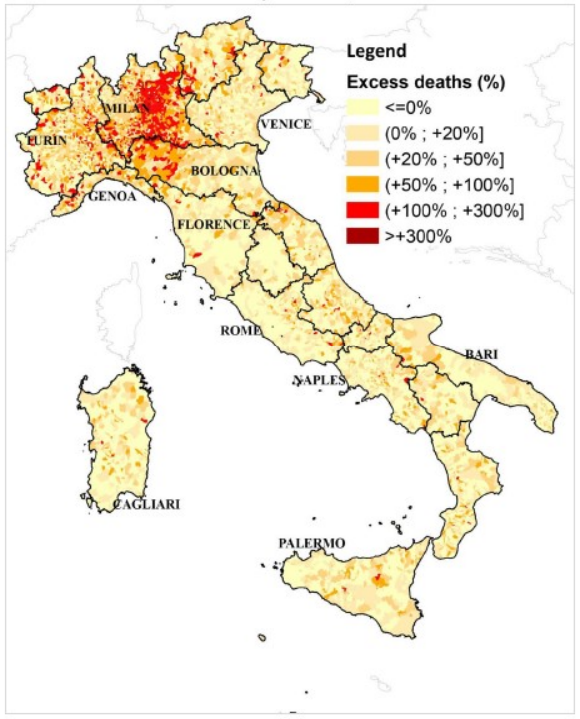
STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (3/6)

Estimated excess mortality at the subnational level of Italy (Cerqua et al. 2021).

A from February 21, 2020, to March 31, 2020



B from February 21, 2020, to June 30, 2020



C from February 21, 2020, to September 30, 2020

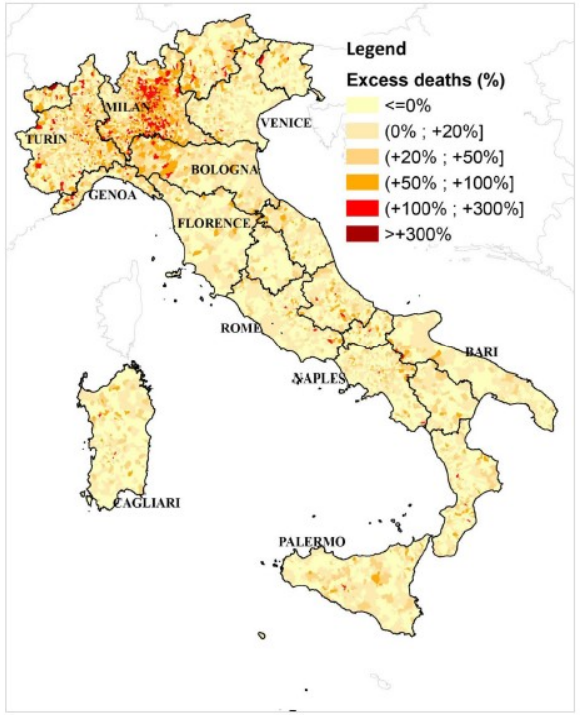


Fig. 1 Percentage of municipal excess deaths detected from February 21, 2020, to September 30, 2020, with respect to the counterfactual scenario estimated via ML techniques. **A** From February 21, 2020, to March 31, 2020 (note: excess mortality estimates for the north of Italy, 23,603; official number of COVID-19 deaths, 11,011. Gap between these estimates on March 31, 12,592). **B** From February 21, 2020, to June 30, 2020 (note: excess mortality estimates for the north of Italy, 40,001; official number of COVID-19 deaths, 29,752. Gap between these estimates on June 30, 10,249). **C** From February 21, 2020, to September 30, 2020 (note: excess mortality estimates for the north of Italy, 39,362; official number of COVID-19 deaths, 30,580. Gap between these estimates on September 30, 8,782)

Fig. 1 (continued)

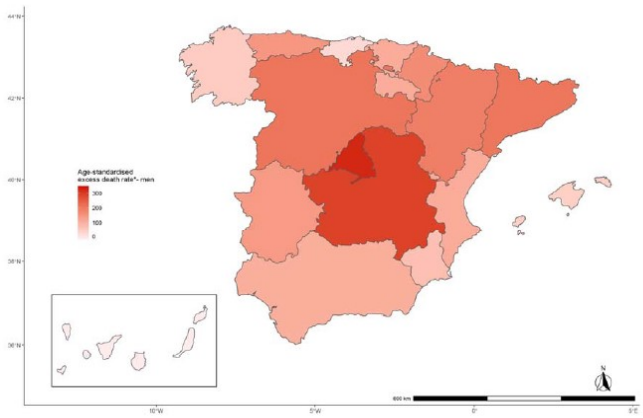
Fig. 1 (continued)

STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (4/6)

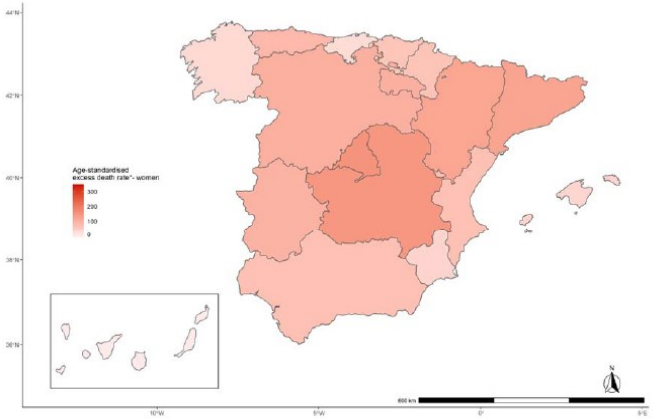
Estimated excess mortality at the subnational level of Spain (Islam et al. 2021).

Figure 3: Age-standardised excess death rates in Spanish regions in 2020-2021

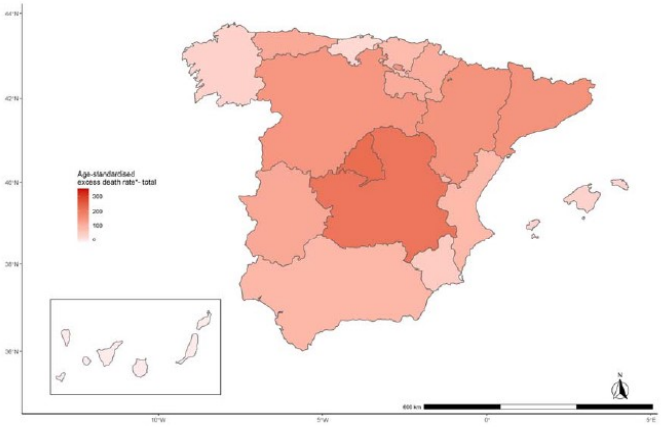
3(A): Men



3(B): Women



3(C): Total



STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (5/6)

Estimated excess mortality at the subnational level of Sweden (Fonseca-Rodriguez et al. 2021, Kolk et al. 2022).

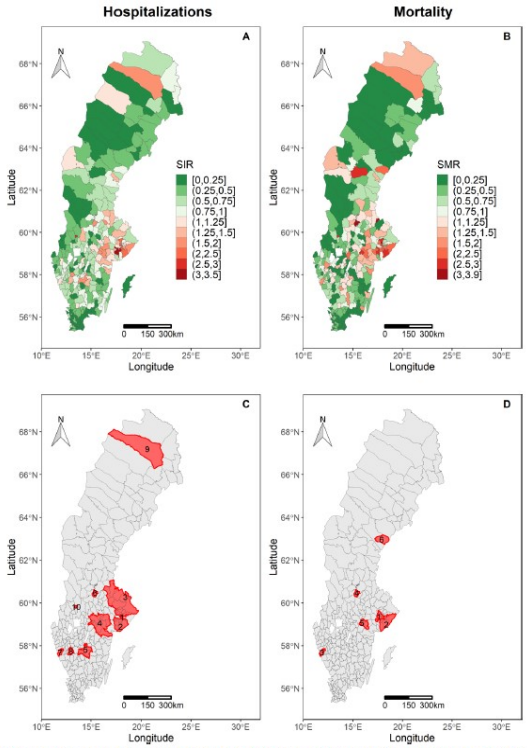
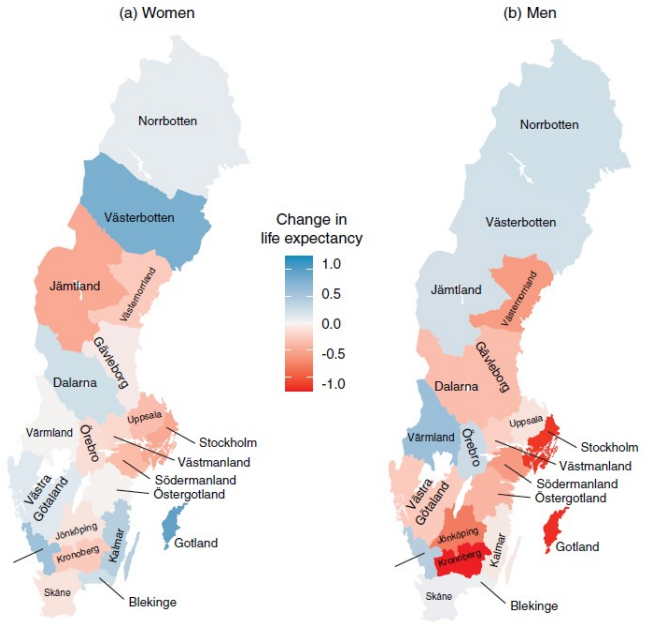


Figure 2 Standardisedincidence of hospitalisation ratios (SIRs) (A) and standardised mortality ratios (SMRs) (B) by municipalities and their respective spatial clusters (red areas) of COVID-19 hospitalisations (C) and deaths (D) until 5 October 2020.

Figure 6(c):
Map of regional changes in life expectancy (e_0) at birth in different regions of Sweden for 2017–2019 and 2020



STUDIES AT THE NATIONAL AND SUBNATIONAL LEVEL (6/6)

Estimated excess mortality at the subnational level of England, Greece, Italy, Spain and Switzerland (Konstantinoudis et al. 2022).

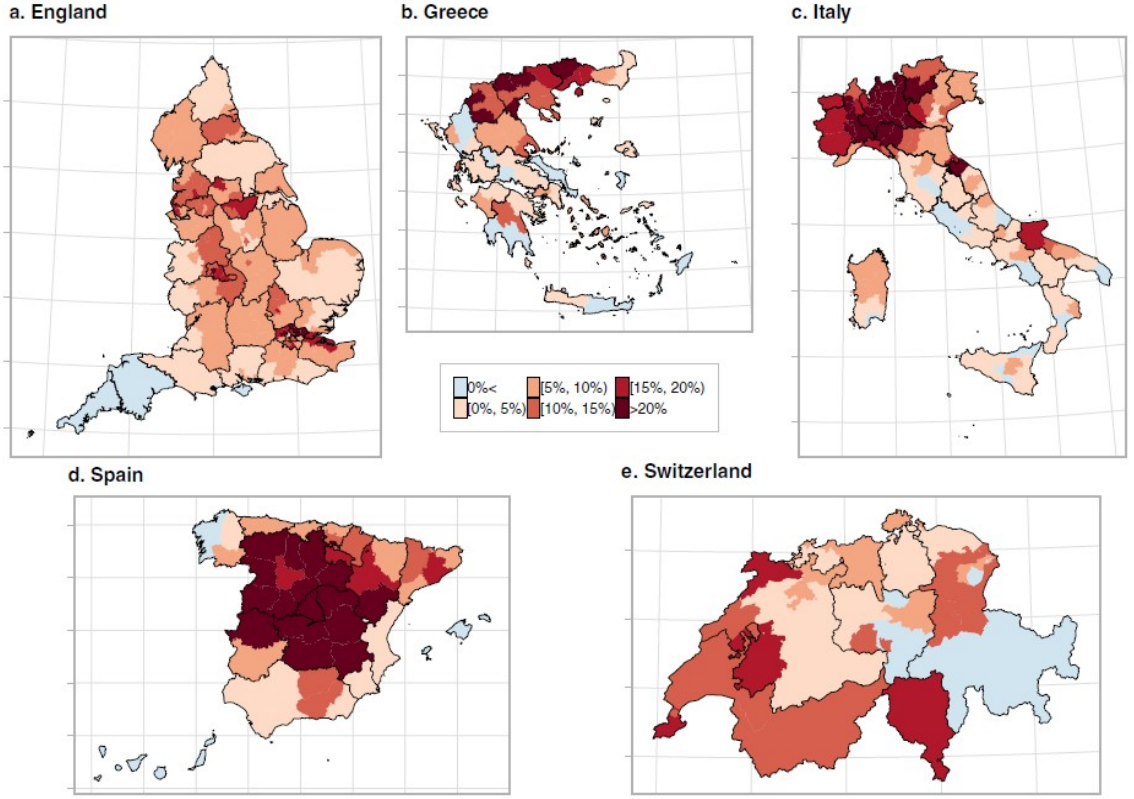
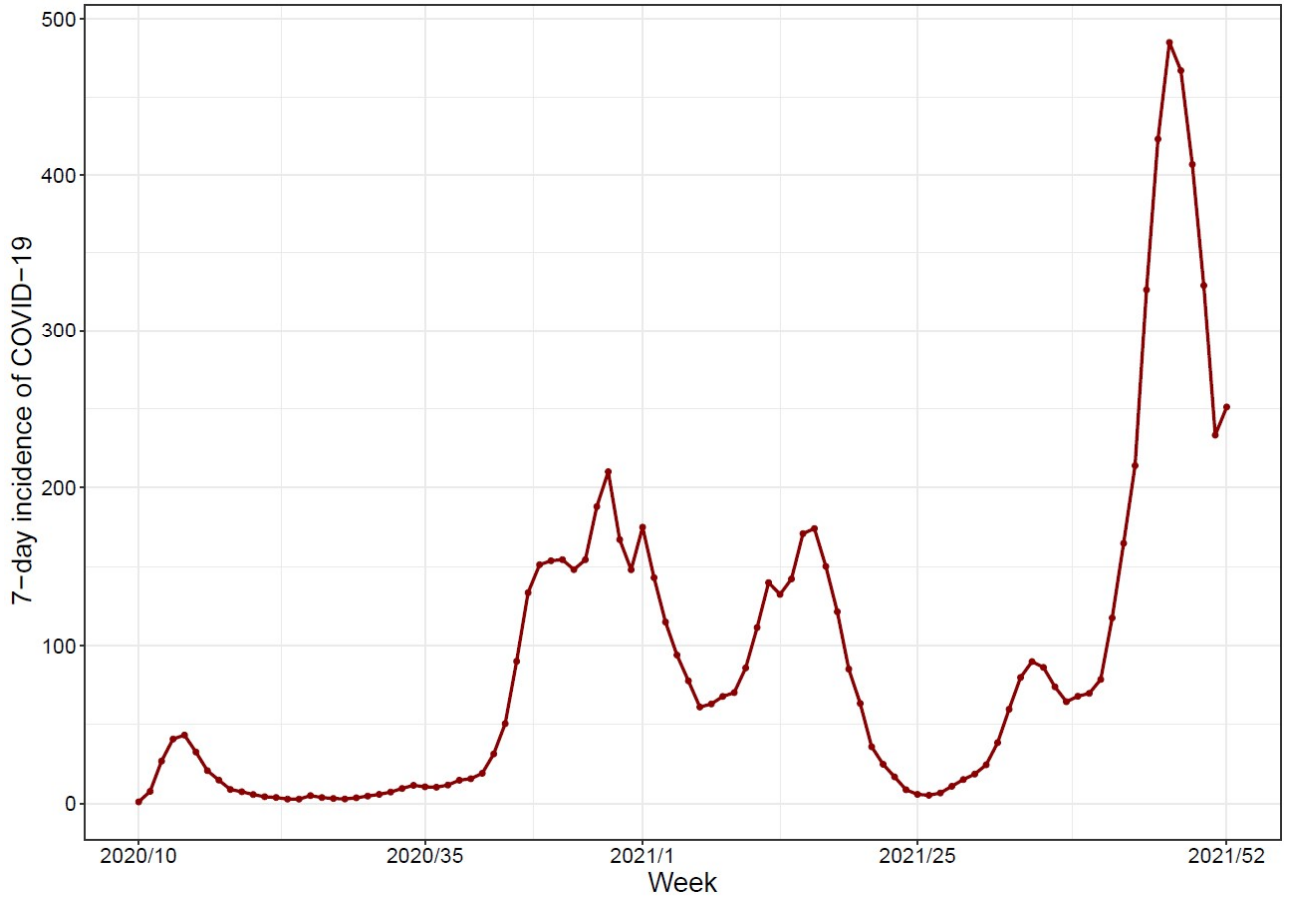


Fig. 2 Median relative excess deaths (%) by NUTS3 region in 2020. a Median relative excess deaths (%) in England. **b** Median relative excess deaths (%) in Greece. **c** Median relative excess deaths (%) in Italy. **d** Median relative excess deaths (%) in Spain and **e** median relative excess deaths (%) in Switzerland in categories. Areas in blue indicate areas that observed less deaths than expected had the pandemic not occurred, whereas the different shades of red indicate the higher relative excess mortality. The black solid lines correspond to the NUTS2 region borders.

COVID-19 PANDEMIC IN GERMANY (1/2)

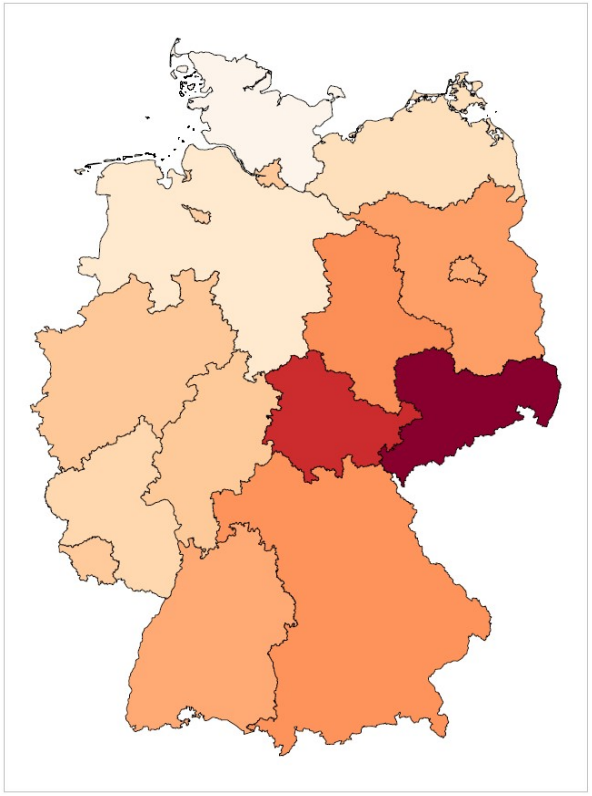
7-day incidence of COVID-19 disease in Germany.



Source: RKI 2022.
https://www.rki.de

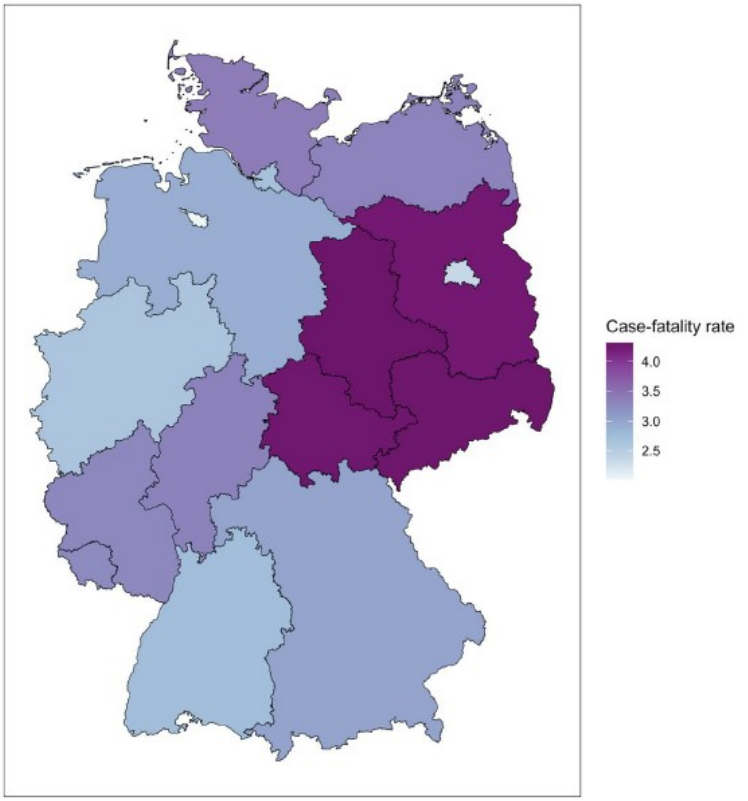
COVID-19 PANDEMIC IN GERMANY (2/2)

Cumulative numbers of COVID-19 cases across federal states of Germany, 2020-2021.



Source: RKI 2022. https://www.rki.de

Cumulative case-fatality rates (CFRs) in the German federal states from the beginning of the pandemic until February 9, 2021 (Morwinsky et al. 2021).



MOTIVATION FOR THE STUDY ON GERMANY

Geographical location of Germany.

Socioeconomic differences across regions.

Previous research: different periods of study.

Focus on the specific regions; not including all of the federal states in the study.

Use of the confirmed COVID-19 deaths as a measure.

Use of the average mortality as expected mortality level.

RESEARCH QUESTIONS

What is the real burden of pandemic in terms of excess mortality within Germany?

Does the excess mortality pattern follow the pattern of COVID-19 morbidity?

What structural indicators may contribute to the explanation of differences in excess mortality at the macro level?

DATA

Federal states: week-specific death counts. Age groups: 0-64, 65-74, 75-84, 85+ years. Districts: month-specific death counts. All age groups aggregated.

Annual population exposures by 5-year age groups.

Annual death counts by 5-year age group and federal state for 2020 (used for age-standardization of weekly specific mortality).

Study period: 2020/15-2021/52.

Numbers of confirmed Covid-19 cases per 100,000 of inhabitants are published by the Robert-Koch Institute (RKI) in the regular situational reports.

Data on the occupation of the intensive care units (ICU) are published by the RKI (DIVI-Intensivregister).

Socioeconomic indicators from the INKAR database reflecting the structural characteristics of the German regions in 2019.

We used state-level indicators: compositional (e.g., income, employment and educational composition) and contextual covariates (e.g., state-level BIP, availability of medical services, investment in regional projects).

METHODS: CALCULATION OF AGE-STANDARDIZED DEATH RATES (1/3)

Due to lack of information on the detailed age groups at the subnational level, we can use the method of calculation of the weekly standardized death rates (SDR) proposed by Klimkin et al. (2020) and use annual death rates available for the 5-year age groups.

We can use correction coefficient for the calculation of weekly SDR:

$$R_y^i = \frac{\sum p_x^s \times M_{y,x}^i}{CDR_y^i},$$

$$SDR_{y,w}^i = CDR_{y,w}^i \times R_y^i$$

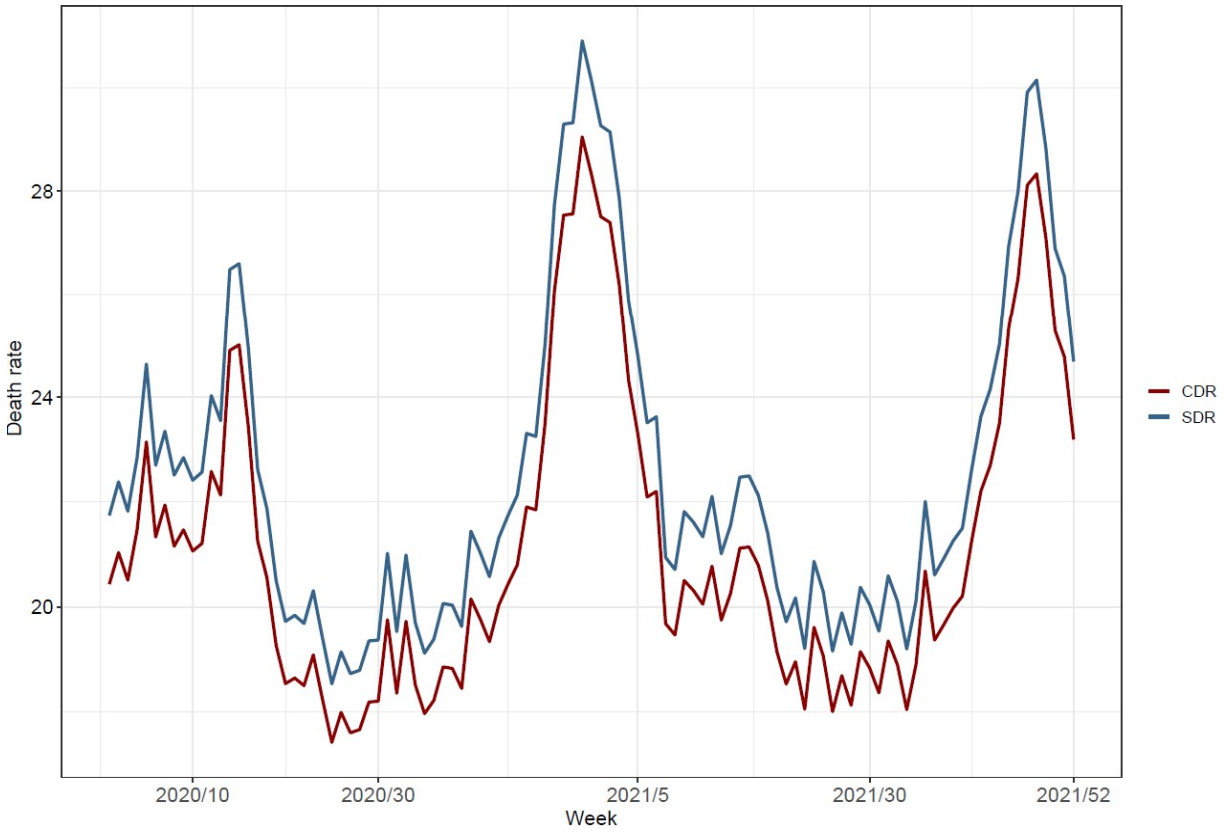
Where CDR_y^i is the region-specific annual crude death rate,

$M_{y,x}^i$ is the year-age-specific death rate in the region,

p_x^s is the age-specific population share in the standard population.

Klimkin et al. (2020). Calculation of Week-Specific Age-Standardized Death Rates from STMF Data on Mortality by Broad Age Intervals. *Max Planck Institute for Demographic Research*, Rostock, Germany.

Weekly crude and standardized death rates, Bavaria, both sexes.



METHODS: CALCULATION OF EXPECTED MORTALITY (2/3)

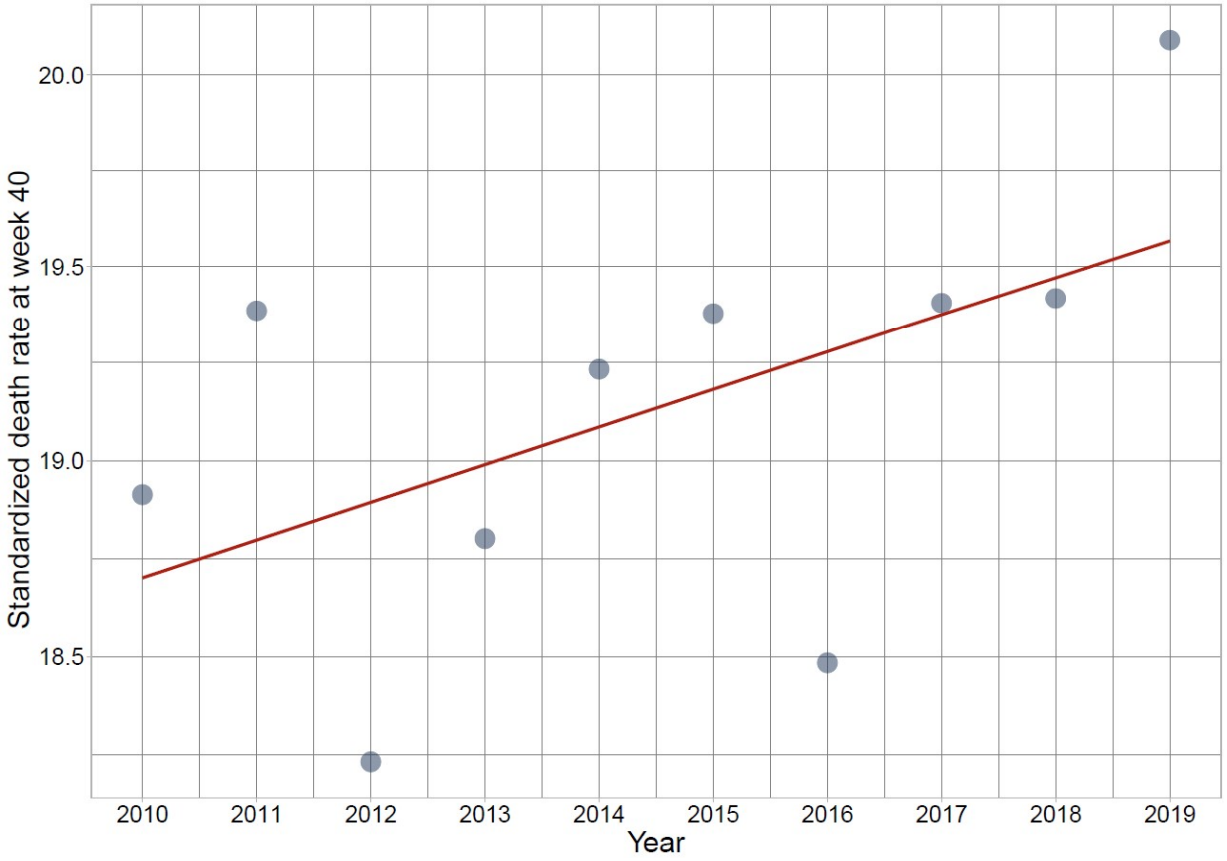
Federal states: Expected mortality level is estimated as state-specific mortality trends calculated separately for each week:

$$\hat{x}_\iota = \hat{a}_\iota + \hat{b}_\iota T$$

Where $\hat{x}_\iota$ is the estimated value of mortality trend (SDR) in the week ι, T is the year (2010-2019).

Districts: District-specific Bayesian GLM regression models.

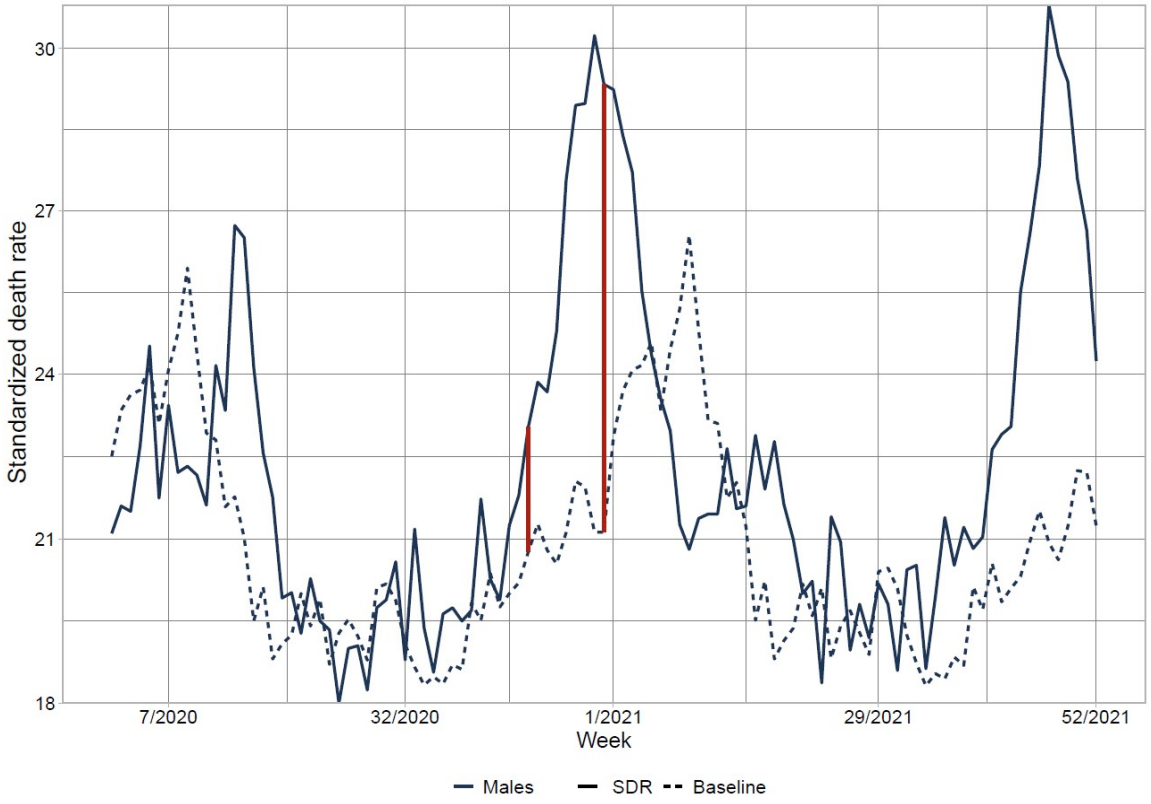
Week- and state-specific mortality trend.



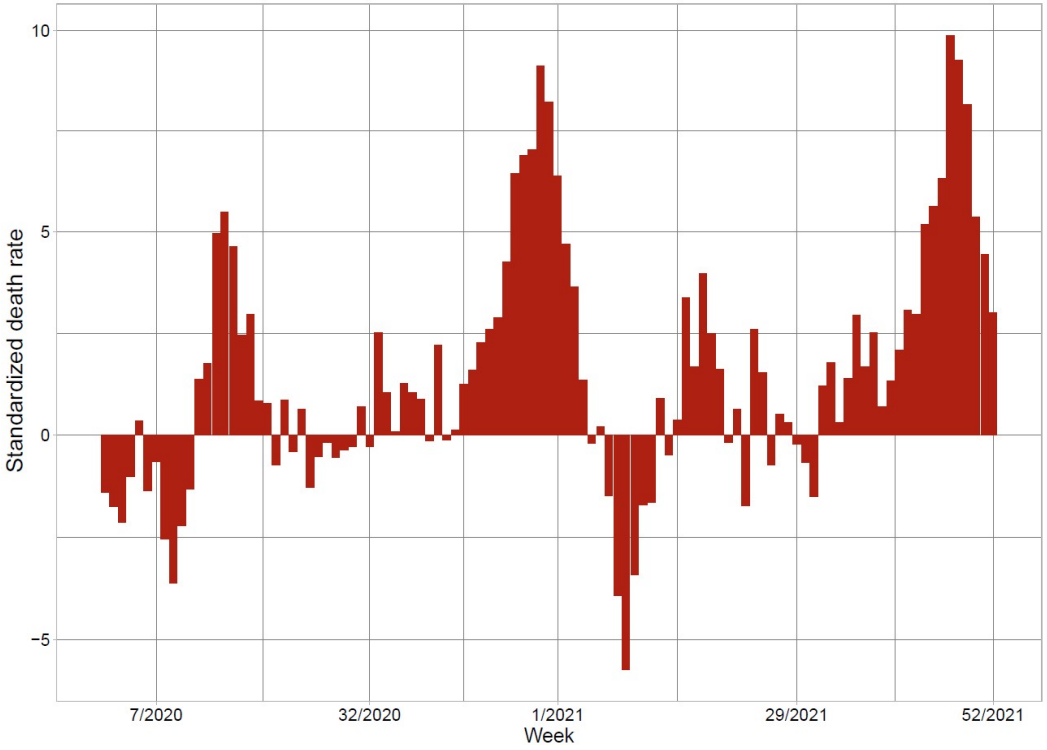
METHODS: CALCULATION OF STATE-SPECIFIC EXCESS MORTALITY (3/3)

Excess mortality is calculated as difference between observed and expected levels of mortality.

Observed and expected weekly death rates.



Weekly excess mortality.



RESEARCH QUESTIONS

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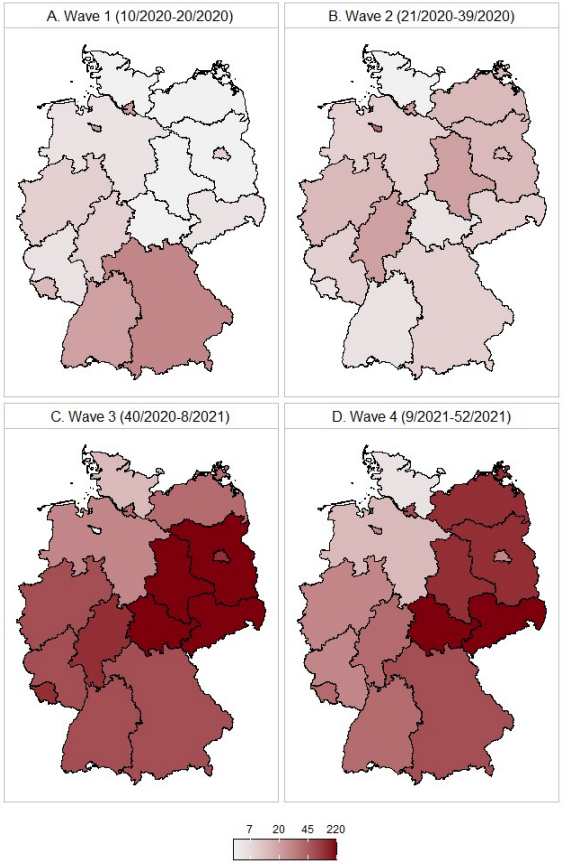
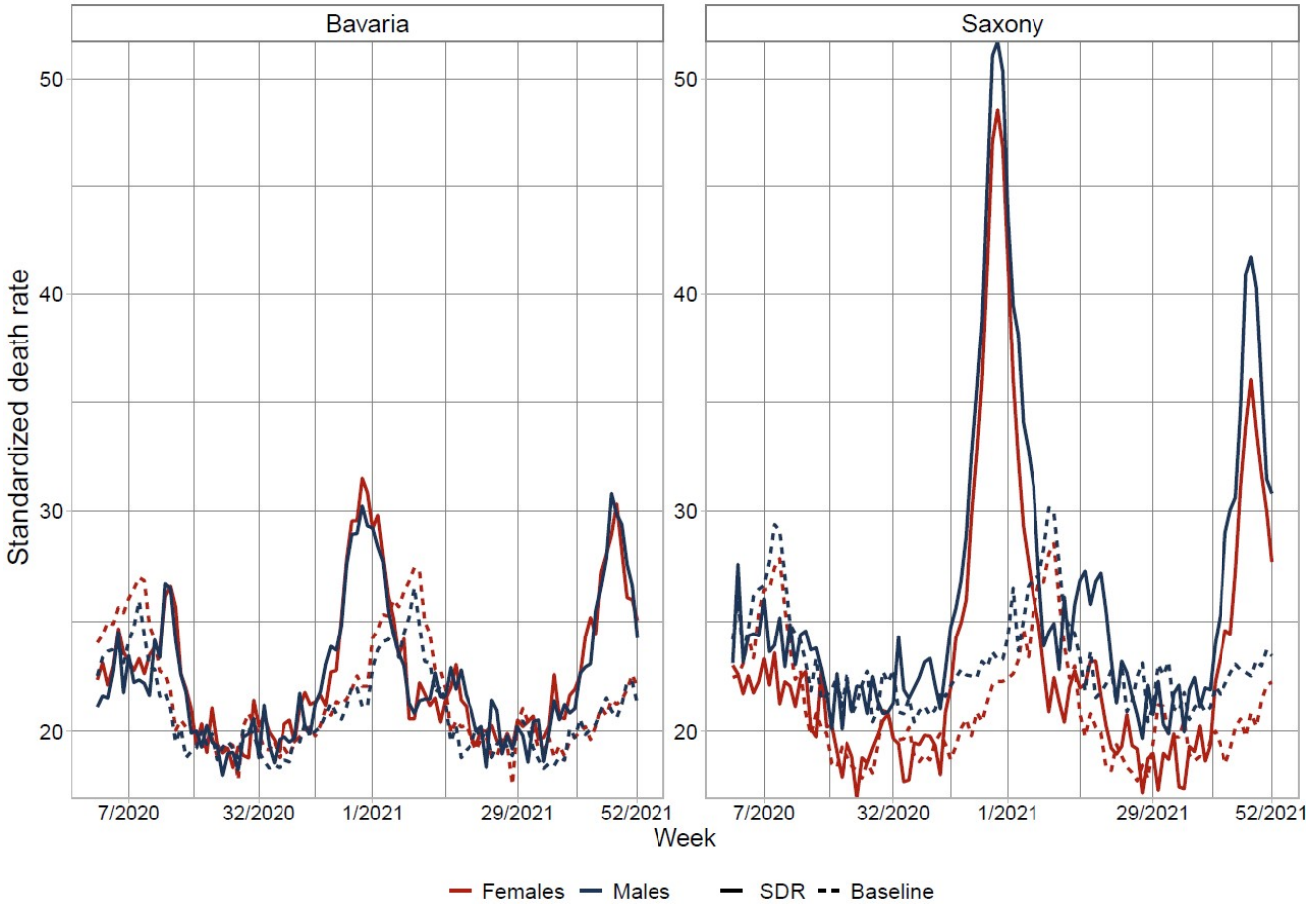
HETEROGENEITY IN MORTALITY DURING COVID-19 PANDEMIC IN GERMANY (1/9)

Excess death rates across federal states of Germany during the COVID-19 pandemic in 2020 and 2021, both sexes.



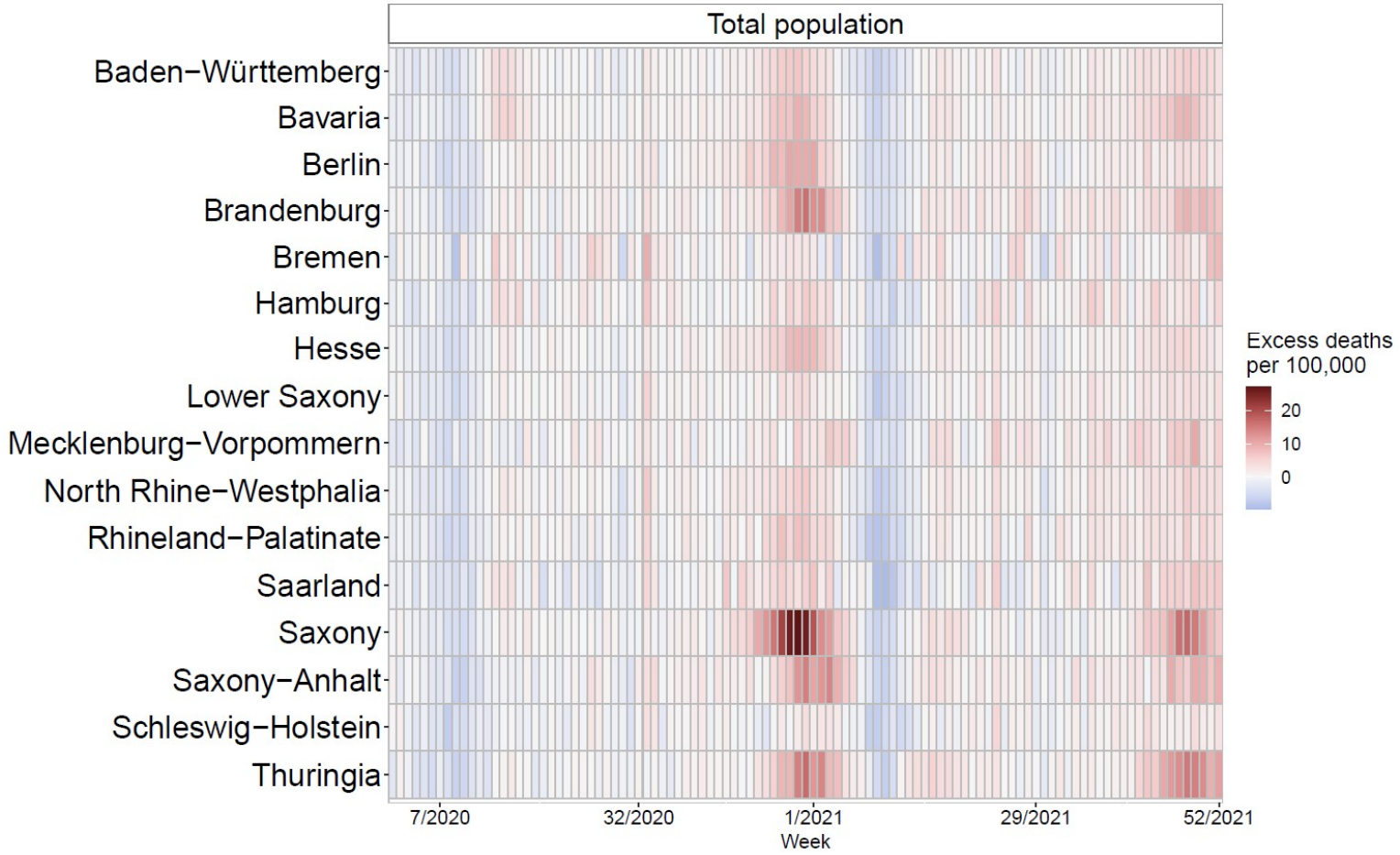
HETEROGENEITY IN MORTALITY DURING COVID-19 PANDEMIC IN GERMANY (2/9)

Observed and expected weekly standardized death rates (SDR) in Bavaria and Saxony.



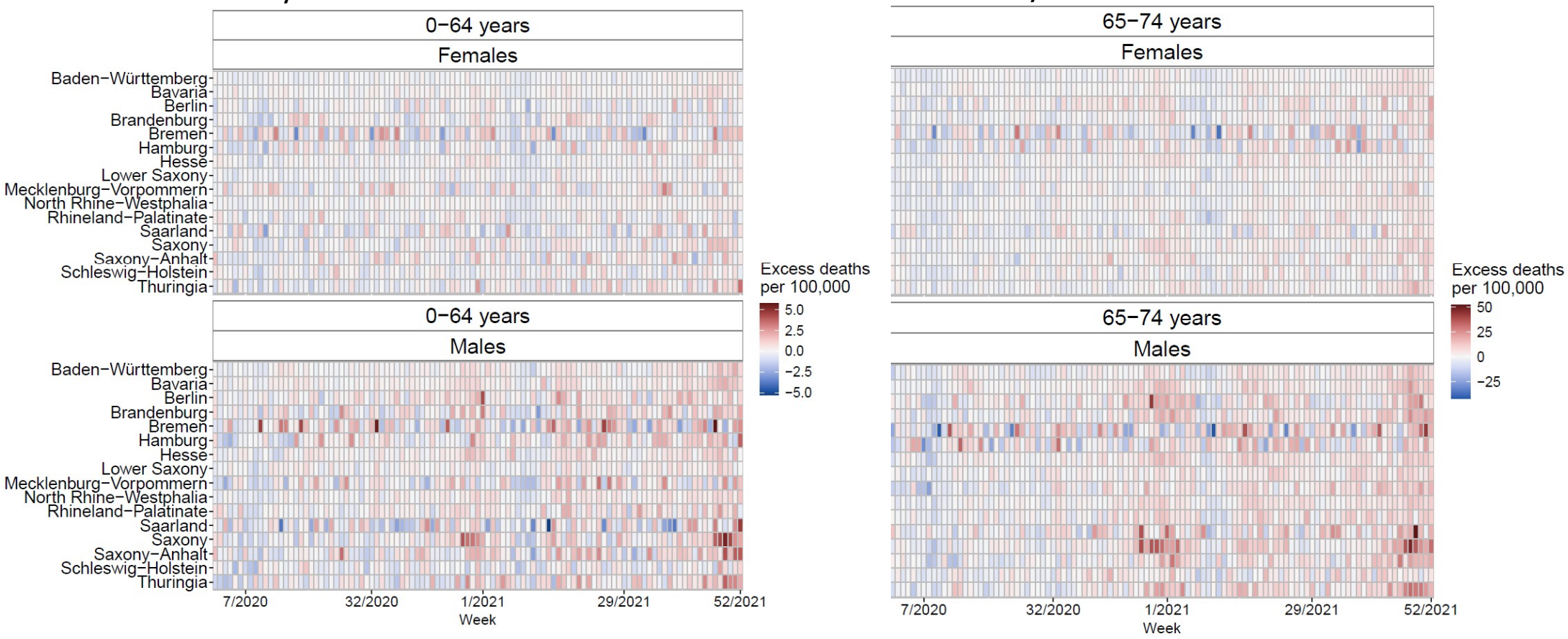
HETEROGENEITY IN EXCESS MORTALITY (AGE-STANDARDIZED DEATH RATES)(3/9)

Weekly excess death rates across federal states of Germany, both sexes.



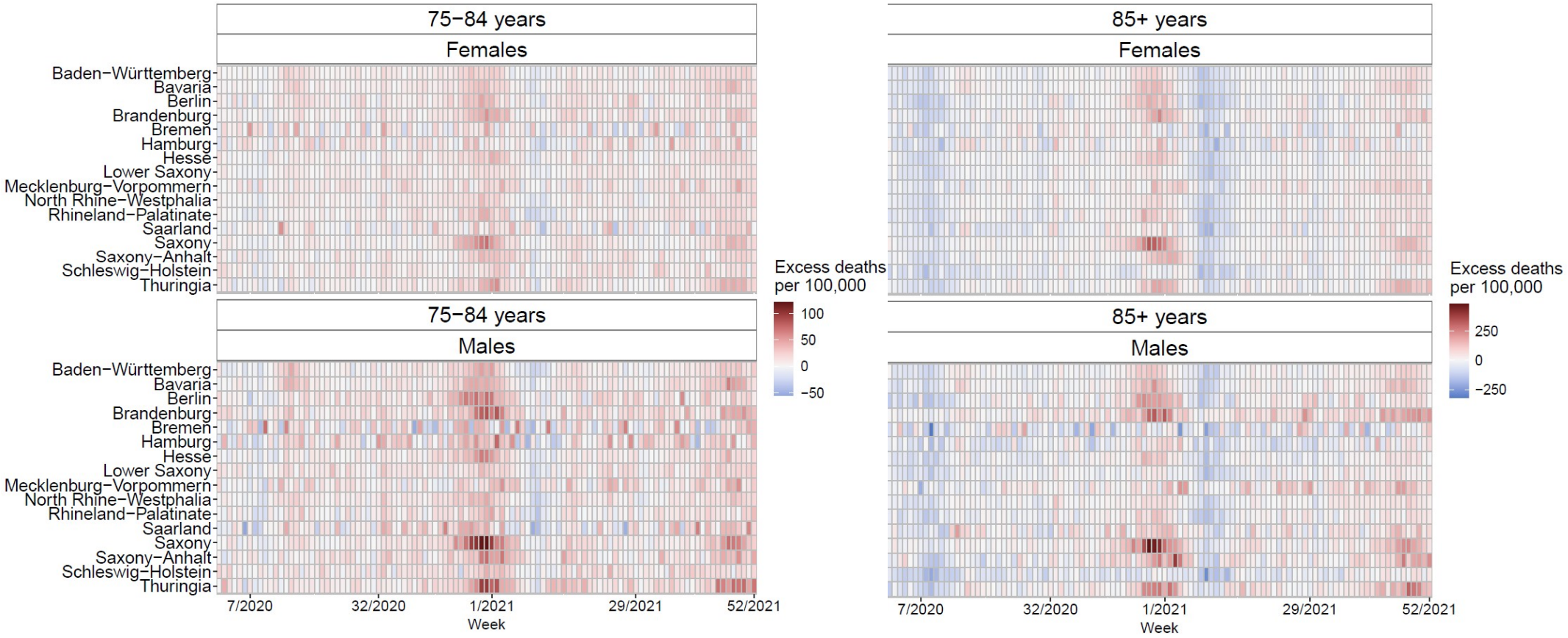
HETEROGENEITY IN EXCESS MORTALITY BY SEX AND AGE GROUP (AGE-STANDARDIZED DEATH RATES) (4/9)

Weekly excess death rates across federal states of Germany.



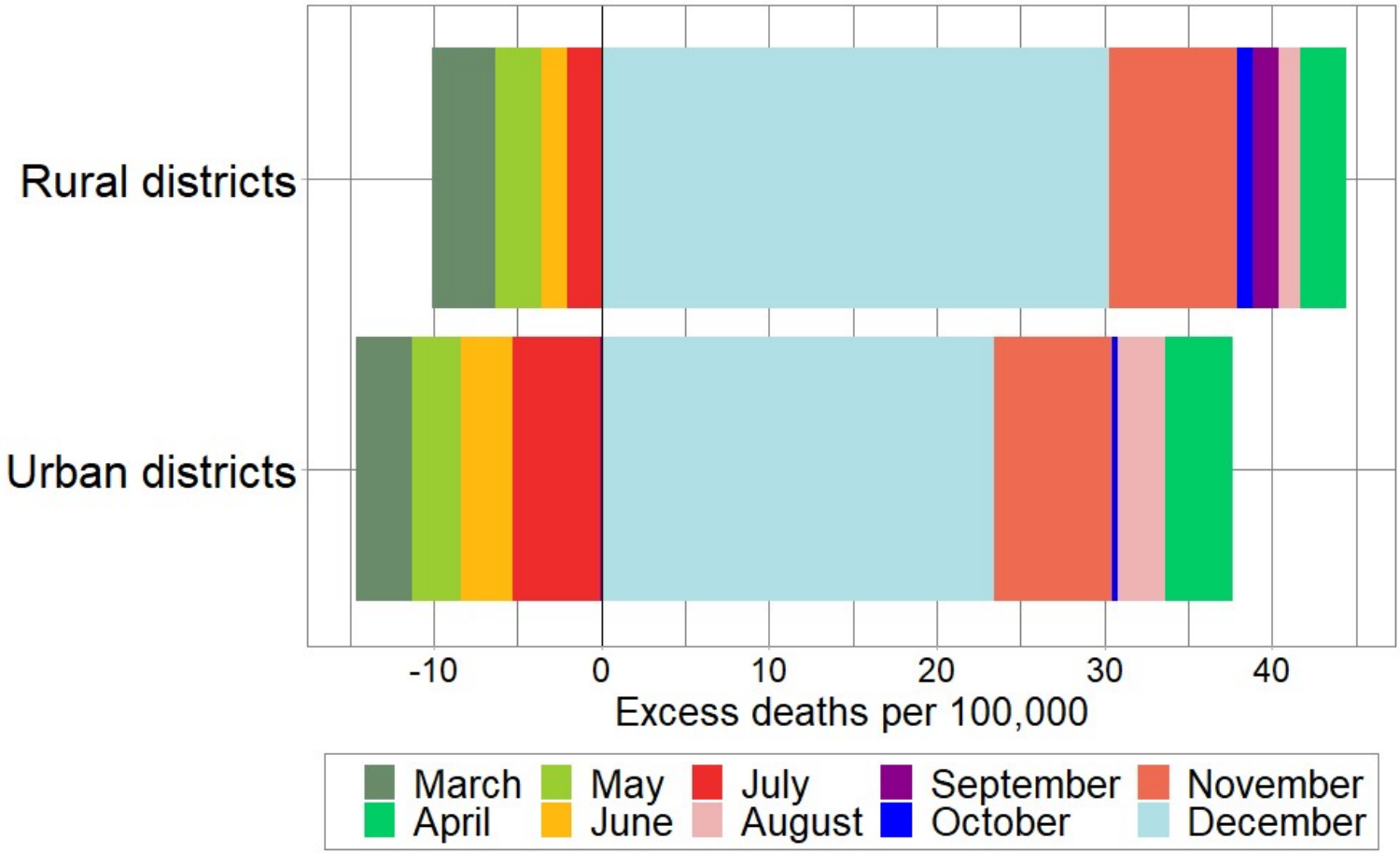
HETEROGENEITY IN EXCESS MORTALITY BY SEX AND AGE GROUP (AGE-STANDARDIZED DEATH RATES) (5/9)

Weekly excess death rates across federal states of Germany.



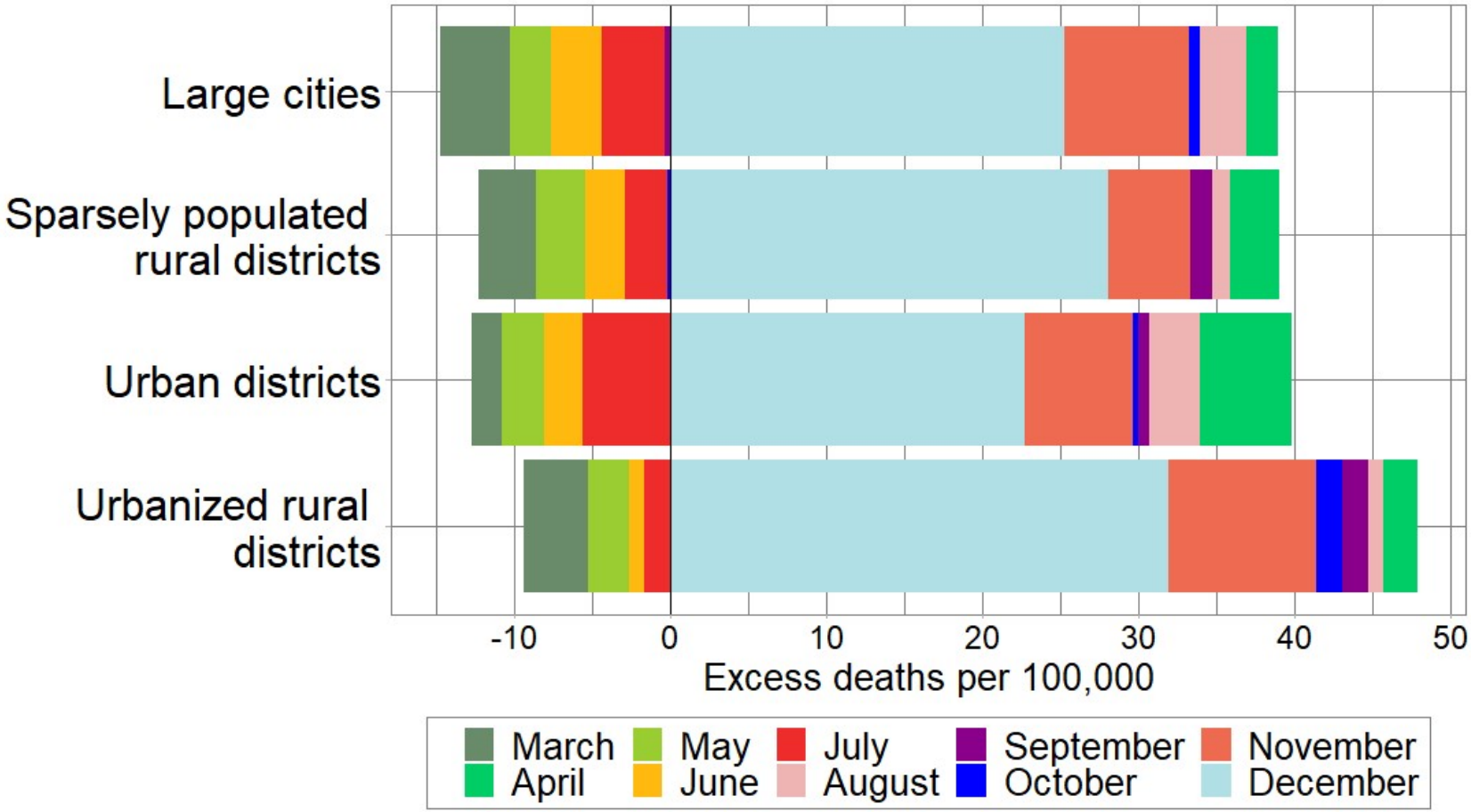
HETEROGENEITY IN EXCESS MORTALITY (6/9)

Monthly excess mortality by spatial type (groups of districts) during the COVID-19 pandemic in 2020.



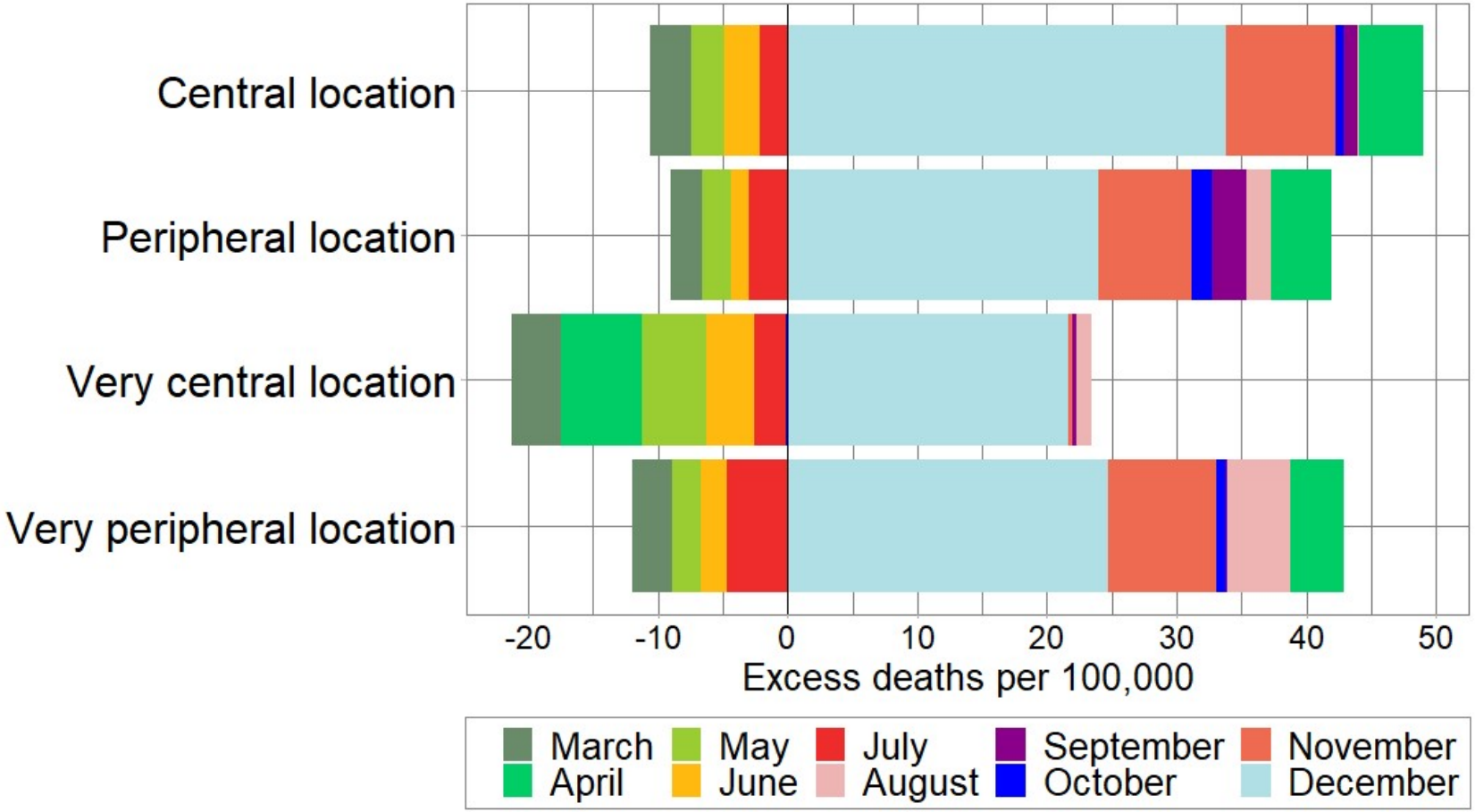
HETEROGENEITY IN EXCESS MORTALITY (7/9)

Monthly excess mortality by spatial type (groups of districts) during the COVID-19 pandemic in 2020.



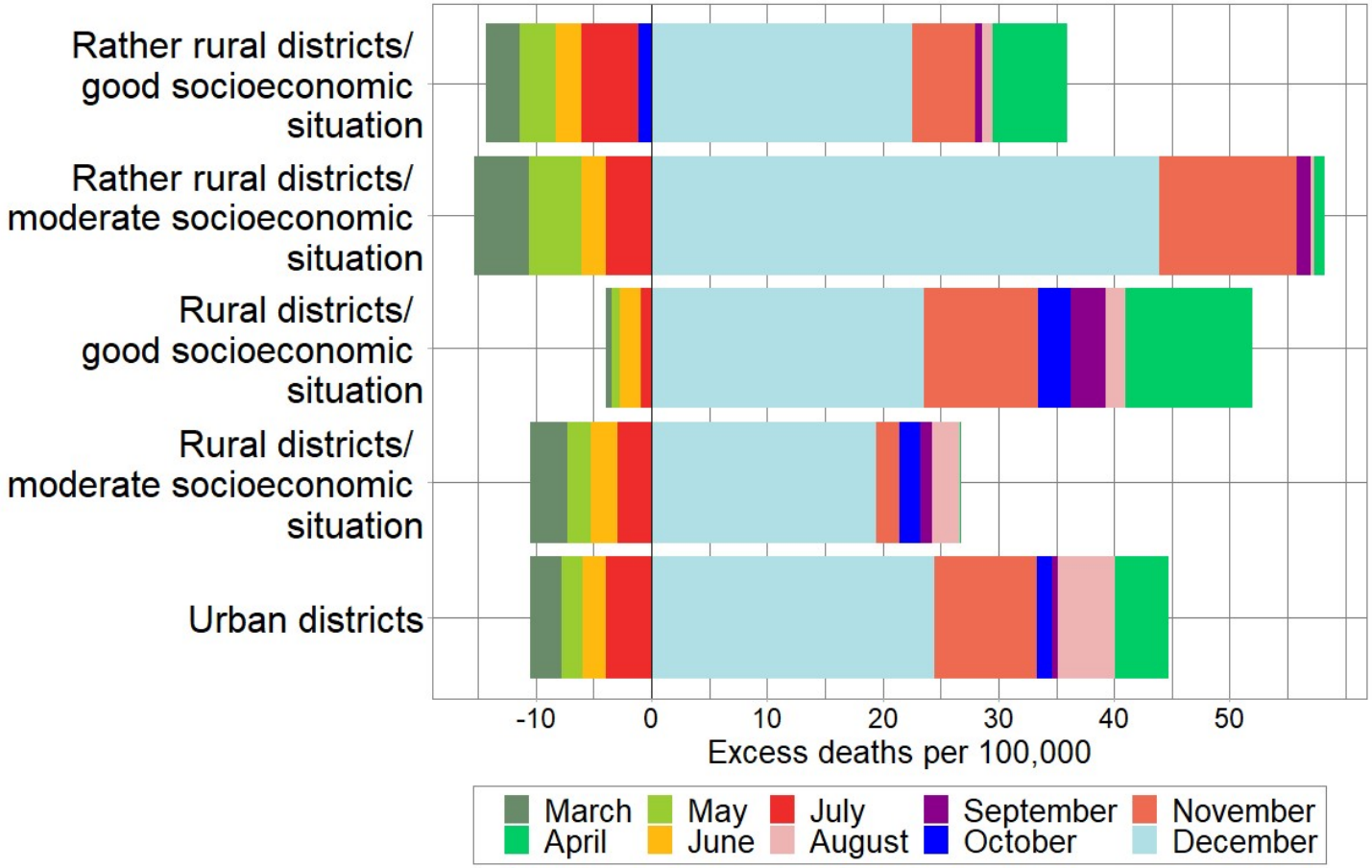
HETEROGENEITY IN EXCESS MORTALITY (8/9)

Monthly excess mortality by spatial type (groups of districts) during the COVID-19 pandemic in 2020.



HETEROGENEITY IN EXCESS MORTALITY (9/9)

Monthly excess mortality by spatial type (groups of districts) during the COVID-19 pandemic in 2020.



RESEARCH QUESTIONS

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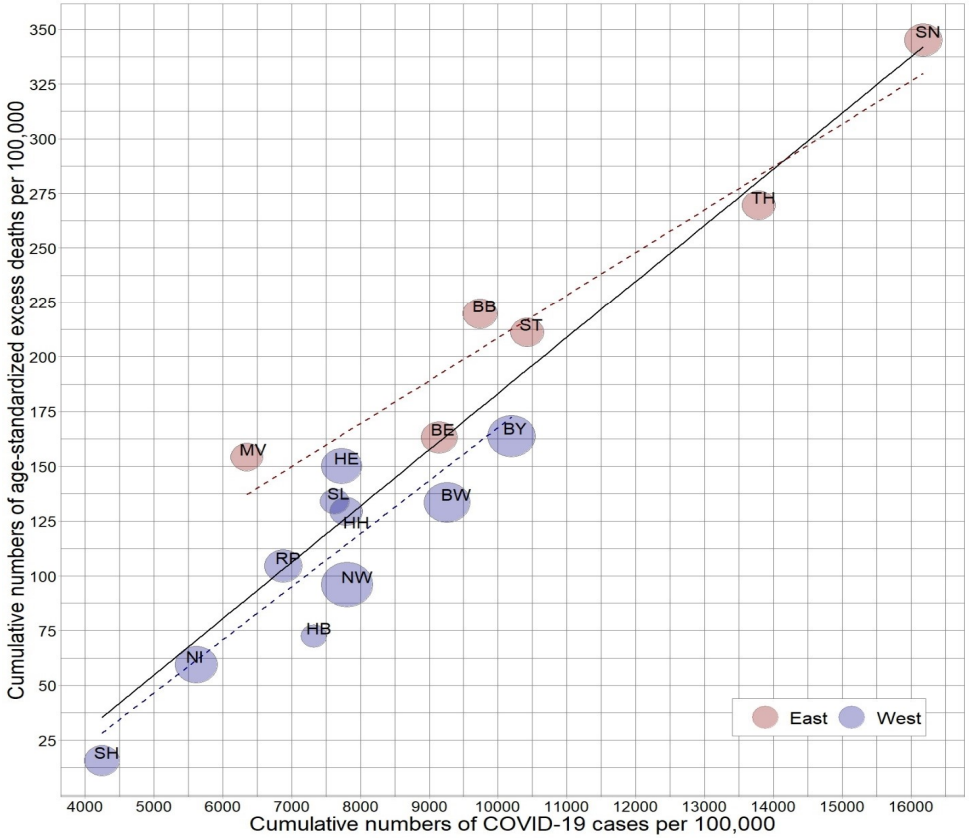
RELATIONSHIP BETWEEN EXCESS MORTALITY AND COVID-19 MORBIDITY, 2020-2021 (1/2)

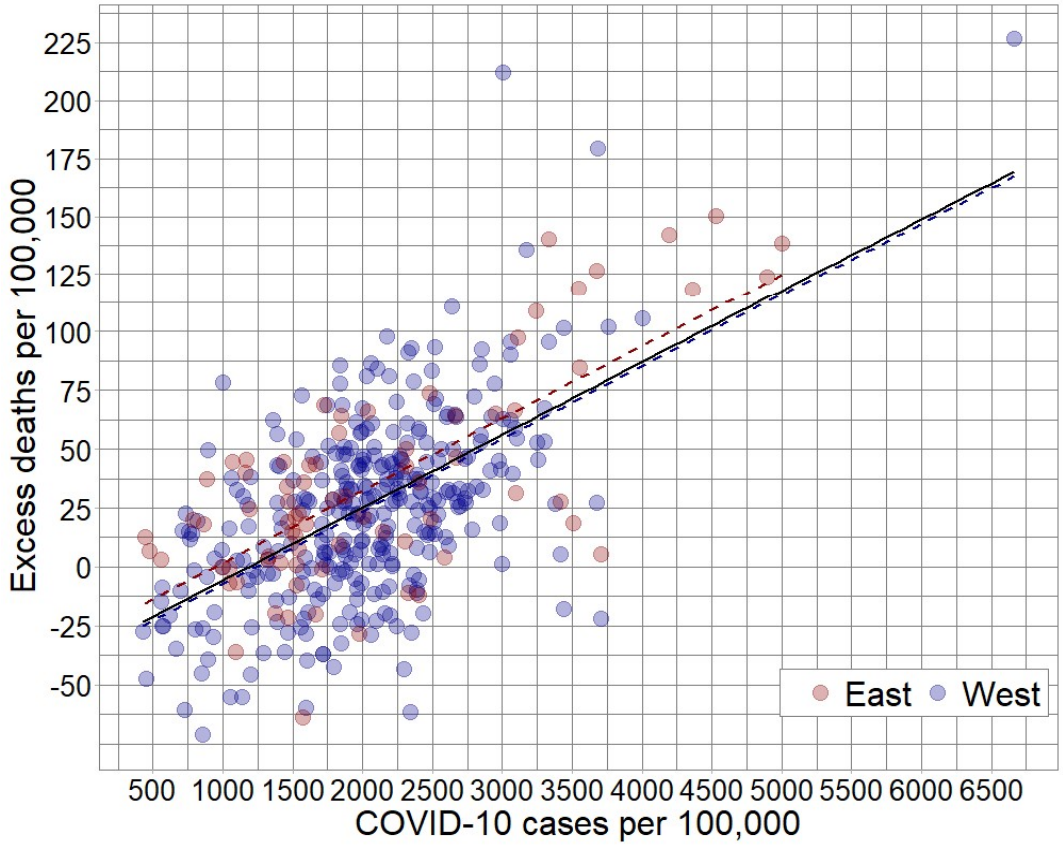
Cumulative numbers of excess deaths and COVID-19 cases per 100,000 at the federal state level of Germany.



Source: RKI 2022.
https://www.rki.de

RELATIONSHIP BETWEEN EXCESS MORTALITY AND COVID-19 MORBIDITY, 2020-2021 (2/2)

Cumulative numbers of excess deaths and COVID-19 cases per 100,000 at the district level of Germany.



Source: RKI 2022.
https://www.rki.de

RESEARCH QUESTIONS

What is the real burden of pandemic in terms of excess mortality within Germany?

Does the excess mortality pattern follow the pattern of COVID-19 morbidity?

What structural indicators may contribute to the explanation of differences in excess mortality at the macro level?

IMPACT OF SELECTED STRUCTURAL INDICATORS ON EXCESS MORTALITY IN 2020-2021

Fixed-effects regression models including cumulative numbers of age-standardized excess death (over the period of 2020/15-2021/52) as dependent variable, Covid-19 morbidity and selected structural indicators as independent variable, and East-West indicator as group variable #.

Covariate	Regression coefficient	Standard error
Cumulative numbers of confirmed COVID-19 cases	0.02*** (0.016, 0.025)	0.002
Percent of intensive care units occupied by COVID-19 patients (maximal occupation)	5.028** (2.493, 8.24)	1.344
Employment rate	12.143** (4.949, 20.667)	3.766
Economic activity rate (employed and unemployed population)	15.599* (3.718, 27.347)	5.831
Share of employed population without professional education	-23.86*** (-32.403, -14.293)	4.38
Employment rate of population aged 55-65 years	14.414** (5.807, 24.686)	4.513

Notes. # Standardized regression coefficients with their 95% confidence limits.
* p<0.05; ** p<0.01; *** p<0.001

SUMMARY

Higher excess mortality in the eastern than in the western federal states **at the same level** of COVID-19 morbidity.

Inconsistency between patterns of COVID-19 morbidity and excess mortality during the pandemic.

South-to-North gradient in registered COVID-19 morbidity vs. **East-to-West gradient in excess mortality.**

Strong effect of COVID-19 morbidity on the excess mortality cumulated over the study period.

Lack of statistical relationship between the majority of selected socioeconomic indicators and excess mortality.

Employment structure of the subnational populations contribute to the explanation of the spatial variation in excess mortality in Germany.

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THANK YOU FOR LISTENING!