



All-cause and Cause-Specific Excess Deaths during the COVID-19 Pandemic

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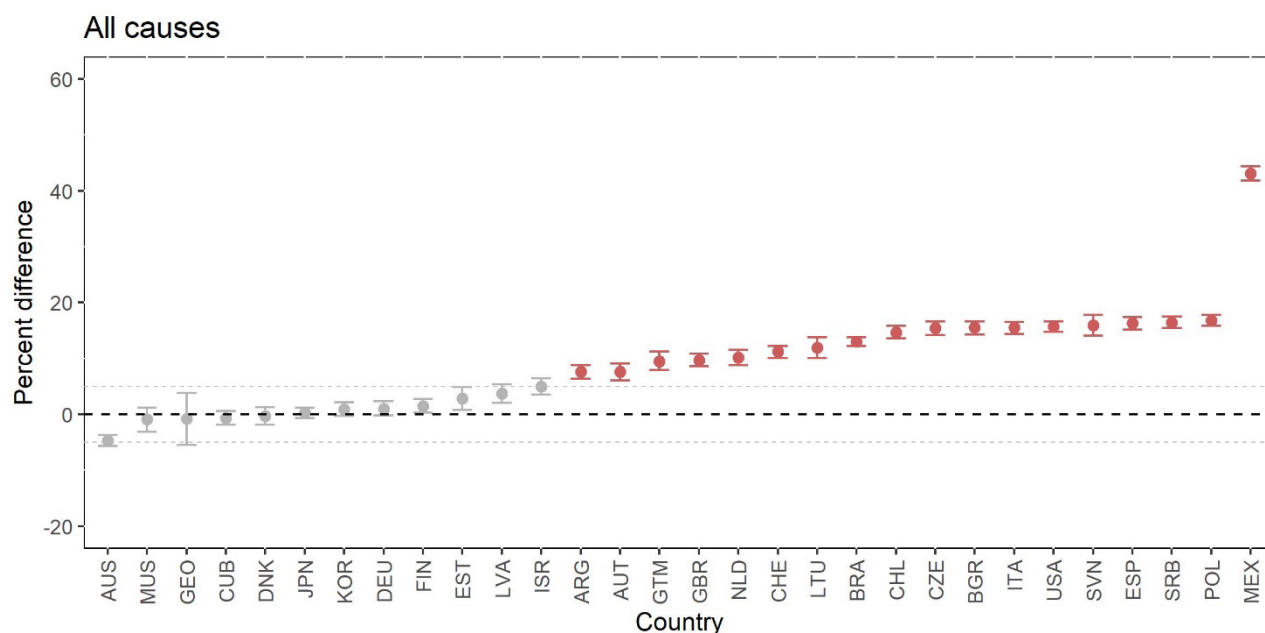
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SUMMARY

We estimated the excess mortality during the COVID-19 pandemic (2020-2023) in selected countries worldwide. In Europe, half a million excess deaths occurred annually during the first three years of the pandemic, while a 2.1% excess was observed in 2023 (108,629 deaths). Significant excess mortality was recorded worldwide for all-cause mortality, cardiovascular disease, and diabetes, with peaks in COVID-19 cases closely aligning with these excess deaths. No increase in cancer-related mortality was observed. Gross domestic product per capita, national health expenditure, and vaccination rates were inversely associated with excess mortality. These findings provide insights into the public health impact of COVID-19 and inform future policy decisions.

Keywords: COVID-19; SARS-CoV-2; pandemic; excess mortality; cause-specific mortality; diabetes.

GRAPHICAL ABSTRACT



Percent differences in the number of deaths from any cause registered in 2020 relative to the expected deaths and corresponding confidence intervals by country.

Country abbreviations (ISO 3166 - Country code): ARG (Argentina), AUS (Australia), AUT (Austria), BGR (Bulgaria), BRA (Brazil), CHE (Switzerland),

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CHL (Chile), CUB (Cuba), CZE (Czech Republic), DEU (Germany), DNK (Denmark), ESP (Spain), EST (Estonia), FIN (Finland), GBR (United Kingdom), GEO (Georgia), GTM (Guatemala), ISR (Israel), ITA (Italy), JPN (Japan), KOR (The Republic of Korea), LTU (Lithuania), LVA (Latvia), MEX (Mexico), MUS (Mauritius), NLD (Netherlands), POL (Poland), SRB (Serbia), SVN (Slovenia), USA (United States).

BACKGROUND

The COVID-19 pandemic emerged as a health crisis, leading to seven million deaths officially attributed to SARS-CoV-2 globally. However, certified death counts do not fully capture the pandemic's true impact, as they exclude both deaths not officially attributed to COVID-19 and the indirect consequences of disrupted healthcare systems [1]. To address this gap, researchers have focused on excess mortality, defined as the difference between observed and expected deaths based on historical data [2]. This report, which includes three studies conducted by our research group, analyzes excess mortality across various countries from all causes and specific causes between 2020 and 2023, focusing on demographic and healthcare-related differences.

METHODS

Study 1 investigated total excess mortality and geographic disparities in Europe from 2020 to 2023, using weekly death counts from the Short-term Mortality Fluctuations data series [3]. Study 2 examined all-cause and cause-specific excess deaths across 30 countries worldwide in 2020, using data from the World Health Organization (WHO) [4]. Study 3 explored the association between COVID-19 cases and monthly cause-specific mortality in 16 countries, using monthly cause-specific death data retrieved directly from national statistics offices [5]. Excess deaths were calculated as the difference between observed deaths and expected deaths. Expected deaths were estimated through quasi-Poisson regression models, including demographic and temporal variables along with population size as an offset. Excess deaths were presented in both absolute and relative terms, with 95% confidence intervals derived from Monte Carlo simulations. To assess the robustness of the estimates, we applied the main model to estimate expected deaths for pre-pandemic years using historical mortality data from prior periods, and for pandemic years using varying baseline periods. Additionally, in Study 1, we considered the association between excess mortality and selected socioeconomic indicators, and in Study 3 we calculated Spearman's correlation coefficient (r_s)

to assess the relationship between monthly cause-specific excess mortality from 2020 to 2021 and registered COVID-19 cases.

RESULTS

In Study 1, from 2020 to 2023, 22,254,542 deaths were registered across 29 European countries, with an estimated 1,642,586 excess deaths (+8.0%). The highest excess mortality occurred in 2021 (+11.2%), followed by 2020 (+10%), 2022 (+8.6%), and 2023 (+2.1%). Central and Eastern Europe experienced a higher overall increase at +13.2%. The proportion of the population living below the poverty line and the Gini index were directly associated with increased excess death rates, while gross domestic product per capita, health expenditure, and the percentage of people fully vaccinated by the end of 2021 and 2022 were inversely associated. In Study 2, we estimated about 1.4 million excess deaths from all causes across 30 worldwide countries in 2020 (12.2%). Significant excess deaths from ischemic heart disease and cerebrovascular diseases were observed in a third of the countries, from diabetes in 19 countries and from ill-defined causes in 20 countries. In Study 3, a positive correlation was found between COVID-19 cases and monthly excess mortality from all causes in all 16 countries (r_s ranging from 0.61 to 0.91), from cardiovascular disease (CVD) in 11 countries (r_s from 0.45 to 0.85), and for diabetes in 13 countries (r_s from 0.42 to 0.79). Excess mortality was estimated for all causes in 14 countries for both 2020 and 2021, for CVD in seven countries for 2020 and in nine countries for 2021, and for diabetes in 11 countries for 2020 and 12 countries for 2021. No excess mortality was estimated for cancer in any of the countries considered. Overall, estimates based on different combinations of baseline periods were similar in most countries, and estimates for excess deaths in 2019 were near zero.

CONCLUSION

Half a million excess deaths occurred annually in Europe during each of the first three years of the pandemic, with only a modest excess observed in 2023. Globally, substantial excess mortality was recorded for all-cause deaths, CVD, and diabetes, with peaks in COVID-19 cases closely aligning with these excess deaths, while no increase was observed for cancer-related mortality. The response to COVID-19 highlighted major inequalities in health outcomes, influenced by public health policies, demographic structures, socioeconomic factors, and health infrastructure. This research contributes to a deeper understanding of the public health impact of COVID-19, providing insights to inform future policy

decisions and ultimately improve preparedness for similar health emergencies.

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