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Changes in stillbirths and child and youth mortality in 2020 and 2021 during the COVID-19 pandemic

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Abstract

Background: The COVID-19 pandemic has been extensively studied for its impact on mortality, particularly in older age groups. However, the pandemic effects on stillbirths and mortality rates in neonates, infants, children and youth remain poorly understood. This study comprehensively analyses the pandemic influence on young mortality and stillbirths across 112 countries and territories in 2020 and 104 in 2021.

Methods: Using data from civil registers and vital statistics systems (CRVS) and the Health Management Information System (HMIS), we estimate expected mortality levels in a non-pandemic setting and relative mortality changes (p-scores) through generalized linear models. The analysis focuses on the distribution of country-specific mortality changes and the proportion of countries experiencing deficits, no changes and excess mortality in each age group.

Results: Results show that stillbirths and under-25 mortality were as expected in most countries during 2020 and 2021. However, among countries with changes, more experienced deficits than excess mortality, except for stillbirths, neonates and those aged 10–24 in 2021, where, despite the predominance of no changes, excess mortality prevailed. Notably, a fifth of examined countries saw increases in stillbirths and a quarter in young adult mortality (20–24) in 2021. Our findings are highly consistent between females and males and similar across income levels.

Conclusion: Despite global disruptions to essential services, stillbirths and youth mortality were as expected in most observed countries, challenging initial hypotheses. However, the study suggests the possibility of delayed adverse effects that require more time to manifest at the population level. Understanding the lasting impacts of the COVID-19 pandemic requires ongoing, long-term monitoring of health and deaths among children and youth, particularly in low- and lower-middle-income countries.

Keywords: COVID-19 pandemic, infant mortality, youth mortality, stillbirths, excess mortality.

Key Messages

- This study aims to assess the global impact of the COVID-19 pandemic on stillbirths and child and youth mortality during the years 2020 and 2021.
- We found that despite the pandemic severity and the related socioeconomic disruptions worldwide, most of the 112 countries and territories under analysis experienced no changes in stillbirths and under-25 mortality.
- These findings are important because the impact of the pandemic on the youngest ages remains poorly understood; they contribute essential information for conceiving tailored interventions that can effectively mitigate the adverse consequences of the pandemic on children and youth; and highlight the urgency of strengthening surveillance systems for monitoring health and deaths among children and youth, particularly in low-income and lower-middle-income countries.

Introduction

In 2020 and 2021, more than 6.5 million COVID-19 deaths were officially reported worldwide. It is well established that the risk of death from COVID-19 increases exponentially with age,[1,2] the pre-existence of comorbidities and social disadvantages.[3] It has also been established that official records bias the actual toll of the pandemic due to a lack of testing and the misclassification of causes of death.[4,5] A great deal of research aims to assess the overall mortality outcomes of the pandemic.[6–9] However, most of these analyses have focused on mortality at old ages, while very little is known about the impact of the pandemic on pregnancy outcomes and mortality among the youngest age groups.

Deaths caused directly by COVID-19 are rare at young ages[10] and are mainly related to children with severe pre-existing health problems.[11,12] According to official reports from

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countries for which information on direct COVID-19 deaths by age is available, as of the end of 2022, only 0.6% (30 092) of confirmed COVID-19 deaths were of individuals under age 25.[13] However, children, adolescents and youth may be indirectly affected by the pandemic, as various pandemic-related disruptions could have adversely impacted their health and well-being. First, one of the earliest consequences of the pandemic was the saturation and disruption of healthcare systems in most countries.[14–16] Second, with notable variations from one country to another, most governments adopted several non-pharmaceutical strategies, such as lockdowns, to mitigate the spread of infections. In several cases, these measures drastically disrupted food supply chains, daycare centres and schools, transportation, and many other social institutions and services, leading to a global economic recession.[17,18] These and other developments might have negatively affected the physical and mental health of pregnant women, children and youth during the COVID-19 pandemic. It has been hypothesized that the disruption of healthcare systems and decreased access to food during the pandemic exacerbated pre-existing undernutrition levels and other vulnerabilities,[19] particularly in low- and middle-income countries.[20]

Despite the potential risks to the well-being of unborn infants, children and youth during the COVID-19 pandemic, analyses of the total impact of the pandemic on mortality at the youngest ages are scarce. This study aims to analyse the changes in stillbirths and mortality among people under 25 during the COVID-19 pandemic in 2020 and 2021. We estimate these changes by measuring variations in stillbirths and child and youth mortality rates relative to the expected levels in a pandemic-free scenario.

Data and methods

Data

Civil registration and vital statistics systems data

Data consist of annual counts of live births, stillbirths (at 28 weeks or more of gestation) and deaths for seven age groups [i.e. neonates (under 28 days of age), infants (under 1 year of age) and the age groups 1–4, 5–9, 10–14, 15–19 and 20–24] between 2015 and 2021 obtained from civil registration and vital statistics systems (CRVS). We retrieved country-specific CRVS data supplied by countries to UNICEF in response to a data call and through several databases, including the Human Mortality Database (HMD),[21] the Short-term Mortality Fluctuation data series (STMF),[21] DemoData,[22] Eurostat,[23] the World Health Organization Mortality Database (WHO-MDB)[24] and the Short-term Fertility Fluctuations data series (STFF).[25] Mortality data are available in death counts; in the cases of Bangladesh, China, India and South Africa, data were provided either in death rates (m_x) or death probabilities (q_x).

We identified multiple sources for various countries and territories, prioritizing those with the most detailed age grouping resolution and the broadest period coverage. When more than one source met these criteria, we prioritized the sources in the following order: country-specific CRVS, HMD, STMF, DemoData, Eurostat and WHO-MDB.

Annual population estimates by age group between 2015 and 2021 were obtained from the HMD for the populations for which this information was available and from the World Population Prospects 2022 (WPP)[26] for the rest. We used data on annual live births to account for changes in fertility during the pandemic.

We confined our analysis to countries with available data for at least three years during 2015–2019 and a population under 25 years old of at least 500 000 for a robust estimation of expected levels and uncertainty. Furthermore, data from Armenia and Azerbaijan were excluded due to the significant impact of the Second Nagorno-Karabakh War on youth mortality in 2020[27]. Applying these criteria, we identified CRVS data for 99 countries in 2020 and 90 in 2021.

Health management information system data

We also analysed monthly Health Management Information System (HMIS) data from 15 low- and lower-middle-income countries in sub-Saharan Africa (12) and Southeast Asia (3). Although HMIS data comprise administrative public hospital data–typically with lower coverage than civil register data–we expected to identify signals of mortality change since underreporting is likely consistent across observed years. Because the available observation period for HMIS data is considerably shorter than for CRVS data (in most cases, from January 2018), we used monthly data for a more robust baseline estimation.

Data coverage

Table 1 presents the number of countries and territories included in the primary analyses with CRVS and HMIS data on births, stillbirths and deaths by age group and income level for 2020 and 2021. Countries and territories were categorized by income level according to the most recent World Bank income classification.[28] As evident from Table 1, this study exhibits a notable bias towards upper-middle- and high-income populations due to data availability constraints. This distortion is visually represented in Figure 1, illustrating the percentage coverage of the global population under analysis by age group and income level.

Figure 2 displays the global distribution of countries with available CRVS or HMIS data by year. More comprehensive

Table 1. Number of countries and territories included in the analysis with data on live births, stillbirths and mortality under age 25 years, by age, income level and data source, in 2020 and 2021

	2020	2021
Total countries/territories	112	104
Live births	110	101
Stillbirths (>28 weeks)	77	60
Age group		
Neonatal (<28 days)	90	80
Infant (<1 year)	98	89
1–4 years	94	86
0–4 years	104	96
5–9 years	87	79
10–14 years	90	82
15–19 years	91	83
20–24 years	90	83
Income level		
Low	10	10
Lower-middle	22	18
Upper-middle	32	28
High	48	48
Data source		
CRVS	99	90
HMIS	15	15

CRVS, Civil register and vital statistics systems; HMIS, Health Management Information System.

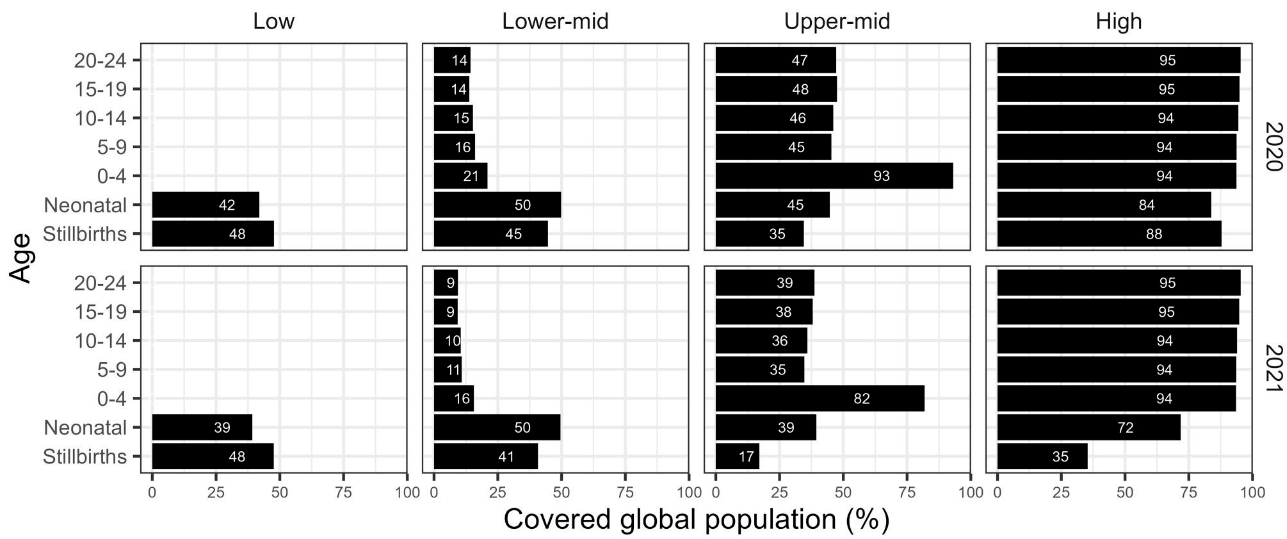

Figure 1. Coverage of the global population under observation by age group and income level

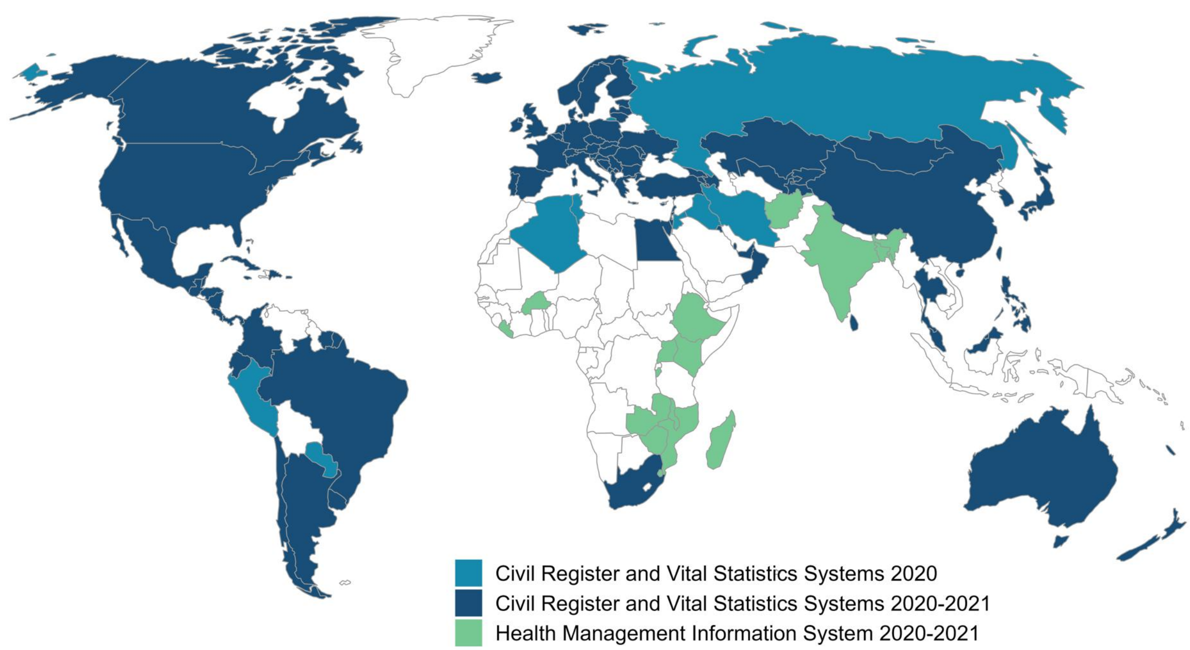

Figure 2. Countries and territories with available Civil Registration and Vital Statistics Systems and Health Management Information System data on stillbirths or all-cause mortality at any age group under 25 for 2020 and 2021. Besides Health Management Information System data, Bangladesh also has Civil Registration and Vital Statistics data on infant and child mortality in 2020 and 2021, and India on infant mortality in 2020

information on data availability, population coverage, and sources by age group, income level and year can be found in Supplementary Tables S1–S4 and Figures S1–S5 (available as Supplementary data at *IJE* online).

Methods

We define mortality *change* or *disturbance* as the difference between the observed all-cause mortality and the expected mortality 'in the absence of the pandemic' –also denoted as baseline mortality– during 2020 and 2021. These disturbances are categorized as *excess* (when mortality is higher than expected), *non-substantial changes* (when falling within prediction intervals) or *deficits* (when lower than expected). The method we used for CRVS data accounts for secular changes in mortality, as well as variations in population size and age structure over time. We obtained the baseline mortality by fitting a country- and age-specific generalized linear model to annual death counts between 2015 and 2019. The model uses a quasi-Poisson likelihood to account for overdispersion. A linear regression model was employed for countries reporting death rates and probabilities instead of counts. These models were then utilized to predict the expected deaths for 2020 and 2021.

We obtained a monthly baseline for countries with HMIS data by fitting a generalized additive model to include a cyclic spline component accounting for within-annual seasonality. Monthly baseline estimates were then aggregated to compute annual relative changes and uncertainty levels.

After obtaining baseline mortality estimates, we computed the *p-score* index[29] to measure mortality changes. P-scores indicate the relative change in observed mortality compared to the baseline, expressed in percentage. The p-score index for measuring mortality changes offers two key advantages. Firstly, it provides a clear interpretation by indicating the percentage change in mortality compared to the expected value in the absence of the pandemic. Secondly, it enables comparisons of mortality changes across countries, irrespective of differences in mortality levels and population sizes. Additional details on the models for baseline estimation and p-score calculation are available in the Supplementary Materials (available as Supplementary data at *IJE* online). Given the substantial disparities in data and methodologies, our findings from CRVS and HMIS data are presented separately.

Results

Figure 3 presents two summary plots of the age-specific p-score estimates for the 99 countries with CRVS data included in the analysis. Figure 3A plots the distribution of all country-specific p-score estimates by age group for 2020 and 2021, indicating whether they resulted in deficits, no changes or excess. Although p-score values vary widely across countries and age groups (between -88% and 126%), the p-score interquartile ranges (horizontal black bars) are spread between -23% and 23% in all observed age groups. In the Supplementary materials, we plot p-score estimates for each age group and country with CRVS data (Supplementary Figures S8 and S9, available as Supplementary data at *IJE* online) and display them in maps (Supplementary Figures S10–S17, available as Supplementary data at *IJE* online).

Figure 3B plots the proportion of countries and territories with CRVS data showing mortality deficits, no changes and excess by age group and year. According to this plot, across all observed age groups, most countries (70–89%, as indicated by the purple bars) experienced mortality as expected in 2020 and 2021.

However, besides the overall pattern of non-substantial changes in mortality, as presented in Figure 2, it is enlightening to focus on the composition of excess (indicated in red) and deficits (in blue) among the countries that did experience

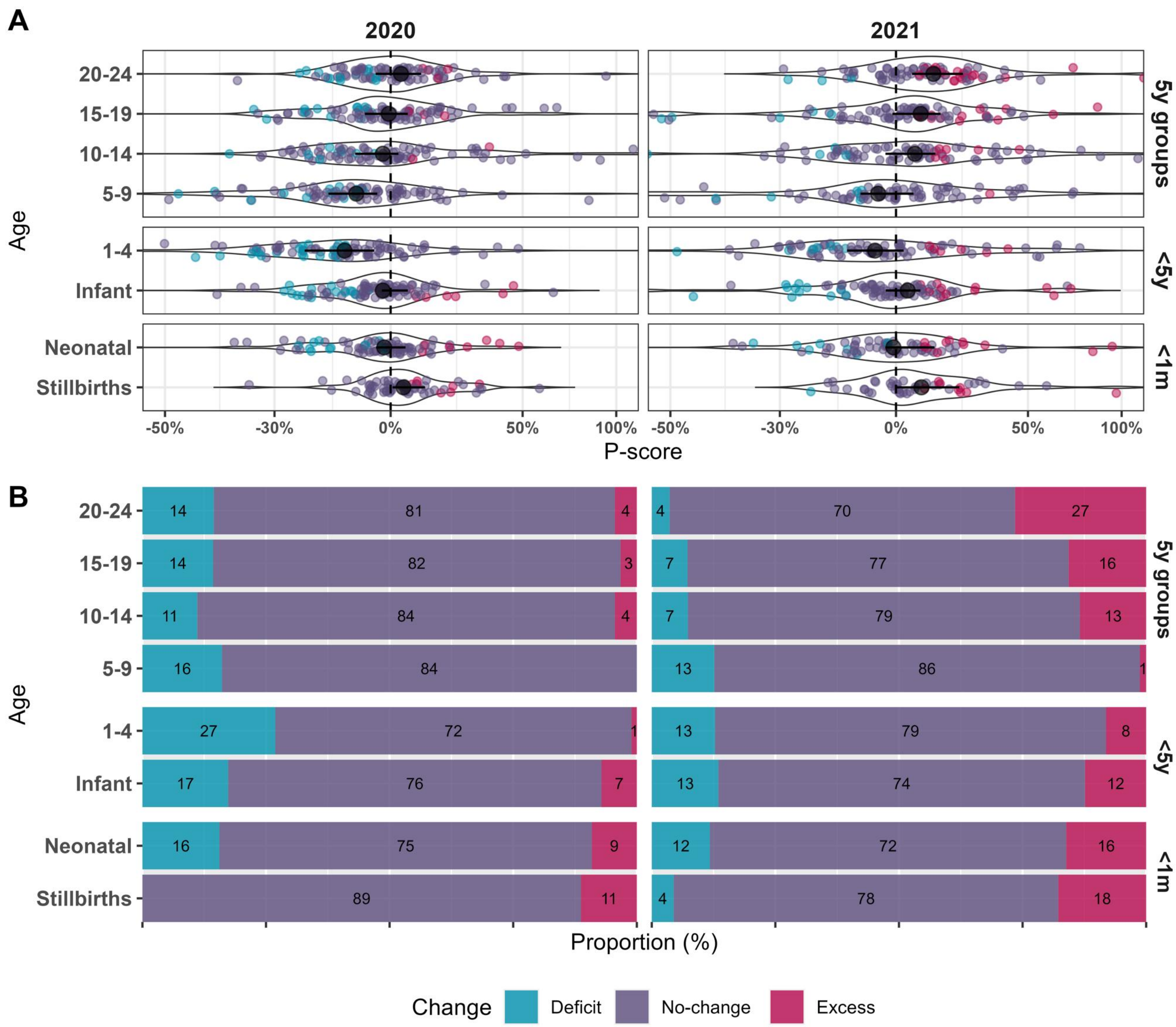

Figure 3. Summary of p-score estimates in 2020 and 2021 by age group among countries and territories with Civil Registration and Vital Statistics Systems data. Panel (A) depicts the distribution of country-specific p-score values by age group. Black dots and horizontal black bars indicate the population-weighted median and 25th and 75th percentiles of the p-score distributions. Panel (B) plots the proportion (in percentage) of estimates resulting in deficits, no changes (i.e. within the 95% prediction intervals) and excess mortality

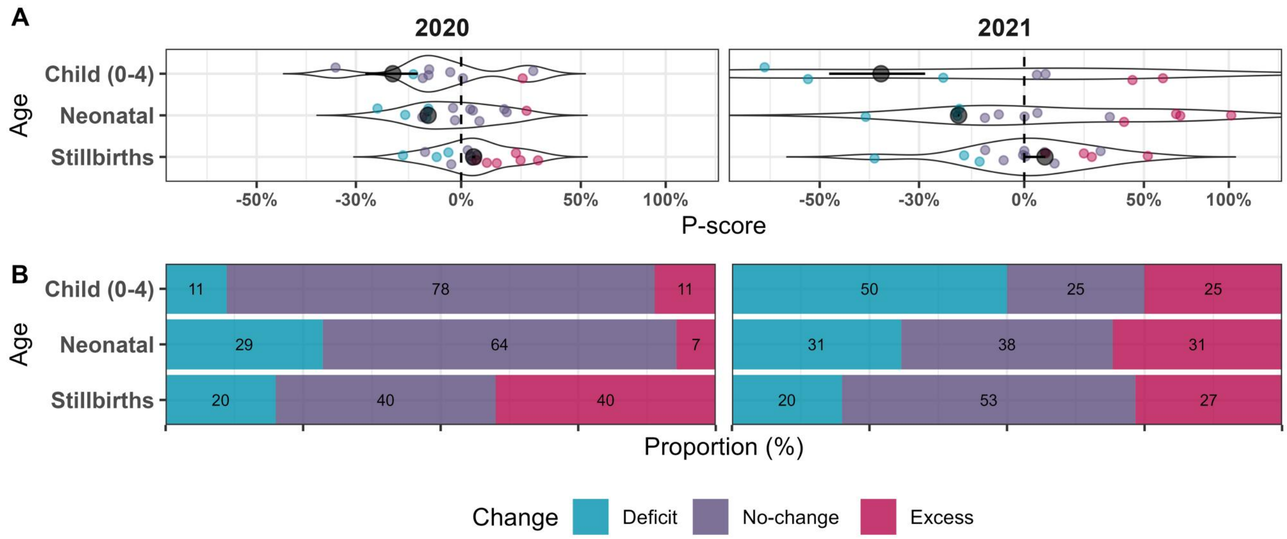

Figure 4. Summary of p-score estimates for 2020 and 2021 for stillbirths and neonatal and child mortality among countries and territories with Health Management Information System data. Panel (A) depicts the distribution of country-specific p-score values by age group. Black dots and horizontal black bars indicate the population-weighted median and 25th and 75th percentiles of the p-score distributions. Panel (B) plots the proportion (in percentage) of estimates resulting in deficits, no changes (i.e. within the 95% prediction interval) and excess mortality

changes in mortality. Stillbirths were the only group in which, among the countries showing changes, more countries experienced an excess rather than a deficit in both years. In 2020, across all age groups, except for stillbirths, deficit deaths were considerably more prevalent than excess among countries experiencing mortality changes. The landscape is different in 2021, where, besides stillbirths, excess mortality was also more frequent than deficits for neonates and those aged 10–14, 15–19 and 20–24, again among the countries experiencing changes. Remarkably, overall, in 2021, one in every five countries witnessed an increase in stillbirths, and one in every four saw an increase in deaths at ages 20–24—though these two observations are not necessarily true for a single country simultaneously.

Our sex-specific findings (Supplementary Figure S18, available as Supplementary data at *IJE* online) indicate no differences in mortality disturbances between females and males under 25. We also found similarities across the income levels under observation (Supplementary Figures S19 and S20, available as Supplementary data at *IJE* online): a considerably predominant tendency toward countries experiencing no changes in mortality, a weak tendency toward mortality deficits in 2020, and increases in excess for some ages in 2021. Regardless of income level, more countries experienced excess than deficits in stillbirths and deaths at ages 20–24 in 2021.

Figure 4 presents summary p-score estimates for the 15 countries with HMIS data. The pattern of these results is similar to the one observed among countries with CRVS data in Figure 3 in at least two aspects. First, in most countries, stillbirths and mortality rates were as expected. Second, a greater number exhibited excess rather than deficits in the countries where stillbirth changes were observed in both years.

Discussion

We analysed relative changes in stillbirths and child and youth mortality in 112 countries in 2020 and 104 in 2021. Our findings suggest that, despite the severe health crisis and socioeconomic disruptions experienced during the COVID-19 pandemic, most countries and territories analysed had the expected stillbirth and mortality levels across all observed age groups during both years. Nevertheless, in the case of countries where changes are observed, there are noticeable differences between both years. While in 2020, mortality reductions were more frequent than increases in all age groups except stillbirths, in 2021, increases were more prevalent than reductions among stillbirths and mortality among those aged 10–24 years. Notably, the observed age patterns of mortality change remained consistent between females and males in both years. Regarding income levels, we found a similar pattern in the distribution and proportions of relative changes in stillbirths and deaths across lower-middle-, upper-middle- and high-income countries.

Considering the ample evidence of minimal direct adverse effects caused by the COVID-19 disease at young ages, it is highly likely that both estimated excess and deficits were mostly indirectly influenced by the pandemic. In other words, mobility restrictions, isolation, the closure of schools, other non-pharmaceutical strategies adopted by governments, and disruptions in healthcare and food supply systems might have driven most stillbirth and mortality perturbations described in this study.

Although the mechanisms modulating the observed disturbances in mortality are beyond the scope of this paper, we can hypothesize about them. Our finding regarding stillbirth increases in 11% and 18% of the observed countries in 2020 and 2021 could be related–in addition to COVID-19 infections among pregnant women[30,31]—to pandemic-related anxiety,[32] nutritional deficiencies, reduced access to or delays in antenatal care, and decreases in preterm births.[33–36] However, the mechanisms driving excess stillbirths during the pandemic remain quite speculative, as several studies have reported conflicting evidence and further analyses are needed.[36,37]

The finding that more countries experienced excess stillbirths than deficits, alongside a greater prevalence of deficits in infant mortality than excess, suggests a potential connection through *harvesting effect* mechanisms. The increase in stillbirths could be the consequence of mortality displacements from infancy to gestational age. Nevertheless, while this mechanism appears consistent with our findings on infant mortality deficits in 2020, it does not explain the prevalence of mortality deficits among children aged 1–9 in both years nor the rise in the proportion of countries experiencing excess neonatal deaths in 2021. Addressing these patterns remains a crucial focus for future research.

The increases in mortality in 2021 for adolescents (10–19) in 13–16% of the observed countries and one-fourth for young adults (20–24) could be associated with pandemic-related psychosocial stressors that disproportionately affected these ages. Many children and youth at developmentally sensitive life stages suffered prolonged social isolation—in many cases trapped in dysfunctional family settings—loss of social support and safety nets and increased economic instability, among other stressors.[38,39] These risks were considerably higher for specific populations, such as youth suffering from substance abuse[39,40]—as was the case with the exacerbation of the pre-existing opioid epidemic in the United States and Canada[41,42]—, sexual and gender minorities, and pre-existing psychological disorders.[43] In addition to these indirect mechanisms affecting young ages, it is also plausible that a fraction of the excess mortality we found in 2021 for ages 20–24 was directly caused by COVID-19. Evidence shows that the new SARS-CoV-2 virus variants that emerged in 2021 increased risks of developing severe outcomes at young ages.[44,45]

Sensitivity analyses

We performed three robustness checks to evaluate how sensitive our estimates are to the definition of the training period, the inclusion of small populations and the time resolution of data. Our main findings hold when (i) using six training periods (5–10 years) for baseline estimation (Supplementary Figures S21 and S22, available as Supplementary data at *IJE* online); (ii) when incorporating countries and territories with relatively modest youth populations (<500 000 under 25) (Supplementary Figure S23, available as Supplementary data at *IJE* online); and (iii) when using weekly-based data instead of annual data (Supplementary Figure S24, available as Supplementary data at *IJE* online).

Moreover, to assess the uniqueness of our findings in the context of the pandemic years 2020 and 2021, we reproduced our analyses to estimate mortality changes in 2017, 2018 and 2019 across 75 countries (Supplementary Figure S25, available as Supplementary data at *IJE* online). The outcomes suggest that the disturbances observed in 2020 and 2021 are unique to the pandemic context and are not attributable to random fluctuations in mortality that might occur in any typical year. Further details on the sensitivity analyses can be found in the Supplementary Materials (available as Supplementary data at *IJE* online).

Limitations

We acknowledge several limitations. First, as the data section mentions, our investigation suffers from a substantial bias towards high- and upper-middle-income countries due to data availability. The efficient and adequate collection and publication of register and vital statistics data require considerable resources. Unfortunately, most lower-middle- and low-income countries cannot release rapid mortality updates that are sufficiently reliable to analyse nationally representative short-term mortality fluctuations. Our analyses of HMIS data from low- and lower-middle-income countries suggest strong similarities to the CRSV data findings in the magnitude and direction of relative changes in stillbirths and child mortality. Nevertheless, future research efforts should prioritize analysing data from lower-income settings to ensure a more inclusive and nuanced understanding of the pandemic impacts on youth mortality.

A second limitation of our study concerns data quality, specifically delays and under-registration of vital events. Registration delays in 2020 and 2021 result in a downward bias in mortality changes. However, enough time has passed to allow adjustments to the registration of deaths occurring in 2020, where deficits resulted in even larger proportions than those obtained for 2021. Although further register of delayed events might increase the mortality change estimates, we do not expect those adjustments to alter our findings substantially. Regarding the under-registration of vital events, as we measure mortality changes in relative terms, constant levels or gradual changes of under-registration would not lead to bias in our estimates. We have not found evidence suggesting that vital statistics coverage was systematically modified during 2020 or 2021, although this is possible for several low- and middle-income countries.

Identifying the mechanisms that modulated the observed changes in mortality requires different data and methods from the ones used in this study. For instance, further analyses on changes in the composition of mortality by cause of death would be required to understand better the mechanisms driving mortality changes. Likewise, further analyses across subnational populations (e.g. by geography, socioeconomic status and race) are needed to assess heterogeneity within countries.

Conclusion

We found no widespread changes in stillbirths and mortality among the ages and countries under observation. However, among the countries that experienced changes in mortality in 2020, lower-than-expected mortality predominates in all groups but stillbirths. In 2021, together with stillbirths, neonates and those aged 10–24 also saw a predominance of excess rather than deficits. In particular, the increase in the proportion of countries with higher-than-expected mortality in 2021 for stillbirths (18%) and ages 20–24 (27%) is noteworthy.

These findings are surprising given the considerable disruption of food supply and healthcare systems during the pandemic. Nevertheless, our findings do not invalidate the hypotheses that predict a detrimental impact of the pandemic on the health of the youngest segments of the population in the mid or long term. These disruptions may take more time to impact mortality at the youngest ages noticeably. Close and long-term monitoring of health and deaths among children and youth is required to understand the lasting impacts of the COVID-19 pandemic fully. This monitoring would require faster and better vital statistics systems, particularly deficient in low- and middle-income countries. Finally, further analyses with additional data on causes of death are needed to fully understand the mechanisms behind the changes in mortality we found in this study. This information will be essential for assessing the effectiveness of governmental responses and strategies intended to mitigate the burden of the pandemic.

Ethics approval

This research project does not require ethics approval as it uses only macro data that are freely available online.

Data availability

All underlying input data from civil registration systems are openly available databases. All the software codes for reproducing the analyses are available in OSF at https://dx.doi.org/10.17605/OSF.IO/FNUEY.

Supplementary data

Supplementary data are available at *IJE* online.

Author contributions

E.A. contributed to conceptualization, data collection and curation, methodology, software, validation, formal analysis, visualization and writing—original draft. L.H., H.C., D.S. and D.Y. contributed to conceptualization, data collection and curation and writing—review & editing. J.M. contributed to data curation.

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Conflict of interest

None declared.

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