Global, regional, and national minimum estimates of children affected by COVID-19-associated orphanhood and caregiver death, by age and family circumstance up to Oct 31, 2021: an updated modelling study

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Summary

Background In the 6 months following our estimates from March 1, 2020, to April 30, 2021, the proliferation of new coronavirus variants, updated mortality data, and disparities in vaccine access increased the amount of children experiencing COVID-19-associated orphanhood. To inform responses, we aimed to model the increases in numbers of children affected by COVID-19-associated orphanhood and caregiver death, as well as the cumulative orphanhood age-group distribution and circumstance (maternal or paternal orphanhood).

Methods We used updated excess mortality and fertility data to model increases in minimum estimates of COVID-19-associated orphanhood and caregiver deaths from our original study period of March 1, 2020–April 30, 2021, to include the new period of May 1–Oct 31, 2021, for 21 countries. Orphanhood was defined as the death of one or both parents; primary caregiver loss included parental death or the death of one or both custodial grandparents; and secondary caregiver loss included co-residing grandparents or kin. We used logistic regression and further incorporated a fixed effect for western European countries into our previous model to avoid over-predicting caregiver loss in that region. For the entire 20-month period, we grouped children by age (0–4 years, 5–9 years, and 10–17 years) and maternal or paternal orphanhood, using fertility contributions, and we modelled global and regional extrapolations of numbers of orphans. 95% credible intervals (CrIs) are given for all estimates.

Findings The number of children affected by COVID-19-associated orphanhood and caregiver death is estimated to have increased by 90·0% (95% CrI 89·7–90·4) from April 30 to Oct 31, 2021, from 2 737 300 (95% CrI 1 976 100–2 987 000) to 5 200 300 (3 619 400–5 731 400). Between March 1, 2020, and Oct 31, 2021, 491 300 (95% CrI 485 100–497 900) children aged 0–4 years, 736 800 (726 900–746 500) children aged 5–9 years, and 2 146 700 (2 120 900–2 174 200) children aged 10–17 years are estimated to have experienced COVID-19-associated orphanhood. Globally, 76·5% (95% CrI 76·3–76·7) of children were paternal orphans, whereas 23·5% (23·3–23·7) were maternal orphans. In each age group and region, the prevalence of paternal orphanhood exceeded that of maternal orphanhood.

Interpretation Our findings show that numbers of children affected by COVID-19-associated orphanhood and caregiver death almost doubled in 6 months compared with the amount after the first 14 months of the pandemic. Over the entire 20-month period, 5·0 million COVID-19 deaths meant that 5·2 million children lost a parent or caregiver. Our data on children's ages and circumstances should support pandemic response planning for children globally.

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Introduction

COVID-19-associated orphanhood and caregiver loss have become major global issues. Since the first US report in February, 2021,[1] modelling studies estimated that, globally, more than 1·5 million children had lost a parent or caregiver by April, 2021.[2] Racial and ethnic disparities in orphanhood have also been identified in the USA.[3,4] For children, the potential consequences of parent or

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Research in context

Evidence before this study

We searched PubMed, PsycINFO, Google Scholar, Web of Science, JSTOR, Academic Search Premier, and Public Library of Science for research articles published between Jan 1, 2020, and Nov 30, 2021, using the search terms "COVID-19*", "coronavirus*", "pandemic*", "orph* mort* death", "child* parent* grand* caregiver* coresid*", "household*", "bereave*", and "foster*", and found two publications that examined national estimates and one that estimated global numbers of children who have experienced orphanhood or death of a caregiver due to COVID-19. New evidence from the COVID-19 pandemic and past evidence from previous epidemics, including HIV/AIDS and Ebola virus disease, and the 1918 influenza pandemic indicates that large numbers of children were affected by orphanhood or death of their caregivers. Evidence related to COVID-19-associated deaths and orphanhood is accruing at a fast rate.

Added value of this study

This new modelled analysis updates previous global estimates with mortality data from 21 countries, and it adjusts estimations on the magnitude of children experiencing the death of a parent, custodial grandparent, or co-residing grandparent or kin due to the COVID-19 pandemic. With these new estimates for the study period from March 1, 2021, to Oct 31, 2021, we found that during the 20 months of the pandemic until the end of that period, more than 5·2 million children experienced the death of a primary or secondary caregiver. In that time, 5·0 million deaths due to COVID-19 were reported globally. Progression of COVID-19 pandemic associated orphanhood and death of caregivers has continued to accelerate globally, with the number of children affected increasing by 90% from April 30 to Oct 31, 2021. Our study further finds that globally, a larger proportion of adolescents (age 10–17 years) have experienced the death of parents or caregivers, relative to children of younger ages. We also find that in most countries, the death of a father has occurred with greater frequency than the death of a mother. Paternal and maternal deaths increase the risks of physical, emotional, and sexual violence, mental health problems, and family economic hardship, and the death of a father or mother can affect children differently.

Implications of all the available evidence

National and global implementations of evidence-based responses to the COVID-19 pandemic are urgently needed within a framework that comprehensively addresses first-order and second-order effects of the disease. Effective responses are key and should combine equitable vaccine access with evidence-based programmes for bereaved children, tailored to burden, location, age, and the circumstances of loss. We propose integrating care for children into every national COVID-19 response plan. This approach includes three components: prevent the death of caregivers by accelerating equitable COVID-19 vaccine delivery; prepare families to be safe and nurturing; and protect orphaned children using evidence-based strategies that address their increased risks of poverty, childhood adversity and violence, and strengthen their recovery.

caregiver loss are devastating and enduring, including institutionalisation, abuse, mental health problems, adolescent pregnancy, and chronic and infectious diseases.[5,6] Because of such consequences in the HIV/AIDS epidemic, the multibillion-dollar US President's Emergency Plan for AIDS Relief (PEPFAR) provides 10% of bilateral funding to support orphans and vulnerable children.[7] Research suggests that the types of programmes these PEPFAR investments build, including economic strengthening and positive parenting, are effective and cost-effective, thus supporting their widespread application to orphaned and vulnerable children in the COVID-19 pandemic.[8,9] As rates of COVID-19-associated orphanhood surge, an evidence-based emergency response is becoming increasingly urgent.

As this rapidly evolving pandemic progresses with new variants, shifting locations, vaccine disparities, and new data, an adequate response for children will depend on epidemiological characterisation of COVID-19-associated orphanhood and caregiver death, by time, person, and place. Data on changes over time across regions and nations will help to prioritise responses. Data on rates of orphanhood by age group and the circumstances of maternal or paternal orphanhood are required to implement developmentally appropriate, evidence-based interventions. Finally, an understanding by region and nation of the burden and surges in orphanhood and caregiver death will help governments and development partners to focus investments on the children at greatest risk, in the locations most affected.

We previously used the best data available on excess mortality and COVID-19 mortality, from 21 countries (representing 76% of COVID-19 deaths), to model global minimum estimates of children affected by COVID-19-associated orphanhood and caregiver death, for the first 14 months of the pandemic (March 1, 2020–April 30, 2021).[2] Loss of grandparents was included in that report, given their crucial role in care of children, particularly in lower-income settings.[2] The percentage of children living in extended family households that include grandparents is 38% worldwide and nearly 50% in the Asia Pacific region.[10]

Using new excess mortality and COVID-19 mortality data, we aimed to estimate the increase in the number of children affected by COVID-19-associated orphanhood and caregiver death during the 6 months immediately following our original report. We further sought to model global distributions of orphanhood by age group and circumstance (maternal or paternal orphanhood) for every region and nation, and to link our findings to an evidence-based strategy for COVID-19 emergency response programming.

Methods

Overview

In this modelling study, we used new excess death and COVID-19 death data to examine the increase in global minimum estimates of orphanhood and caregiver loss from the 14-month period of our previous study[2] (March 1, 2020–April 30, 2021) to the following 6-month period from May 1 to Oct 31, 2021. The appendix (p 2) gives the data sources. We defined orphanhood as the death of one or both parents;[11] primary caregiver loss as the death of one or both parents, or of one or both co-residing custodial grandparents aged 60–84 years (household composition data only included grandparents or other kin 60 years or older); and secondary caregiver loss as the death of one or more co-residing grandparents or older kin; appendix p 3).[2] We then estimated the age category and circumstance (maternal or paternal orphanhood) of these children by WHO region and globally (appendix p 4). We used the Guidelines for Accurate and Transparent Health Estimates Reporting.[12]

Data extraction

Using methods previously described,[2] we extracted COVID-19 and excess deaths where disaggregated data were available between March 1, 2020, and Oct 31, 2021, for 21 study countries (Argentina, Brazil, Colombia, England and Wales, France, Germany, India, Iran, Italy, Kenya, Malawi, Mexico, Nigeria, Peru, Philippines, Poland, Russia, South Africa, Spain, the USA, and Zimbabwe). Compared with our previous study, our data for the entire 20-month period were improved by newly available mortality data for our 21 study countries, particularly for Peru, India, and Poland, and we therefore did new back calculations for the original 14-month period (March 1, 2020–April 30, 2021) as well as new calculations for the subsequent 6-month period (May 1–Oct 31, 2021; appendix p 2). For our back calculations and our new calculations, we used the maximum value between COVID-19 deaths and excess deaths for countries where age–sex disaggregates were available, and we applied an adjustment factor using age–sex-disaggregated COVID-19 deaths where only total excess deaths were available. We used the term COVID-19-associated deaths to describe the combination of deaths caused directly by COVID-19 or indirectly by associated causes (eg, decreased access to health services), reported as excess deaths. Excess deaths were derived by subtracting average deaths between 2015 and 2019 from average deaths during the same period in 2020–21.

We used fertility data between 2003 and 2020 and child mortality data by 5-year age bands to calculate the average number of children per person of each age and sex. We then multiplied this estimate by the numbers of COVID-19-associated deaths in each 5-year age–sex band to calculate the number of children losing a parent. We adjusted for children who lost both parents (ie, double orphans) to avoid duplicate counts.[2] We also included a sensitivity analysis examining potentially reduced fertility due to COVID-19 in 2021 (appendix p 6).

Considering the loss of caregiving grandparents, we used UN household composition data for the proportion of adults older than 60 years co-residing with children aged younger than 18 years without a parent to define primary grandparent caregivers, and with a parent for secondary grandparent caregivers.[13] Other co-residing kin (aged 60 years or older) could also be classed as secondary caregivers. We included co-residing grandparents because they provide substantial financial, psychosocial, and practical support to households, and their loss can place children at risk of institutional placement, poverty, mental health issues, and abuse.[14] We multiplied these proportions by COVID-19-associated deaths to generate numbers of affected children, conservatively assuming one death resulted in only one child experiencing caregiver death.

See Online for appendix

Updated global extrapolations

We used methods previously described[2] to produce global extrapolations for COVID-19-associated orphanhood and caregiver death. This approach showed strong correlation between the ratio of orphanhood to deaths and total fertility rate (Pearson r^2=0·93).[2] We used logistic regression and further incorporated a fixed effect for western European countries into our model for the entire 20-month period, since the original model over-predicted caregiver loss in that region (appendix p 3):

$$\text{Ratio of orphanhood to caregiver loss} = \frac{\delta e^{\alpha+\beta\times\text{TFR}+\gamma\times\text{western Europe}}}{1+\delta e^{\alpha+\beta\times\text{TFR}+\gamma\times\text{western Europe}}}$$

where TFR is the total fertility rate; e is the exponential function; western Europe is 1 if the country is within western Europe or 0 otherwise; and α, β, γ, and δ are constants to be fit, combined with bootstrapping, to address uncertainty. We then estimated the percentage increase in orphanhood and caregiver death for the recent 6-month study period compared with the original 14-month period.

Orphanhood by age category and circumstance

We adjusted our previous methods[2] to estimate the age composition of children who lost mothers (maternal orphans), fathers (paternal orphans) for the entire period from March 1, 2020, to Oct 31, 2021. Instead of summing individual contributions to the average number of children an adult of each sex would have between 2003 and 2020, we estimated yearly fertility contributions separately (appendix p 5). Therefore, when multiplying by deaths, we obtained the average number of children for every year of age, between 0 and 17 years, that an adult would have in each adult age band. We assumed that fertility is negligible for both sexes for ages younger than

15 years, for females older than 50 years, and males older than 80 years. Our total number of countries for age-specific analyses was reduced to 20, because we excluded Russia due to scarcity of data on age of death.

We classified children into age groups based on differing needs, risks, and response strategies: 0–4 years, 5–9 years, and 10–17 years. We used population data from the 2020 US Census Bureau and Office for National Statistics (for England and Wales) to calculate orphanhood cases per 1000 children aged 0–17 years.[15,16] We did not adjust for double orphans, as they accounted for 0·1% of all orphanhood. We used bootstrapping to calculate uncertainty around age-specific calculations (appendix p 6). Credible intervals (CrIs) are the 95% quantiles from 1000 samples. We further assessed whether risks of orphanhood among the 0–4 years age group increased compared with the first 14 months, potentially due to greater vulnerability of younger aged adults to deaths from delta variants.

We fit a Bayesian multinomial logistic regression to our data from 20 study countries to estimate the proportion of orphans by age group and circumstance, using adult age proportions and gross domestic product (appendix p 6).

We used the extrapolated number of orphans, combined with our Bayesian model, to estimate orphanhood by age group and circumstance from March 1, 2020, to Oct 31, 2021, for all countries that had reported COVID-19 deaths up to Oct 31, 2021, according to data from Johns Hopkins University of Medicine Coronavirus Resource Center (appendix p 6). Analyses were done with R (version 4.1.2).

For the **Coronavirus Resource Center** see https://coronavirus.jhu.edu/

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

From the end of the first 14-month period on April 30, 2021, to the end of the new 6-month period on Oct 31, 2021, the number of children affected by COVID-19-associated orphanhood and caregiver death increased by 90·0% (95% CrI 89·7–90·4), increasing from 2 737 300 (1 976 100–2 987 000) children during March 1, 2020–April 30, 2021, to 5 200 300 (3 619 400–5 731 400) children during March 1, 2020–Oct 31, 2021 (table 1). During the 6 month-period from May 1 to Oct 31, 2021, at least 2 463 100 (95% CrI 1 643 300–2 744 500) children experienced COVID-19-associated orphanhood and caregiver death (table 1). Back calculations using new mortality data for our original 14-month study period yielded substantially higher minimum estimates for numbers of children affected by orphanhood and caregiver death than previously reported (table 1).

For the entire 20-month period, we estimate that a minimum of 3 367 000 (95% CrI 2 166 400–3 940 500) children have been orphaned globally and that 3 550 000 (2 377 700–4 280 900) children have lost their primary caregivers (table 1). An additional 1 650 300 (95% CrI 1 645 000–1 653 700) children experienced death of secondary caregivers (see appendix p 9 for study country estimates).

Globally, the cumulative minimum number of children affected by COVID-19-associated orphanhood and caregiver death, 5 200 300 (95% CrI 3 619 400–5 731 400), exceeded the reported number of COVID-19 deaths, 5·0 million. This relationship was particularly visible during our new 6-month study period (figure 1A). Minimum estimates of children affected by orphanhood and caregiver death exceeded COVID-19 deaths for the African, Eastern Mediterranean, and South-East Asia regions (figure 1B). Increases in COVID-19-associated orphanhood and caregiver deaths in the 6-month study period from

	Real-time minimum estimates for March 1, 2020 to April 30, 2021*	Back-calculated minimum estimates for March 1, 2020 to April 30, 2021†	Real-time minimum estimates for May 1, 2021 to Oct 31, 2021†	Total estimates for March 1, 2020 to Oct 31, 2021†	Percentage increase from April 30 to Oct 31, 2021†
Children affected by orphanhood	1 042 000 (806 000–1 083 000)	1 772 300 (1 167 500–1 999 500)	1 594 700 (998 800–1 941 100)	3 367 000 (2 166 400–3 940 500)	90·0% (89·6–90·6)
Children affected by orphanhood or death of primary caregivers	1 134 000 (884 000–1 185 000)	1 880 200 (1 284 200–2 181 900)	1 669 800 (1 093 500–2 099 100)	3 550 000 (2 377 700–4 280 900)	88·8% (88·4–89·5)
Children affected by death of secondary caregivers	428 000 (424 000–431 000)‡	857 000 (854 300–859 900)	793 300 (790 700–793 900)	1 650 300 (1 645 000–1 653 700)	92·6% (92·4–92·6)
Children affected by death of primary (including orphanhood) or secondary caregivers, or both	1 562 000 (1 299 000–1 683 000)	2 737 300 (1 976 100–2 987 000)	2 463 100 (1 643 300–2 744 500)	5 200 300 (3 619 400–5 731 400)	90·0% (89·7–90·4)

Data in parentheses are 95% credible intervals. All extrapolations are based on our set of 21 study countries, which together accounted for 76% of COVID-19 mortality between March 1, 2020, and April 30, 2021: Argentina, Brazil, Colombia, England and Wales, France, Germany, India, Iran, Italy, Kenya, Malawi, Mexico, Nigeria, Peru, the Philippines, Poland, Russia, South Africa, Spain, the USA, and Zimbabwe. All comparisons in Discussion section are based on these extrapolations using newly available updated data. *Previously reported by Hillis and colleagues.[2] †Based on newly available excess death and COVID-19 death reports. ‡This number is not reported by Hillis and colleagues.[2]

Table 1: **Extrapolations for global minimum estimates of children affected by COVID-19-associated orphanhood and caregiver deaths, March 1, 2020–Oct 31, 2021**

May 1 to Oct 31, 2021, ranged from 46·7% (95% CrI 46·5–46·9) in the Americas to 296·1% (274·9–317·9) in the Western Pacific region. Increases in COVID-19-associated orphanhood and caregiver death also occurred in European (56·7% [95% CrI 56·2–57·1]), Eastern Mediterranean (59·4% [59·0–59·8]), African (76·1% [75·9–76·2]), and South-East Asia (119·6% [118·9–120·4]) regions (appendix p 12).

Up-to-date estimates for numbers of children affected for every country can be found using a real-time calculator.

During the 20-month study period, there were large differences in the total number of orphaned children across the 20 study countries, ranging from 2400 (95% CrI 2200–2500) children in Germany to 1 917 100 (1 905 000–1 928 300) children in India (table 2). Calculations of estimated orphanhood cases per 1000 children showed highest rates in Peru (8·28 [95% CrI 8·03–8·45] per 1000 children) and South Africa (7·22 [7·07–7·36] per 1000 children; appendix p 10).

Despite these huge differences between countries, children aged 10–17 years accounted for the largest orphanhood numbers globally; they comprised 2 146 700 (95% CrI 2 120 900–2 174 200) of 3 374 900 (3 335 800–3 415 100) orphaned children in our global estimates in our age analysis, contributing 63·6% (63·4–63·8) to the total (table 2). Across the period, 491 300 (95% CrI 485 100–497 900) children aged 0–4 years and 736 800 (726 900–746 500) children aged 5–9 years are estimated to have experienced COVID-19-associated

For the **global orphanhood estimates real-time calculator from Imperial College London** see https://imperialcollegelondon.github.io/orphanhood_trends/

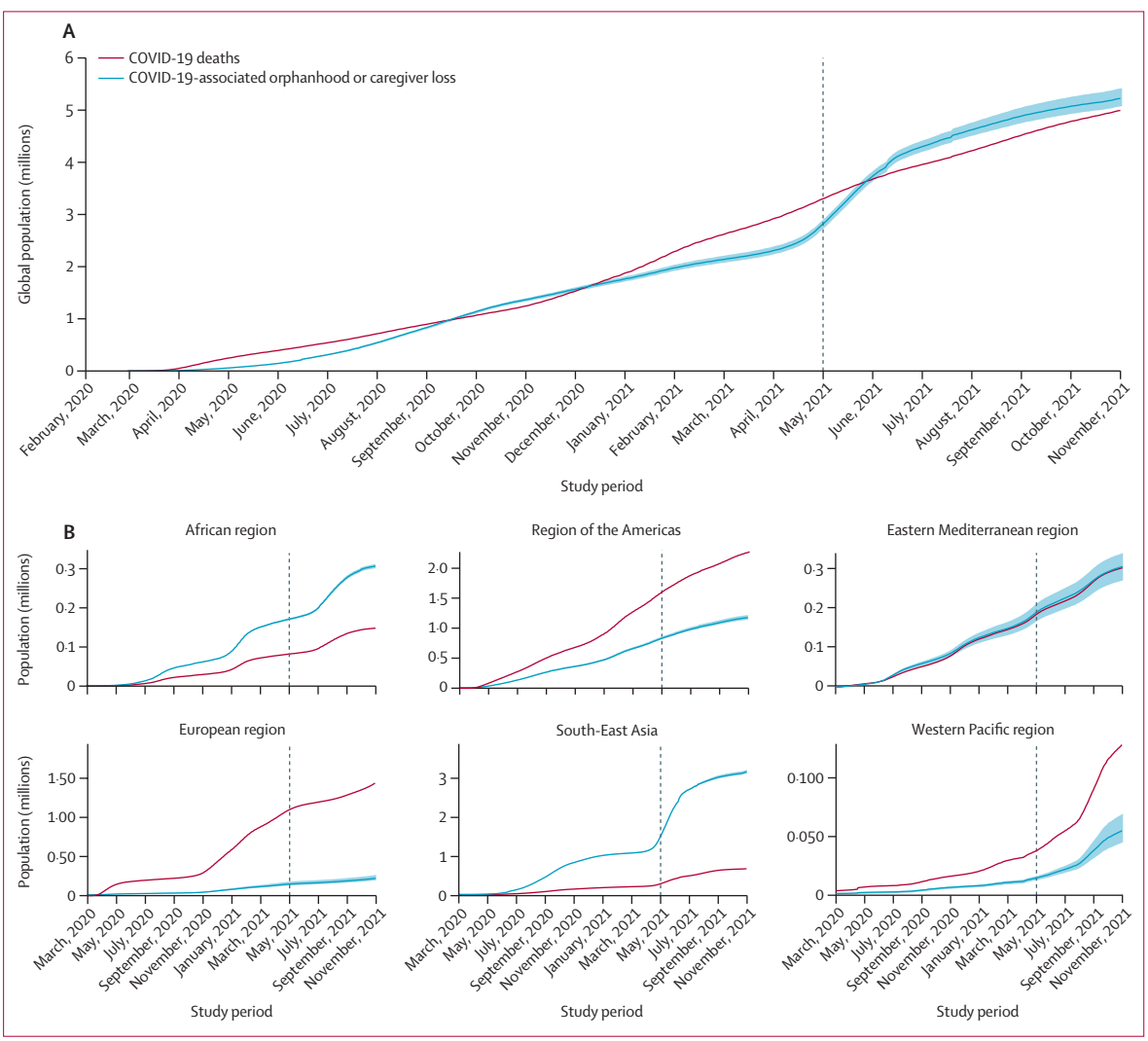

Figure 1: **Global (A) and regional (B) estimates of COVID-19-associated orphanhood and caregiver loss and reported COVID-19 deaths, March 1, 2020–Oct 31, 2021**

Estimates of children affected by orphanhood and caregiver loss and COVID-19 reported deaths are for all countries that had reported COVID-19 data up to Oct 31, 2021, according to data from Johns Hopkins University of Medicine Coronavirus Resource Center. All estimates are based on newly available excess death and COVID-19 death reports, updating our previous study.[2] The shading shows 95% credible interval for our estimation. The dashed vertical line shows the division between the first 14-month and second 6-month periods of our studies.

	Ages 0–4 years	Ages 5–9 years	Ages 10–17 years	Total	Maternal orphans	Paternal orphans
Argentina*	4300 (4100–4500)	6500 (6200–6800)	19 400 (18 800–20 000)	30 300 (29 400–30 900)	7000 (6700–7200)	23 300 (22 600–23 900)
Brazil	32 200 (31 000–33 300)	41 900 (40 800–43 100)	95 800 (94 200–97 400)	169 900 (167 300–172 500)	38 500 (37 800–39 200)	131 400 (129 100–133 700)
Colombia	7500 (7100–7800)	11 700 (11 100–12 200)	36 100 (34 900–37 100)	55 300 (53 700–56 600)	12 500 (12 000–12 900)	42 800 (41 400–44 000)
England and Wales	1500 (1400–1600)	2500 (2300–2600)	6500 (6300–6600)	10 400 (10 200–10 600)	2800 (2700–3000)	7600 (7400–7800)
France	600 (500–700)	1100 (1000–1200)	3600 (3500–3700)	5300 (5100–5500)	1400 (1300–1500)	3900 (3700–4100)
Germany*	300 (200–400)	500 (400–600)	1500 (1400–1600)	2400 (2200–2500)	600 (500–600)	1800 (1700–1900)
India	266 100 (263 500–268 600)	405 900 (401 600–409 600)	1 245 100 (1 237 200–1 252 700)	1 917 100 (1 905 000–1 928 300)	421 800 (417 500–426 500)	1 495 300 (1 484 500–1 505 200)
Iran	12 000 (11 700–12 200)	16 500 (16 200–16 800)	42 700 (42 200–43 100)	71 200 (70 300–72 000)	15 700 (15 300–16 100)	55 500 (54 700–56 200)
Italy	400 (300–400)	700 (700–800)	2700 (2600–2800)	3800 (3600–3900)	800 (700–900)	3000 (2800–3100)
Kenya*	1800 (1700–1900)	2200 (2100–2400)	4300 (4100–4500)	8400 (8000–8700)	1400 (1300–1600)	6900 (6600–7200)
Malawi*	600 (500–700)	800 (700–900)	2000 (1800–2200)	3500 (3200–3700)	700 (600–800)	2800 (2500–3000)
Mexico	25 500 (25 100–25 800)	43 500 (43 100–43 900)	123 600 (122 600–124 500)	192 500 (191 000–194 000)	52 800 (52 000–53 600)	139 700 (138 500–140 900)
Nigeria*	1000 (900–1200)	1400 (1300–1500)	3100 (2900–3300)	5500 (5300–5900)	800 (700–900)	4700 (4500–5000)
Peru*	12 900 (12 200–13 500)	19 000 (18 000–19 700)	48 300 (46 500–49 700)	80 200 (77 700–81 800)	18 200 (17 700–18 900)	62 000 (59 800–63 300)
Philippines*	2400 (2300–2500)	3800 (3700–4000)	10 100 (9900–10 300)	16 300 (16 000–16 700)	6900 (6600–7200)	9400 (9200–9700)
Poland	1000 (1000–1100)	1500 (1400–1600)	4000 (3900–4100)	6500 (6400–6700)	1400 (1300–1500)	5100 (5000–5300)
South Africa	27 000 (26 200–27 900)	35 600 (34 600–36 700)	71 900 (70 100–73 600)	134 500 (131 600–137 200)	42 100 (40 900–43 300)	92 500 (90 200–94 500)
Spain	300 (200–400)	500 (500–600)	2000 (1900–2100)	2800 (2700–2900)	800 (700–800)	2100 (1900–2200)
USA	30 200 (30 000–30 400)	38 100 (37 800–38 300)	81 100 (80 600–81 500)	149 300 (148 500–150 200)	44 200 (43 700–44 700)	105 200 (104 500–105 800)
Zimbabwe*	2000 (1900–2200)	2300 (2100–2500)	3600 (3400–3800)	8000 (7500–8300)	2200 (2000–2400)	5700 (5300–6000)
Total for 20 study countries	429 700 (425 400–433 700)	636 300 (628 800–642 700)	1 807 300 (1 794 700–1 819 400)	2 873 300 (2 852 100–2 891 600)	672 600 (665 800–679 300)	2 200 700 (2 183 900–2 215 100)
Global extrapolation	491 300 (485 100–497 900)	736 800 (726 900–746 500)	2 146 700 (2 120 900–2 174 200)	3 374 900 (3 335 800–3 415 100)†	793 600 (784 000–804 200)	2 581 300 (2 550 900–2 613 800)
Global extrapolation percentage	14·6% (14·4–14·7)	21·8% (21·7–22·0)	63·6% (63·4–63·8)	..	23·5% (23·3–23·7)	76·5% (76·3–76·7)

Data in parentheses are 95% credible intervals. Totals for 20 study countries and global extrapolation are also given alongside the percentages of each category in the extrapolation. *We use only COVID-19-attributed death data for these countries. †The global extrapolation total varies slightly to the one presented in table 1 because we did not account for double orphanhood in the age analysis owing to very small numbers (0·1%), and we included more uncertainty in this model (appendix pp 3, 5–6).

Table 2: **Estimated numbers of children orphaned in three age groups and maternal versus paternal orphanhood, for 20 study countries, and global extrapolation, March 1, 2020–Oct 31, 2021**

orphanhood globally. We also found the age-related composition of orphanhood changed little between the 6-month study period and our original study period (appendix p 26), despite proliferation of the delta variant, which could potentially increase risks of orphanhood among younger children. Peru, South Africa, India, and Mexico showed the highest rates of orphanhood among children aged 10–17 years (appendix p 10).

We found that children were more likely to have experienced the loss of a father than a mother: globally, 76·5% (95% CrI 76·3–76·7) of children were paternal orphans, whereas 23·5% (23·3–23·7) were maternal orphans (table 2). Overall, we estimated 793 600 (95% CrI 784 000–804 200) children to be maternal orphans and 2 581 300 (2 550 900–2 613 800) to be paternal orphans. Paternal orphanhood rates exceeded maternal ones in all

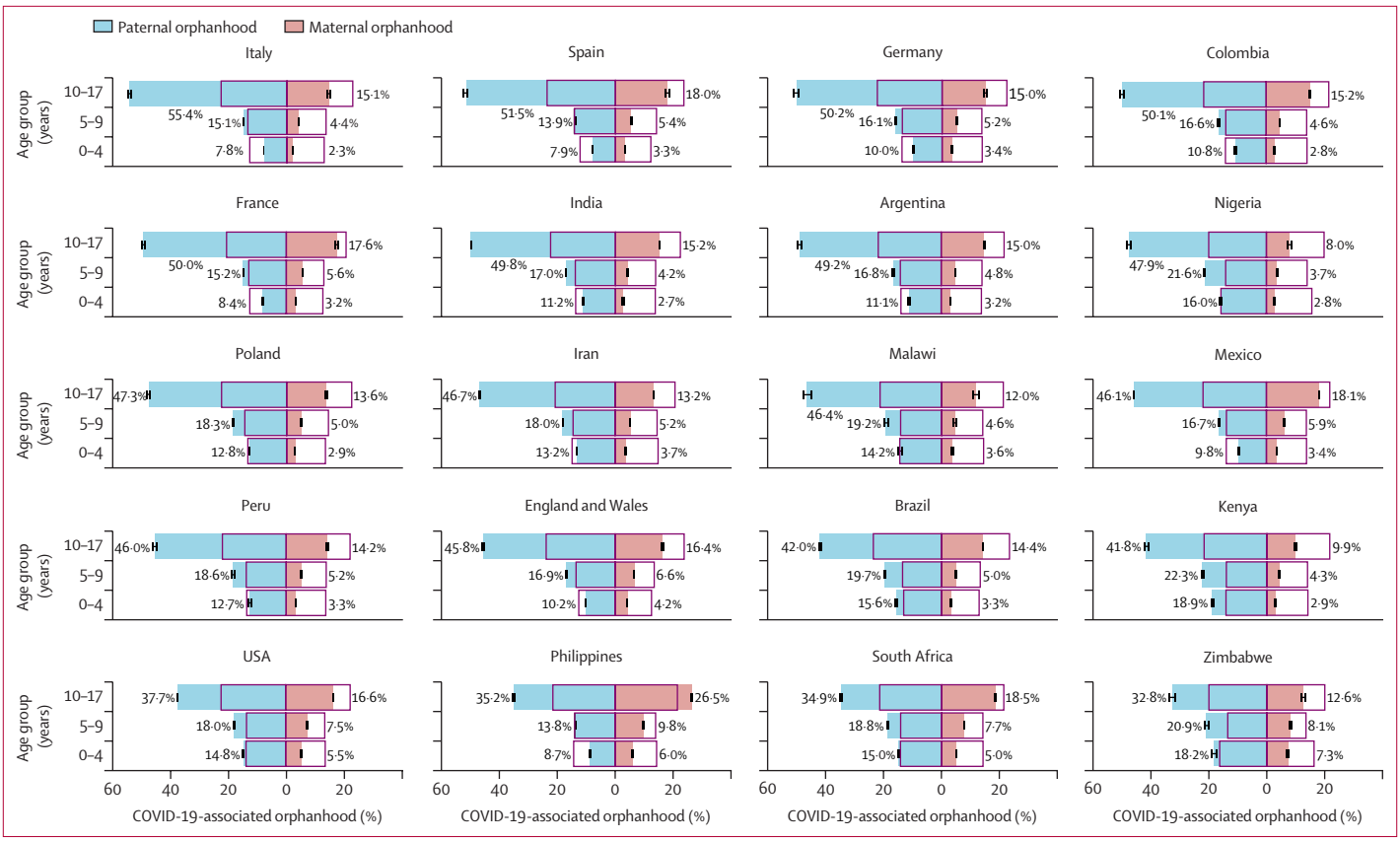

Figure 2: **COVID-19-associated orphanhood by age category and circumstance in each study country, March 1, 2020–Oct 31, 2021**
All estimates are based on newly available excess death and COVID-19 death reports. Percentages of orphanhood in the three age categories and two circumstances (maternal or paternal orphanhood), with error bars indicating 95% credible intervals. Boxes within each chart represent the proportion of orphanhood that would be expected if maternal or paternal orphanhood were equally likely.

countries, and were highest in Peru, South Africa, India, and Mexico (appendix p 10).

The category contributing most to orphanhood was therefore paternal orphans aged 10–17 years, who ranged from comprising 32·8% (95% CrI 31·5–34·1) of orphanhood in Zimbabwe to 55·4% (54·5–56·2) in Italy. The group contributing the next most was paternal orphans aged 5–9 years, ranging from contributing 13·8% (13·5–14·1) to COVID-19-associated orphanhood in the Philippines to 22·3% (21·6–23·0) in Kenya (appendix p 13). All country estimates where COVID-19 deaths have been reported are provided in the appendix (pp 15–25).

Analyses for study countries by orphanhood age category and circumstance showed that for each age group, proportions for paternal orphanhood exceeded that for maternal orphanhood (figure 2; appendix p 13). When distributions of paternal and maternal orphanhood by age were compared with the proportion expected if a child was equally likely to be a paternal or maternal orphan, marked disparities were observed, particularly for age groups 10–17 years and 5–9 years (figure 2).

The results of global extrapolations showed that 48·0% (95% CrI 47·8–48·2) of all COVID-19 associated orphanhood was paternal orphans aged 10–17 years and 15·6% (15·5–15·8) was maternal orphans aged 10–17 years (figure 3A; appendix p 14). Globally, a further 17·0% (95% CrI 16·9–17·2) of all COVID-19 associated orphanhood was paternal orphans aged 5–9 years, and 11·5% (11·3–11·6) were paternal orphans aged 0–4 years, with 4·8% (4·7–4·9) maternal orphans aged 5–9 years and 3·1% (3·0–3·2) maternal orphans aged 0–4 years. Regional extrapolations showed that the proportion of children aged 10–17 years affected by orphanhood ranged from 57·2% (95% CrI 56·3–58·1) in the African region to 68·2% (67·0–69·2) in the Eastern Mediterranean (figure 3B; appendix p 14).

Discussion

We found a surge in COVID-19-associated orphanhood and caregiver death over our new 6-month study period (May 1–Oct 31, 2021), with the total number of children affected nearly double that observed in the first 14 months (March 1, 2020–April 30, 2021). By Oct 31, 2021, 5·0 million COVID-19 deaths had occurred, and roughly 5·2 million children had lost a parent or caregiver due to COVID-19-associated death. This finding means that, globally, for every one reported COVID-19 death, at least

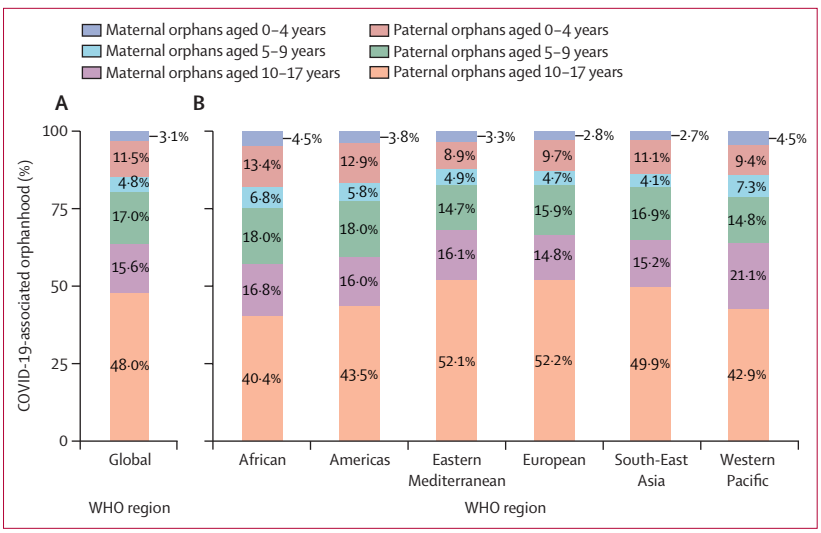

Figure 3: **Global (A) and regional (B) percentages of maternal and paternal orphanhood by age category, March 1, 2020–Oct 31, 2021**

All estimates are based on newly available excess death and COVID-19 death reports. For 95% credible intervals see the appendix (p 14).

For **global estimates from the real-time calculator** see https://imperialcollegelondon.github.io/orphanhood_calculator/#/country/Global

one child experienced orphanhood or caregiver death. For regions with higher total fertility rates, such as the African, Eastern Mediterranean, and South-East Asia regions, the numbers of children affected by orphanhood and caregiver deaths exceeded numbers of COVID-19 deaths. For South-East Asia, increases were also linked to devastating surges and new excess death data for India. These data suggest that rapid acceleration of vaccine uptake is strategically necessary for protecting children in these three regions, but these same three regions have the lowest vaccine coverage. Estimates of COVID-19 vaccine coverage by Sept 9, 2021, showed that 4% of the population in the African region, 21% in the Eastern Mediterranean region, and 34% in the South-East Asia region had received at least one dose; coverage was 53% for European, 56% for the Americas, and 67% for the Western Pacific regions.[17]

Our initial report[2] had showed a minimum estimate of more than 1·5 million children affected by COVID-19-associated death of parents and caregivers based on real-time mortality data for the first 14 months of the pandemic. Compared with that estimate, the use of new excess mortality data updated this minimum estimate to more than 2·7 million children, using back calculations. National COVID-19-associated mortality data, however, help to form the basis for minimum estimates, and for regions such as Africa, such estimates remain often vastly under-reported.[18] Consequently, we expect that future reports of minimum estimates will also increase as the quality of excess mortality and COVID-19 mortality data improves. New WHO mortality estimates show that the African region has under-reporting of death rates by a factor of 10.[19] Consequently, the real-time global minimum estimate for the number of children affected by COVID-19-associated orphanhood and caregiver death reached more than 6·7 million children by Jan 15, 2022, after adjustment for this under-reporting in the COVID-19 calculator. As new variants such as omicron emerge, it will also be important to assess their effect on caregiver deaths.

Our findings suggest an urgent need for pandemic responses to prioritise children affected by deaths of parents and caregivers. Effective national strategies should be tailored to children's age and the circumstances of loss.[3] Two noteworthy findings were the elevated proportions of paternal compared with maternal loss (three of every four children affected by orphanhood lost their fathers), and the disproportionate orphanhood among young adolescents (accounting for two of every three children whose parents died). Increased risks for children of paternal death appear to be linked to trends of later fertility and greater risk of death from COVID-19.[2] Although increased risks of paternal and adolescent orphanhood occurred in every country and region, the numbers of children affected in all subgroups are disturbing. Globally, we estimated that nearly 500 000 children aged younger than 5 years, more than 735 000 children aged 5–9 years, and more than 2·1 million children aged 10–17 years were estimated to be orphaned during the pandemic until Oct 31, 2021. Nearly 800 000 children have experienced the death of their mothers, and almost 2·6 million children are estimated to have experienced the death of their fathers. The largest share of orphanhood among children aged 0–4 years and 5–9 years are in the African region and region of the Americas, whereas the largest share among those aged 10–17 years is in European and Eastern Mediterranean regions. For South Africa, at least one in every 200 children in every age group has experienced COVID-19-associated orphanhood.

Evidence addressing parent and caregiver death indicates that age matters. Children of all ages experience grief and might also experience inadequate care, altered mood of the surviving parent or caregiver, food insecurity, marginal housing, and family disintegration, but associated effects, needs, and vulnerabilities vary by age. Younger bereaved children need immediate full-time nurturing and ongoing support for early childhood development, and the quality of care affects subsequent development, health, and mental health. Adolescents face post-orphanhood risks (varying across contexts) including sexual violence, exploitation,[20] HIV infection,[21] suicide, child labour, adolescent pregnancy, separation from family, household poverty, and leaving school to care for younger siblings.[20–22] Our finding that adolescents were most likely to lose a parent or caregiver can inform priorities for national plans. This age group benefits from parenting or caregiving approaches focused on communication, connection, and supervision,[23] and good parenting or caregiving increases confidence, resilience, and reduces risk behaviour.[24,25] Evidence-based interventions for adolescents, combining

positive parenting with economic strengthening, education, life skills, and services, are effective for preventing violence, other social vulnerabilities, adolescent pregnancy, child marriage, and HIV infection.[2] Both the PEPFAR DREAMS programme and the WHO INSPIRE package endorse these evidence-based approaches, using a life-course approach to support individual, familial, community, and societal programmes and policies.[2]

Parental loss also raises risks of institutionalisation, with age-related effects. Children entering institutions at younger ages and for long durations have reduced cognitive development, and older children have increased risk of violence and exploitation. Evidence shows such placement should be avoided, and family-based care through kinship, fostering, adoption, or *Kafalah* (a Muslim practice of fostering or guardianship) should be prioritised. Safe, stable, and nurturing family-based care that is sensitive to the bereaved child's age and developmental stage can support recovery, protect from future risks, and prevent institutionalisation.[26,27]

It is also important to understand that mothers, fathers, and grandparents all matter, but with some differences in effects that vary by culture and context. The loss of a primary breadwinner is linked to sudden and lasting family economic hardship.[28] For example, studies in sub-Saharan Africa show that paternal death is associated with decreased monitoring, guidance, and boundary setting;[29] increased risks of sexual violence, adolescent pregnancy, and early marriage for girls.[30] Loss of a primary socio-emotional caregiver can decrease social connectedness and family cohesion, and studies have shown such effects on maternally orphaned children.[31] These effects are mediated by varying family compositions—eg, single, dual, multigenerational, blended, traditional, and non-traditional—and by differing cultural approaches to adolescence, such as child marriage as a response to severe poverty. Adolescent girls affected by orphanhood have particularly heightened risks of school non-enrolment, non-attendance, sexual violence, and exploitation. Evidence confirms that parental monitoring reduces such risks.[32] Building parenting skills for remaining caregivers and life skills for adolescents can promote recovery by strengthening agency, self-esteem, and peer relationships.

Comprehensive responses that are sensitive to age and circumstances of bereaved children can restore hope and build resilience. Lessons from other epidemics demonstrate compounded social, economic, and psychological ramifications of orphanhood, and effective benefits of multifactored interventions.[33] Support for such interventions by governmental, civil society, and faith sectors can divert accumulated stressors, alleviate escalating suffering, and help children to find strength, experience growth, and develop new abilities.[34,35] Two decades of coordinated HIV/AIDS programming for orphans and vulnerable children have demonstrated that investments in evidence-based programmes (eg, cash transfers, parenting support, and safe schools) promotes resilience for children, families, communities, and nations.[35] Thus, the care received after caregiver death shapes the consequences of that death.

We note some limitations to our study. Although our findings only provide minimum estimates of children facing pandemic-associated orphanhood and caregiver deaths, we have refined these estimates with newly available excess mortality data. For orphanhood age and loss circumstances, under-estimates also occur for study countries reporting only COVID-19 mortality due to variable SARS-CoV-2 testing and death reporting, not excess mortality (appendix p 2). Although disaggregated COVID-19 mortality data were not available for every country, use of a stable COVID-19 fatality ratio makes it unlikely that this limitation substantially biased our models. Furthermore, the absence of age-disaggregated and sex-disaggregated data for both fertility and mortality data in many countries made it necessary to develop extrapolation methods to model minimum numbers and age proportions of children orphaned. The most important limitation is that our estimates are generated by modelling and thus cannot measure actual numbers of children affected by parent or caregiver death. Future pandemic responses should include surveillance of numbers of children affected for every parental and caregiver death, to track needs for services and provide referral platforms.

We found that globally, the heart-breaking hidden pandemic of over 5·2 million children affected by orphanhood and caregiver death, has outpaced the 5·0 million COVID-19 deaths. These data identify an almost one-to-one correspondence in the magnitude of COVID-19 deaths and that of children's COVID-19-associated loss of parents and caregivers. At the current rate, one child faces parental or caregiver death every 6 s. Our data suggest the surge of orphanhood and caregiver deaths must be urgently addressed with sustainable and scalable solutions, and integrated into coordinated and collaborative global, regional, and national strategies.

Effective COVID-19 responses should combine equitable vaccine access with evidence-based programmes for bereaved children, tailored to burden, geography, sex, age, and loss circumstances.[7] We propose immediate integration of care for children into every national COVID-19 response plan, as described in the joint report *Children: the hidden pandemic, February 2022—updated interim estimates*, prepared through the collaboration of the US Centers for Disease Control and Prevention, WHO, US Agency for International Development, the World Bank, the University of Oxford (Oxford, UK), Imperial College London (London, UK, Harvard University (Boston, MA, USA), and University College London (London, UK).[36] Care for children includes three components: prevent death of caregivers by accelerating equitable COVID-19 vaccine delivery; prepare families to be safe and nurturing; and protect

children using evidence-based strategies to reduce risks of poverty, childhood adversity and violence, and strengthen their recovery.

Contributors

HJTU and ABl guided and performed all the statistical and modelling analysis, and verified the underlying data. HJTU and SF wrote the entire appendix. Additional authors contributing to the formal analysis included SB, CAD, and OR, and these authors had full access to the data. HJTU and SH guided the conceptualisation and investigation, and wrote the first draft. SH guided the review and editing. LC, PSG, ABu, GB, LR, PG, CAN, CD, AV, and LS commented on the manuscript, and HJTU, SH, AV and LS had final responsibility for the decision to submit to publication.

Declaration of interests

CAD reports grants from the UK Medical Research Council and grants from NIHR during the conduct of the study. LC reports grants from UK Research and Innovation (UKRI) Global Challenges Research Fund during the conduct of the study. All other authors declare no competing interests.

Data sharing

Source code and data necessary for the replication of our results and figures will be available at publication from https://github.com/ImperialCollegeLondon/covid19_orphans. All data come from public sources and consist of aggregates (hence no individual data are included) with the exception of de-identified data from the Demographic and Health Surveys.

For **data from the Demographic and Health Surveys** see https://dhsprogram.com/

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