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Global minimum estimates of children affected by COVID-19-associated orphanhood and deaths of caregivers: a modelling study

Susan D Hillis, H Juliette T Unwin*, Yu Chen*, Lucie Cluver, Lorraine Sherr, Philip S Goldman, Oliver Ratmann, Christl A Donnelly, Samir Bhatt, Andrés Villaveces, Alexander Butchart, Gretchen Bachman, Laura Rawlings, Phil Green, Charles A Nelson III†, Seth Flaxman†*

Summary

Background The COVID-19 pandemic priorities have focused on prevention, detection, and response. Beyond morbidity and mortality, pandemics carry secondary impacts, such as children orphaned or bereft of their caregivers. Such children often face adverse consequences, including poverty, abuse, and institutionalisation. We provide estimates for the magnitude of this problem resulting from COVID-19 and describe the need for resource allocation.

Methods We used mortality and fertility data to model minimum estimates and rates of COVID-19-associated deaths of primary or secondary caregivers for children younger than 18 years in 21 countries. We considered parents and custodial grandparents as primary caregivers, and co-residing grandparents or older kin (aged 60–84 years) as secondary caregivers. To avoid overcounting, we adjusted for possible clustering of deaths using an estimated secondary attack rate and age-specific infection–fatality ratios for SARS-CoV-2. We used these estimates to model global extrapolations for the number of children who have experienced COVID-19-associated deaths of primary and secondary caregivers.

Findings Globally, from March 1, 2020, to April 30, 2021, we estimate 1 134 000 children (95% credible interval 884 000–1 185 000) experienced the death of primary caregivers, including at least one parent or custodial grandparent. 1 562 000 children (1 299 000–1 683 000) experienced the death of at least one primary or secondary caregiver. Countries in our study set with primary caregiver death rates of at least one per 1000 children included Peru (10·2 per 1000 children), South Africa (5·1), Mexico (3·5), Brazil (2·4), Colombia (2·3), Iran (1·7), the USA (1·5), Argentina (1·1), and Russia (1·0). Numbers of children orphaned exceeded numbers of deaths among those aged 15–50 years. Between two and five times more children had deceased fathers than deceased mothers.

Interpretation Orphanhood and caregiver deaths are a hidden pandemic resulting from COVID-19-associated deaths. Accelerating equitable vaccine delivery is key to prevention. Psychosocial and economic support can help families to nurture children bereft of caregivers and help to ensure that institutionalisation is avoided. These data show the need for an additional pillar of our response: prevent, detect, respond, and care for children.

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*Joint first authors

†Joint senior authors

CDC COVID-19 Response Team, US Centers for Disease Control and Prevention, Atlanta, GA, USA (S D Hillis PhD, A Villaveces MD); **MRC Centre for Global Infectious Disease Analysis and the Abdul Latif Jameel Institute for Disease and Emergency Analytics, School of Public Health** (H J T Unwin PhD, Prof S Bhatt PhD, Prof C A Donnelly ScD) **and Department of Mathematics** (Y Chen MSc, S Flaxman PhD, O Ratmann PhD), **Imperial College, London, UK; Department of Social Policy and Intervention** (Prof L Cluver PhD), **Department of Statistics** (Prof C A Donnelly), **and Department of Computer Science** (S Flaxman), **University of Oxford, Oxford, UK; Department of Psychiatry and Mental Health, University of Cape Town, Cape Town, South Africa** (Prof L Cluver); **Institute of Global Health, University College London, London, UK** (Prof L Sherr PhD); **Maestral International, Minneapolis, MN, USA** (P S Goldman MA); **Section of Epidemiology, Department of Public Health, University of Copenhagen, Copenhagen, Denmark** (Prof S Bhatt); **Prevention of Violence Unit, WHO, Geneva, Switzerland** (A Butchart PhD); **Office of Global HIV/AIDS, US Agency for International Development, Washington, DC, USA** (G Bachman MBA); **World Bank Group, Washington, DC, USA** (L Rawlings PhD); **World Without Orphans, London, UK**

Introduction

The first year of the COVID-19 response focused on preventing, detecting, and responding to infections, and on mitigating morbidity and mortality[1]—more than 145 million cases had caused more than 3 million COVID-19 deaths by April 30, 2021.[2] Hundreds of thousands more died from pandemic-associated sequelae.[3] Although safe and effective vaccines raise hope for ending the pandemic, current challenges to ensuring global access are formidable.[4]

Because most COVID-19 deaths occur among adults, not children, attention has been focused, understandably, on adults. However, a tragic consequence of high numbers of adult deaths is that high numbers of children might lose their parents and caregivers to COVID-19, as occurred during the HIV/AIDS, Ebola, and 1918 influenza epidemics.[5] Our goal is to shine a bright light on this urgent and overlooked consequence that is harmful for children.

Orphanhood, defined by UNICEF as death of one or both parents,[6] and death of caregivers can have severe consequences.[5] Because COVID-19 can lead to death within weeks,[1] families have little time to prepare children

(P Green MA); **Department of Pediatrics, Harvard Medical School and Boston Children's Hospital, Boston, MA, USA** (Prof C A Nelson III PhD)

Correspondence to: Susan Hillis, CDC COVID-19 Response Team, US Centers for Disease Control and Prevention, Atlanta, GA 30333, USA **shillis@cdc.gov**

Research in context

Evidence before this study

We searched PubMed, JSTOR, Academic Search Premier, PsycINFO, Web of Science, Google Scholar, and Public Library of Science from Jan 1, 2020, to Feb 5, 2021, using the search terms "orph* mort* death", "child* parent* grand* caregiver* coresid*", "household*", "COVID-19*", "coronavirus*", "pandemic*", "bereave*", and "foster*" and found no publications that examined global numbers of children who have experienced orphanhood or death of a caregiver due to COVID-19. However, evidence from previous epidemics such as HIV/AIDS, Ebola, and the 1918 influenza pandemic shows large numbers of children lost their caregivers due to pandemic-associated deaths.

Added value of this study

To our knowledge, this modelled analysis is the first to provide new data and evidence on the magnitude of children experiencing the death of a parent, custodial grandparent, or co-residing grandparent due to the COVID-19 pandemic. We found that more than 1·1 million children experienced the death of a primary caregiver, such as a parent or custodial grandparent, during the first 14 months of the pandemic, and more than 1·5 million children experienced the death of primary caregivers and co-residing grandparents (or kin). Many more children will experience such losses as the pandemic progresses. Parent or caregiver deaths increase the risks of mental health problems; physical, emotional, and sexual violence; and family economic hardship. These adverse experiences increase risks of suicide, infectious diseases such as HIV/AIDS, adolescent pregnancy, and chronic diseases. This study highlights evidence-based responses necessary within the COVID-19 global and national response.

Implications of all the available evidence

The magnitude of parent and caregiver loss in COVID-19 shows an urgent need for ensuring equitable global access to vaccines, along with evidence-based programmes and services. Evidence from other epidemics, such as HIV/AIDS and Ebola, shows that these programmes must strengthen the capacity of families to care for children and to prevent child separation, avoid the institutionalisation of children, and provide psychosocial supports. Low-cost accelerator approaches that combine cash transfers, positive parenting interventions, and education support might be the most effective. More than a million children should not remain under the radar.

for the trauma they experience when a parent or caregiver dies. Evidence shows institutionalisation—a common response even when there is a surviving parent—can result in developmental delays and elevated abuse.[7] Children losing primary caregivers have higher risks of experiencing mental health problems; physical, emotional, and sexual violence; and family poverty.[8–10] These adverse experiences raise risks of suicide, adolescent pregnancy, infectious diseases including HIV/AIDS, and chronic diseases.[11,12] Because of such findings, 10% of bilateral funding is invested to support orphans and vulnerable children within the multi-billion-dollar President's Emergency Plan for AIDS Relief (PEPFAR).[13]

It is important to focus broadly on family members commonly serving as caregivers for children, including not only parents but also grandparents. Grandparents increasingly live in multigeneration households, and play an indispensable role as caregivers for grandchildren.[14] Furthermore, the percentage of children living in extended family homes that include their grandparents is 38% worldwide and nearly 50% in the Asia-Pacific Region.[15] Grandparents, who are often the most vulnerable to COVID-19, frequently provide psychosocial, practical, or financial support for their grandchildren.[16] In Brazil, 70% of children receive such financial support,[17] yet Brazil ranks second globally for COVID-19 deaths, reducing options for kinship care. In the USA, 40% of grandparents living with grandchildren serve as their primary caregivers;[18] in the UK, 40% of grandparents provide regular care for grandchildren.[19] In Africa and Latin America, custodial grandparents often serve as guardians, caring for grandchildren whose parents migrated for work, died of AIDS or other causes, or are separated by conflict or war.[20] Other forms of family-based care, such as foster care and adoption, can also be severely constrained by mitigation measures.[21] Although many grandparents are in the older age groups prioritised by WHO for vaccines, data from April, 2021, show that many of the countries with the highest rates of COVID-19-associated deaths might not reach herd immunity for more than 4 years.[4] Thus, COVID-19 will continue to fuel the loss of parents and family members, leaving children whose parents die with fewer options than existed before the pandemic.

Data on the magnitude of COVID-19-associated deaths among caregivers are needed to guide global responses. The impact of these deaths on children can be influenced by variations in fertility, delayed childbearing, gendered aspects of parental death, and rates of primary caregiving by co-residing grandparents, alongside the prevalence of multigenerational households, which are often linked to pre-pandemic prevalence of female employment and lone parenthood. Here, we use the strongest available data on excess deaths, COVID-19 deaths, and fertility to estimate the number of children younger than 18 years who have lost mothers, fathers, or co-residing grandparents because of COVID-19-associated deaths. We model data for 21 countries that accounted for nearly 77% of global COVID-19 deaths as of April 30, 2021, to extrapolate a global minimum estimate for the total number of children experiencing COVID-19-associated deaths in parents or caregivers. We then synthesise evidence-based recommendations addressing the needs of these children and families.

Methods

Overview

We used methods similar to Lotka and colleagues[22] and those used by the UNAIDS Reference Group for estimating AIDS orphans[5,23] to estimate COVID-19-associated orphanhood among children younger than 18 years (appendix pp 2–5). We extended these to incorporate deaths of grandparents aged 60–84 years who lived with their grandchildren. We assumed co-residing grandparents helped to provide some type of relational, practical, or financial caregiving for grandchildren. Key aspects of such care include face-to-face contact or psychosocial support, caregiving behaviours (eg, feeding, teaching, or supervision), and financial support for household and educational expenses.[16]

We developed estimates of pandemic-associated orphanhood and caregiver deaths using excess mortality and COVID-19 deaths for 21 countries that accounted for 76·4% of global COVID-19 deaths up to April 30, 2021 (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). We based calculations of orphanhood and caregiver deaths on age-and-sex-stratified excess death data when available, because reported counts of confirmed COVID-19 deaths underestimate pandemic-associated deaths.[3] We further examined effects of age and sex variations in mortality on orphanhood and loss of caregivers. For countries without disaggregated excess mortality data, we adjusted the total number of children experiencing COVID-19-associated deaths of parents or caregivers using data on differences between COVID-19 deaths and excess deaths (see appendix pp 7–60 for methodological details). As we used aggregate country-level information and estimates from statistical models, no individuals are studied.

All analyses were done using R (version 4.0.2).

Deaths

We extracted available excess deaths and COVID-19 deaths from March 1, 2020, to April 30, 2021, using 5-year age bands or the level of disaggregation provided. For countries reporting COVID-19 and excess deaths, we used the larger of these two values in each age band to calculate the number of orphans, because we are interested in orphans associated with the pandemic as a whole. In this Article, we use the term COVID-19-associated deaths to refer to the combination of deaths caused directly by COVID-19 and those caused indirectly by other associated causes, such as lockdowns, restrictions on gatherings and movement, and decreased access or acceptability of health care and of treatment for chronic diseases, which are reported in the excess deaths. If excess deaths were not routinely reported for a given country, we calculated them by subtracting the monthly deaths in 2020–21 from the monthly average between 2015 and 2019. For Russia, where age-stratified and sex-stratified COVID-19 deaths and excess deaths were unavailable, we disaggregated excess deaths using published age-specific COVID-19 infection–fatality ratios estimates (appendix pp 2, 48–50). Where appropriate, we adjusted our deaths by the excess-to-COVID-19-deaths ratio (appendix pp 7–60). In light of the rise in COVID-19-associated deaths in India since February, 2021, we further used estimates of COVID-19-associated deaths to illustrate the impact of such a crisis on increases in orphanhood and death of caregivers.

See Online for appendix

Fertility rates

To estimate numbers of children orphaned as a result of the pandemic, we needed female and male fertility rates at the same disaggregation level as deaths (5-year age bands) for the years in which children younger than 18 years were born (2003–20). We assumed fertility in 2021 was the same as in 2020. In England and Wales, we used country-specific data available for both male and female fertility. For countries with Demographic and Health Survey data, we used the own-child method to calculate male and female fertility using the same source (appendix pp 2–3). For all other countries, we used the UN World Prospects female fertility rates and calculated male fertility rates using the UN Statistics Division data on men's fertility and fatherhood, alongside population estimates (appendix pp 2–3).

Paternal, maternal, or double orphans

We calculated the average number of children that each adult of a given age would have in 2020 by summing the average number of children born to a man or woman over each of the past 17 years at the age the adult would have been in each year, and adjusting for child mortality where necessary (appendix p 4). We assumed a fertility rate of zero for women older than 50 years but used data for men up to age 80 years. We then multiplied the average number of children for each 5-year age band by the number of male and female deaths in corresponding parental age bands to calculate the number of children losing a mother (maternal orphans) or father (paternal orphan). We adjusted for possible clustering of deaths between parents using an estimate of secondary attack rates and age-specific infection–fatality ratios to provide unduplicated counts for children losing one parent (single orphan) or both parents (double orphan; appendix p 4).[24] It was not possible to consider families with two parents of the same gender because of lack of available data for the proportion of same gender parents in every country. Due to the lack of globally consistent data on orphanhood, estimates of pre-existing single orphans were not available, so our estimates of double orphans only capture those whose parents both died during the pandemic.

We report the ratio of orphanhood to age-specific COVID-19-associated deaths. We calculated this ratio by dividing our estimate of the number of children

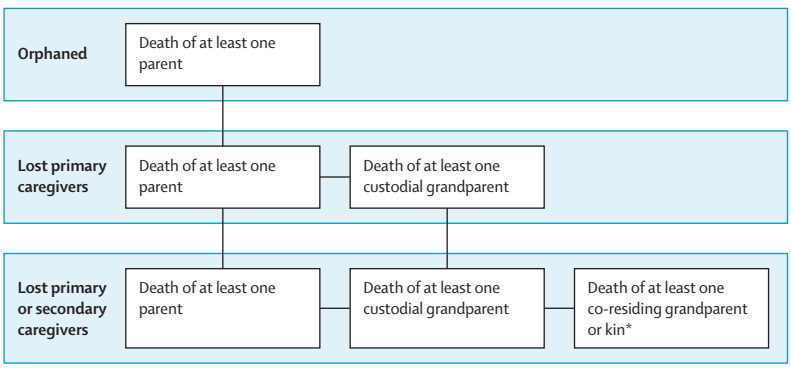

Figure 1: **Classification of deaths of parents, custodial (skip-generation) grandparents, and other co-residing grandparents or older kin**
*Grandparents or other older kin (≥60 years of age) co-residing with family members younger than 18 years.

orphaned by parental age group in broad age categories (which varied sightly due to country-specific differences in reporting) by the number of COVID-19-associated deaths in the age category. A ratio larger than 1 suggests a larger family size, such that one parental death can lead to multiple children orphaned. While the ratios are similar to age-specific fertility rates, they take into account the age pattern of COVID-19 mortality. We further calculated rates of orphanhood and caregiver loss per 1000 people using International Census Data. Rates are provided for combined categories, not individual categories, so as to provide estimates of minimum total numbers of children affected.

COVID-19-associated deaths in co-residing grandparents

To estimate COVID-19-associated deaths in co-residing grandparents, we used two UN Population Division measures of household composition: custodial grandparents and other co-residing grandparents. Custodial grandparents are skip-generation grandparents, defined as grandparents aged 60–84 years who live with their grandchildren in absence of parents. Other co-residing grandparents (or kin) are grandparents aged 60–84 years (or other co-residing kin aged 60–84 years, such as aunts or uncles) who live in multigenerational households with at least one family member younger than 18 years, along with at least one of their parents (appendix pp 4–5).[20] We truncated deaths of grandparents at 85 years, since we were aiming for a conservative estimate, and a large proportion of deaths in people older than 85 years in Europe and the USA were in care homes, which are excluded from the household composition data. We again adjusted these numbers using the estimated secondary attack rate and age-specific infection–fatality ratios to avoid overcounting the estimated 1·03% of children who lost parents and grandparents (appendix pp 4–5).

We limited loss of grandparents or older kin to a maximum of two per child (one male and one female), owing to limitations in global household composition data. However, low secondary household attack rates means the number of children experiencing further co-residing caregiver losses is likely to be negligible.

We assumed that extended family members aged 60 years or older who lived with family members younger than 18 years most likely represented grandparents and grandchildren, although the older adult might be an aunt, uncle, or cousin. A systemic review addressing grandparents co-residing with grandchildren reports that in multigenerational families, grandparents and parents provide care for the children together, through involvement or resources.[16] Because the death of a parent or abrupt death of a close family member is the most frequently cited type of trauma exposure experienced by children, we considered the abrupt death of either co-residing grandparents or other co-residing extended family aged 60 years or older to represent a substantial loss for the affected child.[25] From a public health perspective, the inclusion of these older adult family members is crucially important, as their prioritisation for vaccines renders their premature deaths highly preventable.

Global extrapolation

We used data from the 21 countries to develop global extrapolations for the impact of COVID-19-associated deaths on the numbers of children orphaned due to deaths of parents, losing primary caregivers (parents or custodial grandparents), and losing primary or secondary caregivers (parents, custodial grandparents, or co-residing grandparents or kin; figure 1). We based our estimates on the larger of either excess deaths or COVID-19 deaths for 12 countries with data available, and on COVID-19 deaths for nine countries with unavailable excess death data. To extrapolate beyond these 21 countries, we relied on the high correlation between total fertility rate (TFR) and the ratio of orphans to deaths (Pearson r^2=0·93) and fit a logistic model using least squares to estimate the two logistic parameters and gamma, a scaling parameter. We obtained COVID-19 deaths from each country from Johns Hopkins University and TFRs from the UN Population Division World Prospects data (appendix p 5). We considered uncertainty from the TFR in our global estimates by assuming our TFR was normally distributed with the medium fertility variant estimate for 2020–25 as our mean, and estimating the SD from the low and high variants given. We then calculated the global numbers of orphans by sampling the TFR for each country 1000 times and using our previously fitted logistic model. Our central estimates include country-specific estimates from our study, but 95% credible intervals (CrIs) are based solely on the samples.

We completed a leave-one-out sensitivity analysis to show how our central estimates of total number of children experiencing death of parents and caregivers varied if we fit the models to our data leaving out one country each time (appendix p 5). A second sensitivity analysis also considered whether our findings differed

	Orphanhood				Loss of custodial grandparent			Loss of primary caregivers*
	Maternal only	Paternal only	Double orphans	Total	One skip-generation grandmother only	One skip-generation grandfather only	Both skip-generation grandparents	
Europe								
England and Wales	2357	6136	2	8495	172	218	1	8886
France	1068	2995	1	4064	121	185	1	4371
Germany†	369	1221	0	1590	108	133	1	1832
Italy	671	2529	1	3201	191	175	1	3568
Poland†	942	2217	0	3159	493	441	4	4097
Russia	8194	14 093	6	22 293	3994	3409	28	29 724
Spain	617	1691	1	2309	173	186	1	2669
Americas								
Argentina†	2658	10 341	4	13 003	533	577	4	14 117
Brazil	25 608	87 529	13	113 150	8567	8577	69	130 363
Colombia	5270	24 576	5	29 851	1413	2018	11	33 293
Mexico	33 342	97 951	32	131 325	4429	5342	36	141 132
Peru	19 568	73 119	15	92 702	2501	3754	18	98 975
USA	29 222	75 645	17	104 884	4172	4618	34	113 708
Africa								
Kenya†	738	3574	0	4312	62	126	0	4500
Malawi†	371	1862	0	2233	41	93	0	2367
Nigeria†	556	3297	0	3853	37	57	0	3947
South Africa	26 673	55 733	16	82 422	8305	3868	30	94 625
Zimbabwe†	746	1921	0	2667	55	76	0	2798
Southeast Asia								
India†	25 500	90 751	12	116 263	1132	1766	9	119 170
Eastern Mediterranean								
Iran	8916	31503	7	40 426	231	337	2	40 996
Western Pacific								
Philippines†	2481	4019	2	6502	346	376	3	7227
Total	195 867	592 703	134	788 704	37 076	36 332	253	862 365

*Primary caregivers comprise parents and custodial grandparents. †All estimates for these countries are based on COVID-19 deaths, due to either the unavailability of data for excess deaths, or in the case of Poland, to COVID-19 deaths being higher than excess deaths.

Table 1: **Loss of primary caregivers due to COVID-19-associated deaths or excess mortality in 21 included countries from March 1, 2020, to April 30, 2021**

when we used TFRs from the Institute for Health Metrics and Evaluation (IHME) instead of UN Population Division TFRs.

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

In 21 countries, we estimated that by April 30, 2021, 862 365 children had been orphaned or lost a custodial grandparent due to COVID-19-associated death. Of these, 788 704 children were orphaned of a mother, father, or both, with most losing one parent; 73 661 lost at least one custodial grandparent; and 355 283 lost at least one co-residing grandparent or older kin (tables 1, 2). Countries with the highest numbers of children losing primary caregivers (parents or custodial grandparents) by April were South Africa, Peru, the USA, India, Brazil, and Mexico, with the number of children ranging 94 625 to 141 132 (table 1). Countries with at least one child per 1000 children experiencing COVID-19-associated deaths among primary caregivers were Peru, South Africa, Mexico, Brazil, Colombia, Iran, the USA, Argentina, and Russia, with rates ranging from 10·2 in Peru to 1·0 in Russia (table 2).

Among the 21 included countries, 1 217 648 children were orphaned or bereft of their custodial grandparents or other co-residing grandparents (table 2). Rates of children losing primary or secondary caregivers were highest in Peru (14·1 per 1000 children), South Africa (6·4), and Mexico (5·1). For India, the rapid increase in COVID-19-associated deaths from February to

	Orphanhood*		Loss of primary caregivers†		Loss of secondary caregivers (other co-residing grandparents or kin)			Loss of primary or secondary caregivers	
	Number	Rate per 1000 children	Number	Rate per 1000 children	Number losing a female caregiver	Number losing a male caregiver	Number losing two caregivers	Number	Rate per 1000 children
Europe									
England and Wales	8495	0·6	8886	0·6	442	1118	4	10 450	0·8
France	4064	0·3	4371	0·3	204	965	2	5542	0·4
Germany‡	1590	0·1	1832	0·1	279	681	2	2794	0·2
Italy	3201	0·3	3568	0·4	629	1580	5	5782	0·6
Poland‡	3159	0·5	4097	0·6	1720	2786	14	8617	1·3
Russia	22293	0·8	29724	1·0	12352	14338	100	56514	2·0
Spain	2309	0·3	2669	0·3	1181	2119	10	5979	0·7
Americas									
Argentina‡	13003	1·0	14117	1·1	1898	3474	15	19504	1·5
Brazil	113150	2·1	130363	2·4	22639	36714	183	189899	3·5
Colombia	29851	2·0	33293	2·3	5919	10824	47	50083	3·4
Mexico	131325	3·3	141132	3·5	23544	38682	191	203549	5·1
Peru	92702	9·6	98975	10·2	11670	25831	96	136572	14·1
USA	104884	1·4	113708	1·5	8770	14143	71	136692	1·8
Africa									
Kenya‡	4312	0·2	4500	0·2	60	309	0	4869	0·2
Malawi‡	2233	0·2	2367	0·2	30	135	0	2532	0·3
Nigeria‡	3853	0·0	3947	0·0	108	431	1	4487	0·0
South Africa	82422	4·4	94625	5·1	12773	11748	96	119242	6·4
Zimbabwe‡	2667	0·4	2798	0·4	55	134	0	2987	0·5
Southeast Asia									
India‡	116263	0·3	119170	0·3	26291	41298	213	186972	0·5
Eastern Mediterranean									
Iran	40426	1·7	40996	1·7	3320	9836	28	54180	2·3
Western Pacific									
Philippines‡	6502	0·2	7227	0·2	1292	1873	10	10402	0·3
Total of 21 included countries	788704	··	862365	··	135176	219019	1088	1217648	··
Estimated global total (95% CrI)§	1042000 (806000–1083000)	··	1134000 (884000–1185000)	··	··	··	··	1562000 (1299000–1683000)	··

Data are total number of children or rate per 1000 children younger than 18 years. CrI=credible interval. *Losing mother, father, or both. †Losing one or both parents or losing one or both skip-generation grandparents. ‡All estimates for these countries are based on COVID-19 deaths, due to either the unavailability of data for excess deaths, or in the case of Poland, to COVID-19 deaths being higher than excess deaths. §95% CrIs provide uncertainty surrounding our minimum estimate, rather than attempting to account for all sources of error.

Table 2: **Numbers and rates of loss of primary or secondary caregivers due to COVID-19-associated deaths and excess mortality from March 1, 2020, to April 30, 2021**

April, 2021, was associated with an 8·5-times increase in the number of children orphaned or losing caregivers in April (43139 more children than March total) compared with March (5091 more children than February total; appendix pp 24–25).

When examining how variations by sex and age in deaths and average numbers of children influenced estimates of paternal versus maternal orphans, we found that, with the exception of South Africa, deaths were greater in men than women in every country, particularly in middle-aged and older parents (figure 2A).

In England and Wales, France, the USA, India, and Latin American and African countries, the number of children whose parents died before middle age (ie, between around 15 and 50 years of age) was greater than the number of COVID-19-associated adult deaths before middle age (figure 2B). The highest numbers of paternal orphans were associated with deaths in males aged 45–64 years, and the highest numbers of maternal orphans with deaths in females aged 15–44 years (appendix pp 7–60).

Estimates for age-specific average numbers of living children were often higher for men than women,

Figure 2: **Country-specific COVID-19-associated deaths by age and sex, and ratio of orphans to deaths**

(A) Country-specific COVID-19-associated deaths by age and sex, based on sex-and-age disaggregated data. Details on how COVID-19-associated deaths were calculated for countries with different types of data are included in the appendix (pp 7–60). (B) Country-specific ratios of orphans (children losing their mother, father, or both) to COVID-19-associated deaths by age and sex. Numbers are reported in the appendix (pp 7–60). *COVID-19 deaths, where no excess death data were available. †COVID-19 deaths adjusted by excess deaths, where excess death data were available but not disaggregated by age and sex. ‡Composite deaths. §Adjusted for under-reporting, not excess deaths. ¶Excess deaths.

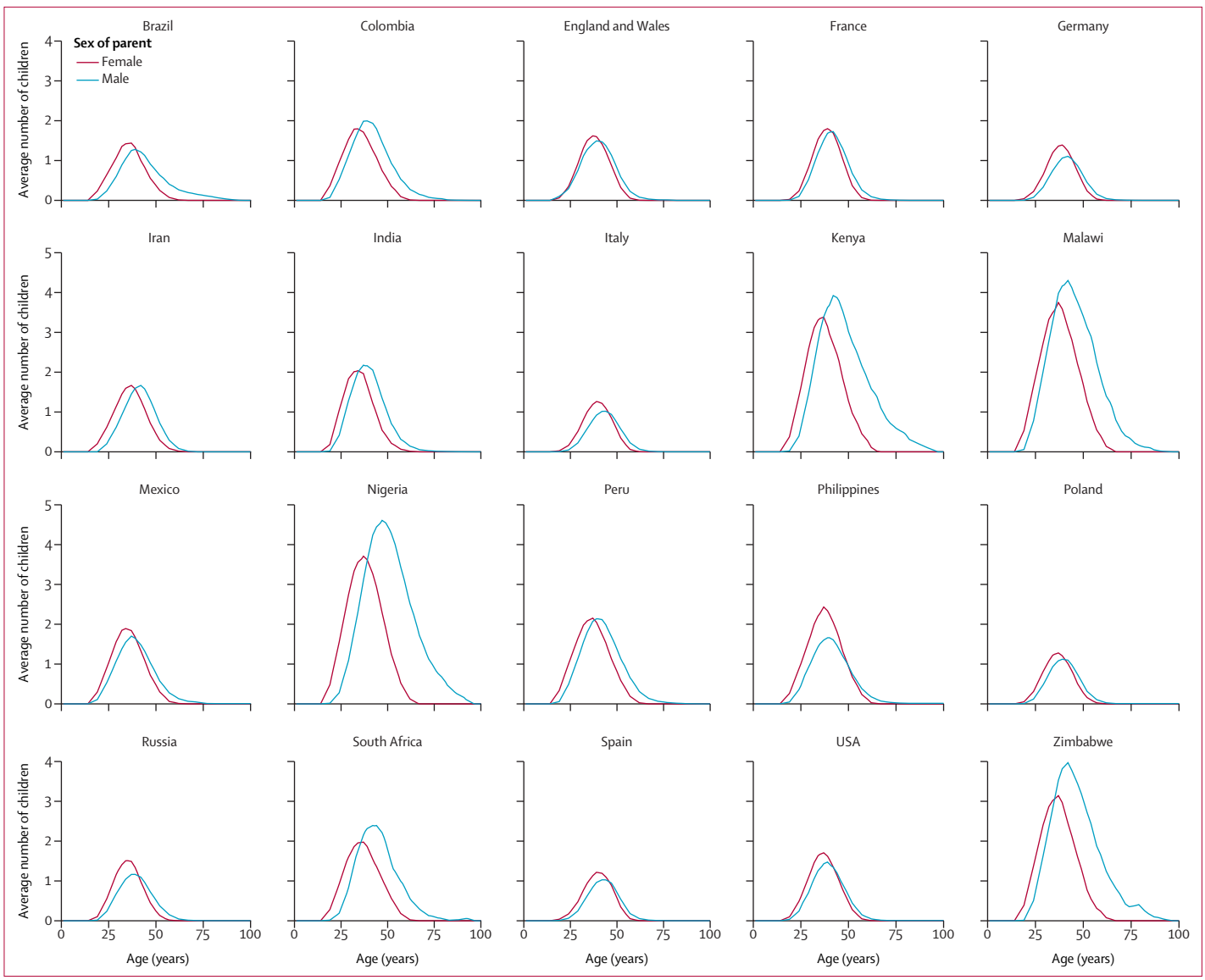

Figure 3: **Country-specific average number of living children by age and sex, based on male and female fertility rates**
Argentina is not included, as both female and male fertility were imputed rather than calculated (appendix pp 7–60).

especially in Kenya, Malawi, Nigeria, Zimbabwe, and South Africa (figure 3). This, in combination with higher male death rates, helps to explain the greater number of paternal versus maternal orphans, which ranged from 1·6-times to 5·9-times higher across the 21 countries (table 1).

Finally, we used our estimates for the numbers of children who were orphaned or experienced death of custodial grandparents or other co-residing grandparents or kin to compute global extrapolations for minimum estimates of the number of children losing parents, primary caregivers, or primary or secondary caregivers because of COVID-19-associated deaths. Fitting regression models allowed us to predict the ratio of children orphaned or with deceased caregivers to the total COVID-19-associated deaths reported in each country (figure 4). From these results, we developed global extrapolations for the impact of COVID-19-associated deaths on children, which suggest that up to April 30, 2021, a minimum of 1 042 000 children (95% CrI 806 000–1 083 000) experienced orphanhood, 1 134 000 children (884 000–1 185 000) experienced orphanhood or death of custodial grandparents, and 1 562 000 children (1 299 000–1 683 000) experienced orphanhood, or deaths of their custodial or other co-residing grandparents or kin. We observed a rapid escalation in our estimates during our study period: in the final month, the total number of children orphaned or losing caregivers increased by 220 000 from 1·34 million at the end of March to 1·56 million at the

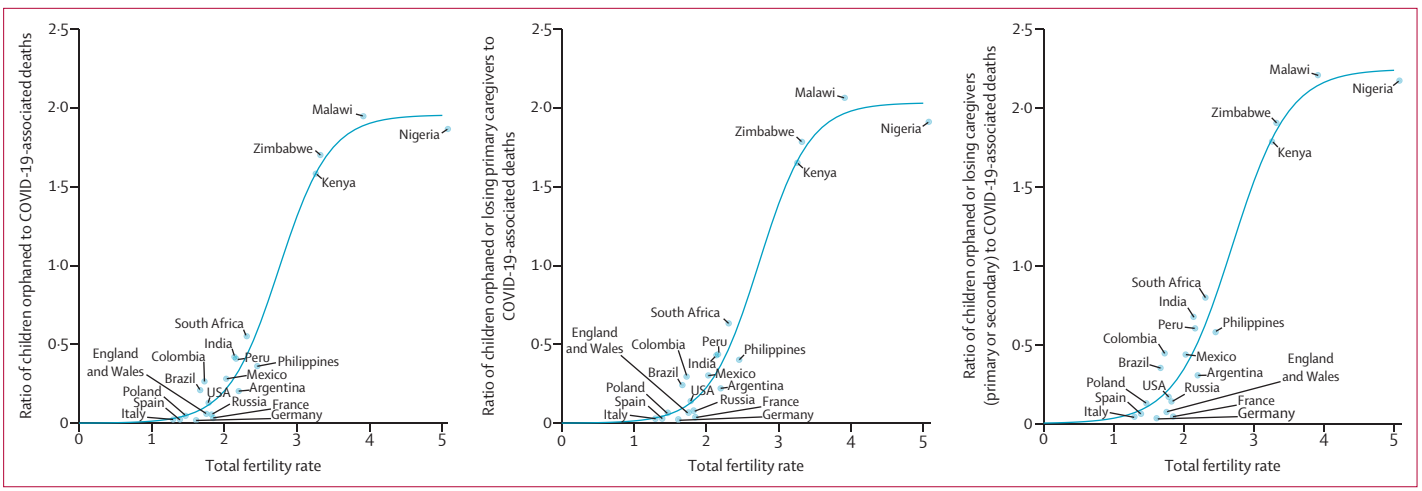

Figure 4: **Logistic regression models of ratios of children who lost parents or caregivers to the number of COVID-19-associated deaths**
Figure shows the logistic regression model for predicting the dependent variable ratio of children affected to all COVID-19-associated deaths, in children experiencing orphanhood (A), children losing primary caregivers (orphaned or losing custodial grandparents; B), or children losing primary caregivers or other co-residing grandparents or kin (C; appendix pp 5, 60–66). Fitted ratios for each country in our extrapolation are shown the appendix (pp 67–71).

end of April (appendix pp 62, 67). We also report extrapolations for these outcomes for every nation with at least one COVID-19 death by WHO Region in the appendix (pp 62–65). Both the leave-one-out sensitivity analysis and the sensitivity analysis based on IHME TFRs yielded findings very close to those from our full model (appendix pp 66–67).

Up-to-date minimum estimates by country of children affected by COVID-19-associated orphanhood and death of caregivers are available online, alongside interactive visualisations enabling comparisons between countries and over time.

Discussion

Our data suggest that from March 1, 2020, to April 30, 2021, the COVID-19 pandemic left at least 1 134 000 children globally whose lives have been permanently changed by the COVID-19-associated deaths of their mothers, fathers, or custodial grandparents. Of these children, 1 042 000 were orphaned of their parents. More than 1·5 million children experienced death of their parents, custodial grandparents, or grandparents or kin who lived with them. Among the 21 countries included in our study, those with more than one in 1000 children experiencing a COVID-19-associated death in a primary caregiver were Argentina, Brazil, Colombia, Iran, Mexico, Peru, South Africa, the USA, and Russia. For adults aged 15–50 years, the estimated number of children orphaned was greater than the number of adult deaths. Overall, there were up to five times more children with deceased fathers than deceased mothers.

Observed variations in COVID-19-associated deaths between countries were influenced by differences in COVID-19 deaths, excess mortality, fertility, and prevalence of grandparent caregivers. Our findings suggest high numbers of children have become single orphans because of COVID-19-associated deaths of younger and middle-aged adults, particularly fathers. Paternally orphaned children are more likely than non-orphans to experience sexual violence, potentially linked to household economic vulnerability.[8,26] Up to 23% of children in countries considered in this analysis are raised by single parents, whose death can have extreme consequences for children.[27] Increases in orphanhood that are associated with COVID-19 occur against a backdrop of more than 140 million existing orphans in need of global health and social care prioritisation.[28]

Even with surviving parents, COVID-19-associated death in a grandparent who lives with their grandchildren represents an important loss.[29] Childcare by grandparents is associated with increased parental labour-force participation, school attendance, educational attainment, and communication skills.[16] Orphaned children cared for by custodial grandparents after losing their parents might face secondary trauma after losing that caregiver from COVID-19.[30]

Evidence from previous epidemics shows that ineffective responses to the death of a parent or caregiver, even when there is a surviving parent or caregiver, can lead to deleterious psychosocial, neurocognitive, socioeconomic, and biomedical outcomes for children.[31] Psychosocial threats for children and adolescents bereft of parents or caregivers include increased risk of post-traumatic stress disorder, depression, and suicidal attempts.[30] These consequences can be compounded by mitigation-related isolation, school closures, and inability to participate in bereavement practices.[32]

By contrast, evidence-based responses can inspire hope by addressing these challenges in the context of COVID-19.[33] It is essential to support effective bereavement approaches, including psychosocial support

For **up-to-date minimum estimates of children affected by country** see https://imperialcollegelondon.github.io/orphanhood_calculator

For **interactive visualisations of minimum estimates of children affected** see https://imperialcollegelondon.github.io/orphanhood_trends

groups, empowering surviving caregivers to facilitate adaptive grieving, open communication, and trauma-focused cognitive behavioural therapy.[30]

Other psychosocial risks include domestic abuse and sexual, emotional, and physical violence.[12] Preventing violence and supporting positive parenting are essential, especially in stressed families experiencing new care arrangements.[33] Evidence-based resources adapted for virtual and digital platforms show promise for reducing parental stress and preventing abuse.[12,33] Child helplines should remain open.[12,21] Programmes should ensure girls are protected from child marriage, unwanted pregnancies, and HIV infection. The PEPFAR DREAMS programme has prevented such outcomes for millions of adolescent and pre-adolescent girls—including many orphans—through evidence-based interventions combining positive parenting, norms change, economic strengthening, education, life-skills programmes, and clinical services for victims.[34] This is a promising model for responding to COVID-19, as it is consistent with the widely adopted INSPIRE technical package, which comprises seven strategies for ending violence against children, developed by WHO, the Centers for Disease Control and Prevention (CDC), UNICEF, US Agency for International Development (USAID), and partners. The DREAMS and INSPIRE packages are largely aligned in their approaches, endorsing many similar evidence-based programmes, models, and platforms, and using a life-course approach to address individual, familial, community, and societal interventions. INSPIRE covers implementation of laws, norms change, safe environments, parenting support, income strengthening, response services, and education and life skills.[12] There is increasing evidence that INSPIRE strategies can readily be adapted to digital approaches, and a broad array of global stakeholders in ending violence against children supports them.[12,33]

Children experiencing COVID-19-associated deaths of parents or caregivers are at greater risk of family separation and institutionalisation. However, most bereaved children are not without adults to care for them. Some will remain with single parents; others might enter kinship, foster, or adoptive care. Of the 4200 children orphaned by COVID-19 in New York state, 23% are at elevated risk of being placed in foster care.[35] Institutionalisation should be avoided because of its clear damage to psychosocial, physical, and neural development. Instead, investments should favour strengthening family-based care.[28] Research shows that low-cost accelerator approaches focused on family strengthening—a subset of the same strategies that work in preventing violence—can improve multiple outcomes for children with deceased caregivers. Investments are urgently needed for accelerator programmes adapted to COVID-19, which combine economic interventions, positive parenting, and education support.[36] The focus should be on family strengthening where there is a surviving caregiver, or ensuring safe, stable, and nurturing family-based care through kinship, the Islamic practice of kafalah, foster care, or adoption.[28]

Negative socioeconomic impacts are strongly associated with adult deaths.[37] These might further decrease household consumption because of lost income and loss of childcare, which limits a surviving adult's ability to work.[16,38] Longer-term impacts for children include lower educational attainment and reduced income as adults.[39] Evidence from the HIV/AIDS epidemic shows that cash transfers and social protection reduce poverty and its associated effects. During COVID-19, cash transfers are being designed to offset consequences of pandemic-induced increases in poverty.[38]

Finally, biomedical consequences and considerations will influence the success in addressing psychosocial, socioeconomic, and neurocognitive challenges. Deaths of parents and caregivers can be prevented through investments that accelerate equitable access to vaccines, as well as to testing and therapeutics. For all programmes serving children and families, attention to personal protective behaviours remains key to mitigating the spread of SARS-CoV-2.

There are limitations that might have biased our findings. We underestimated the total numbers of children facing pandemic-associated orphanhood and caregiver deaths, as estimates for some countries in our study were based on COVID-19 mortality (because excess mortality was unavailable), which is under-reported because of variable SARS-CoV-2 testing and reporting. Although age-and-sex-stratified COVID-19 death data were not available for every country, our use of a stable COVID-19 infection–fatality ratio makes it unlikely that this limitation substantially biased our models. It is also unlikely that variations in fertility rates biased our global extrapolations because the leave-one-out analyses yielded similar findings when each country was omitted. Additionally, because evidence suggests that poverty-associated factors are associated with significantly higher numbers of COVID-19 cases and deaths than are comorbidities, it is likely that net variations in fertility rates associated with these factors (ie, higher rates associated with poverty and lower rates with comorbidities) would lead towards underestimation of global minimum estimates for orphanhood (see appendix pp 6, 7, 60–66 for further analysis and references).[40] Due to lack of data on country-specific prevalence of pre-existing single orphans from other causes, our estimates of double orphans are limited to deaths of both parents during the pandemic.

Future pandemic responses will be strengthened by including surveillance of parental and caregiver death (including by age, sex, and location) to track the need for support services and provide a platform for referral. As source data are limited by incomplete information on grandparents, further research elucidating prevalence and types of care that co-residing grandparents and extended family members provide are also needed.

Although evaluation of the age distribution of children facing the death of parents and caregivers was beyond the scope of this Article, the consideration of such data can help to inform future programme responses.

Globally, despite increasing vaccine uptake in high-income countries, rates of global COVID-19 cases and deaths continue to increase. In the 2 months following the end of our study period, reported global COVID-19 deaths increased from 3·2 million on April 30, 2021, to more than 4·0 million on July 7, 2021.[41] As adult deaths grow exponentially, we expect the numbers of children orphaned and losing caregivers to grow exponentially as well—in April, 2021, in India, for example, we estimated an 8·5-times increase in the numbers of children newly orphaned compared with the previous month. Variants of concern, which show increased transmissibility, immune evasion, or severity, including among younger populations, might further accelerate deaths of parents and caregivers.

The COVID-19 pandemic has been rapid and ruthless, and its impacts are ongoing. To be effective, the global response must be equally rapid. This new evidence of the effects of adult COVID-19-associated deaths on children is compelling. Multilateral organisations, national and local governments, non-governmental and faith-based organisations, voluntary organisations, and donors need to incorporate evidence-based programmes into their COVID-19 response plans to address the impact of caregiver COVID-19-associated deaths on children. Throughout this pandemic, children have been falling under the radar. Together, we must advance equitable vaccine delivery, avoid child institutionalisation, and support families to care for children with deceased parents or caregivers, as outlined in the joint report *Children: The Hidden Pandemic 2021*, prepared through the collaboration of the CDC, WHO, USAID, World Bank, University of Oxford, Imperial College London, Harvard University, and University College London.[42] Now is the time to focus on a group that will continue to grow as the pandemic progresses: the more than 1 million children who have lost a parent and another half a million children who have lost a grandparent caregiver living in their own home. These unnamed children are the tragic overlooked consequence of the millions of pandemic dead.

Contributors

HJTU and YC guided and performed all the statistical and modelling analysis. SF, SB, CAD, and OR contributed to the formal analysis. SDH guided the conceptualisation and investigation, wrote the first draft of the Article, and guided the writing, review, and editing. HJTU and YC wrote the appendix. All authors contributed to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content. HJTU and YC directly accessed and verified the underlying data, in consultation with SF. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

Source code and data necessary for the replication of our results and figures are available online. All data come from public sources and consist of aggregates (hence no individual data are included), with the exception of deidentified data from the Demographic and Health Surveys, which are available online.

For the **source code and data** see https://github.com/ImperialCollegeLondon/covid19_orphans

For **DHS data** see https://dhsprogram.com

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