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COVID-19-Associated Orphanhood and Caregiver Death in the United States

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The findings and conclusions in this article are those of the authors and do not necessarily represent the view or official position of the U. S. Centers for Disease Control and Prevention.

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Abbreviations: NH, non-Hispanic; CDC, Centers for Disease Control and Prevention; US, United States

Table of Contents Summary: We found marked variation by race and ethnicity, overall and within US states, in risks of COVID-19-associated orphanhood and death of grandparent caregivers among children.

What's Known on this Subject: Caregiver death increases risks of short-term trauma and life-long adverse consequences for children. One microsimulation research letter estimated parental deaths in the US to Feb 2021. A global study aggregated COVID-associated orphanhood and co-resident caregiver deaths across 21 countries.

What this Study Adds: We report overall and US state-specific findings, disaggregated by race/ethnicity, for COVID-19-associated orphanhood and death of grandparent caregivers. High rates of orphanhood, marked disparities, and state-specific differences show the overlooked burden among children at greatest risk, in states most affected.

Authors' Contributions:
Dr. Hillis guided the conceptualization and investigation, wrote the first draft of the Article, guided the writing, and led the reviews and revisions of the manuscript.

Drs. Unwin and Ratmann contributed to the conceptualization or design of the work; the interpretation of the data; guided and performed the statistical analyses, verified the underlying data, led writing of the methods section, prepared all visualizations, and performed all analyses for and contributed to the Supplementary Material.

Dr. Blenkinsop performed the statistical analyses, verified the underlying data, led writing of the methods section, prepared all visualizations, and performed all analyses for and wrote the Supplementary Material.

Drs. Flaxman and Donnelly contributed to the conceptualization and the formal analyses, and reviewed and revised the manuscript critically for important intellectual content.

Drs. Villaveces, Massetti, Cluver, Annor, Liburd, Demissie, Mercy, Nelson, and Sherr contributed to the conceptualization or design of the work; the interpretation of the data; the writing and revising the manuscript; and to providing critically important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Abstract

Background: Most COVID-19 deaths occur among adults, not children, and attention has focused on mitigating COVID-19 burden among adults. However, a tragic consequence of adult deaths is that high numbers of children might lose their parents and caregivers to COVID-19-associated deaths.

Methods: We quantified COVID-19-associated caregiver loss and orphanhood in the US and for each state using fertility and excess and COVID-19 mortality data. We assessed burden and rates of COVID-19-associated orphanhood and deaths of custodial and co-residing grandparents, overall and by race/ethnicity. We further examined variations in COVID-19-associated orphanhood by race/ethnicity for each state.

Results: We found that from April 1, 2020 through June 30, 2021, over 140,000 children in the US experienced the death of a parent or grandparent caregiver. The risk of such loss was 1.1 to 4.5 times higher among children of racial and ethnic minorities, compared to Non-Hispanic White children. The highest burden of COVID-19-associated death of parents and caregivers occurred in Southern border states for Hispanic children, Southeastern states for Black children, and in states with tribal areas for American Indian/Alaska Native populations.

Conclusions: We found substantial disparities in distributions of COVID-19-associated death of parents and caregivers across racial and ethnic groups. Children losing caregivers to COVID-19 need care and safe, stable, and nurturing families with economic support, quality childcare and evidence-based parenting support programs. There is an urgent need to mount an evidence-based comprehensive response focused on those children at greatest risk, in the states most affected.

Introduction

High COVID-19 mortality rates may have severe unrecognized consequences: large-scale death of parents and caregivers for children[1, 2]. By July 31, 2021, over 600,00 people had died of COVID-19 in the US, with thousands more deaths related directly or indirectly to COVID-19[3, 4]. To date, little attention has focused on children who suffer COVID-associated death of parents and co-residing grandparents serving as caregivers – and the attendant loss of salient nurturing, financial support, and care[1, 2, 5].

UNICEF defines orphanhood as death of one or both parents[6]. The definition includes children losing one parent, because they have increased risks of mental health problems, abuse, unstable housing, and household poverty[7-9]. For children raised by single parents, the COVID-

19-associated death of that parent may represent loss of the person primarily responsible for providing love, security, and daily care[10]. During an unprecedented pandemic, many children are at risk of such loss, as 23% of American children live in single-headed households[11, 12]. Children who lose caregivers to the pandemic may face intensified trauma, and may have an immediate need for kinship or foster care at a time when pandemic restrictions may limit access to protective services[12-15].

Beyond parents, grandparents are increasingly indispensable, often providing basic needs. In the US from 2011 to 2019, 10% of children lived with a grandparent[16, 17], and in 2019, 4.5 million children lived with a grandparent providing their housing[16]. Black, Hispanic, and Asian children are twice as likely as White children to live with a grandparent[18]. The majority of children co-residing with grandparents live with a single parent or no parents[19]. When custodial grandparents raising grandchildren in the absence of parents die, these children, functionally, face orphanhood a second time. With many caregiving grandparents in highest-risk ages for COVID mortality, children may face a serious new adversity[20].

COVID-19-associated deaths have disproportionately affected racial and ethnic minority populations, and may inequitably affect their children[21]. Disparities in numbers of children affected might be influenced by variations in fertility, age at childbearing, comorbidities, access to health services, social vulnerability, longevity[22], and rates of caregiving by grandparents. Assessing disparities in COVID-19-associated orphanhood and death of grandparent caregivers by race/ethnicity is key to building a response framework that serves children at greatest risk and in greatest need[23].

We estimated nationally and for each state, the numbers of children aged 0 - 17 who have deceased mothers, fathers, or co-resident grandparents because of COVID-19-associated deaths.

We developed demographic models to estimate variations by race/ethnicity in numbers and rates of children experiencing COVID-19-associated deaths of caregivers. We then summarized evidence-based recommendations addressing the needs of these children.

Methods

Overview. In this observational modeling study, we used fertility rates, excess mortality and COVID-19 mortality, and household composition data to estimate numbers, rates, and ratios for children <age 18 affected by COVID-19-associated orphanhood and deaths among caregivers. This approach is similar to methods previously described to quantify global estimates of these outcomes[24]. We report findings for COVID-19-associated deaths of parents and caregivers for the US and every state, disaggregated for Hispanic and Non-Hispanic populations, including White, Black, Asian, and American Indian/Alaska Native populations (Supplementary Material (SM)).

Data Sources and Populations. We used excess deaths and COVID-19 deaths from the National Center for Health Statistics, from April 1, 2020 through June 30, 2021[25], disaggregated by state, age (0-14, 15-29, 30-49, 50-64, 65-74, 75-84, 85+) and race/ethnicity[26]. We use 'COVID-19-associated deaths' to describe the combination of deaths caused directly by COVID-19, or indirectly by associated causes (e.g., decreased access to health services), reported as excess deaths. Excess deaths are derived by subtracting monthly average deaths between 2015 and 2019 from monthly average deaths in 2020/2021. We used the larger value between excess deaths and COVID-19 deaths per age band, because we are interested in orphanhood associated with the pandemic.

To estimate numbers of children orphaned by death of a parent, we needed female and male fertility rates at the same disaggregation level as deaths (categories above) for the years children ages <18-years-old were born (2003 – 2020). We used birth certificate data from the CDC Natality Online Database[27] to calculate age- and sex-specific fertility rates (average number of children born per woman or man) over time for women ages 15-49 and men 15-77 (SM)). For each state (a), gender (s), and race/ethnicity (r), we calculated the average number of children per adult of a given age/gender/race/ethnicity, which we further adjusted for childhood mortality and denote by $\mathrm{F}_{a,s,r}$(SM). Data were available for 2003-2019 for women and for 2016-2019 for men; therefore, we used Poisson regression models for each state, race/ethnicity and age group to estimate trends in male fertility (SM). Given unavailability of fertility data after 2019, we assumed 2019 rates held constant for 2020/2021. Although a recent report showed a 3.7% decline in fertility in late 2020[28], this change is unlikely to meaningfully bias our orphanhood estimates for children <age 18, as it would only affect the early infancy age, and evidence suggests 75% of orphaned children are over age 10[1].

Data on co-residing grandparent caregivers were derived from the 2019 US Census American Community Survey (ACS). ACS measures whether any grandchildren live with a grandparent in the household, and whether the grandparent is responsible for their basic needs, including food, shelter, clothing, day care[29]. Grandparent responsibility is further classified by absence of the parent in the home (SM). We used ACS data routinely tabulated on co-residing grandparents for persons ≥age 30[29] to determine proportions of adults by gender, race/ethnicity and state, who were grandparent caregivers.

Outcomes. Our outcomes were consequences of COVID-19-associated death of parents or co-residing grandparents, and included ‘orphanhood,’ ‘loss of primary caregivers,’ and ‘loss of primary or secondary caregivers' (Diagram). We defined 'orphanhood' as death of one or both parents[6]. 'Primary caregivers' have been described as parents, or grandparents responsible for most basic needs and care, and 'secondary caregivers,' grandparents providing some basic needs or care[18, 30, 31]. We defined 'loss of primary caregivers' as orphanhood, death of custodial grandparents providing parental care for their grandchildren in the absence of parents[32], or death of co-residing grandparents (living with grandchild(ren) and child's parents) responsible for most basic needs (e.g., food, housing, clothing, day care)[18]. We operationalized 'loss of secondary caregivers' as death of grandparents providing housing, but not most basic needs.

Analyses. We estimated numbers of children orphaned by COVID-19-associated death of parents for each state, by age category (a), gender (s), and race/ethnicity (r) of parent, by multiplying excess deaths in each sex/age/race/ethnicity bracket (denoted by $D_{a,s,r}^{parent}$) with the corresponding cohort fertility rates (denoted by $\mathrm{F}_{a,s,r}$):

$$C_{a,s,r}^{orphaned} = D_{a,s,r}^{parent} * \mathrm{F}_{a,s,r}.$$

To avoid duplicating children who lost both parents, we adjusted estimates based on published household secondary attack rates and infection fatality ratios (SM).

To estimate the number of children affected by death of custodial, primary caregiver, and secondary caregiver grandparents, we multiplied the proportions of the respective grandparent totals derived from the ACS data with COVID-19-associated deaths to produce minimum estimates of custodial, primary, or secondary grandparent caregiver loss (SM). To avoid double-counting children experiencing deaths of more than one caregiver, we adjusted our estimates (SM).

We report numbers and rates of children experiencing each outcome, disaggregated by race/ethnicity. We calculated uncertainty for frequency measures from 1000 resampled data sets by summarizing estimates and taking the lower 2.5 and upper 97.5 centile to obtain 95% bootstrap intervals for central analysis estimates (SM). We display state-specific findings using visualizations. Finally, we report rate ratios and 95% confidence intervals for variation by race/ethnicity in children's risk of COVID-19-associated death of caregivers.

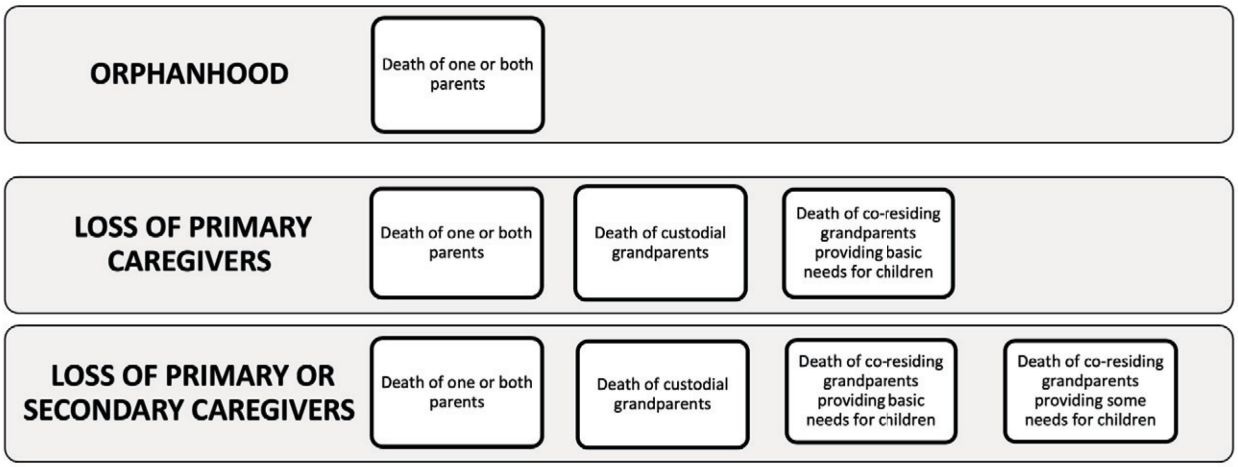

Diagram: Classification of deaths of parents, custodial grandparents, co-residing grandparents providing most basic needs, and co-residing grandparents providing some basic needs

Results

Burden of COVID-19-associated orphanhood and death of caregivers

During 15 months of the COVID-19 pandemic,120,630 children in the US experienced death of a primary caregiver, including parents and grandparents providing basic needs, because of COVID-19-associated death. Additionally, 22,007 children experienced death of secondary caregivers, for a total of 142,637 children losing primary or secondary caregivers(Table 1). Approximately 91,256 children in racial/ethnic minority groups experienced death of primary caregivers, far surpassing the 51,381 of Non-Hispanic White children experiencing such loss (SM).

States with large populations had the highest number of children facing COVID-19-associated death of primary caregivers: California (16,179), Texas (14,135), and New York

(7,175, Figure 1A). Analyses by race/ethnicity highlight states with disparities in orphanhood and death of primary caregivers (Figure 1B). In southern states, including along the U.S-Mexico border, a large proportion of children whose primary caregivers died were of Hispanic ethnicity: 10,863 (67%) in California, 8,223 (58%) in Texas, 773 (49%) in New Mexico. Among children losing caregivers in the Southeast, a large proportion were Black: 1,336 (54%) in Louisiana, 1,098 (45%) in Alabama, 1,016 (57%) in Mississippi. Affected children who were American Indian/Alaska Native were more frequently represented in Arizona 875 (18%), New Mexico 604 (39%), Oklahoma 314 (23%), Montana 175 (38%), and South Dakota 523 (55%).

Variations by race/ethnicity in loss of parent or grandparent caregivers (Table 1) were linked to differences in age composition, family size, family structure, and age-specific mortality rates (SM, Figures 2-8). For Hispanic and Black populations, respectively, 7% and 10% of children losing a primary caregiver faced death of grandparents, versus 14% among White children.

Racial and ethnic disparities at national and state levels.

Nationally, COVID-19-associated deaths were distributed across racial and ethnic groups in proportions similar to racial/ethnic distributions of the population (Figure 2A). However, we found substantial disparities in distributions of COVID-19-associated death of primary caregivers across racial and ethnic groups. We estimate White children account for 35% of children who lost primary caregivers, whilst White persons represent 61% of the total population. In contrast, children of racial and ethnic minorities account for 65% of children losing primary caregivers, compared to 39% of the total population. Hispanic and Black children account for 32% and 26% respectively, of all children losing their primary caregiver, compared to 19%, and 13%, of the total population. Similar patterns occurred across many states (Figure

2B). For example, though Black populations represent <40% of the population, and bear 45% and 40% of COVID-19-associated deaths in Mississippi and Louisiana respectively, Black children comprise the majority of children losing primary caregivers (57% and 54%, respectively). Additionally, we compared deaths by race/ethnicity per 100,000 residents >age 15 (Figure 3A) and estimated loss of primary caregivers per 100,000 children <age 18 by race/ethnicity (Figure 3B). Both overall and in many states, we found higher mortality rates in White persons, and higher rates of loss of primary caregivers among children of racial and ethnic minorities.

Rates of COVID-19-associated death of parents and grandparent caregivers were higher for all racial and ethnic groups, than for White children. An estimated 1 of every 753 White children experienced death of their parent or grandparent caregiver, compared to 1 of 168 American Indian/Alaska Native children (Table 2). Compared to the group at lowest risk, White children, we found American Indian/Alaska Native children, Black, Hispanic children, and Asian children were 4.5, 2.4, 1.8, and 1.1 times more likely, respectively, to lose a parent or caregiver. Consideration of factors that may influence these findings showed death rates and fertility rates were generally higher among non-White than among White persons (Table 2, SM).

States with highest disparities for children in COVID-19-associated death of caregivers

We identified states with the greatest racial/ethnic disparities for children affected by death of caregivers to help inform evidence-based responses focused on children at greatest risk, in states most affected. First, we ranked states by COVID-19 associated death rates (Figure 4A). Then, we identified the top 10 states with highest rankings for 3 measures of burden and gap, for COVID-19-associated death of primary caregivers: number of children affected, rate of children affected, and comparative rates of children affected among Hispanic or non-White children versus NH

White children. There was variability between these 3 measures, for which states ranked in the top 10 most affected. The highest numbers of children facing death of primary caregivers were observed for California and Texas (25% of total, Fig 4B), while the rate among children of COVID-19-associated deaths of primary caregivers was >1/400 children in New Mexico, Arizona, Tennessee and the District of Columbia (Fig 4C). States with largest disparities between non-White and White children in COVID-19-associated orphanhood were Alaska, North Dakota, New Hampshire, South Dakota and the District of Columbia (Fig 4D).

Discussion

From April 1, 2020 through June 30, 2021, COVID-19-associated deaths accounted for the loss of parents and caregivers for over 140,000 children; the lives of these children are permanently changed by the deaths of their mothers, fathers, or grandparents who provided their homes, needs, and care. We observed marked racial and ethnic disparities in the risk of COVID-19-associated orphanhood or death of grandparent caregivers, affecting 1 of 753 White children, 1 of 412 Hispanic children, 1 of 310 Black children, and 1 of 168 American Indian/Alaska Native children. The highest burden for children of COVID-19-associated death of primary caregivers occurred in Southern border states for Hispanic children, Southeastern states for Black children, and in states with tribal areas for American Indian/Alaska Native populations. Although over half of COVID-19-associated deaths occurred in the White population (5 of 10), the majority of children facing COVID-19-associated orphanhood or deaths of caregivers (almost 7 of 10) occurred in non-White minority populations, with Black, Hispanic, and American Indian/Alaska Native children being disproportionately affected.

The COVID-19 pandemic has thrown into sharp contrast the social and health disparities in disease occurrence, severity, and outcomes between geographies, and racial and ethnic groups[33, 34]. These disparities impact orphanhood and death of caregivers among children of minority race/ethnicity at much higher rates[35]. Factors affecting such inequities include structural and social determinants of health, such as discrimination, neighborhood environment, barriers in access to healthcare, occupation, educational gaps, economic instability, living arrangements and unstable housing[36]. These factors increase exposure to SARS-CoV-2 infection among racial and ethnic minorities due to their disproportionate representation in essential jobs and increased likelihood of living in multigenerational homes. These social determinants of health may have negative impacts on children who face immediate and life-long consequences of losing a caregiver responsible for their needs and nurture[35].

Orphanhood and caregiver loss, an Adverse Childhood Experience (ACE), may result in profound long-term impact on health and well-being for children[37-40]. Loss of parents is associated with mental health problems, shorter schooling, lower self-esteem, sexual risk behaviors, and risks of suicide, violence, sexual abuse, and exploitation [8, 9, 39, 41-44]. Loss of co-residing grandparents can impact psychosocial, practical, and/or financial support for grandchildren[5]. After a caregiver's death, family circumstances may change, and children may face housing instability, separations, and lack of nurturing support[37, 41]. Families with children have been particularly impacted by COVID-19-associated deaths, and Black, Hispanic, and American Indian/Alaska Native families have been disproportionally affected[21].

The death of custodial grandparents may compound the family adversities that led to the child being cared for by grandparents, rather than parents. Children living in grandparent-headed, versus parent-headed homes, are more likely to have experienced other ACEs, such as incarceration of a parent, separation or divorce, parental alcohol/drug abuse or mental health problems, or domestic violence[45]. Thus, the death of a grandparent often adds another level of adversity that further increases the likelihood of long-term health and social consequences of ACEs[36].

Yet, there is hope. Safe and effective vaccines can stop COVID-19-associated orphanhood and death of caregivers from negatively impacting children and families. However, formidable challenges persist linked to equitable vaccine access for all racial and ethnic populations, and increasing prevalences of variants of concern[46].

For children who experience COVID-19-associated death of their caregivers, evidence-based responses can help improve short- and long-term outcomes. First, maintaining children in their families wherever possible is the priority. This necessitates ensuring families experiencing COVID-19 bereavement are supported, and those needing kinship or foster care are rapidly served[47]. For a strained child welfare system serving over 400,000 foster children in 2020, increased investments will be critical, particularly in states with the highest numbers of children affected[48].

Child resilience after caregiver loss can be bolstered through programs and policies that promote safe, stable, nurturing relationships and address childhood adversity[35], including preventing violence and abuse[49]. Key combination strategies that have strong evidence and established mechanisms of delivery include: 1) strengthening economic supports to families; 2) quality childcare and educational support, and 3) evidence-based programs to strengthen parenting skills and family relationships[50, 51].

These strategies are critically important when family stressors have led to violence and economic vulnerability; using life course approaches sensitive to the child's age lessens their risks[49]. Many community initiatives have innovated the delivery of cost-effective, noncommercial, evidence-based support during COVID-19 restrictions, to reach groups most impacted by caregiver loss. Programs need to support family-based alternative care, such as kinship, foster, or adoptive care for children who have no surviving caregivers; such effective programs can prevent violence, reduce substance use, and improve family mental health, with cost-effectiveness of $6 saved for every $1 spent[52]. These provisions must be sensitive to racial disparities and structural inequalities, to reach the children that need them most. The success of these strategies, in the context of disparities, will hinge on engaging community-led initiatives that change the systems driving structural inequities[36, 53].

This study has several limitations. First, the numbers of children experiencing COVID-19-associated orphanhood and caregiver deaths may be underestimated, due to delays or underreporting of deaths[54]. Further underestimation of the numbers of children affected may have occurred, because the prevalence for co-residing grandparent caregivers was only available in ACS for grandparents providing housing. We also considered factors that may have caused our assumption of comparable fertility rates between 2019 and 2020 to bias our estimates of orphanhood. Because excess mortality had the largest absolute impact on men and women who were above age 60, we expect any reduction of the denominators for men and women of reproductive age in 2020 to have been minimal and thus, not an important source of bias. However, recognizing modest reductions in birth rates in 2020 may have biased our orphanhood estimates, we plan that future estimates will integrate the 2020 and 2021 fertility rates after data becomes available. Additionally, we assumed the race of bereft children matched that of the deceased caregiver, which may have led to over- or under-estimates of findings by race/ethnicity.

Future reports may extend these findings by including gender of deceased caregivers and ages for children affected.

Our analysis extends a previous report from the US, which highlights increased risk of COVID-19-associated parental bereavement,[1] by including findings by race-ethnicity. Our paper extends the report on global estimates of COVID-19-associated orphanhood in 21 countries, including the US[55], by adding state-specific findings by race/ethnicity, and using precise ACS grandparent data. Future pandemic responses will be strengthened by incorporating routine monitoring of "children living in the household," into vital statistics[56, 57].

Conclusions

Our findings suggest an immediate need to integrate care for children into COVID-19 Emergency Response priorities, which focus on vaccination, mitigation, testing, contact tracing, and disease management. The magnitude of COVID-19-associated parent and caregiver death suggests effective responses should combine equitable access to vaccines with evidence-based programs for bereaved children, focusing on areas with greatest disparities. We propose adding a new pillar of Emergency Response, 'Care for Children', to support a comprehensive 3-pronged approach – 'prevent, prepare, and protect.' The aims of this approach include: *prevent* COVID-19-associated death of caregivers by accelerating equitable access to vaccines; *prepare* safe and loving family-based care support services; and *protect* children using evidence-based strategies that address their increased risks of childhood adversity and violence, and strengthen their recovery. Because inequalities permeate each of these aims, successful implementation will require intentional investment to address individual, community, and structural inequalities.

Effective action to reduce health disparities and protect children from direct and secondary harms from COVID-19 is a public health and moral imperative[58, 59].

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Table 1: Total estimated children losing parents, and primary or secondary caregiving grandparents, in the US, by race and ethnicity

Race/ethnicity	Parents (a)	Custodial grandparents (b)	Co-residing grandparents providing primary care (c)	Primary caregiver* (a+b+c)	Other co-residing grandparents (d)	Total† (a+b+c+d)
Non-Hispanic White	36472 [36146-36885]	2332 [2321-2339]	3626 [3614-3638]	42430 [42094-42835]	8951 [8924-8979]	51381 [51032-51793]
Non-Hispanic Black	27831 [27571-28172]	1154 [1143-1161]	1883 [1865-1888]	30868 [30589-31218]	3969 [3947-3992]	34837 [34547-35193]
Non-Hispanic American Indian or Alaska Native	3332 [3237-3579]	152 [151-164]	244 [241-254]	3728 [3642-3981]	352 [344-362]	4080 [3990-4330]
Non-Hispanic Asian	4585 [4455-4694]	65 [63-69]	162 [160-168]	4812 [4685-4924]	1331 [1324-1353]	6143 [6013-6269]
Hispanic	36164 [35777-36556]	813 [808-820]	1815 [1803-1825]	38792 [38403-39191]	7404 [7377-7454]	46196 [45802-46631]
Total	108384 [107906-109132]	4516 [4504-4536]	7730 [7705-7750]	120630 [120145-121390]	22007 [21969-22085]	142637 [142151-143482]

* Primary caregivers are parents, custodial grandparents and co-residing grandparents providing primary care.

† Refers to primary caregivers plus other co-residing grandparents

.

Table 2: Rates of COVID-19 associated deaths, total fertility rates, rates of loss of primary or secondary caregivers, proportionate burden, and rate ratio by race and ethnicity

Race/ethnicity	Rates of COVID-19 associated death per 100k residents	Total fertility rates *	Loss of parents or caregivers per 100k children <18 yrs of each race and ethnicity	Proportionate burden among children by race and ethnicity	Rate ratio (Loss or parents or caregivers per 100k children/Lost caregivers per 100k non-Hispanic White children)
Non-Hispanic White	283 [283-284]	1.77 [1.77-1.77]	133 [132-134]	1 of 753 [746-757]	1
Non-Hispanic Black	448 [446-451]	1.93 [1.93-1.93]	322 [319-325]	1 of 310 [307-313]	2.42 [2.40-2.45]
Non-Hispanic American Indian or Alaska Native	541 [538-558]	1.99 [1.99-2.0]	592 [579-628]	1 of 168 [159-172]	4.46 [4.35-4.74]
Non-Hispanic Asian	238 [237-241]	1.69 [1.68-1.69]	146 [143-149]	1 of 682 [671-699]	1.10 [1.08-1.13]
Hispanic	339 [338-341]	2.34 [2.34-2.34]	242 [240-245]	1 of 412 [408-416]	1.83 [1.80-1.85]
Total population (without race disaggregation)	313 [312-314]	1.91 [1.91-1.91]	194 [193-195]	1 of 515 [512-518]	

**expected number of children ages 0-17 per woman in 2020*

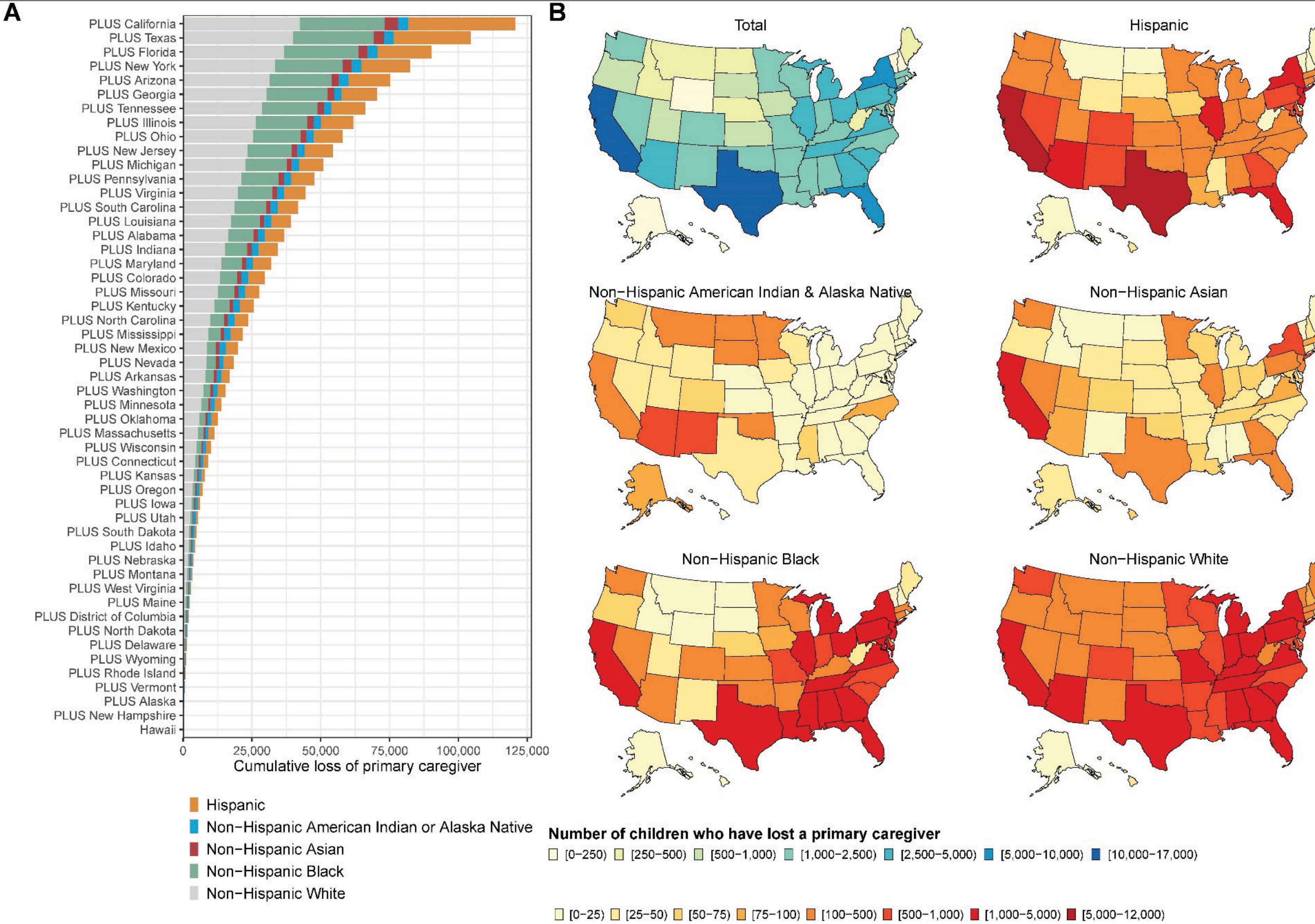

Figure 1: A. Total estimated children losing at least one primary caregiver (parent or custodial grandparent) to COVID-19; cumulative totals across states ordered by number of caregivers lost from bottom lowest (New Hampshire) to top highest (California). B. Estimated children losing at least one primary caregiver by race and ethnicity

Figure 2: Share of population, **COVID-19 associated** deaths and children losing primary caregivers (parents or custodial grandparents) to COVID-19, by race and ethnicity, for US total (A)and by state (B).

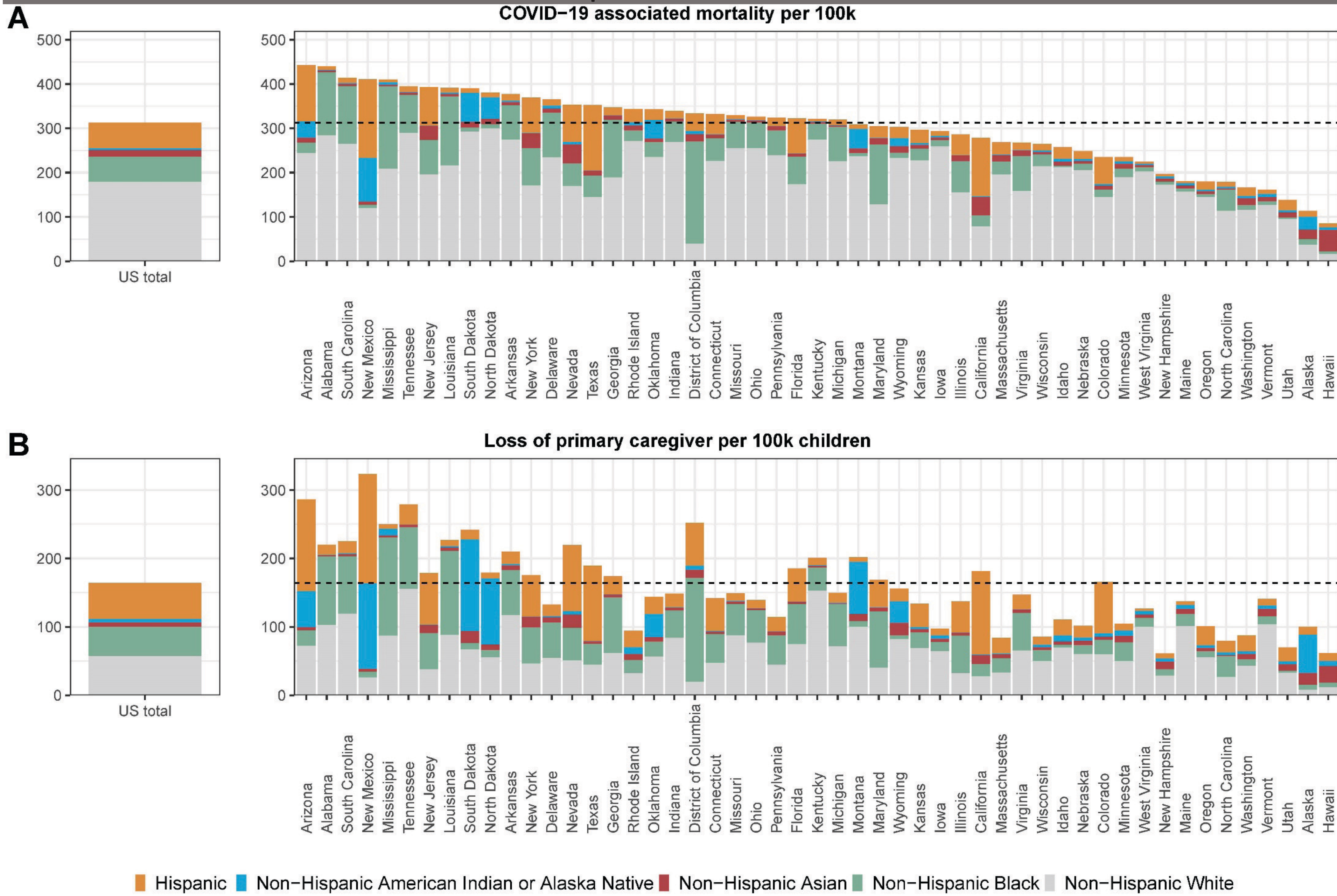

Figure 3: A) **COVID-19 associated** deaths per state by race/ethnicity per 100,000 residents >age 15 in each state. B) Estimated loss of primary caregiver per 100,000 children <age 18 in each state by race and ethnicity. Rates at national level on the left; and state level on the right.

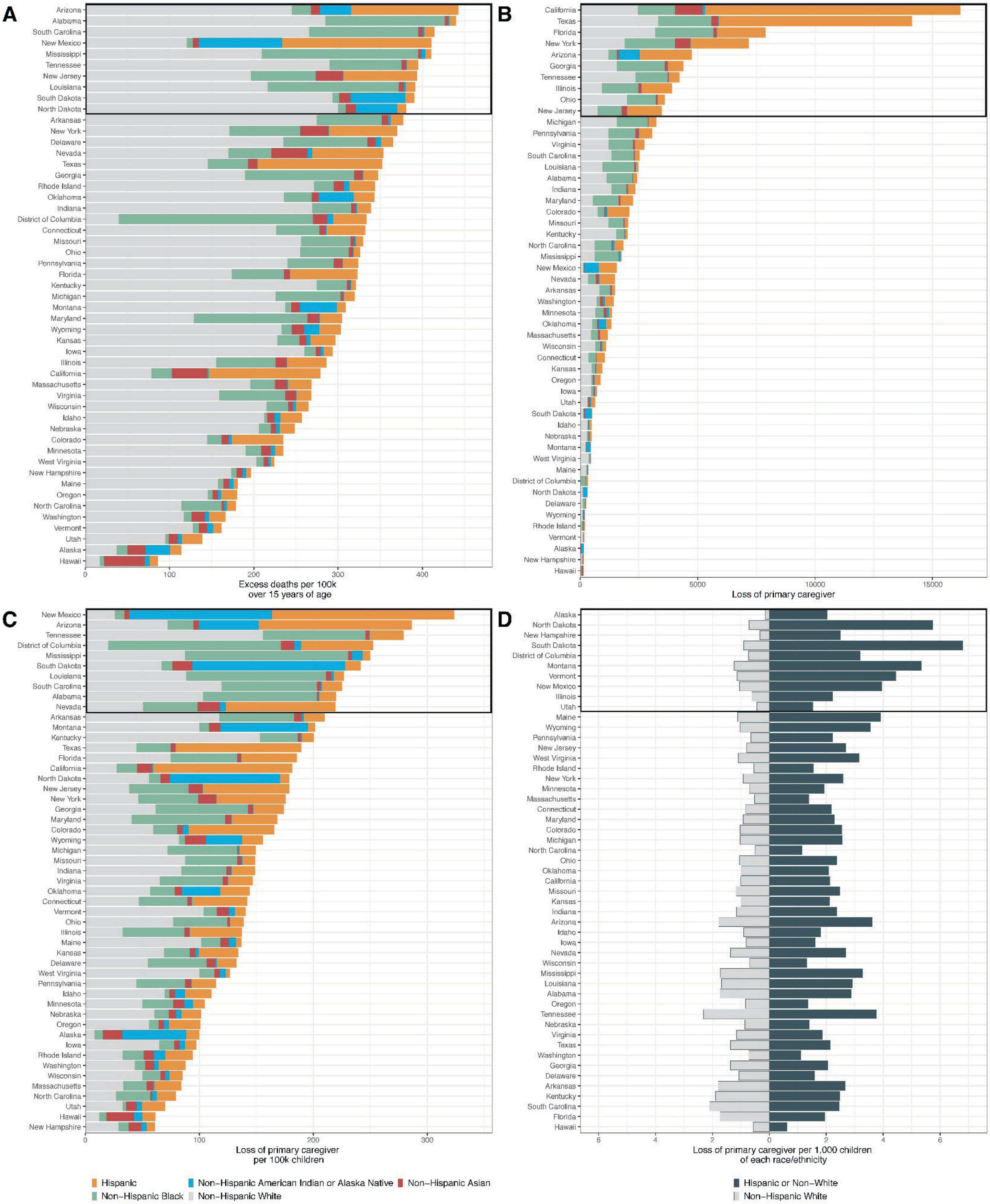

Figure 4: Findings by state and race/ethnicity: A) Rate of **COVID-19 associated** deaths per 100,000 residents >15 B) Number of children losing a primary caregiver C) Loss of primary caregiver per 100,000 children ages 0-17 D) Rate of orphanhood per 1,000 Hispanic or Non-White children and per 1,000 Non-Hispanic White children (ordered by rate ratio of Hispanic or Non-White/Non-Hispanic children)

COVID-19-Associated Orphanhood and Caregiver Death in the United States Supplementary Materials

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1 Methods

Here we describe how we adapted methods previously applied by Hillis et al. to estimate death of caregivers due to COVID-19 using high resolution mortality and fertility data for the United States [1]. Further details on the framework underpinning our approach can be found in work by Lokta et al. [2]

1.1 Mortality data

We extracted total excess deaths and COVID-19 attributable deaths reported to the CDC National Center for Health Statistics (NCHS) by state, age, race and ethnicity from 1 April 2020 through 30th June 2021 [3]. The CDC calculates the excess deaths as the number of deaths recorded in each quarter of 2020-2021 that are above/below the average number of deaths in equivalent quarters from 2015-2019. These are weighted to account for under-reporting of deaths in recent quarters and are presented cumulative over our time period.

Data were available for the following age groupings: 0-14, 15-29, 30-49, 50-64, 65-74, 75-84, 85+ year and race/ethnicities: Hispanic, Non-Hispanic Black, Non-Hispanic White, Non-Hispanic Asian, Non-Hispanic Native Hawaiian or Other Pacific Islander, Non-Hispanic American Indian or Alaska Native and Other. Due to the reporting categories in female fertility data, Non-Hispanic Native Hawaiian or Other Pacific Islanders were grouped together with Non-Hispanic Asian for the analysis.

Strata with fewer than 10 excess deaths were suppressed to meet NCHS confidentially standards, so we imputed missing data at random between 1 and 9. 21.7% of cell counts were suppressed and needed to be imputed, and were most common among younger age groups. For each state, race and ethnicity, we took the larger of excess deaths or COVID-19 attributable deaths for the analysis.

1.2 Fertility rate

The age-specific fertility rate (AFR) per 1000 women or men in state s, age group a and of race and ethnicity r is defined as

$$AFR_{sar}=1000 \times \frac{\text{Number of live births to women in state } s, \text{ of race/ethnicity } r, \text{aged } a}{\text{Number of women in state } s, \text{ of race/ethnicity } r, \text{ aged } a}. \quad (1)$$

1.2.1 Female fertility data

We used the 1999-2006 and 2007-2019 natality datasets from CDC WONDER which report on the number of live births from birth certificate data between 2003-2019 [4]. The dataset reported on bridged race categories (4 categories which do not include individuals of more than one race). Specifically, White, Black, Asian (including Native Hawaiian and Other Pacific Islanders), American Indian or Alaska Native. Race and ethnicity were defined as Hispanic (any race) and each of Non-Hispanic White, Black, Asian and American Indian or Alaska Native to match reporting categories of excess death data. Age of mother is reported in 5-year intervals, and we assume a fertility rate of zero for women below 15 and over 50 years of age.

We extracted population data produced by the US Census Bureau in collaboration with the NCHS by year, age and bridged raced categories from the CDC WONDER database.

We summarise below the method taken to obtain fertility rates by year for each state, age of mother, race and ethnicity of mother, and how missing fertility rates were imputed.

- For years 2003-2019:
  1. Extract number of live births of women of a given year, age, bridged race (4 categories), ethnicity.
  2. Extract population sizes for corresponding strata.
  3. Divide (1) by (2) to calculate fertility rates.
- For 2020 assume same fertility rates as 2019.

1.2.2 Male fertility data

The CDC only began collecting data on paternal characteristics since 2016, in the extended natality dataset [5]. Race of father is reported as one of 6 single race categories: White, Black, Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, More than one race. Births among Native Hawaiian or Other Pacific Islanders were aggregated with births among Asian fathers to correspond with reporting of female natality data. Age of father is reported in 5-year intervals, and we assume a fertility rate of 0 for men below 15 and over 77 years of age. We chose 77 years as a cut-off since fertility was very low at 60 and this enabled children being born to 60 year olds in 2003 to be included.

Population data were extracted from population estimates produced by the US Census Bureau by year, age and single race categories from the CDC WONDER database [6]. The approach to estimating fertility rates by year for each state, age, race and ethnicity of father is summarised below.

- For years 2016-2019:
    1. Extract number of births of men of a given age, single race (6 categories), ethnicity
    2. Extract population sizes for corresponding strata
    3. Divide (1) by (2) to calculate fertility rates.
- For 2020 assume same fertility rates as 2019.

1.2.3 Imputation of missing fertility rates

To impute missing fertility rates, we used a Poisson model fit to male and female birth counts with a gender and year effect, and population as an offset: 14.8% of female fertility rates were imputed, 18.8% of male fertility rates were imputed between the years natality data was collected (2016-2019) and all male fertility rates were imputed before 2016. We fit to both male and female fertility data, and include gender as a predictor, because historic trends are similar in categories where we have both male and female fertility and this enables us to more accurately estimate the missing data. Our model is fit separately for each state, race/ethnicity and age of parent, and has the form:

$$log(\lambda) = \alpha + \beta_1 X_1 + \beta_2 X_2 \tag{2}$$

where λ is the fertility rate, α is the estimated log rate for men at year 0, β_1 is the estimated effect of year X_1, and β_2 is the estimated effect of being female vs. male, on the log rate. To predict missing fertility rates,

- For women:
    1. The estimated fertility rate for females in year i is $\hat{\lambda}_{if} = \exp(\alpha + \beta_1 X_1 + \beta_2 X_2)$, where $\alpha + \beta_2$ is the estimated log fertility rate for women at year 0 and β_1 is the estimated effect of year $X_1 = i$ on the log rate.
- For men:
    1. The estimated fertility rate for men in year i is $\hat{\lambda}_{im} = \exp(\alpha + \beta_1 X_1)$, where α is the estimated log fertility rate for men at year 0 and β_1 is the estimated effect of year $X_1 = i$ on the log rate.
    2. For strata in which we could not fit a state, race and age-specific model (e.g. due to missing data), models were fit to age and race-specific data across all states, to obtain predictions of fertility rates.
    3. To predict fertility rates in men aged 50+, since female data are not reported for 50+ women models were fit in the same way to male fertility data only, between 2016-2019, across all states.

Figure 1 shows the fertility rates for Hispanic men and women in New York as an example of extracted fertility data, with any missing rates imputed.

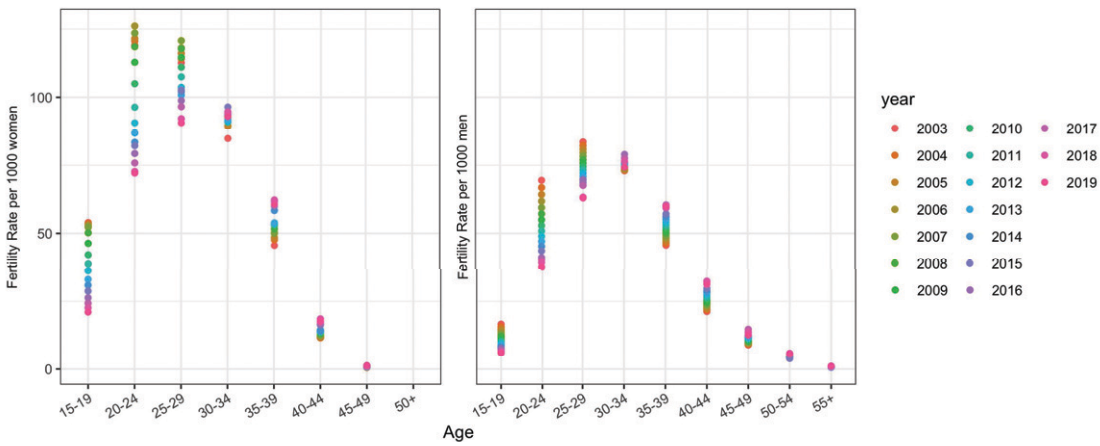

Figure 1: Fertility for men and women of Hispanic origin in New York between 2003-2016. Male data between 2003-2015 estimated using trends over time estimated from Poisson model.

1.3 Grandparent data

Grandparent data were retrieved from the U.S. Census Bureau Table S1002 which summarises total grand-parents living with their own grandchildren under 18 years in each state, collected by the American Community Survey (ACS) [7]. The question asked for respondents is as follows:*Does this person have any of his/her own grandchildren living in this house or apartment?* The survey also summarised the number of grandparents living with grandchildren who are responsible for care, by asking the following question regarding provision of care:*Is this grandparent currently responsible for most of the basic needs of any grandchildren under the age of 18 who live in this house or apartment?* Both totals, which we denote respectively by $G^{30+,\text{co-reside}}$ and $G^{30+,\text{most-responsible}}$, are supplemented for each state with the proportions by race, and the proportion who are reported to be Hispanic, which we combine into the proportion by race/ethnicity, p_r. The totals are also supplemented for each state with the proportions by gender p_s.

Further, the ACS table reports the proportion of grandparents who provide care that live with their grandchild in absence of the parent (custodial grandparents), which we denote by $p^{\text{custodial}}_{s,r}$. Despite there being no direct question in the survey on this, the ACS derive grandparent responsibility from information on the presence of a parent, which is also listed in column "Householder or spouse responsible for grandchildren with no parent of grandchildren present" of Table S1002. We consider grandparents to be primary caregivers to the children if they are responsible custodial grandparents or if the grandparent also lives with a parent of the child but is responsible for the basic needs of the child. Remaining grandparents who live with their grandchildren are classified as secondary caregivers. We estimate the number of grandparents over 30 living with their grandchildren of each sex, race and ethnicity as follows:

$$G^{\text{custodial}}_{s,r} = G^{30+,\text{most-responsible}} \times p_s \times p_r \times p^{\text{custodial}}_{s,r} \tag{3}$$

$$G^{\text{co-reside-primary}}_{s,r} = G^{30+,\text{most-responsible}} \times p_s \times p_r \times \left(1 - p^{\text{custodial}}_{s,r}\right) \tag{4}$$

$$G^{\text{co-reside-secondary}}_{s,r} = G^{30+,\text{co-reside}} \times p_s \times p_r - G^{\text{custodial}}_{s,r} - G^{\text{co-reside-primary}}_{s,r} \tag{5}$$

where $s \in \{\text{male,female}\}$, and as before $r \in$ {Hispanic,Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic American Indian or Alaska Native}.

1.4 Numbers of orphans from death of parents

We used methods as described previously [1] to estimate the number of children orphaned and to de-duplicate orphans who may have lost both parents. For each state, we considered the expected number of children of an adult of age a, gender s, and race/ethnicity r in year y from Section 1.2, which we denote by $F_{y,a,s,r}$. We adjusted the expected births for child mortality based on UN estimates of national survival rates to reach adulthood [8]. Denoting the survival rates of children of age a in year y by $S_{y,a}$, we calcuate the number of children $F_{a,s,r}$ an individual of a given age, sex and race/ethnicity is expected to have in 2020 with

$$F_{a,s,r} = \sum_{i=0}^{17} F_{2020-i,a-i,s,r} \times S_{2020-i,i}, \tag{6}$$

which sums over the yearly category specific expected number of births over the past 18 years while adjusting for childhood mortality, and where a ranges from age 15 to 50 for women, and 15 to 77 for men. We then aggregated the sex-race/ethnicity-specific average number of children in 2020 so they match the age categories in the mortality data (15-29, 30-49, 50-64, 65-74, 75-84).

The age category-sex-race/ethnicity-specific numbers of children orphaned were calculated by multiplying the average number of children per age-sex-race/ethnicity category and the number of COVID-19 associated deaths in this category, $D^{\text{parent}}_{a,s,r}$, according to equation 7:

$$C^{\text{orphaned}}_{a,s,r} = F_{a,s,r} \times D^{\text{parent}}_{a,s,r}, \tag{7}$$

where a corresponds to the age category of the parent (15-29, 30-49, 50-64, 65-74, 75-84), s to the gender of the parent and r to race/ethnicity of the parent.

To obtain the total sex-race specific numbers of children orphaned, we summed over the age groups of the parents, as in equation 8:

$$C^{\text{orphaned}}_{s,r} = \sum_{a \in A} C^{\text{orphaned}}_{a,s,r}, \tag{8}$$

where A=(15-29, 30-49, 50-64, 65-74, 75-84).

We also de-duplicated children who may have lost both parents to COVID-19. For each parent lost, we estimate the number of second parents who were infected and amongst them the number of second parents who died. We conservatively assume that all children have two parents, and we assume that the second parent is of the same age as the first parent. Specifically, we use the household secondary attack rate (SAR) to calculate the number of children whose second parent would get infected and the infection fatality ratio (IFR) to work out how many of those would die [9, 10],

$$C^{\text{double-orphaned}}_{a,s,r} = F_{a,s,r} \times D^{\text{parent}}_{a,s,r} \times \text{IFR}_a \times \text{SAR}, \tag{9}$$

where estimates of household secondary attack rates are taken from [9], and the infection fatality ratios are from [10]. Combining the estimates for both genders and ensuring we are not left with negative counts, we aggregate by gender and race/ethnicity through:

$$C^{\text{double-orphaned}}_{r} = \sum_{a \in \mathcal{A}} \min\left(C^{\text{double-orphaned}}_{a,\text{male},r}, C^{\text{double-orphaned}}_{a,\text{female},r}\right), \tag{10}$$

where $\mathcal{A}$=(15-29, 30-49, 50-64, 65-74, 75-84), s is the gender of the parent, and r is the race/ethnicity of the parent. To de-duplicate orphaned children, we subtract (10) from (8), and list separately de-duplicated orphans of mothers, de-duplicated orphans of father, and double orphaned children.

1.5 Numbers of children losing care from grandparents

To estimate children losing grandparents in one of the three categories of grandparents who co-reside with their grandchildren, we multiplied the number of COVID-19 associated deaths across adults aged 30 years or older by the proportion of adults who are classified as one of the three types of grandparents who provide care, by state, race and ethnicity. Specifically, we calculated

$$C^{\text{loss-custodial-grandparent}}_{s,r} = \frac{G^{\text{custodial}}_{s,r}}{N^{30+}_{s,r}} \times D^{30+}_{s,r} \tag{11}$$

$$C^{\text{loss-primary-grandparent}}_{s,r} = \frac{G^{\text{co-reside-primary}}_{s,r}}{N^{30+}_{s,r}} \times D^{30+}_{s,r} \tag{12}$$

$$C^{\text{loss-secondary-grandparent}}_{s,r} = \frac{G^{\text{co-reside-secondary}}_{s,r}}{N^{30+}_{s,r}} \times D^{30+}_{s,r}, \tag{13}$$

where s corresponds to the gender of the grandparent and r to race/ethnicity of the grandparent, and $N^{30+}_{s,r}$ denotes for each state the number of adults of gender s and race/ethnicity r that are aged 30 or above. We again de-duplicated following the method in equation 10. Throughout, we consider custodial grandparents and those who are responsible for care as primary caregivers, and those who co-reside but did not claim responsibility for childcare are secondary caregivers.

1.6 Quantifying Uncertainty

To quantify uncertainty in estimates, we carried out repeat analyses on bootstrapped samples of data which may carry uncertainty. Namely, we sampled from the excess death data and birth data as follows:

- Mortality data:

  1. Total excess deaths, d_{sgr}, and COVID-19 deaths, c_{sgr}, between Q2 2020 - Q1 2021 were reported for state s, gender $g \in$ {male,female}, race/ethnicity $r \in${Hispanic,Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic American Indian or Alaska Native}, age group $a \in \{15-29, 30-49, 50-64, 65-74, 75-84, 85+$. For each strata, we sampled excess deaths and COVID-19 deaths from Poisson distributions, with parameters $\lambda = d_{sgra}$ and $\lambda = c_{sgra}$, respectively.
  2. In instances where excess deaths were negative, we sampled from a Poisson distribution with $\lambda = |d_{sgr}|$, and applied a negative sign to the sampled value.
  3. We then took the maximum value of excess deaths and COVID-19 deaths in each strata.

- Fertility data:

  1. Births b_{sgr} were reported by state s, gender $g \in$ {male,female}, race/ethnicity $r \in${Hispanic,Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic American Indian or Alaska Native}, age group $a \in \{15-19, 20-24, 25-29, 30-34, 35-39, 40-45, 45-49, 50-54, 55+\}$ for males, $a \in \{15-19, 20-24, 25-29, 30-34, 35-39, 40-45, 45-49, 50+\}$ for females. We sampled births from a Poisson distribution, with parameter $\lambda = b_{sgr}$.

We carried out all analyses for 1000 resampled data sets. Estimates of caregiver loss were summarised, taking the lower 2.5 and upper 97.5 centile, to obtain 95% bootstrap intervals for central analysis estimates. Denominators for our ratios were not resampled and used as reported from the corresponding sources.

2 Results

2.1 Mortality data

Figure 2 shows the total COVID-19 associated deaths across the study period by age group and gender. The COVID-19 associated deaths are the maximum of total excess deaths and COVID-19 attributable deaths in each strata. The largest burden of absolute mortality is among men aged 65-84, and among women in 75+. Accounting for population structure, Figure 3 indicates the relative burden to be highest among 85+ in both genders. Figures 4 and 5 show the absolute and relative mortality by race and ethnicity. There are clear differences in the structure of deaths by age, with a higher burden among younger non-White and Hispanic men, whilst the burden of absolute deaths is largest among non-Hispanic White men aged 75-84. American Indian and Native Alaskan populations reported the highest mortality among men aged 30-74, and among women aged 65-74. Mortality rates suggest the relative burden is highest among 85+ across all races, suggesting differences in life expectancy may drive the differences in the distribution of deaths by age and race.

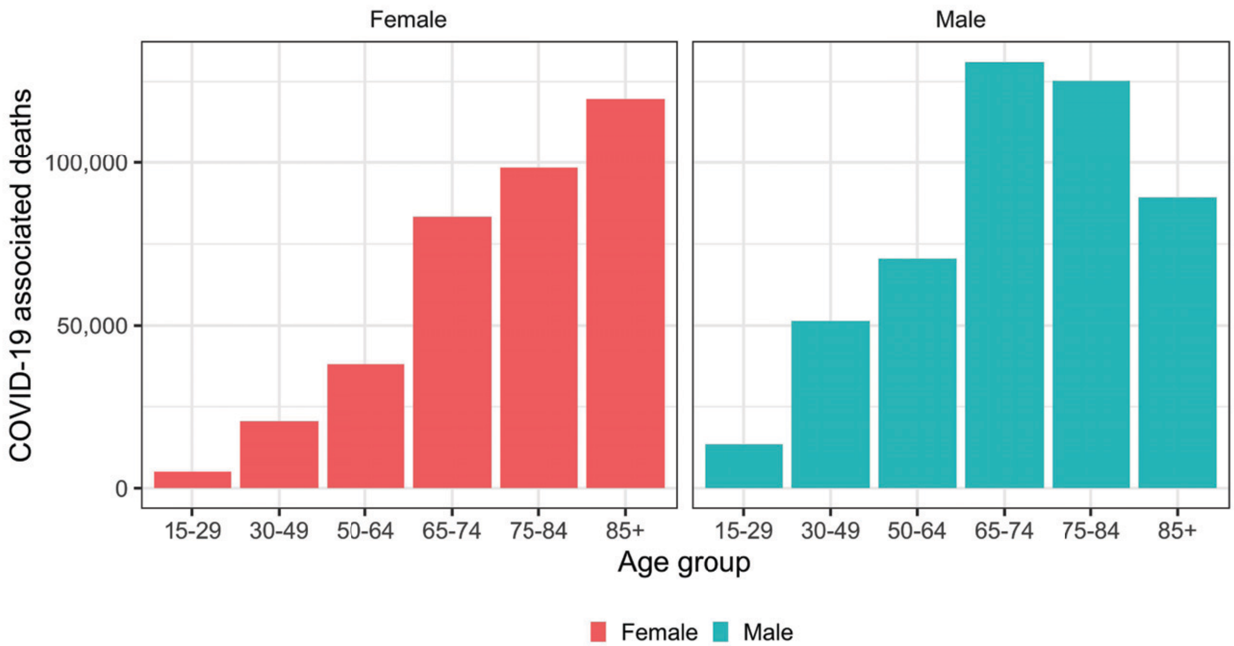

Figure 2: Total COVID-19 associated deaths by age group and gender from January 2020-June 2021.

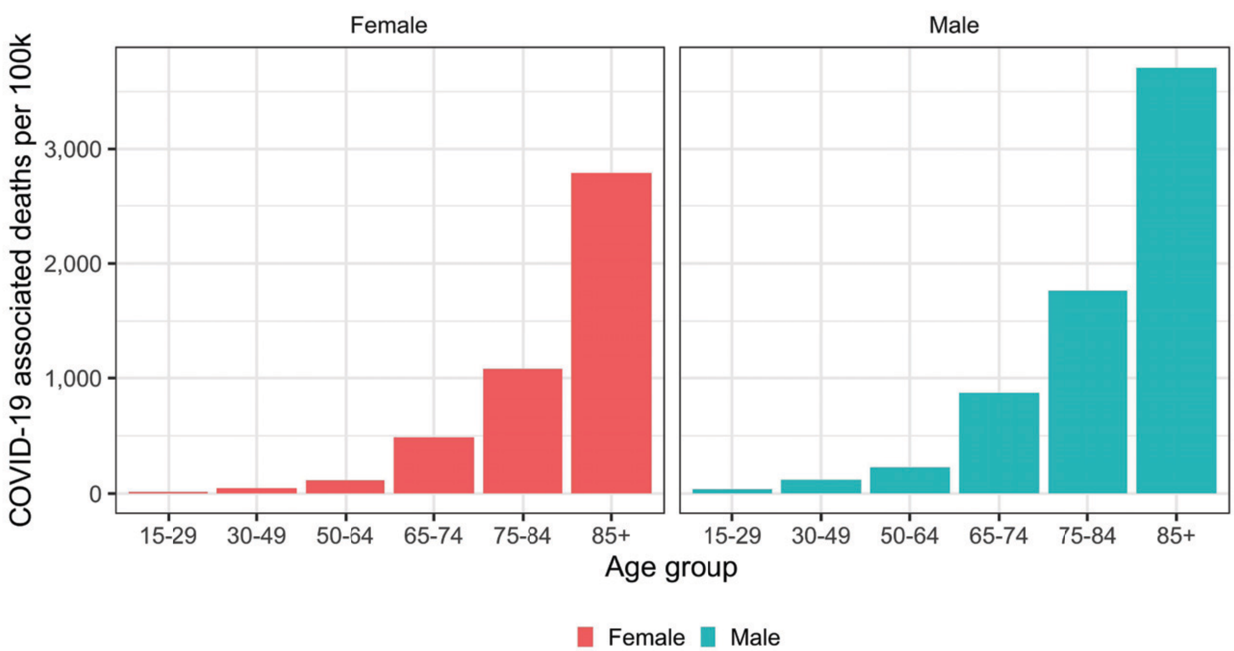

Figure 3: Total COVID-19 associated deaths per 100,000 of each age group and gender from January 2020-June 2021.

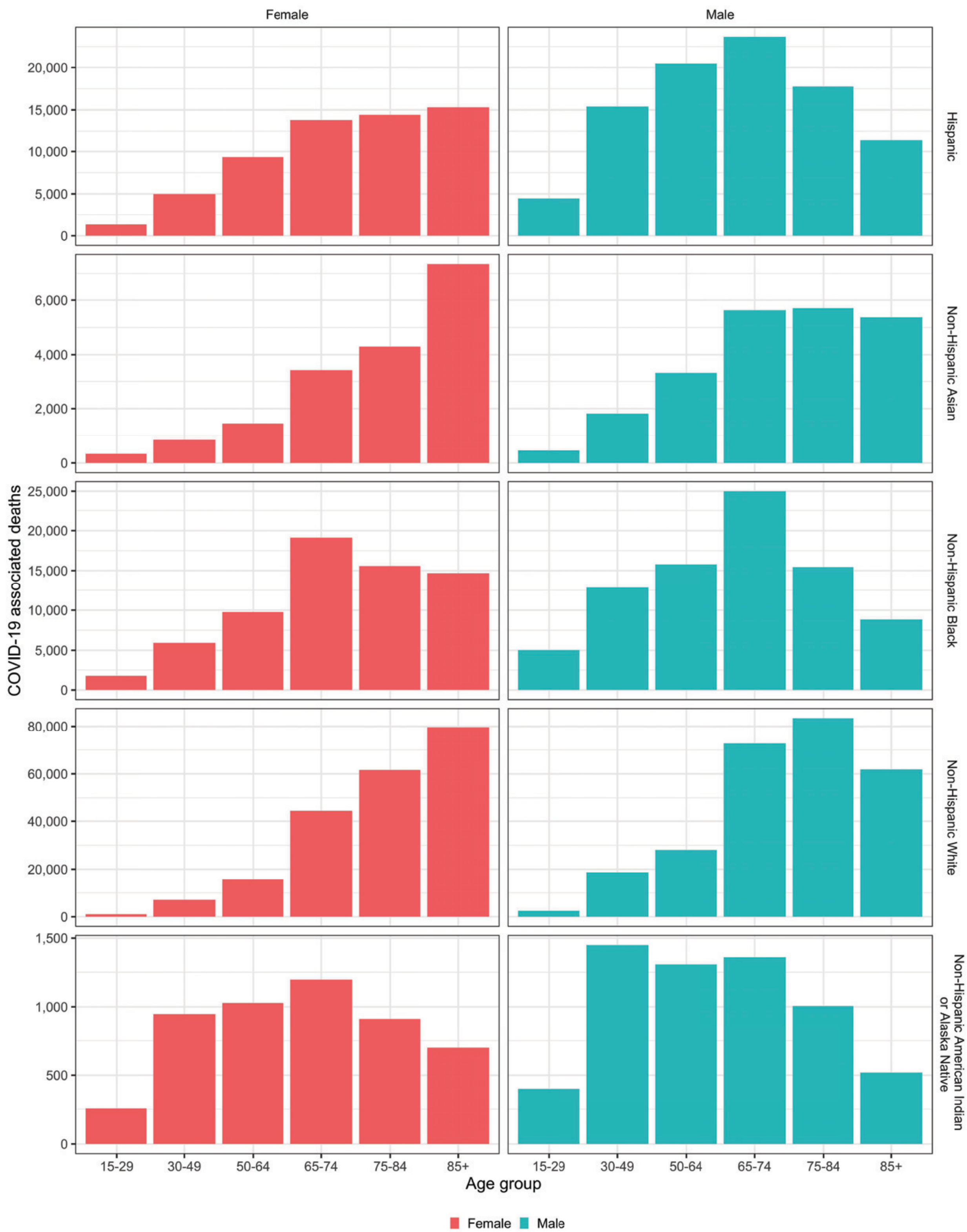

Figure 4: Total COVID-19 associated deaths by age group, gender, race and ethnicity from January 2020-June 2021.

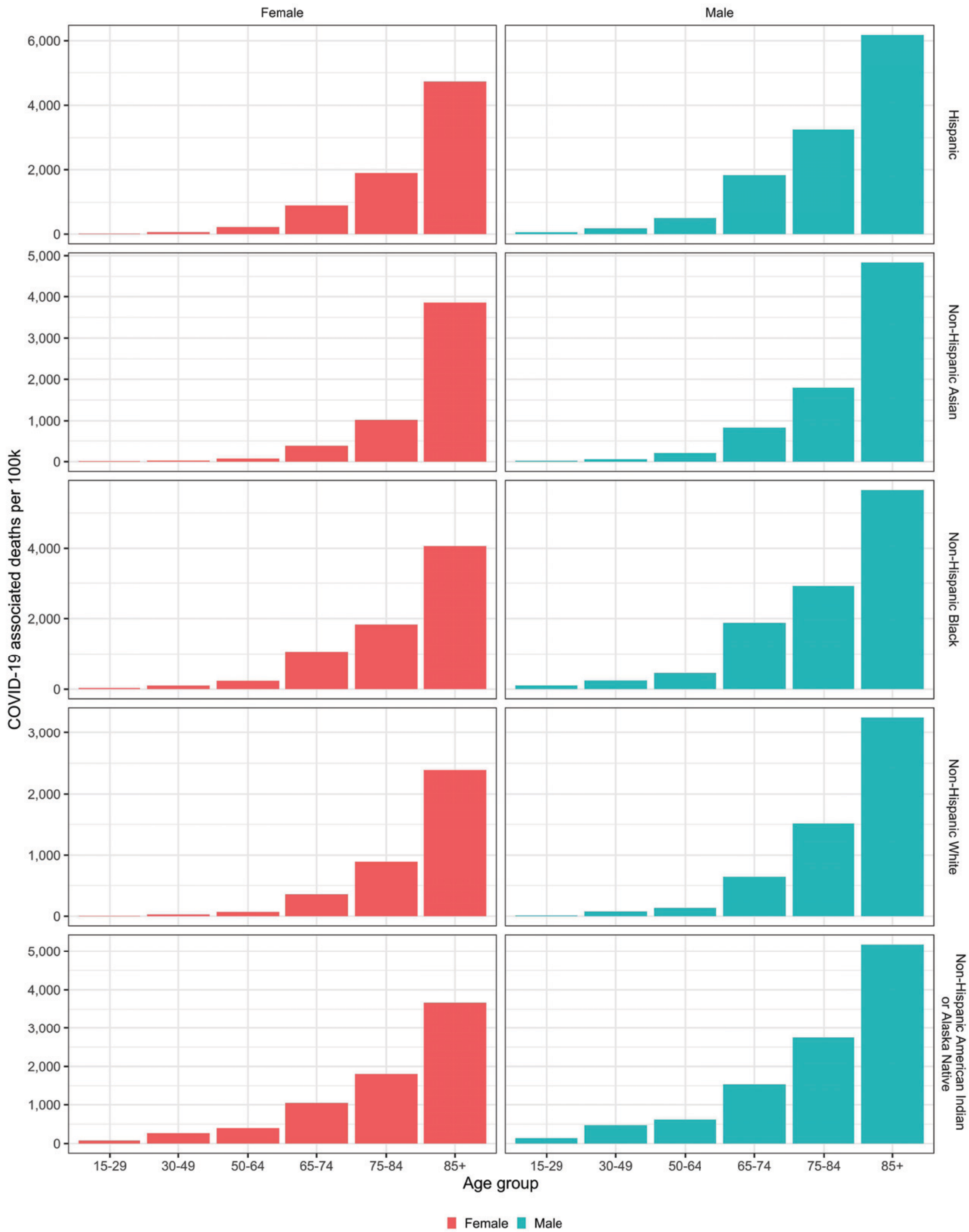

Figure 5: Total COVID-19 associated deaths per 100,000 of each age group, gender, race and ethnicity from January 2020-June 2021.

2.2 Demographics, family size and structures

2.2.1 Population size

Figure 6 shows the population composition by age, race and ethnicity. There are clear differences in population structure; for example the Hispanic population has a very large young population in comparison to non-Hispanic populations.

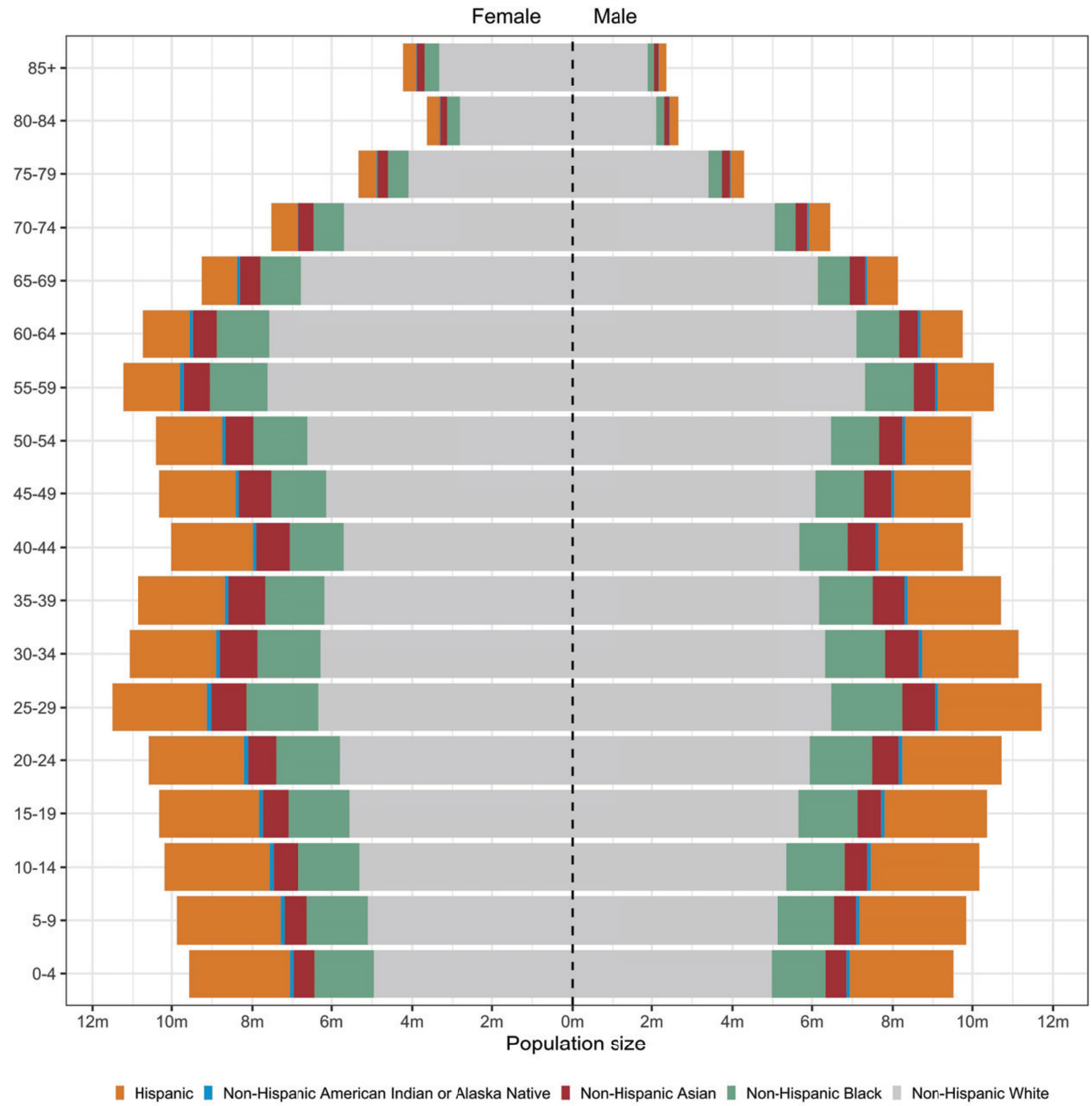

Figure 6: Population size (in millions) by age, race and ethnicity.

2.2.2 Expected number of children per parent

Fertility data from 2003-2019 were used to estimate the expected number of children the average male/female of a given age would have by race and ethnicity in each state. Figure 7 shows the distribution of the expected number of children for Arizona, as an example. The figure suggests higher fertility rates among the Hispanic population may contribute to more children affected per death of caregiver, compared to deaths among non-Hispanic populations.

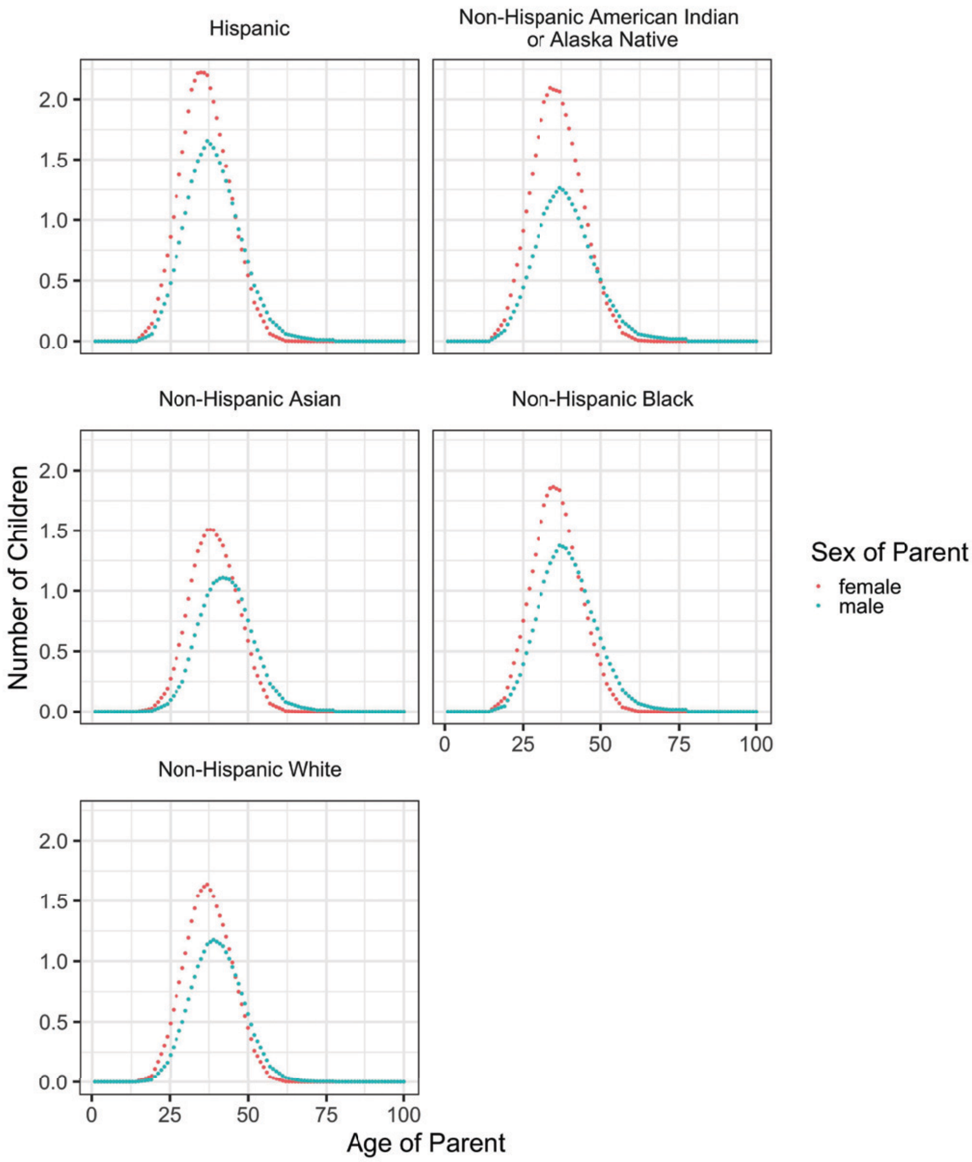

Figure 7: Expected number of children per male/female of a given age in Arizona, by race and ethnicity.

2.2.3 Co-residing grandparents

Figure 8 shows the estimated proportion of the population who are grandparent caregivers who live with their grandchildren, broken down by those who are a) custodial (primary caregivers), b) other co-residing grandparents who live with the children and their parents and are responsible for care (primary caregivers) and c) other co-residing grandparents who provide housing but are not responsible for other basic needs (secondary caregivers). The Hispanic population have the highest proportion of grandparents co-residing with their grandchildren, followed by the American Indian and Alaska Native population, and the non-Hispanic White population have the lowest. Custodial grandparents, who live with their grandchildren in absence of their parents are most common among the American Indian and Alaska Native population, and approximately half of grandparents who live with their grandchildren are considered to be primary caregivers.

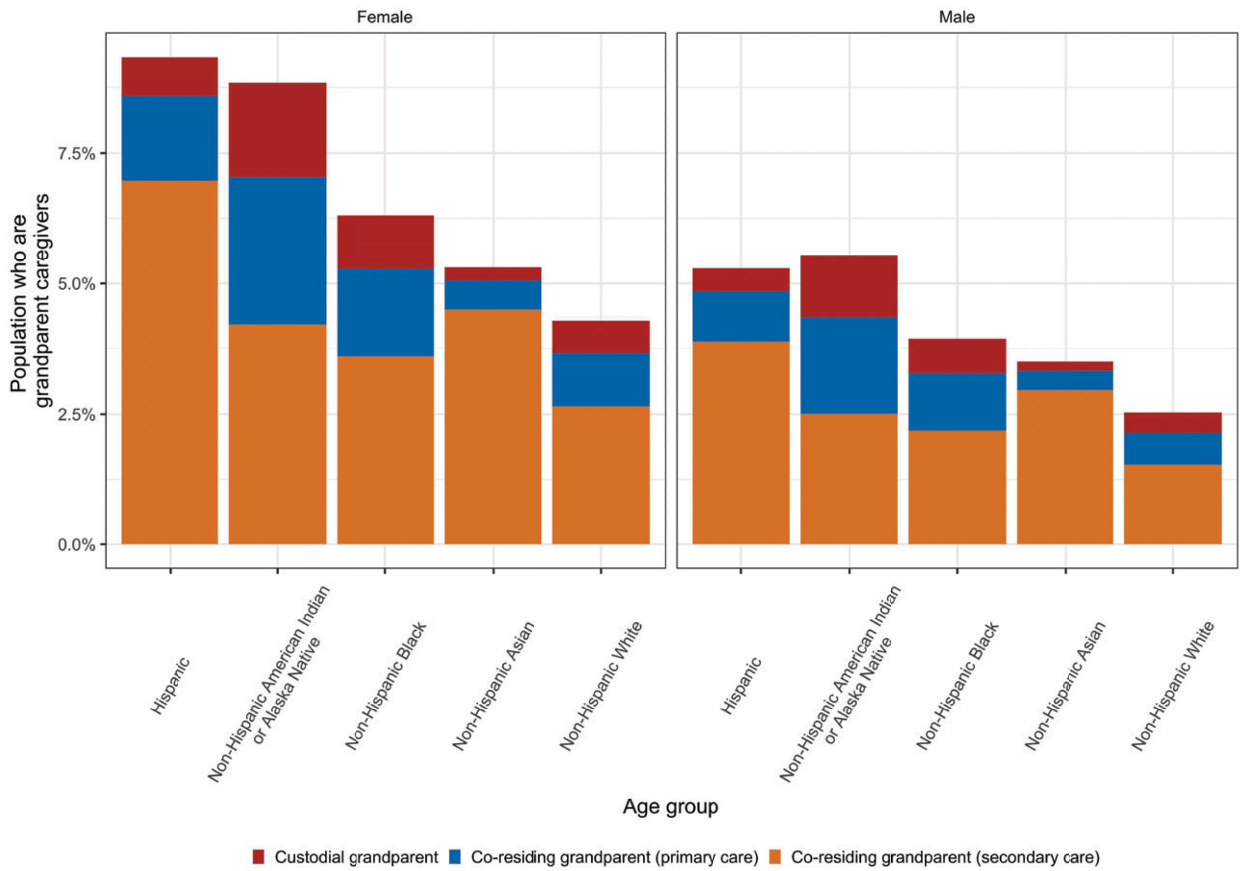

Figure 8: Proportion of adults over the age of 30 who live with their grandchildren, by race and ethnicity.

2.3 Deaths of caregivers by state, race and ethnicity

Table 1 presents the numbers of lost primary caregivers by state, race and ethnicity, ordered by states with the largest total burden. States with large populations (California, Texas, New York and Texas) are estimated to have the highest numbers lost primary caregivers.

Table 2 presents the rates of lost primary caregivers (number of lost caregivers per 100,000 children in each state), ordered by total rates in each state. Smaller states, or rural states with smaller populations, such as the District of Columbia, Wyoming and North Dakota are estimated to have high relative burdens of lost primary caregivers.

Table 1: **Number of children experiencing death of primary caregiver by state and race/ethnicity [95% confidence interval].** Ordered by total in each state. '-' are small counts suppressed due to all data for this category being imputed.

State	Hispanic	Non-Hispanic American Indian or Alaska Native	Non-Hispanic Asian	Non-Hispanic Black	Non-Hispanic White	Total
California	10863 [10665-11078]	107 [93-127]	1168 [1115-1226]	1572 [1500-1639]	2469 [2386-2553]	16179 [15940-16425]
Texas	8223 [8047-8395]	32 [25-42]	296 [268-327]	2251 [2162-2330]	3333 [3237-3426]	14135 [13908-14360]
Florida	2075 [1990-2160]	14 [9-20]	135 [114-152]	2479 [2378-2576]	3196 [3101-3290]	7899 [7741-8060]
New York	2475 [2390-2564]	18 [14-24]	639 [596-683]	2146 [2067-2222]	1897 [1830-1970]	7175 [7034-7318]
Arizona	2230 [2135-2328]	875 [816-947]	76 [62-89]	373 [333-405]	1200 [1146-1261]	4754 [4616-4888]
Georgia	672 [609-733]	11 [8-19]	108 [95-132]	2053 [1969-2132]	1561 [1496-1628]	4405 [4291-4529]
Tennessee	449 [396-497]	9 [9-21]	51 [43-72]	1358 [1287-1427]	2361 [2277-2441]	4228 [4106-4353]
Illinois	1298 [1234-1369]	13 [8-18]	121 [98-134]	1546 [1479-1617]	930 [890-986]	3908 [3800-4026]
Ohio	311 [271-348]	9 [7-19]	59 [41-70]	1225 [1160-1287]	2004 [1927-2072]	3608 [3493-3712]
New Jersey	1479 [1404-1560]	9 [5-16]	233 [210-262]	1020 [965-1077]	747 [711-788]	3488 [3392-3596]
Michigan	314 [281-352]	19 [14-26]	25 [18-40]	1322 [1258-1388]	1557 [1494-1631]	3237 [3142-3347]
Pennsylvania	569 [520-613]	13 [6-20]	149 [134-178]	1138 [1082-1197]	1209 [1158-1255]	3078 [3000-3168]
Virginia	403 [362-446]	8 [5-16]	88 [69-99]	1024 [966-1081]	1221 [1159-1283]	2744 [2652-2838]
South Carolina	202 [173-230]	14 [10-22]	33 [20-37]	943 [891-994]	1345 [1281-1410]	2537 [2443-2624]
Louisiana	99 [78-113]	24 [11-27]	52 [37-66]	1336 [1270-1405]	963 [912-1019]	2474 [2370-2558]
Alabama	163 [130-190]	9 [9-21]	16 [8-24]	1098 [1036-1155]	1137 [1082-1194]	2423 [2332-2512]
Indiana	321 [276-353]	14 [7-17]	59 [41-66]	622 [573-667]	1338 [1275-1397]	2354 [2246-2426]
Maryland	534 [486-589]	9 [6-16]	71 [57-82]	1096 [1041-1153]	542 [502-579]	2252 [2172-2342]
Colorado	953 [886-1019]	63 [51-79]	61 [46-71]	265 [236-300]	758 [713-809]	2100 [2009-2195]
Missouri	154 [127-179]	16 [11-24]	47 [33-55]	626 [578-672]	1206 [1147-1268]	2049 [1964-2119]
Kentucky	108 [85-133]	-	26 [21-41]	334 [304-368]	1546 [1472-1622]	2024 [1943-2116]
North Carolina	392 [354-432]	94 [77-115]	36 [35-56]	706 [664-749]	627 [587-667]	1855 [1790-1936]
Mississippi	49 [40-66]	66 [56-86]	22 [18-35]	1016 [966-1072]	620 [573-664]	1773 [1717-1859]
New Mexico	773 [721-827]	604 [559-659]	21 [15-33]	39 [27-50]	126 [108-145]	1563 [1493-1647]
Nevada	654 [603-705]	33 [26-47]	131 [114-151]	323 [281-356]	344 [315-378]	1485 [1409-1564]
Arkansas	129 [104-152]	13 [8-19]	48 [38-62]	461 [425-498]	825 [778-878]	1476 [1408-1546]
Washington	385 [348-426]	64 [54-82]	127 [109-149]	143 [123-165]	709 [667-754]	1428 [1368-1499]
Minnesota	132 [110-149]	102 [83-129]	123 [105-148]	352 [313-392]	649 [602-696]	1358 [1290-1429]
Oklahoma	239 [207-273]	314 [281-355]	58 [38-60]	199 [174-225]	528 [499-570]	1338 [1268-1404]
Massachusetts	331 [295-362]	17 [7-20]	78 [66-95]	288 [257-316]	470 [440-503]	1184 [1126-1238]
Wisconsin	152 [129-171]	47 [38-67]	55 [45-72]	202 [193-243]	642 [604-681]	1098 [1065-1174]
Connecticut	360 [323-397]	7 [8-34]	27 [21-39]	315 [282-348]	354 [331-386]	1063 [1022-1140]
Kansas	242 [211-278]	20 [16-31]	34 [25-46]	158 [132-186]	486 [448-527]	940 [886-1010]
Oregon	240 [210-271]	33 [24-46]	43 [25-48]	70 [56-88]	482 [449-522]	868 [814-919]
Iowa	74 [60-90]	36 [16-38]	35 [24-45]	96 [77-117]	477 [436-519]	718 [660-761]
Utah	193 [164-227]	41 [33-55]	86 [66-98]	26 [19-41]	306 [267-345]	652 [601-711]
South Dakota	30 [22-44]	290 [252-332]	38 [17-39]	20 [12-34]	145 [126-173]	523 [479-573]
Idaho	105 [86-127]	40 [22-45]	21 [20-43]	19 [11-29]	312 [280-346]	497 [459-544]
Nebraska	83 [68-103]	21 [10-27]	32 [17-38]	59 [46-79]	290 [259-320]	485 [442-521]
Montana	15 [10-26]	175 [148-208]	-	19 [9-24]	229 [202-258]	461 [416-501]
West Virginia	13 [9-21]	-	18 [9-23]	47 [36-63]	363 [333-396]	460 [423-497]
Maine	13 [4-15]	15 [11-27]	19 [14-37]	43 [34-73]	258 [230-289]	348 [328-407]
District of Columbia	85 [71-106]	-	16 [7-19]	204 [186-228]	27 [22-37]	340 [316-375]
North Dakota	15 [14-31]	175 [150-210]	-	18 [14-35]	101 [85-122]	324 [315-392]
Delaware	35 [26-50]	-	16 [7-26]	105 [91-120]	113 [99-131]	272 [249-304]
Wyoming	25 [18-37]	42 [33-59]	-	-	110 [89-122]	209 [180-230]
Rhode Island	52 [36-60]	-	19 [17-31]	40 [29-51]	70 [64-81]	202 [179-225]
Vermont	-	-	-	14 [4-20]	126 [105-146]	171 [146-196]
Alaska	20 [9-27]	95 [72-118]	29 [24-48]	12 [12-28]	14 [10-27]	170 [155-218]
New Hampshire	20 [11-26]	-	29 [14-33]	24 [13-31]	76 [66-91]	161 [128-170]
Hawaii	29 [21-40]	-	62 [43-67]	16 [9-26]	31 [22-43]	157 [128-174]

Table 2: **Number of children experiencing death of primary caregiver per 100,000 children per state [95% confidence interval].** Ordered by total rates in each state. '-' are small counts suppressed due to all data for this category being imputed.

State	Hispanic	Non-Hispanic American Indian or Alaska Native	Non-Hispanic Asian	Non-Hispanic Black	Non-Hispanic White	Total
Alabama	15 [12-17]	1 [1-2]	1 [1-2]	100 [94-105]	103 [98-108]	220 [212-228]
Alaska	12 [5-16]	56 [42-69]	17 [14-28]	7 [7-16]	8 [6-16]	100 [91-128]
Arizona	134 [129-140]	53 [49-57]	5 [4-5]	22 [20-24]	72 [69-76]	287 [278-295]
Arkansas	18 [15-22]	2 [1-3]	7 [5-9]	66 [60-71]	117 [111-125]	210 [200-220]
California	122 [120-124]	1 [1-1]	13 [13-14]	18 [17-18]	28 [27-29]	182 [179-184]
Colorado	75 [70-80]	5 [4-6]	5 [4-6]	21 [19-24]	60 [56-64]	166 [159-173]
Connecticut	48 [43-53]	1 [1-5]	4 [3-5]	42 [38-46]	47 [44-52]	142 [136-152]
Delaware	17 [13-24]	-	8 [3-13]	51 [44-58]	55 [48-64]	133 [121-148]
District of Columbia	63 [53-79]	-	12 [5-14]	151 [138-169]	20 [16-27]	252 [235-278]
Florida	49 [47-51]	0 [0-0]	3 [3-4]	58 [56-60]	75 [73-77]	185 [182-189]
Georgia	27 [24-29]	0 [0-1]	4 [4-5]	81 [78-84]	62 [59-64]	174 [170-179]
Hawaii	11 [8-16]	-	24 [17-26]	6 [4-10]	12 [9-17]	61 [50-68]
Idaho	23 [19-28]	9 [5-10]	5 [4-10]	4 [2-6]	70 [62-77]	111 [102-121]
Illinois	46 [43-48]	0 [0-1]	4 [3-5]	54 [52-57]	33 [31-35]	137 [134-142]
Indiana	20 [17-22]	1 [0-1]	4 [3-4]	39 [36-42]	85 [81-88]	149 [142-153]
Iowa	10 [8-12]	5 [2-5]	5 [3-6]	13 [10-16]	65 [59-70]	97 [90-103]
Kansas	35 [30-40]	3 [2-4]	5 [4-7]	23 [19-27]	69 [64-75]	134 [126-144]
Kentucky	11 [8-13]	-	3 [2-4]	33 [30-36]	153 [146-161]	201 [193-210]
Louisiana	9 [7-10]	2 [1-2]	5 [3-6]	123 [117-129]	88 [84-94]	227 [217-235]
Maine	5 [2-6]	6 [4-11]	7 [6-15]	17 [13-29]	102 [91-114]	137 [129-160]
Maryland	40 [36-44]	1 [0-1]	5 [4-6]	82 [78-86]	41 [38-43]	169 [163-175]
Massachusetts	24 [21-26]	1 [0-1]	6 [5-7]	20 [18-22]	33 [31-36]	84 [80-88]
Michigan	15 [13-16]	1 [1-1]	1 [1-2]	61 [58-64]	72 [69-75]	150 [145-155]
Minnesota	10 [8-11]	8 [6-10]	9 [8-11]	27 [24-30]	50 [46-54]	105 [99-110]
Mississippi	7 [6-9]	9 [8-12]	3 [3-5]	143 [136-151]	87 [81-94]	250 [242-262]
Missouri	11 [9-13]	1 [1-2]	3 [2-4]	46 [42-49]	88 [83-92]	149 [143-154]
Montana	7 [4-11]	77 [65-91]	-	8 [4-10]	100 [88-113]	202 [182-219]
Nebraska	17 [14-22]	4 [2-6]	7 [4-8]	12 [10-17]	61 [54-67]	101 [92-109]
Nevada	97 [89-104]	5 [4-7]	19 [17-22]	48 [42-53]	51 [47-56]	220 [208-231]
New Hampshire	8 [4-10]	-	11 [5-13]	9 [5-12]	29 [25-35]	61 [49-65]
New Jersey	76 [72-80]	0 [0-1]	12 [11-13]	52 [50-55]	38 [36-40]	179 [174-185]
New Mexico	160 [149-171]	125 [116-136]	4 [3-7]	8 [6-10]	26 [22-30]	324 [309-341]
New York	61 [59-63]	0 [0-1]	16 [15-17]	53 [51-54]	46 [45-48]	176 [172-179]
North Carolina	17 [15-18]	4 [3-5]	2 [1-2]	30 [28-32]	27 [25-29]	79 [77-83]
North Dakota	8 [8-17]	97 [83-116]	-	10 [8-19]	56 [47-67]	179 [174-217]
Ohio	12 [10-13]	0 [0-1]	2 [2-3]	47 [45-50]	77 [74-80]	139 [135-143]
Oklahoma	26 [22-29]	34 [30-38]	6 [4-6]	21 [19-24]	57 [54-61]	144 [137-151]
Oregon	28 [24-31]	4 [3-5]	5 [3-6]	8 [7-10]	56 [52-61]	101 [95-107]
Pennsylvania	21 [19-23]	0 [0-1]	6 [5-7]	42 [40-45]	45 [43-47]	115 [112-118]
Rhode Island	24 [17-28]	-	9 [8-14]	19 [14-24]	33 [30-38]	94 [83-105]
South Carolina	18 [15-20]	1 [1-2]	3 [2-3]	84 [79-88]	119 [114-125]	225 [217-233]
South Dakota	14 [10-20]	134 [116-153]	18 [8-18]	9 [6-16]	67 [58-80]	242 [221-265]
Tennessee	30 [26-33]	1 [1-1]	3 [3-5]	90 [85-94]	156 [150-161]	279 [271-287]
Texas	110 [108-113]	0 [0-1]	4 [4-4]	30 [29-31]	45 [43-46]	190 [187-193]
Utah	21 [18-24]	4 [4-6]	9 [7-11]	3 [2-4]	33 [29-37]	70 [65-77]
Vermont	-	-	-	12 [3-16]	104 [86-120]	141 [120-161]
Virginia	22 [19-24]	0 [0-1]	5 [4-5]	55 [52-58]	65 [62-69]	147 [142-152]
Washington	24 [21-26]	4 [3-5]	8 [7-9]	9 [8-10]	44 [41-46]	88 [84-92]
West Virginia	4 [2-6]	-	5 [2-6]	13 [10-17]	100 [92-109]	127 [117-137]
Wisconsin	12 [10-13]	4 [3-5]	4 [4-6]	16 [15-19]	50 [47-53]	86 [83-91]
Wyoming	19 [13-28]	31 [25-44]	-	-	82 [66-91]	156 [134-172]

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COVID-19-Associated Orphanhood and Caregiver Death in the United States

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