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PUBLIC HEALTH

The long-lasting effect of armed conflicts deaths on the living: Quantifying family bereavement

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Armed conflicts escalate combatant and civilian mortality and produce considerable levels of family bereavement. Yet, we know little about the prevalence of bereavement in conflict-affected populations. The violent loss of kin affects individuals across several dimensions, including trauma, mental health, socioeconomic status, and caregiving, especially during childhood and old age. Here, we propose a method to quantify population-level loss of parents and offspring in conflict-affected populations. Our analyses demonstrate that bereavement levels consistently surpass fatality rates in 16 conflict-affected settings. Using demographic projections, we show that these populations will continue to experience considerable levels of bereavement in the coming decades, independent of the future development of the respective conflicts. This quantification underscores bereavement as a profound yet understudied consequence of conflict with potentially far-reaching implications lingering long after the conflict's end.

INTRODUCTION

Fatalities during armed conflicts are often counted or estimated and always mourned. At the same time as this close attention to fatalities, it is largely unacknowledged that each death implies the loss of a close family member for surviving relatives. In the context of armed conflicts, this "family bereavement" refers to the degree to which living individuals experience the violence through the death of family members. Previous studies in the context of mortality crises have noted that family structures have a multiplicative effect, so that each death is experienced as an instance of bereavement by multiple surviving relatives (*1*, *2*). The death of one child, for example, may result in the bereavement of one or two of her biological parents (not to mention any potential child's grandparents, siblings, cousins, etc.). Accordingly, bereavement rates are expected to far exceed fatality rates. Conflict-induced bereavement lingers over time as family structures act as repositories of memory of the violence for decades after the end of the conflict (*3*). For example, a girl who lost a parent to war when she was a child may carry this experience for the rest of her life. Consequently, bereavement can perpetuate the impact of a conflict decades into the future, well after the violence has subsided.

Bereavement events can have major health, social, and political repercussions. Parental loss can leave children as orphans or half-orphans, with consequent loss of care and social and economic resources, as well as trauma and mental and physical health repercussions (*4*). Bereavement of adults who lose children can influence trauma and health, as well as essential caregiving during older age, especially in contexts with few resources for aging (*5*–*8*). On a collective level, populations in which large numbers of individuals have suffered conflict bereavement can face pressing public health and caregiving challenges. These include, but are not limited to, higher burdens of mental and physical health problems, paired with fewer medical and caregiving resources (*9*–*11*). In addition, because parent-child kinship ties play a major role in the intergenerational transmission of memory, culture, and trauma, collective experiences of the violent death of a parent or a child could influence cultural change and perceptions of the conflict (*12*, *13*). Net of any institutional effort to promote a specific narrative, this could be counterproductive for efforts to promote political reconciliation and security (*14*).

This study aims to highlight the enduring human costs of armed conflicts by quantifying the levels of family bereavement that they produce. We ask: How high are the levels of conflict-induced bereavement of immediate family members (loss of parents and loss of offspring) over the 1989–2023 period in a selection of high-intensity armed conflicts? How long and at what intensity are these levels of bereavement projected to last in the population? To answer these questions, we propose a methodology that combines life-table methods (*15*) and demographic models of kinship (*16*, *17*). We use our methodology with data on conflict-related fatalities from the Uppsala Conflict Data Program (UCDP), a widely trusted data source (*18*, *19*), combined with model-based age profiles of conflict mortality (*20*). As this study aims to develop this new methodology, we concentrate on bereavement caused by the death of offspring and parents because parent-child ties are among the most consequential and lasting social relations for individuals. Other more distant kinship ties, to partners, siblings, cousins, aunts and uncles, etc. also play important roles in children's, adults', and elders' lives and caregiving. Bereavement of these relatives must also influence health, well-being, culture, and memory on individual and collective levels. These other kinship ties can be addressed in future research.

We demonstrate our methodology to quantify conflict-related family bereavement in 16 populations that had the highest conflict- -related fatality counts over the last decade (2014–2023) and since the start of the records (1989–2023). For more details, see Materials and Methods. The results in the main text analyze the conflicts in Syria, Palestine (including Gaza, the West Bank, and East Jerusalem), Afghanistan, and Ukraine, the four populations with the highest proportions of the population lost to conflict in the last decade (2014–2023). Results for the remaining 12 populations are included in the Supplementary Materials.

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RESULTS

Bereavement rates are higher than fatality rates

We start by showing the distribution of conflict-related mortality in the four populations with the highest share of the population lost to conflict between 2014 and 2023. Figure 1 shows direct conflict death rates over time and by age group of the victim combining all available empirical and modeled data (note the different vertical scales in each panel). The figure exemplifies that conflict mortality affects individuals across a broad age range. This is because conflict mortality includes deaths of combatants (who tend to be in prime age) and civilians (who can be of any age). Figure 1 shows modeled age-specific death counts for Afghanistan, Syria, and Ukraine. These estimates consider (i) the dynamics of the conflict, (ii) the model mortality pattern, and (iii) the age-sex structure of each population. Age-specific death counts are observed for Palestine and estimated for the other populations. These figures show the mortality dynamics of the conflict but, by themselves, do not provide information on the prevalence of bereavement in the population.

A key tenet of our work is that one conflict death usually generates multiple "bereavement" events. For example, the death of a father of two is the loss of a parent for two members of the population (his two offspring). Similarly, the death of this same person can also be the loss of an offspring, seen from the perspective of his parents. The consequence of this "multiplier" effect is that bereavement rates are substantially higher than fatality rates. Figure 2 exemplifies this for the four populations we consider. Note that the shaded areas represent incidence rates: deaths and bereavements that happen in any given year and do not accumulate over time. Bereavements caused by the death of offspring are higher than fatalities, sometimes much higher as in the case of Syria. Even more notable are the bereavements from parents, which are around three times higher than fatalities in all cases. Bereavements from parents tend to vary in magnitude, given the markedly different fertility rates in Syria, Palestine, and Afghanistan, versus Ukraine. Bereavements from offspring do not differ as much between the sites, because individuals can only have zero, one, or two living parents. To contextualize these numbers, fig. S6 presents the share of conflict-induced bereavement relative to the total bereavement from all-cause mortality in the population. It is noteworthy that during high-intensity conflict periods, most of the total bereavement can be attributable to conflict mortality.

We can also compute "bereavement multipliers" to express the average number of relatives that are left bereaved by every conflict death. In Table 1, offspring bereavement (OB) and parental bereavement (PB) multipliers indicate, respectively, the average number of parents (OB mult.) and children (PB mult.) that grieve each conflict death in the population. The ratio between both multipliers (OB/PB) indicates the number of children losses experienced per parent loss in the population. The multiplier ratio (OB/PB) is also informative about country-specific family bereavement configurations. For instance, the number of children losses per parent loss in Palestine (0.9) was twice the one in Afghanistan (0.5) and the highest one among the 16 populations under analysis (see table S2). Multiplier ratios depend on the age structures of the conflict mortality and of the population, as well as on the preexisting kinship structures.

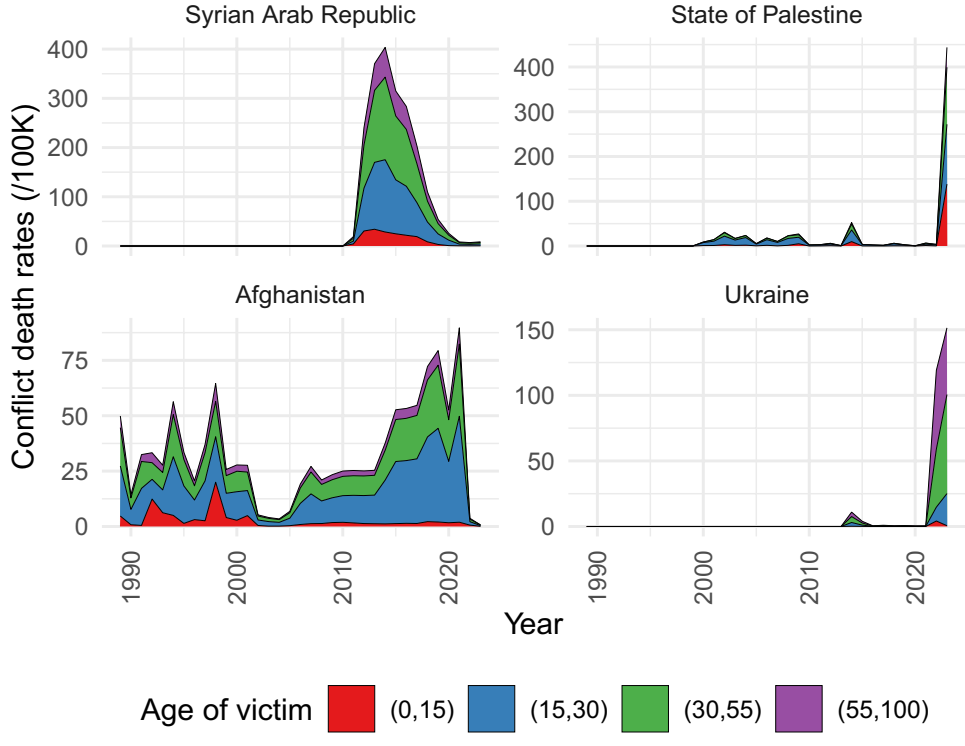

Fig. 1. Conflict death rates (per 100,000 individuals) by age of the victim in a selection of high-intensity conflicts. Data on the raw number of conflict deaths for Syria, Afghanistan, and Ukraine (1989–2023) come from (*18*).The age distribution of mortality for these populations was modeled using data provided by (*20*). For Palestine, data come from (*32*) (2000–2023) and (*26*) (for deaths since 7 October 2023); the latter was distributed over age using empirically observed distributions reported by the Gaza Ministry of Health.

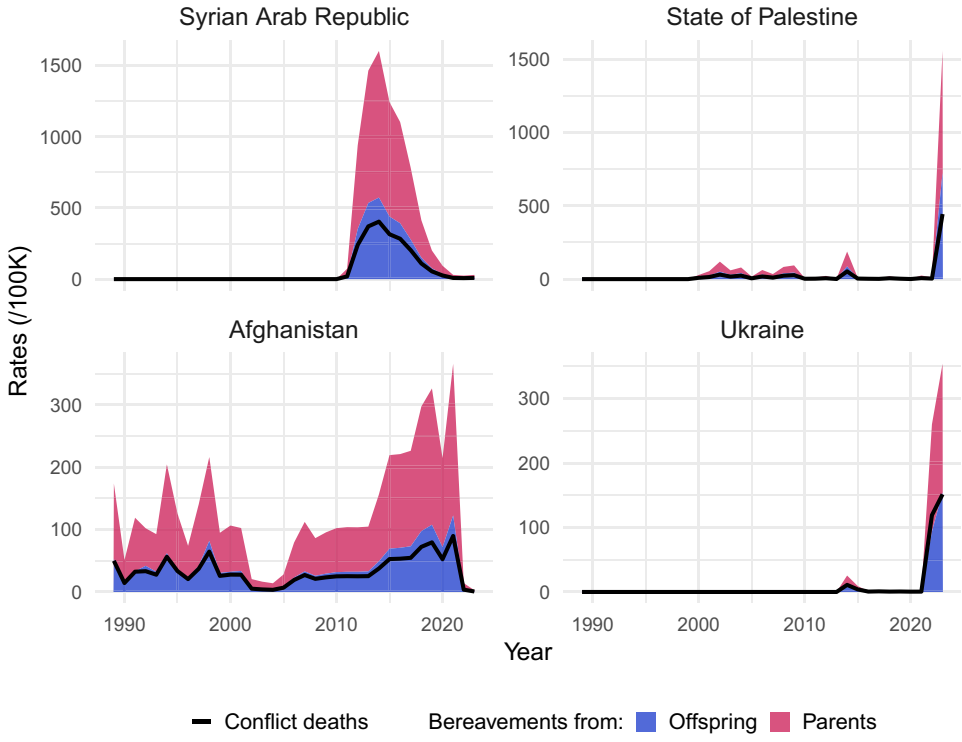

Fig. 2. Incidence of conflict death rates and kin-specific bereavement rates in a selection of high-intensity conflicts. The black line indicates annual conflict death rates for all-aged victims. The blue area shows the offspring loss rates and the red area indicate parental loss rates resulting from these conflict deaths. Note the different scales in the vertical axis.

Table 1. Average bereavement multipliers per conflict death in a selection of high-intensity conflicts during the period 2014–2023. Multipliers are indicated for the number of grieving parents (i.e., offspring bereavement or OB) and grieving children (i.e., parental bereavement or PB) derived from each conflict death. The multiplier ratio corresponds to the ratio of offspring to parental bereavement (OB/PB).

Rank	Population	OB mult.	PB mult.	OB/PB
1	Syrian Arab Republic	1.4	2.5	0.6
2	State of Palestine	1.7	1.9	0.9
3	Afghanistan	1.3	2.7	0.5
4	Ukraine	0.9	1.3	0.7

Bereavement events accumulate over age

A measure of "lifetime bereavement" captures how bereavement events accumulate over the life course of individuals and how these experiences differ by birth cohort. The Lexis diagrams in Fig. 3 show the prevalence of lifetime bereavement in the four populations of interest. The cumulative estimate of the number of kin losses experienced by individuals up to a given age can be read from the values along the diagonal lines in the plot (which represent birth cohorts). Note that this estimate also considers the fact that some bereaved individuals will die over time, contributing to lower the lifetime prevalence of bereavement in the population.

The plot uses colors to show the share of the lifetime bereavement that is due to the death of a child (more blue) and to the death of a parent (more red). An entirely blue pixel indicates that the kin losses are exclusively derived from offspring losses. By contrast, a completely red pixel indicates that all kin losses correspond to parent losses. To aid the interpretation of Fig. 3, consider the value of 97 for Syrians aged 50 in 2023. This means that a total of 97 kin losses to conflict (45 of offspring and 52 of parents) have ever been experienced for every 1000 Syrian born in 1973 who survive to be age 50 in 2023.

The key insight of Fig. 3 is that period shocks derived from surges in conflict mortality increase differently the prevalence of cumulative bereavement across birth cohorts. To evaluate the prevalence of bereavement after 2023, we assume that all armed conflicts are resolved by the end of 2023 or, at least, that they no longer produce conflict deaths. This "zero-deaths" scenario is unrealistic but useful as a conservative measure, as it allows us to determine the degree to which the burden of bereavement would persist in populations even in the total absence of future conflict mortality. The next section explores the persistence of bereavement in more detail.

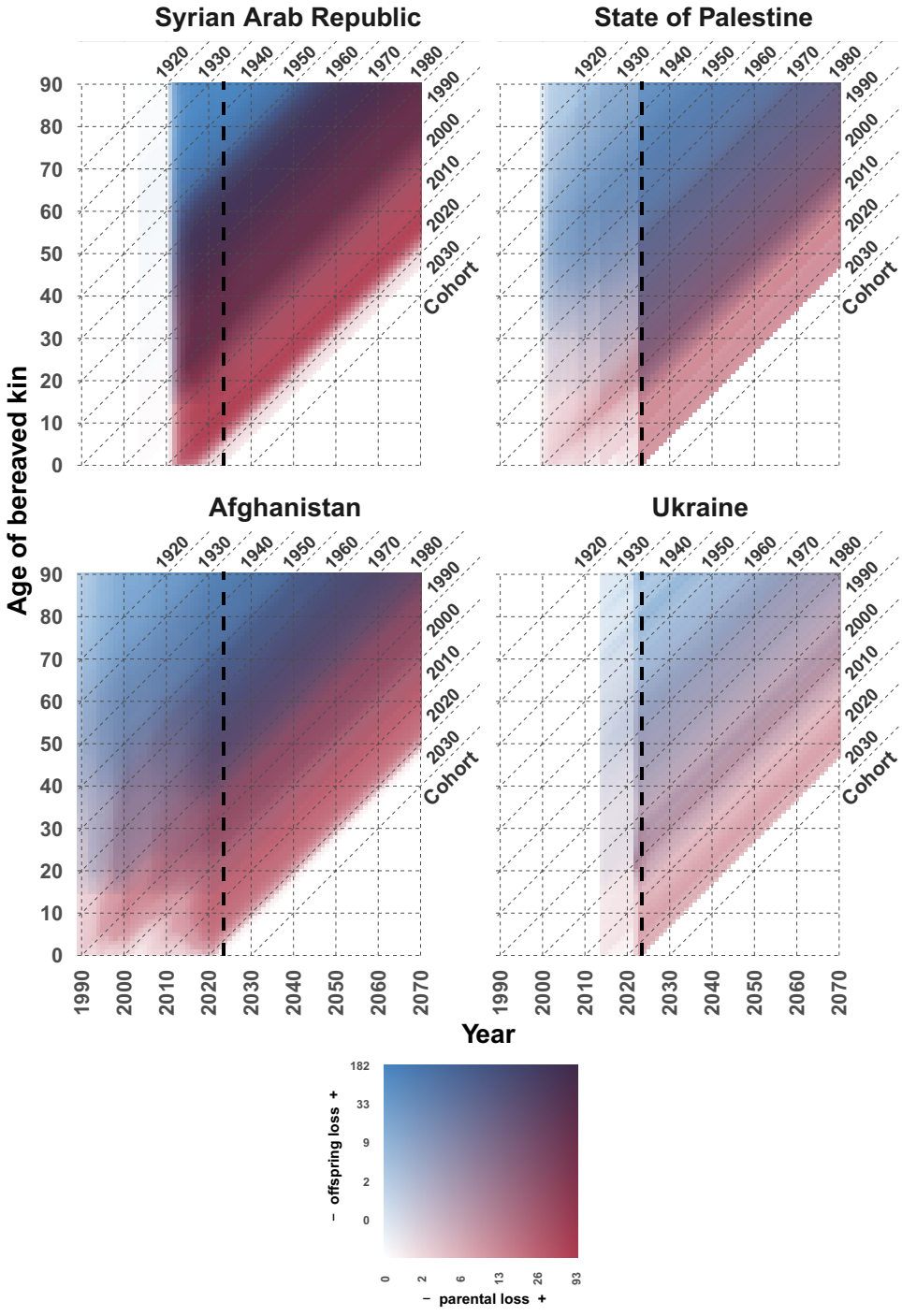

Fig. 3. Lifetime bereavement: Average number of lifetime conflict kin deaths experienced by individuals surviving to each age (per 1000 people). The colors indicate the share of the kin losses that are due to the loss of offspring (more blue) and parents (more red). The black vertical lines, positioned at the end of the year 2023, indicate the start of our counterfactual scenario (which assumes zero conflict deaths between 2024 and 2070). Bereavement events are accumulated over birth cohorts (diagonals in the plot), so that the value at any given year-age pixel represents the average number of kin losses that individuals have experienced in the course of their life, until reaching that age.

We now consider who is bereaved in any given year and what type of bereavement they experience. Figure 4 shows how the burden of bereavement is distributed over birth cohorts (and age) for individuals alive at the end of 2023. Note that age- and cohort-specific bereavement prevalence values in Fig. 4 are equivalent to those shown in Fig. 3 for the year 2023. In general, younger members of the population carry the burden of parental loss, whereas those in the older ages are more likely to have ever lost a child to the conflict. For example, Syrians born in 1958 who were aged 65 in 2023 experienced an average of 166 lifetime kin losses per 1000 individuals. This includes 144 offspring losses and 22 parental losses (per 1000 individuals, on average). In Afghanistan, individuals aged 65 in 2023 have experienced an average of 94 lifetime

conflict kin losses (85 offspring losses and nine parental losses) per 1000 individuals. Note that this only includes kin losses experienced after 1989, when we start observing conflict deaths in the UCDP data.

From a policy perspective, this is important for two reasons. First, studies have shown that the age at which people experience trauma or loss influences the likelihood and severity of mental health problems (*5*, *7*, *8*). This then influences the social resources needed to support such problems. Second, PB decreases the child-care capacity within the family for orphans or half orphans. Alternately, OB influences the family capacity for care of elders (*4*). A region with higher OB could require higher social resources for elder care, whereas a region with higher PB would require more child care resources.

Conflict bereavement persists decades into the future

Figure 5 shows the population-level prevalence of bereavement regardless of the age of the bereaved relatives, essentially a crude bereavement rate. This measure can be interpreted as the sum of all kin losses that a group of 1000 individuals selected at random in any given population and year would have experienced over the course of their entire lives (for offspring loss, this selection is restricted to individuals aged 15+). Consider the burden of offspring loss in Palestine in 2023. If we were to select 1000 Palestinians aged 15 or above at random in 2023 and ask them the total number of offspring that they have lost to conflict, the sum of these experiences of kin death would be 15. This means that by the end of 2023, one of every 67 Palestinians had lost one offspring to the conflict over the course of their lives, on average. In Syria, this is one of every 20 individuals, in Afghanistan one in every 65 individuals and in Ukraine one in every 200 individuals. Note that this average does not account for the fact that mortality may be clustered within certain family groups, so that a small number of individuals may experience considerably higher levels of bereavement than the rest of the population. We discuss the potential effect of clustering in Materials and Methods and in the Supplementary Materials.

The key finding of Fig. 5 is that conflict-affected populations will continue to experience considerable levels of accumulated bereavement even if no more conflict deaths happen after 2023. The shaded area in Fig. 5 represents our projection horizon, starting in 2024, when we assume that no further conflict deaths happen. In Syria, for example, we project an average number of lifetime kin losses of around 27 in 2050. Of these, 22 correspond to parental losses and five to offspring losses. This means that, on average, one in every 45 Syrians will have experienced the death of one parent and one in 200 the death of a child. For Palestine, we project an average number of lifetime losses of 12 by 2050. This translates to seven parental losses and q offspring losses. In other words, one in every 142 Palestinians alive in 2050 will ever have experienced the death of one parent and one in 200 the death of a child. Notice that bereavements continue through 2070, almost 50 years later, although all of these kin losses would have happened before 2024 (since our zero-deaths scenario assumes no conflict deaths after 2023).

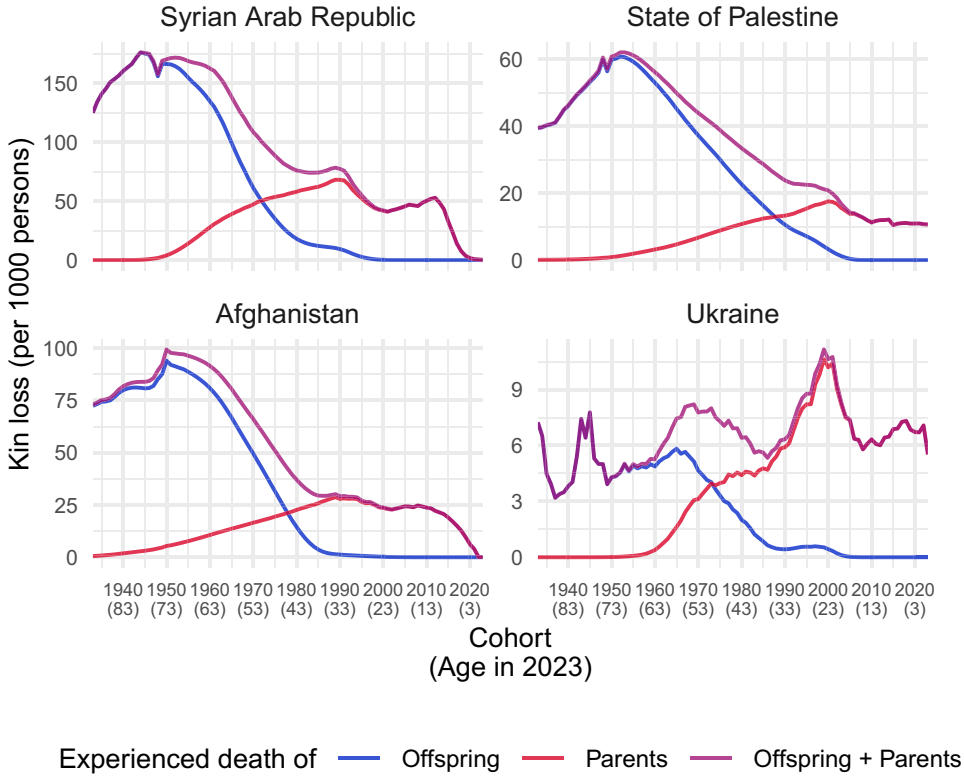

Fig. 4. Lifetime bereavement for the population alive at the end of 2023 by birth cohort/age. The blue line shows the average number of life course conflict offspring deaths experienced by individuals at each age (per 1000 individuals). The red line shows the same but for loss of parents. The purple line is the sum of the red and blue lines. Higher values indicate a higher prevalence of bereavement for individuals born in a given year who are alive at the end of 2023.

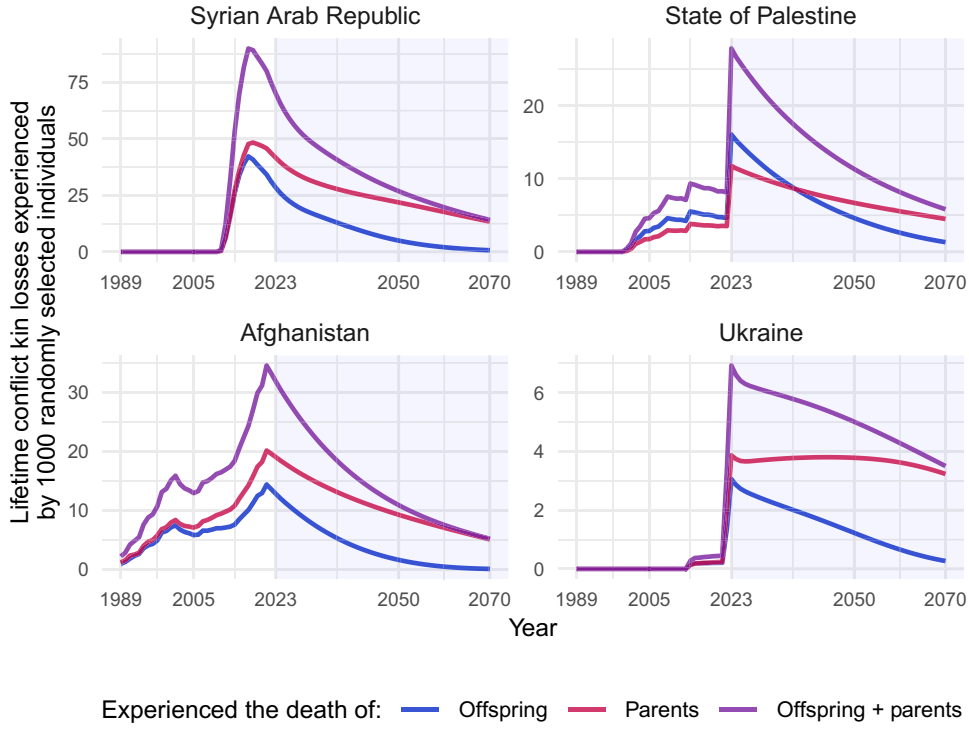

Fig. 5. Crude bereavement rates. Levels of conflict-induced population-level bereavement in four conflict-affected populations. Values can be interpreted as the cumulative prevalence of offspring and/or parental loss in a given year per 1,000 living individuals. "Offspring + Parents" is the sum of the values for parental and OB in any given year. Estimates after 2023 (shaded area) are the result of our zero-deaths scenario, which assumes that no conflict deaths happen after 2023.

DISCUSSION

Implications of conflict bereavement

We aim to highlight the long-lasting impacts of conflict mortality on the burden of bereavement in a population. For this, we focus not just on those who die, but on the many people who survive an armed conflict and are left bereaved by it. Our analysis relied on the notion that each conflict death is experienced by multiple people as the loss of a family member.

Our study of 16 high-intensity armed conflicts shows how conflict mortality produces long-lasting experiences of bereavement for individuals across birth cohorts. Our measure of bereavement refers to a lifelong event (i.e., once an individual has lost a parent or child to conflict, we assume that they remain bereaved for the rest of their life). As a result, individuals exposed to protracted conflicts tend to accumulate instances of bereavement over life. At the same time, individuals in a given birth cohort die out as they age, resulting in a decrease of the population-level prevalence of lifetime bereavement.

Conflict-induced family bereavement has profound emotional and material implications, mostly affecting vulnerable segments of the population. From a public health perspective, survivors of violence will need robust systems of social and mental health support in the years to come. Mounting evidence indicates that the ramifications of losing relatives to conflict markedly differ from those associated with nonconflict causes of death. Notably, the journey to recovery in the former scenario is more arduous and prolonged than losses resulting from nonconflict causes (*6*, *13*). People who lost a family member to conflict not only have to cope with the loss itself but also with the traumatic aspects of that loss (*5*). Traumas stemming from conflict-related bereavements have been identified as elevating the risk of various mental health issues among survivors, including but not limited to post-traumatic stress disorder, prolonged grief disorder, and major depressive episodes (*7*, *8*). These psychological and emotional challenges can manifest as risk behaviors, encompassing issues like suicidal tendencies and substance use disorders, while also contributing to the onset of physical disease (*7*).

Elevated levels of conflict-related bereavement exert enduring impacts on the population. These lasting effects are not confined to the prolonged endurance of trauma at the individual level, persisting well beyond the initial traumatic events. They also extend to the intergenerational transmission of these traumas. The theoretical construct of "historical trauma" has emerged to expound on the intricate mechanisms through which collective traumas are handed down to successive generations, encompassing physiological, environmental, and social pathways (*13*, *21*). Note that in this study, we limit our analyses to those who experienced kin losses during their life course and do not account for the intergenerational transmission of trauma and memory from previous generations.

Lingering levels of bereavement in a conflict-affected population can limit efforts to achieve political reconciliation. Our projections show that even if all armed conflicts were to end immediately, conflict-affected populations will carry high levels of family bereavement trauma for decades to come. The age distribution of conflict mortality matters greatly in this respect. Higher mortality at young ages will result in more deaths that are not just unexpected (given that they are derived from conflict) but that may also be perceived as "untimely" as offspring are generally expected to outlive their parents (*22*). The persistence of large cadres of individuals with links to conflict victims may lead to the emergence of narratives that

are antithetic to reconciliation. This can contribute to the cycles of conflict and peace and resurgent conflict that we already witness in multiple areas of the world.

The evidence we present can help guide potential interventions aimed at providing support to grieving relatives. We showed that individuals of different ages carry different experiences of bereavement. For example, a population where young-age conflict mortality has been high, such as Palestine, will have a larger cadre of bereaved parents aged 30 and older who will need non-family support in older ages. In settings where combatant or older age mortality is higher, such as Ukraine, we are more likely to see a large population of orphaned children in need of support. Future studies and public health interventions should consider these topics in more detail.

We see multiple avenues for future research. Empirical work can expand our definition of conflict bereavement to include kin beyond parents and offspring, longer periods of conflict exposure, and indirect conflict mortality. Measures of excess mortality, for example, can be used to account for deaths resulting from disruptions in the provision of healthcare, food supply, epidemics, and other relevant factors. Methodological work can improve our demographic models of bereavement to account for the clustering of mortality, differentiated mortality schedules for bereaved and nonbereaved individuals, and to account for the role of selective migration of bereaved households. Such an analysis would only be possible for a limited number of contexts that have the necessary data. In all of these scenarios, we expect bereavement estimates to be higher than ours and our results should accordingly be perceived as conservative or low bound estimates of bereavement.

Limitations

We identify six main limitations of our study. First, we restricted our study to including the bereavement of those exposed to losing a child or a parent exclusively. This approach underestimates population bereavement levels in at least two ways. On the one hand, relevant kin ties go far beyond parents-offspring dyads. Other relatives, such as siblings, partners, grandparents, grandchildren, etc., also suffer considerable levels of grief during armed conflicts. In this study, we only focus on individuals that experienced loss directly. However, memories of conflict and related traumas are transmitted across generations and play a major role in shaping perceptions of these events and the well-being of the population in the long term (*12*, *13*).

Second, we are unable to account for the clustering of conflict mortality within families mainly because of data limitations. Our models assume that all members of the population face the same mortality risks. The risk of dying due to conflict might vary substantially across families. We assessed the potential effect of clustering of mortality by considering a case where particularly high levels of clustering can be expected. According to (*23*), between 7 October and 6 November 2023, 61% of Palestinians killed in the conflict were members of the families suffering the largest fatality counts, with 312 families, loosely defined, experiencing the death of at least 10 of their members. This is the only data on family-level clustering of conflict deaths that we are aware of. Using statistical simulations to mimic this context, we find that, in an illustrative scenario with a level of clustering equivalent to that reported for Palestine by (*23*), we would observe a reduction of the bereavement rates by up to 16%, relative to a counterfactual scenario with no clustering. More broadly, we would like to acknowledge that clustering of mortality could represent an important source of uncertainty in estimates of bereavement. To fully quantify this source of uncertainty, high-quality data for calibration of complex microsimulations would be needed. While that would be beyond the scope of this article, we hope that our initial analyses will motivate research into how clustering can be incorporated into kinship models in a systematic way. We would also like to point out some qualitative differences related to the impact of clustering. While the experience of losing kin in a setting with high clustering of mortality may be experienced by fewer individuals, the experience is likely to be more "intense," in the sense that bereaved individuals are likely to lose multiple family members. For details, see Materials and Methods and the Supplementary Materials (fig. S13).

Third, we assume that the same mortality rates apply to the population of bereaved and nonbereaved individuals. In practice, bereaved individuals may face higher mortality risks. We are unable to include this information in our models since reliable data on the clustering of mortality and on mortality differentials for bereaved persons do not exist for all the settings we consider.

Fourth, our models do not account for migration differences according to bereavement status. This is a concern in conflict-affected regions, which often (but not always) see increased levels of displacement. Much of this migration is likely to be internal, which has no bearing on our estimates, but international displacement is common (*24*). Considerable levels of migration would lead us to overestimate the prevalence of bereavement in a given population. Large outflows of bereaved individuals would imply a reduction in the memories of war in the geographic origin area and an increase of this memory in the destinations. We chose not to include migration in our analysis given the lack of reliable information on how bereavement influences migration, as well as the substantial uncertainty surrounding current and future migration flows. We acknowledge this as a limitation but considered it preferable to making strong, and potentially unjustifiable, assumptions in our model.

Fifth, we are limited by data availability in conflict-affected populations. Our reliance on the UCDP Georeferenced Event Dataset means that we ignore all conflict deaths before 1989, greatly underestimating the prevalence of bereavement in populations that experienced mass violence in previous years. For instance, our estimates do not include preexisting bereavement levels in Afghanistan that resulted from the Soviet-Afghan War between 1979 and 1989. Similarly, we do not account for previous instances of mass violence and genocide in armed conflicts, such as the Holocaust or the conflict in Cambodia. Moreover, the death counts reported by UCDP are usually conservative as the database registers the lowest death count when there is discrepancy between sources (*19*). We used indirect methods to ascertain the age and sex distribution of conflict mortality given the lack of appropriate information in the existing sources (*18*, *19*, *25*). For Palestine, aggregated death counts since 7 October are reported by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (*26*) and are based on information from the Hamas-run Gaza Ministry of Health. Although the accuracy of these data has been controversial, several multilateral organizations have expressed that figures previously published by the Ministry were very close to their own verification, and indirect analyses have found no evidence of inflated mortality reporting (*27*). In the Supplementary Materials, we show sensitivity analyses that take alternative approaches into consideration (*20*).

Sixth, our measure of bereavement considers only direct conflict mortality. Studies have shown that armed conflicts can produce considerable levels of indirect mortality by affecting the provision of healthcare, housing, and family support, among other things (*28*). As a result, we underestimate the indirect effects of conflict in the short and long term.

Seventh, our demographic models of kinship produce population-level averages and do not account for within-population variability in kinship structures since subnational demographic data are not available for the settings we study. Given the lack of information on male fertility, we relied on the androgynous fertility approximation (*29*), which may slightly bias upward the number of living fathers for individuals in contexts with large differentials between male and female fertility (*30*). One last factor is methodological and inherent to demographic model of kinship (*31*): Our models fail to incorporate the intergenerational transmission of demographic behavior, the clustering of family sizes, and distributions of age differences between partners. The results we present should be interpreted with these limitations in mind.

The previous discussion points toward important areas for future development. First, the demographic study of conflict is often limited by data availability. Collecting high-quality data and making data accessible can greatly improve our understanding of how populations are affected by war in the short and in the long term. This can be achieved by establishing new data collection systems, which is challenging, or by sharing existing data with the scientific community. For example, the data on the family clustering of mortality in Palestine shared by (*23*) were extremely useful for our sensitivity analysis, as was the individual-level data on conflict-related deaths shared by (*32*). In the context of data scarcity, methodological developments will continue to be crucial. Future work should develop an approach to include uncertainty around estimates of bereavement using statistical techniques as proposed by (*33*). A similar approach could be incorporated to account for the clustering of mortality. Last, microsimulations and agent-based models offer another promising and relatively unexplored avenue for overcoming some of the limitations of this study.

Armed conflicts increase the number of individuals who have lost a close relative in the population. The resulting bereavement levels substantially surpass those of conflict mortality. Our study of 16 high-intensity conflicts exemplified how the prevalence of family bereavement in any given population is the product of the interaction between conflict mortality and past and future demographic dynamics. Bereavement tends to accumulate over the life course; individuals may experience the loss of a parent when they are young and lose a child when they are older. Crucially, we showed that armed conflicts cast long shadows over family bereavement: Populations will continue to experience a high prevalence of bereavement even if no more conflict deaths happen after 2023. This study introduced a framework for thinking of the prevalence of conflict bereavement in a population as a form of "memory." We argue that the prevalence of bereavement in a population has considerable material, health, and political implications. On the one hand, a high prevalence of trauma may require targeted interventions to deal with mental health issues and caregiving needs at younger and older ages derived from the loss of kin to conflict. On the other hand, the prevalence of bereavement in a population may also influence the way in which individuals think of a conflict and may affect the viability of political reconciliation. The large number of individuals bereaved by armed conflict will require attention and assistance as we edge toward an increasingly volatile future.

MATERIALS AND METHODS

The intuition behind the approach

Consider a population of seven individuals with a known genealogical structure (Fig. 6). In this illustrative example, the population consists of two families: one family with two parents and two offspring and another family with two parents and one child. Seen from the perspective of the offspring, there are six unique child-parent ties (C → A, C → B, D → A, D → B, G → E, and G → F). Seen from the perspective of the parents, there are also six unique parent-child ties (A → C, A → D, B → C, B → D, E → G, and F → G).

Let us assume that C dies in an armed conflict. This would result in the dissolution of two parent-child ties (A → C and B → C). If we focus on parents who are 35 years old, of the three parents in the population, two suffered the severing of parent-child ties because of the conflict. In other words, at the population level, two-thirds of parents experienced one offspring loss to conflict. This means that, on average, each 35-year-old individual in the population lost 0.67 (two-thirds) offspring to conflict. Now, let us consider kin loss from the perspective of offspring and assume that C lives but A dies. The average number of parental losses in the population for 5-year-old bereaved offspring would be one-half, or in other words, each 5-year-old child lost 0.5 parent to conflict. By focusing on ties, this approach to counting losses produces averages that are unaffected by the double counting introduced by common ancestors or descendants. Here, we develop a strategy that relies on a similar logic to estimate the average number of kin losses due to conflict mortality in real populations and based on knowledge of demographic rates.

Data

We retrieved conflict-related deaths by population between 1989 and December 2023 from the UCDP database (*18*, *19*). UCDP defines a conflict death as one arising from either combat between organized actors or violence against civilians within the framework of state- or non–state-based armed conflicts. Organized actors encompass governments of independent states and formally or informally organized groups consciously conducting and planning political campaigns (*34*). We use the UCDP database for our main analyses for two reasons. First, UCDP distinguishes deaths from civilians and (local and foreign) combatants in intra- and inter-State conflicts. Second, it has the largest period coverage in most countries of all the available sources. For Palestine, we used alternative data sources that distinguish between deaths that happened before and after 7 October 2023, when over 1200 people were killed in Israel as a result of a Hamas-orchestrated attack that provoked an unprecedented intensification of the Israel-Palestine armed conflict in Gaza. We obtained age- and sex-specific conflict-related deaths in Palestine between 2000 and 6 October 2023 from the B'Tselem project (*32*), which provides precise information on the sex and exact age of each conflict-related death and has been used in previous studies of the effects of conflict on population health (*35*). Data on total Palestinian deaths from 7 October to 30 December 2023 come from the OCHA (*26*). Note that data for Palestine refers to Gaza, the West Bank, and East Jerusalem. Tables 2 and 3 present the most affected populations during the last decade (2014–2023) and since the start of the records (1989–2023), respectively. The percentage of population

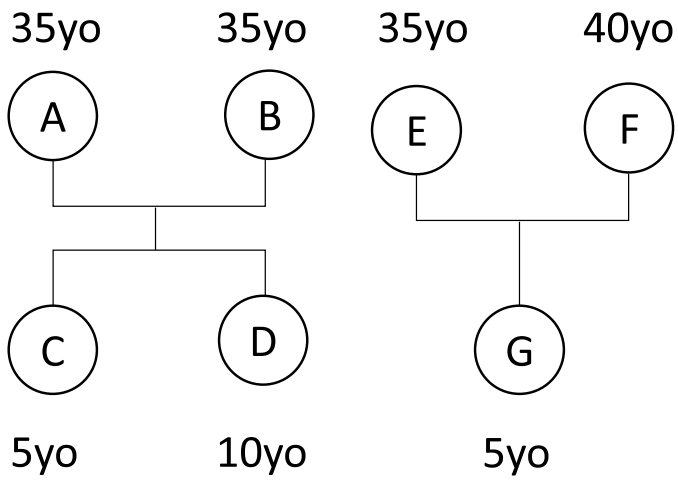

Fig. 6. A hypothetical population composed of two families that have six unique kin ties from parents to offspring and six ties from offspring to parents. The ages of the individuals are shown right above or right below each circle.

Table 2. Ten most affected populations by armed conflict in 2014–2023. The ranking considers the number of conflict deaths (column A) as a proportion of the 2014–2023 average national population (column B). Columns A and B are counts (in thousands) and column C represents values per mille (‰). We focus on the top four most affected populations in the text.

		A	B	C
Rank	**Country**	**Conflict deaths**	**Population**	**Proportion (‰)**
1	Syrian Arab Republic	274	20,568	13.3
2	State of Palestine	28	4,920	5.6
3	Afghanistan	185	37,901	4.9
4	Ukraine	108	42,825	2.5
5	Central African Republic	10	5,245	2.0
6	Yemen	59	31,506	1.9
7	Libya	10	65,53	1.5
8	Iraq	57	41,596	1.4
9	Somalia	23	15,964	1.4
10	Ethiopia	126	114,320	1.1

loss due to conflict is based on the average populations during each period as the reference.

On the basis of these conflict mortality data, we selected the four populations with the largest share of the population lost to conflicts between 2014 and 2023 to present in the main text, namely, Syria, Palestine, Afghanistan, and Ukraine. Syria, Palestine, and Afghanistan have relatively young age structures, whereas the population in Ukraine is relatively older. All of these populations differ in the levels and timing of conflict mortality exposure. The findings for the remaining 12 populations are presented in the Supplementary Materials.

Year-, sex-, and age-specific survival probabilities, age-specific fertility rates (for women only), and population counts used as input for the kinship models come from the 2022 Revision of the United Nations World Population Prospects (UNWPP) (*36*). For the 1950–2022 period, we use empirical rates and for the 2023–2070 period, we use the "median" scenario projections.

Annual sex- and age-specific conflict deaths

We estimated annual sex- and 5-year age-specific conflict deaths by applying the age-sex patterns of crisis deaths produced by (*20*) to the total annual counts reported by UCDP. In particular, we used different age and sex distributions of mortality according to the type of conflict: "conflict civilians" and "conflict combatants" (shown in the main text); and "genocide" (for civilians) and "conflict combatants" (included in the Supplementary Materials as a sensitivity analysis). We then applied the Penalized Composite-link model (*37*) using the ungroup R software library (*38*) to disaggregate death counts into single years of age between ages 0 and 90+.

We followed a slightly different approach for Palestine. For deaths before 7 October 2023, there was no need to impute the age and sex of conflict-related deaths because the sexes and exact ages of the victims are reported by (*32*). For deaths occurring since 7 October 2023, we applied the sex and age structure of deaths reported by the

Table 3. Ten most affected populations by armed conflict in 1989–2023. The ranking considers the number of conflict deaths (column A) as a proportion of the 1989–2023 average national population (column B). Columns A and B are counts (in thousands) and column C represents values per mille (‰).

		A	B	C
Rank	Country	Conflict deaths	Population	Proportion (‰)
1	Rwanda	793	9590	82.7
2	Eritrea	57	2762	20.7
3	Syrian Arab Republic	409	20763	19.7
4	Bosnia and Herzegovina	64	3718	17.1
5	Afghanistan	317	25941	12.2
6	Kuwait	18	2120	8.5
7	State of Palestine	35	4229	8.2
8	Liberia	23	2950	7.9
9	Somalia	62	11270	5.5
10	Congo	16	3839	4

Gaza Health Ministry on 26 October to distribute the total death toll reported by the OCHA on 31 December (since deaths in this data source are not disaggregated by age and sex). In the Supplementary Materials, we present an alternative approach to disaggregating deaths by age and sex for Palestine, based on historical patterns observed during the period 2000–2022, as a sensitivity analysis.

On the basis of our sex- and age-specific conflict deaths estimates, we adjusted probabilities of survival for all populations in the year 2023, as UNWPP estimates assume there are no mortality crises after 2022. In the case of Syria, we also needed to adjust age-specific probabilities of survival in years 2016–2018, as conflict death counts were slightly higher than UNWPP all-cause mortality at some ages.

Kinship structure using demographic models

We produced annual age- and sex-specific estimates of kinship structure by population using demographic kinship models (*16*, *17*, *29*). These models quantify the number of relatives, by age and sex, that could potentially be bereaved by the death of a conflict victim (by age and sex of the hypothetical victim). The models use sex- and age-specific survival probabilities and fertility rates to estimate the average number of living kin for an average member of the population. The equations are, fundamentally, demographic projections similar to the classical cohort-component method (*15*) except that they are used to project the population of kin of an average member of the population (e.g., the population of offspring, of parents, etc.).

Here, we exemplify our modeling approach by showing how to compute the age distribution of daughters in a matrilineal population. All estimates refer to an average member of the population whom we call "focal." The example is based on (*39*), where more details of the inputs and outputs of the models are given. Let $\mathbf{k}_{x,t}$ be a matrix containing the population of daughters of focal when focal is x years old at time t. For example, $k_{25,2000} = [0.16; 0.15; 0.14; \ldots]$ means that women aged 25 in the year 2000 in Afghanistan had, on average, 0.16 living daughters aged 0, 0.15 living daughters aged 1, 0.14 living daughters aged 2, etc. In addition, $\mathbf{o}_x$ is the unit vector for age x, $\mathbf{U}_t$ is a matrix with age-specific survival probabilities, which is applied to the population of existing daughters, and $\mathbf{F}_t$ is a matrix containing age-specific fertility rates, which represents the reproduction of focal. We can project the distribution of focal's daughters for the age $x + 1$ of focal at time $t + 1$ as follows

$$\mathbf{k}_{x+1,t+1} = \mathbf{U}_t\mathbf{k}_{x,t} + \mathbf{F}_t\mathbf{o}_x \quad (1)$$

Here, we use two-sex time-variant kinship models that allow us to ascertain the expected number of male and female kin for an average member of the population (male or female) on a year-by-year basis. We use the androgynous fertility approximation first introduced by (*29*), which assumes that male and female fertility rates are equivalent. In practice, men tend to have lower and later fertility (*40*) but male fertility rates are unavailable for the populations we study. A recent multicountry study (*30*) found that the androgynous fertility provides an acceptable approximation of the total numbers of kin, even in cases where there are substantive differences between male and female fertility schedules. However, we expect that the androgynous fertility approximation will slightly overestimate the number of living fathers.

A detailed description of the models can be found in (*17*, *29*, *39*). We focus on nuclear kin (i.e., parents and offspring) and perform computations using the DemoKin R software library (*41*).

Population-level prevalence of conflict-induced bereavement

As a first step, we want to know $b_{y,t}$, the number of kin lost to conflict in year t among individuals aged y in the population, for a given kin dyad (either from parent to child or from child to parent). In any given year t, we can estimate the absolute number of kin dyads severed by conflict mortality among those aged y as

$$b_{y,t} = \sum_{x=0}^{w} d_{x,t} \times k_{x,y,t} \quad (2)$$

where w is the (open-ended) upper-age bound (90 years) and $d_{x,t}$ is the number of conflict deaths for individuals aged x in year t. $k_{x,y,t}$ is the expected number of kin: the expected number of bereaved kin aged y, resulting from the death of a Focal at age x in year t (for the case of offspring, see Eq. 1). If estimating cases in which offspring aged y experience the death of parents of any age, then $k_{x,y}$ refers to

the expected number of living offspring aged y. Alternatively, $k_{x,y}$ is the expected number of living parents aged y when estimating cases in which parents aged y experience the death of any-age offspring.

We can then obtain the average levels of bereavement at age y and year t, by dividing $b_{y,t}$ by the corresponding population at risk, $n_{y,t}$

$$\bar{b}_{y,t} = \frac{b_{y,t}}{n_{y,t}} \tag{3}$$

The average bereavement, $\bar{b}_{y,t}$, indicates the number of kin lost to conflict per capita among those surviving at age y in year t. It can be also understood as the risk of losing kin to conflict at age y in year t. For instance, in the case of OB, a $\bar{b}_{y,t}$ value of 0.2 would indicate that those aged y in year t, (i) lost 0.2 offspring on average, and (ii) experienced a 20% risk of losing a child to conflict.

We can also estimate the cumulative bereavement (b^A) by aggregating the existing age- and period-specific bereavements over the life course of cohorts, considering also the mortality risk at which the persons experiencing bereavement are exposed over age/time. The aggregation of bereavement over the life course for a cohort aged y in year t can be estimated as

$$b^A_{y,t} = b^A_{y-1,t-1} \times p_{y-1,t-1} + b_{y,t} \tag{4}$$

and

$$b^A_{y^0,t^0} = b_{y^0,t^0} \tag{5}$$

where $p_{y-1,t-1}$ is the life-table probability of surviving from age $y-1$ and time $t-1$ to age y and time t. Note that we assume that bereaved and nonbereaved members of the population have an equal probability of surviving. The initial conditions are given by y^0 and t^0: the age and year at which each cohort is observed for the first time.

The average cumulative bereavement at age y and year t, can be defined as

$$\bar{b}^A_{y,t} = \frac{b^A_{y,t}}{n_{y,t}} \tag{6}$$

This average cumulative bereavement, $\bar{b}^A_{y,t}$, can be interpreted as the mean number of kin lost to conflict during the life course of a cohort born in the year $t-y$, until it reaches age y in year t. Alternatively, this quantity also indicates the risk of ever having lost a relative to conflict up until age y (e.g., the risk of having lost a child to conflict in the years leading to and including age y). Note that we only consider conflict deaths since 1989 given data availability (and since 2000 for Palestine).

At the population level, we are also interested in knowing the bereavement burden in a given year t. Here, we define the population bereavement burden as the cumulative number of conflict bereavement events that an average person in the population at year t ever experienced since the time when we start recording conflict deaths. This is

$$B^A_t = \frac{\sum_{y=0}^{w} b^A_{y,t}}{n_t} \tag{7}$$

where n_t is the population exposed to the risk of kin loss in year t. When estimating child losses, n_t includes all persons aged 15 and over, who are the only ones at risk of ever having lost a child (our kinship models assume that reproduction starts at age 15). If estimating parental losses, n_t includes all ages, as all individuals have been exposed to loss of parents at some point in their life.

Sensitivity analysis

We conduct a range of sensitivity analyses that are included in the Supplementary Materials. First, we evaluate the sensitivity of our estimates to the input data by replicating our analyses using conflict-related death counts reported by the Armed Conflict Location and Event Data Project (*25*). For this source, we include deaths caused by "battles," "explosions/remote violence," and "violence against civilians," and exclude deaths from "protests" and "riots."

Second, we evaluate the sensitivity of the model used to distribute conflict deaths by age and sex. In the main text, deaths of combatants were distributed using the conflict combatant pattern of (*20*). In the Supplementary Materials, we created an alternative scenario for civilian casualties using the genocide age-sex pattern. For Palestine, we aggregate all conflict deaths reported by the Gaza Ministry of Health (*26*) to obtain the total number of conflict deaths (ignoring the age and sex of victims). We then use the average sex and age patterns reported by (*32*) before 2023 to replicate the bereavement analysis.

Last, we evaluate the sensitivity of our bereavement estimates to different levels of conflict mortality family clustering. In the Supplementary Materials, we simulate a population of 200,000 individuals, grouped into 10,000 extended families. We run three scenarios with different family sizes (20, 40, and 60 members each). To simulate mortality clustering, we assign a "frailty multiplier" to each family by drawing from a γ distribution with mean equal to one and variances ranging from 0 to 50. We use this frailty multiplier to adjust a (common) individual-level hazard rate. In order words, we approach the issue in a way similar to how (*42*) addressed heterogeneity, with the main difference that we consider a scenario where members of the same family share the same frailty multiplier. We set the baseline hazard rate to 0.0044, the empirically observed value for Palestine in 2023. The only empirical data on the family clustering of conflict mortality that we are aware of comes from the Israel-Gaza war between 7 October and 6 November 2023. Here, 79% of families (to be interpreted as extended families) with multiple casualties (825 of 1050 families) account for 61% of total deaths (6120 of 10,022 deaths) (*23*). In our simulations, a γ distribution with a variance of 29 accurately replicated these levels of clustering. We ran 1000 simulations with these specifications and estimated the respective bereavement rates. This analysis revealed that the very high level of clustering reported for Palestine would produce bereavement rates that could be up to 16% lower than the values obtained by a counterfactual scenario without clustering of mortality (see the Supplementary Materials, and fig. S13, for more details about our sensitivity analyses related to clustering of mortality and other sources of uncertainty).

Supplementary Materials

This PDF file includes:

Supplementary Text
Figs. S1 to S13
Tables S1 and S2

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