

Towards a demographic analysis of kinship bereavement

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BACKGROUND

Kin deaths are universal, but their frequency, timing, and position within family networks vary across demographic regimes. Existing demographic research describes kin loss, but provides limited tools for summarizing its cumulative and life-course consequences.

OBJECTIVE

We develop a demographic framework to compare bereavement regimes across populations, focusing on three dimensions: cumulative burden, loss of shared lifetime, and generational overlap in kin deaths.

METHODS

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We derive three indicators from age-specific kinship dynamics: bereavement burden, defined from kin-years lived after kin death; shared time lost, measured as expected kin-years of potential coexistence removed by death; and generational overlap, measuring coincidence between age-specific death schedules of different kin types. We apply the framework to female 1950 cohorts in Argentina and Guatemala using UN-2024 data and matrix kinship models.

RESULTS

The comparison identifies contrasting bereavement regimes. Guatemala has much higher burdens from child and sibling deaths and larger total losses of shared time with these kin. Argentina has a higher grandparent burden and greater shared time lost per child death. Death schedules are also more strongly overlapped in Guatemala, particularly for siblings and parents and for children and parents, whereas Argentina displays a more sequential ordering of losses across generations.

CONCLUSIONS

Similar death counts can conceal markedly different bereavement experiences. The demographic meaning of loss depends on when deaths occur, how many kin are exposed, and how losses are sequenced across generations.

CONTRIBUTION

We extend formal kinship demography by providing three interpretable indicators that allow bereavement to be compared systematically across demographic regimes using standard population data.

1 Introduction

The loss of kin is a commonly experienced life event. This follows from the fact that kinship is universal (Caswell, 2019), while mortality is an unavoidable demographic event. More than 60 million deaths occur worldwide each year (United Nations, Department of Economic and Social Affairs, Population Division, 2024), and each death leaves multiple relatives in a state of bereavement. Each of these relatives becomes bereaved at a particular age, in relation to a specific type of deceased kin, within a kinship structure that has evolved throughout the life course and is expected to continue changing over the remaining lifespan.

We refer to bereavement as the state that starts with the “experience of having lost someone close, a significant relationship” (Shear, 2012), in our case a kin relation. The state is persistent in that an individual is bereaved until his/her own death. Bereavement differs from grief, which refers to the “psycho-biological response to bereavement” (e.g., sadness, anger, and guilt), and from mourning, which refers to the “array of psychological processes that are set in motion by bereavement in order to moderate and integrate grief” (Shear, 2012). By kin, we refer strictly to consanguineal relations, excluding losses involving spouses or other non-kin ties.

Large-scale mortality crises, most recently the COVID-19 pandemic, have renewed interest in bereavement as a social and population-level phenomenon. Although bereavement has often been studied within psychiatry, with emphasis on individual psychological responses to loss, recent sociological work highlights that exposure to bereavement is shaped by structural conditions. These conditions influence how often bereavement occurs, which kin are lost, at what ages losses are experienced, and how

grief is distributed across populations (Smith-Greenaway et al., 2025). A life-course perspective is therefore central for understanding bereavement both as an outcome of social inequality and as a mechanism through which inequalities related to race, class, gender, and other axes of stratification may be reproduced (Umberson et al., 2017).

This study approaches bereavement from a demographic perspective, under the premise that each combination of fertility and mortality regimes implies a characteristic population-level pattern of bereavement. Compared with other demographic events, the onset of bereavement depends on the survival of other individuals. Demographic conditions shape the average experience of loss, producing distinct bereavement trajectories that evolve with the demographic transition. The shift from high and early fertility and mortality to lower and later fertility and mortality implies a substantial transformation from predominantly horizontal to more vertical kinship structures, and from losses concentrated at younger ages to losses occurring later in life (Alburez-Gutierrez et al., 2023). Consequently, demographic inequalities across subpopulations translate into inequalities in bereavement experiences (Chang and Robles, 2025).

Although bereavement over the life course can be understood demographically, the social mechanisms linking demographic patterns of loss to grief remain less clearly specified. Cultural frameworks surrounding death shape not only individual emotional responses, but also collective expressions of grief and mourning practices, including associated rituals (Gire, 2014). These cultural meanings influence how loss is interpreted. For example, within Buddhist traditions, the boundary between the living and the dead is often conceived as permeable, a belief that can frame death less as a

definitive rupture and more as a transition. In this sense, measuring grief is complex: while people do not control bereavement, they may have some agency in how grief is expressed and processed. Moreover, the transition marked by death is not defined universally in the same way. In some Pacific cultures, death is not always considered definitive and may be understood as occurring in situations such as illness or sleep. Another example of death as a repeatable event is rebirth with a new identity in Hinduism (Gire, 2014).

Bereavement duration, understood demographically as the expected time lived after the death of kin, is jointly determined by the timing of the kin death and the subsequent survival of the bereaved individual. This exposure-based definition differs from culturally prescribed periods of mourning, which vary substantially across societies. Mourning may be socially recognized for approximately one year in Germany (Hilberdink et al., 2023), for several years in some Chinese traditions following the death of a parent or child, and for even longer through ritual observances in Bali, Indonesia. Thus, demographic exposure to bereavement and culturally meaningful mourning are related but distinct dimensions. Over time, grief trajectories are further shaped by social integration, identity reconstruction, and adaptive coping processes (?).

Although there is growing interest in measuring bereavement from a demographic perspective, there is currently no commonly agreed-upon way to summarize the phenomenon or to determine which dimensions should be prioritized. Acknowledging the complex relationship between bereavement and grief, we treat bereavement as a demographic state and focus on characteristics for which there is evidence of significant health impacts. Previous studies focused on formalizing kin loss in a de-

demographic regime (frequency by age, type of kin, cumulated loss, causes of death) Caswell et al. (2023). This paper represents, to the best of our knowledge, the first attempt to propose a comprehensive toolbox for conceptualizing bereavement from a formal demographic perspective, to provide a concise comparison of different bereavement regimes in time and between countries (or geographic areas in general). We propose three indicators related to burden (frequency and timing, cumulative loss, and its age distribution), loss of shared time (duration), and generational order (disruption in the expected kin sequence). The three measures therefore try to answer different questions: the measure of burden indicates how much bereavement accumulates relative to kin-years experiences; shared time indicates how much relational life is removed; and generational overlap indicates how orderly, compressed, or disrupted the sequence of losses is. Used jointly, the indicators distinguish bereavement regimes that would appear similar under any single measure and support different research agendas. The measure of burden is most useful for studying cumulative health inequality and life-course exposure; shared time for grief, care, and family support; and generational order for mortality crises, premature death, predictability, and disruption of expected intergenerational sequences.

Building on methodological advances in kinship network estimation (Caswell, 2019), we compare selected cohorts from Argentina and Guatemala to examine how demographic change transforms the average experience of bereavement over time. A key advantage of this approach is that it requires only age- and time-specific fertility and mortality schedules, rather than registers or specialized surveys, allowing population-level comparisons to be made more easily.

2 Consequences of bereavement

Bereavement is associated with elevated short- and long-term health risks, including increased substance use, physical illness, depression, and excess mortality (Prior et al., 2018; Colin Murray and Holly G., 2009; Stroebe et al., 2007). These risks are particularly pronounced in the weeks and months following a loss, but their consequences may extend over longer periods. Public health protocols have therefore emphasized the need to identify groups at higher risk of adverse mental health outcomes and to facilitate appropriate clinical support (Aoun et al., 2015). From a demographic perspective, this motivates attention not only to individual responses to loss, but also to the population-level distribution of exposure to bereavement.

The consequences of kin death for health, economic conditions, and well-being depend on multiple factors within a given social environment. One of the most consistent predictors of grief severity across cultural contexts is the closeness of the deceased within the kinship structure, such as the difference between losing a child and losing a more distant relative (Lobb et al., 2010; Fernández-Alcántara and Zech, 2017; ?). This evidence supports distinguishing bereavement by kin type rather than treating all losses as equivalent.

Early bereavement and the accumulation of losses over the life course create a compounded burden linked to increased mortality risk. Among Black Americans, this pattern has been described as experiencing family deaths “too much” and “too soon” (Chang and Robles, 2025). Losing kin “too soon” can be exemplified by exposure to loss during sensitive developmental periods, which may disrupt stress-response systems and emotional regulation, increasing susceptibility to mental health disorders

(Thimm et al., 2020). As a specific consequence, early exposure to parental bereavement increases the risk of school bullying victimization and frequent victimization (Ran et al., 2025). In relation to “too much,” experiencing multiple family deaths before age 50 has been associated with a higher prevalence of cardio-metabolic conditions in midlife (Donnelly, 2022), and individuals facing multiple simultaneous losses, such as those produced by wars, disasters, or accidents, show worse mental health outcomes than those experiencing a single bereavement (Chang and Robles, 2025). This evidence motivates indicators that combine the timing and frequency of kin deaths over the life course.

Although each kin death is unique, a new death may find Focal surrounded by a large kin network or relatively alone. A death occurring in a context with few available relatives also affects Focal’s support network, including care, affection, security, and material support (Logan et al., 2017). Reduced social support after a loss has been identified as a risk factor for the development of PGD (Heeke et al., 2017). The availability of living kin, or kin interaction (Caswell and De Vries, 2025), therefore matters for both the provision of support and the distribution of the consequences of loss, including adjustments in household and family economies. From this perspective, the death of a grandparent has different implications depending on the initial kin configuration: losing one grandparent when all four were alive at Focal’s birth is not equivalent to losing one when only two were present.

Bereavement experiences are further shaped by the timing, predictability, and cause of death. Deaths may be expected or unexpected, sudden or gradual, and may disrupt the usual genealogical ordering of mortality, as when children die before parents or grandparents. Unexpectedness can be defined in demographic terms,

for example through an age threshold or through the position of a death within the age-at-death distribution (Mazzucco et al., 2021). It can also be defined epidemiologically, through causes of death that are sudden, violent, or inconsistent with the prevailing stage of the epidemiological transition. External causes, including suicide, are associated with distinctive grief processes and high psychological impact (Pitman et al., 2016), while violent deaths and non-life-limiting illnesses are associated with a higher risk of prolonged grief disorder (Aoun et al., 2015; Lobb et al., 2010; Smith-Greenaway et al., 2025). When a grandchild dies, grandparents experience a dual challenge: losing a grandchild while also trying to support their adult children (Youngblut and Brooten, 2018). By contrast, an “acceptable death,” understood as controlled and non-dramatic, such as the hospital ideal of a “good death,” may allow time for preparation and social adjustment. Deaths linked to collective violence, such as terrorist attacks or armed conflict, increase the risk of post-traumatic stress disorder, depression, and anxiety (Neria and Litz, 2004). More broadly, the mechanism and context of loss—particularly among refugees, migrants, and conflict survivors—can intensify sudden and harmful bereavement experiences (Heeke et al., 2017). These mechanisms suggest that the ordering and predictability of kin deaths are relevant dimensions of bereavement, especially when deaths occur prematurely or violate expected intergenerational sequences.

Bereavement regimes vary with the broader demographic regime in which they are embedded. In pre-transitional mortality settings, bereavement was often frequent, early, and less clearly ordered by generation (Livi-Bacci, 2017). Individuals were repeatedly exposed to the deaths of close kin during childhood, adolescence, and early adulthood, making bereavement a routine feature of family life rather than an

exceptional event. This normalization of loss has been described ethnographically by Scheper-Hughes (2023), whose concept of “Death Without Weeping” refers to a context in Northeast Brazil where high infant mortality made child death recurrent and socially mediated through rituals, rationalizations, and forms of mystification. Such examples illustrate why the frequency, timing, and social meaning of kin death must be considered together.

Taken together, this literature shows that bereavement is not only an individual psychological experience, but also a socially and demographically structured exposure with implications for health, well-being, and socioeconomic conditions. The next section turns to the demographic foundations of this argument by reviewing the kinship-demographic framework and the main inputs used to formalize bereavement patterns over the life course.

3 Kinship demography and bereavement

Our results rely primarily on the expected distribution of living kin and the frequency of kin deaths by Focal’s age, kin type (children, parents, grandparents, siblings, etc.), and the age and sex of kin, following (Caswell and Song, 2021). We work with two main age-specific outputs: $k(x)$ and $d(x)$. The first, $k(x)$, is the number of living kin of a given type (mother, father, daughter, son, etc.) when Focal is age x . This can be decomposed into two parts (Eq. 1). The first term represents kin who preexist Focal, with an initial age distribution α at the time of Focal’s birth. For example, parents begin as two individuals, if maternal and paternal mortality during pregnancy is ignored, so $\int_0^\omega \alpha(z) dz = 2$. These kin must survive x years

to remain alive when Focal reaches age x . The second part of $k(x)$ is given by β , which represents the subsidy or recruitment term: newborn kin resulting from Focal's own reproduction or from the reproduction of other kin types, such as grandchildren through children, who survive along Focal's life course.¹

$$k(x) = \int_0^\omega \alpha(z) \frac{l(z+x)}{l(z)} dz + \int_0^x \beta(z) \frac{l(x-z)}{l(0)} dz \quad (1)$$

Here $l(x)$ is the survival function from the life table (period or cohort). As a reference for each term in Equation 1, note that for mothers $\beta(z) = 0$ (Focal has no daughters when she is born), whereas for daughters $\alpha(z) = 0$ (there are no children when Focal is born). Thus, depending on whether the relative belongs to an older or younger cohort than Focal, the number of living kin aged z when Focal is age x is given by $k(x, z) = \alpha(z-x) \frac{l(z)}{l(z-x)}$ if $z > x$, or by $\beta(y) \frac{l(x-y)}{l(0)}$ when $z < x$. The total number of living kin at age x is then obtained by integrating over the kin age distribution: $k(x) = \int_0^\omega k(x, z) dz$. The second key output is $d(x)$, the number of deaths of a given kin type when Focal is aged x , and the accumulation until age x is $D(x) = \int_0^x d(a) da$. When kin age is taken into account, this can be expressed as $d(x, z) = \int_0^\omega k(x, z) \mu(z) dz$, where $\mu(z)$ is the mortality rate at age z (period or cohort). These expressions are sufficient to build the core indicators used in this study.

The values of $k(x)$ and $d(x)$ are obtained from matrix kinship models under a female-dominant, two-sex, time-variant framework defined by age-specific fertility and survival schedules (Caswell and Song, 2021), implemented here using Williams

¹An implicit assumption is that new kin represented by β do not include, for example, adoptions in which the age of entry into Focal's network may be greater than 0. This follows from the consanguineal definition of kin used here.

et al. (2023). Throughout, we assume independence between Focal's survival and the survival of her relatives, and among relatives themselves. Treating kin as populations, we measure exposure in kin-years, analogous to person-years in demographic analysis (Caswell and De Vries, 2025), as discussed further below. Deaths are assumed to occur at the end of each yearly interval; hence, each relative alive during an age interval contributes one kin-year to Focal's experience at that age. Our analysis is restricted to four close kin types: children, parents, siblings, and grandparents. Indicators are calculated separately for each kin type. Although these indicators can be generalized to any age x , our aim is to provide a broader picture of loss within a kinship network for an average newborn individual.

To illustrate the proposed indicators, we compare Argentina and Guatemala. We use fertility and mortality schedules by sex and single year of age from United Nations, Department of Economic and Social Affairs, Population Division (2024) for the period 1950–2023. These countries represent contrasting demographic trajectories within Latin America (Fig. 1). From 1950 to 2023, female life expectancy at birth increased from 65 to 80 years in Argentina and from 38 to 75 years in Guatemala. During the same period, the total fertility rate declined from 3.1 to below 1.6 in Argentina, and from nearly 7 to 2.5 in Guatemala. Guatemala also experienced a sharp decline in child mortality, from approximately 25% in 1950 to less than 2% in 2023, converging toward the regional pattern. Around 2010, Guatemala's mean age at childbearing crossed that of Argentina, consistent with two sequential components of the fertility transition: first, the reduction of overall fertility levels, and second, the postponement of fertility through declines in adolescent childbearing. These contrasts are expected to produce different bereavement regimes: larger sibships and higher

early-life mortality in Guatemala, and longer survival and more vertically structured kin networks in Argentina.

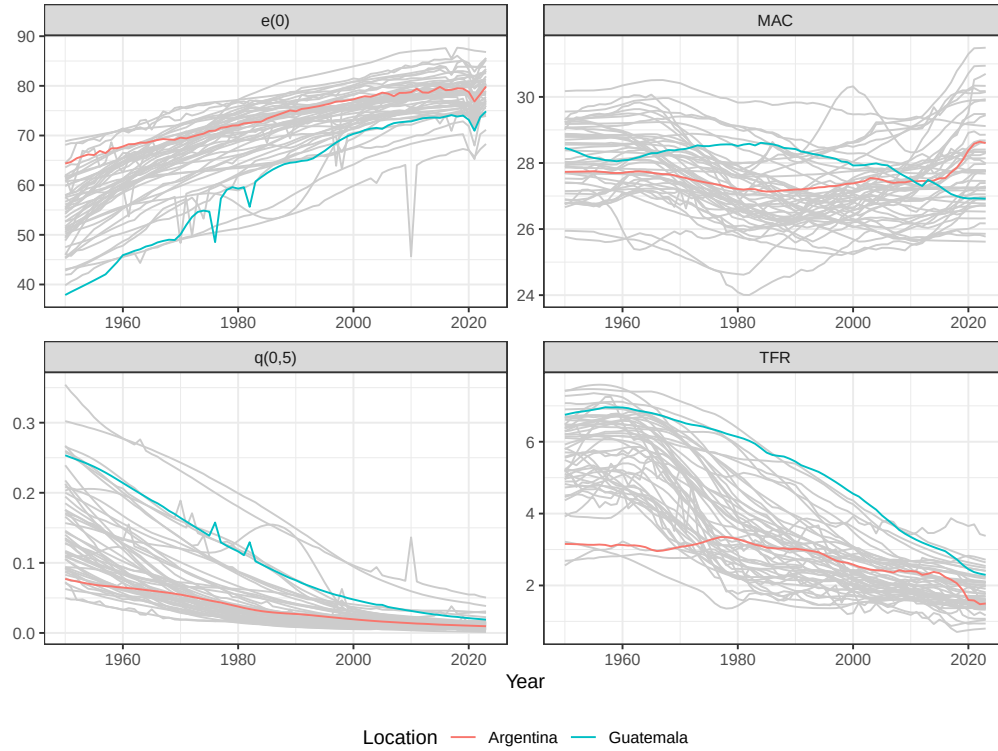


Figure 1: Period life expectancy at birth, probability of dying before age five, total fertility rate, and mean age at childbearing. Latin American and Caribbean countries are shown in grey; Argentina and Guatemala are highlighted in color. Years 1950–2023.

Results from the kinship model for the 1950 cohort highlight substantial differences in bereavement regimes between the two countries (Fig. 2). In Guatemala, during the first years of life, women experienced nearly as many sibling deaths as grandparent deaths. In their twenties, deaths of children exceeded deaths of parents, while in their thirties the frequency of deaths became similar across all kin types. Bereavement trends in Guatemala are expected to be strongly affected by the country's Civil War

and, in particular, by the period of mass violence between 1980 and 1982 (Grace and Sweeney, 2016). The U-shaped age pattern of sibling deaths implies that, by the end of Focal's average lifespan, cumulative sibling deaths reached levels comparable to parental deaths.

Focal's bereavement experience is shaped by multiple demographic dimensions: fertility levels, which determine sibship size and the number of children exposed; mortality levels, including shocks such as crisis periods, which determine the intensity of loss; and the dispersion of age-at-death patterns, shaped by infant mortality, adult survival, longevity, fertility stopping, and fertility postponement. The following sections introduce three indicators that summarize different dimensions of bereavement over Focal's life course. For each indicator, we first present its formulation and then illustrate its behavior using the 1950 female cohorts of Argentina and Guatemala.

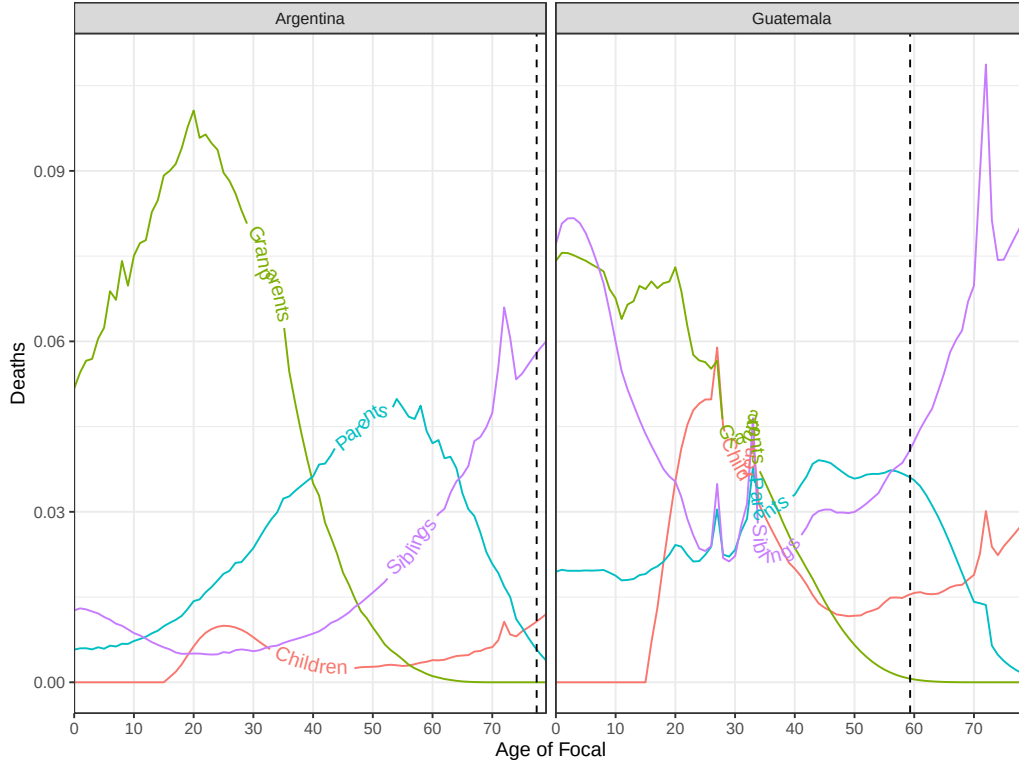


Figure 2: Expected distribution of kin deaths over Focal's life course, by kin type. Female 1950 cohorts of Argentina and Guatemala. The vertical dashed line indicates cohort life expectancy at birth.

4 Burden

4.1 Formulation

Chang and Robles (2025) proposed the Bereaved-Dependent Life Stage indicator, which counts lifetime losses and weights them according to the prematurity of the bereaved individual's developmental stage at the time of loss. These weights are intuitive and symbolically meaningful, but they are not derived from empirical evidence. As noted by Caswell and De Vries (2025), an empirical formulation of such

“bereavement weights” remains an open research problem. In this study, we focus on a simple indicator that allows standardized comparisons across demographic regimes while parsimoniously capturing both quantum (how many deaths occur) and tempo (how early they occur).

Figure 3 presents a schematic representation of this measure. Assume that Focal has three children at ages 15, 20, and 25. Each child may die early, at age 5; die later, at age 30; or survive. The grey area represents Focal’s time in bereavement following the loss. Focal may experience few deaths, represented by one child death, or many deaths, represented by two child deaths. The four panels show the combinations of these two dimensions. Holding the timing of death constant, a larger number of deaths increases burden, as shown by moving downward. Holding the number of deaths constant, later deaths reduce burden, as shown by moving to the right. The highest burden value occurs when deaths are both early and numerous, 63%, while the lowest occurs when deaths are few and late, 13%. In all cases, the indicator is calculated as the grey area divided by the total area.

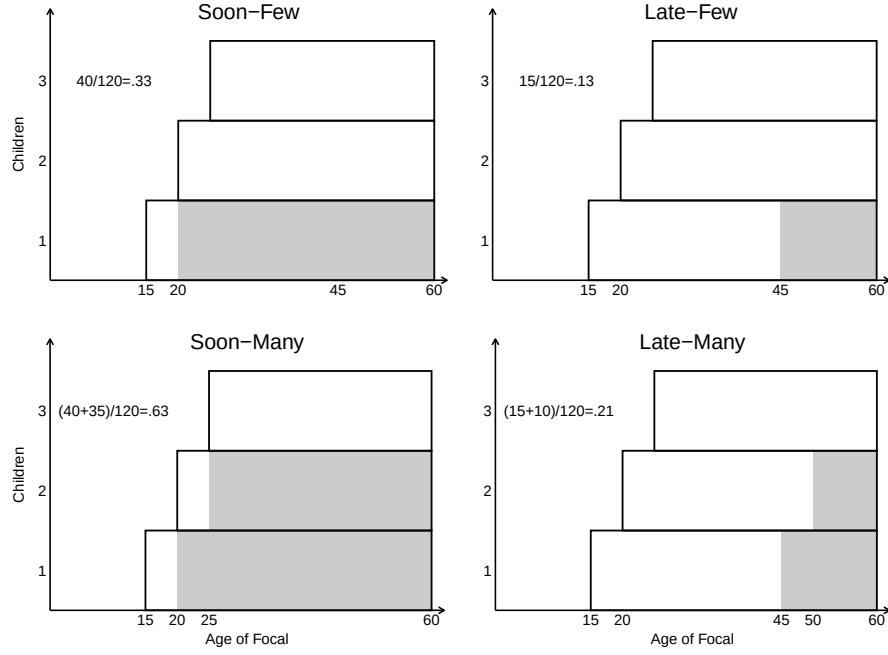


Figure 3: Three children are born when Focal is aged 15, 20, and 25, represented by horizontal bars. The panels combine two numbers of deaths (one, “Few”; two, “Many”) and two timings of death (5 years, “Soon”; 30 years, “Late”). Total kin-years equal 120 ($45+40+35$) in all four cases, assuming a constant fertility calendar. The burden indicator is the ratio between kin-years lived in bereavement and total kin-years ever met, up to Focal’s $e(0) = 60$.

To generalize the measure to any kin type, define $L(x)$ as the total number of kin ever met by Focal up to age x . This quantity can be obtained by projecting kin under the assumption of no mortality for that kin type or, equivalently, by adding the expected number of living kin to the cumulative number of kin losses experienced by Focal, $D(x)$:

$$\begin{aligned}
L(x) &= k(x) + \int_0^x d(a) da \\
&= k(x) + D(x)
\end{aligned} \tag{2}$$

We define the burden indicator $\mathbf{B}$ as the expected proportion of kin-years that Focal has lost before e_0 , Focal's life expectancy at birth. It ranges from 0 to 1, with higher values indicating either that a larger share of kin are lost or that losses occur earlier, since early deaths reduce kin presence over a longer period.

$$\mathbf{B} = \frac{\int_0^{e_0} D(a) da}{\int_0^{e_0} L(a) da} = \frac{D}{L} \tag{3}$$

The indicator has intuitive boundary cases. It equals 0 when Focal experiences no kin deaths before $e(0)$, and it approaches 1 when all kin die immediately after Focal's birth. Conversely, losses that occur only at the end of Focal's expected lifetime contribute little to the burden. The logic is similar to Years of Life Lost (YLL), which measures the amount of life lost when deaths occur before a reference age (Vaupel et al., 1979). In our setting, $e(0)$ provides a natural reference point because the objective is to summarize the average bereavement experience of a newborn under a given demographic regime.

A limitation of this measure is that different combinations of tempo and quantum may yield the same value. For example, one early child death can generate the same number of bereaved kin-years as two later child deaths if the total time lived after loss is identical. This reflects a deliberate trade-off: the indicator is parsimonious

and comparable across populations, but it does not assign different normative or psychological weights to losses occurring at different kin ages, Focal ages, or family contexts. Introducing such weights would require additional assumptions or empirical evidence on the relative severity of different bereavement experiences.

4.2 Application

Figure 4 illustrates how **B** behaves for the 1950 cohorts of Argentina and Guatemala. Bereavement burden displays a vertical hierarchy across kin types: grandparents, parents, siblings, and children. This hierarchy remains even when sibling deaths outnumber parental deaths in Guatemala. For example, the expected numbers of deaths are 1.7 for parents and 2.2 for siblings, while the corresponding values of **B** are 36% and 28%, respectively. This indicates that the measure captures the proportion and timing of lost kin-years, rather than death counts alone.

Guatemalan women experience a substantially higher bereavement burden from child loss than Argentine women: 16% compared with 6%. This means that, relative to the total years they would have lived with their children if no child had died, Guatemalan women spend a much larger share of child kin-years after the death of a child. Interpreted demographically, for every 100 kin-years a woman would have lived with her children in the absence of child mortality, 16 years in Guatemala, compared with 6 years in Argentina, are lived after the death of a child. Thus, the burden of child bereavement is nearly three times higher in Guatemala. This difference is closely associated with fertility levels: Guatemalan women have approximately six children on average, and by age 40 roughly one child has died. This loss occurs about twenty years before the woman's mean lifespan. Argentine women, although

living approximately twenty years longer, face a considerably lower burden of child bereavement.

For ascending kin, the burden indicator reveals a different mechanism. Mortality decline may extend Focal's survival without equally extending the survival of parents or grandparents, who belong to earlier cohorts and were exposed to less favorable mortality conditions. As a result, longer life can increase the time lived after the death of older-generation kin. This is especially visible for grandparents. Argentine women begin life with more living grandparents than Guatemalan women, approximately 3.2 compared with 2.5, and also live longer. Since most grandparents die during Focal's lifetime, this longer survival increases the proportion of grandparent kin-years lived after grandparental death, reaching 72% in Argentina compared with 68% in Guatemala. While cohort $e(0)$ differs by about 15 years between the two countries (Fig. 4), the period gap narrows from roughly 25 years in 1950 to 5 years in 2024 (Fig. 1), illustrating the asynchronous pace at which mortality improvements reshape the survival of adjacent generations. The result highlights an intergenerational feature of the mortality transition: improvements in survival reshape bereavement differently depending on whether kin belong to older, same-age, or younger generations.

Sibling bereavement follows a distinct demographic pattern. In Guatemala, women are born into substantially larger sibships, with almost six siblings on average, but only around 3.2 are still alive at Focal's death. This combination of large sibship size and higher sibling mortality produces frequent and relatively early bereavement, visible in the widening grey area before age 20. As a result, the sibling bereavement burden reaches 28%, compared with 15% in Argentina. In other words, out of every 100 sibling kin-years that would be lived if all siblings survived, 28 in Guatemala and

15 in Argentina are lived with at least one sibling absent due to death.

Overall, these results show that cross-country differences in bereavement are generated by different demographic mechanisms across kin generations. Two dimensions of the mortality transition are especially important: the intergenerational survival gap, which structures bereavement from ancestors, and the persistence of early mortality risks, which shapes bereavement from descendants and younger siblings.

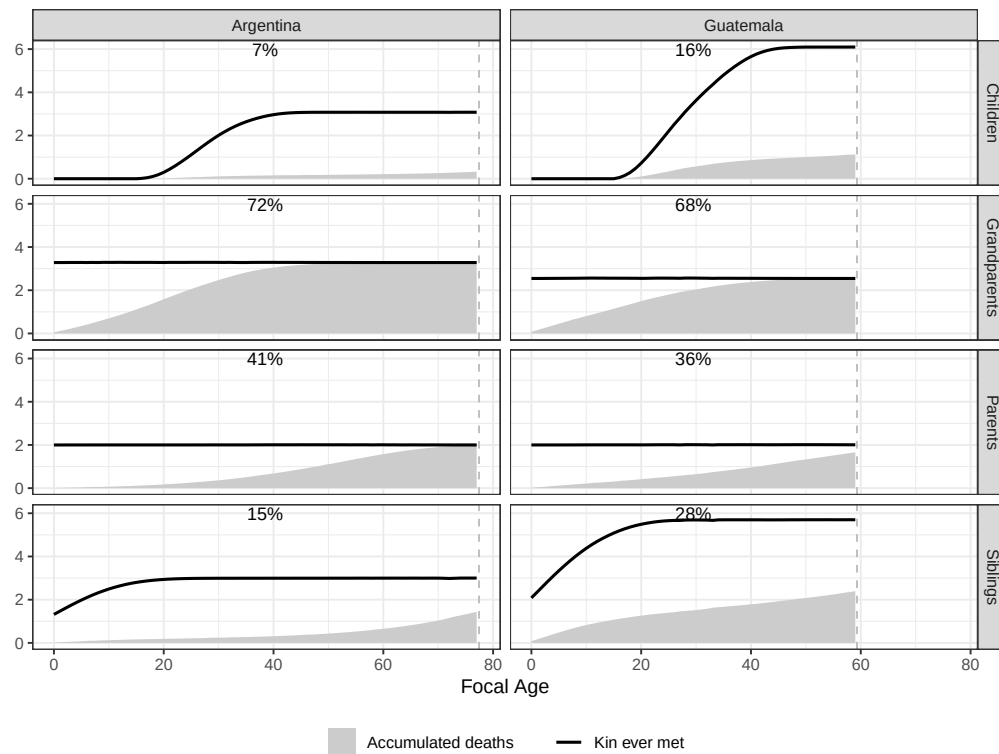


Figure 4: Bereavement burden: ratio of kin-years lived after kin death to total kin-years ever met, represented by the grey area divided by the area under the black line. Estimated values are shown at the top of each facet. Female 1950 cohorts of Argentina and Guatemala. Vertical lines indicate cohort life expectancy at birth.

5 Loss of shared time

5.1 Formulation

Figure 5 shows trajectories for multiple kin types, which can be interpreted as a Lexis-Kin diagram. Focal has three children: one dies during the first year of life, another survives beyond Focal's maximum possible age, here assumed to be $\omega = 100$, and the third dies at age 60. Given the information in the figure, Focal must have reached age 30, when she had her last child. The expected time spent in bereavement from the first child is therefore $9 + e(30)$ years. For the second child, it is $\frac{l(90)}{l(30)}e(90)$, since Focal must first survive to age 90. Focal also has a sibling five years younger who dies at age 65, resulting in an expected time in bereavement of $\frac{l(70)}{l(30)}e(70)$. Her parents, aged 20 and 25 at Focal's birth, die 30 and 50 years later, producing expected bereavement times of $e(30)$ and $\frac{l(50)}{l(30)}e(50)$. Finally, three grandparents died before Focal was born: two 15 years earlier, not shown in the figure, and another 5 years earlier; the last grandparent dies at age 60, when Focal is age 10. The corresponding expected times in bereavement are $3(30 + e(30))$ and $20 + e(30)$.

What does it mean, for example, to accumulate years in bereavement because of children, $9 + e(30) + \frac{l(90)}{l(30)}e(90)$, or because of parents, $e(30) + \frac{l(50)}{l(30)}e(50)$? How should we interpret values that can exceed $e(0)$, or even ω in the case of abundant kin types such as cousins? Kin are populations, and their number can decline or grow over Focal's life course. We therefore calculate kin-years, analogous to person-years in demographic analysis (Caswell and De Vries, 2025): spending five years with one cousin is equivalent to spending one year with five cousins.

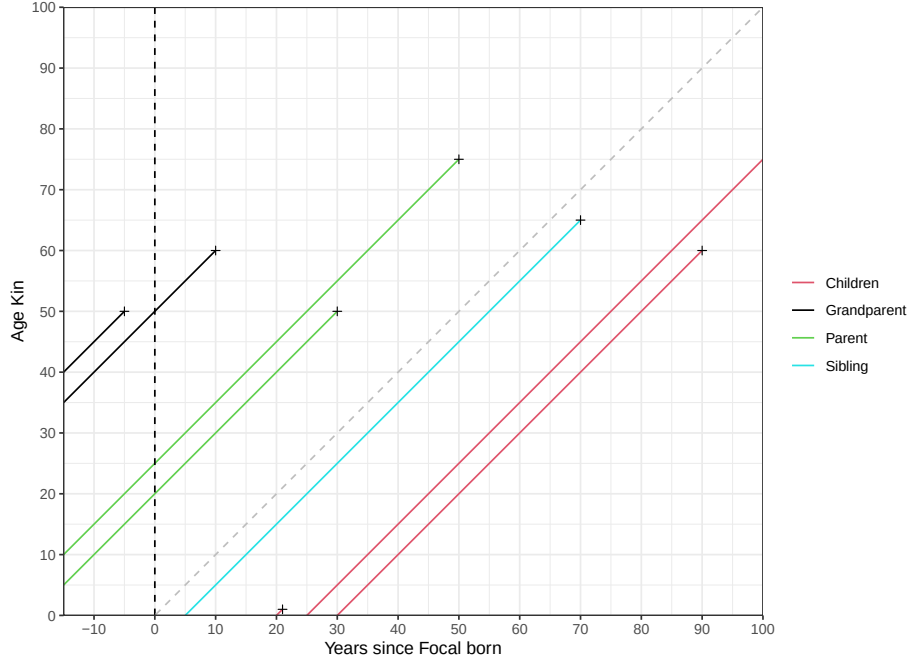


Figure 5: Unique and multiple kin trajectories. Expected time in bereavement requires a population-cohort approach that counts kin-years. Line endings marked with a cross indicate death.

From this point onward, we do not observe the specific experience of each individual in the population, as in Fig. 5. Instead, we estimate the average experience of Focal from birth onward using population rates. This is appropriate for our aim, which is to construct population-level measures using widely available demographic information.

The expected kin-time, or sum of kin-years, lived without a given kin type at age x can be decomposed into three components: past experience, referring to kin who died before Focal reaches age x ; future experience generated by the living kin stock present when she is age x ; and future experience generated by new kin who will be born later and die during Focal's remaining life. We denote these components by

$T_1(x)$, $T_2(x)$, and $T_3(x)$.

Consider the case of $x = 0$, from Focal's birth. For the first component, T_1 , let D' denote the total number of kin deaths that occurred before Focal was born, distinct from D , which represents the accumulation of deaths during Focal's life. Focal will spend all her expected future years in that state, so $T_1 = D'e(0)$. This corresponds to the first grandparent line in Figure 5. For kin alive when Focal is born, T_2 , time in bereavement is given by the age-at-death distribution of each kin cohort multiplied by Focal's life expectancy at the age at which the kin death occurs. Here, $l(x)e(x)$ is a deferred life expectancy, since Focal must first survive to the age at which the kin dies. For the third component, T_3 , Focal experiences deaths from kin who are born after her own birth and then die during her lifetime. The three components—past, present, and future kin deaths—together determine the expected kin-years lived without a given kin type:

$$\begin{aligned}
\mathbf{T} &= T_1 + T_2 + T_3 \\
&= D' e(0) + \int_0^\infty l(a) e(a) \int_0^a d(a, z) dz + \int_0^\infty l(a) e(a) \int_a^\infty d(a, z) dz \\
&= D' e(0) + \int_0^\infty l(a) e(a) \left[\int_0^a d(a, z) dz + \int_a^\infty d(a, z) dz \right] \\
&= D' e(0) + \int_0^\infty l(a) e(a) \int_0^\infty d(a, z) dz \\
&= D' e(0) + \int_0^\infty l(a) e(a) d(a) da
\end{aligned} \tag{4}$$

Next, we consider the shared time between Focal and her kin. “Shared” means that Focal and her relative must be alive at the same time. In terms of lost years

with a grandparent, it is not equivalent for the grandparent to die at age 50 when Focal has just been born or when Focal is already age 30. In actuarial literature, joint survivorship treats the survival of two individuals as two separate random variables. If $T(x)$ and $T(y)$ are the times to death for two persons aged x and y , then $T(y, x) = \min[T(x), T(y)]$ gives the time until the first death, and $p(y, x)$ is the associated joint-survival function. Assuming independence between risks, the joint-survival probability is $p(y \cap x) = p(x)p(y)$, and the expected time during which both individuals are alive is $e(x \cap y)$ (Bowers et al., 1997; Pollard, 1991). Copula approaches relax this assumption by modeling the joint distribution from the marginal distributions and their dependence structure. Estimating family correlations in survival requires observed data on relatives' ages at death, such as father-son pairs, which can be obtained from genealogical databases (Cabrignac et al., 2020).

To move from $\mathbf{T}$ to $\mathbf{S}$, the expected loss of shared years, two modifications are required. First, for kin whom Focal never knew because they died before her birth, expected shared time is zero, so $T_1 = 0$. Second, Focal's life expectancy in T_2 and T_3 must be replaced by joint life expectancy $e(a \cap z)$, where z is the age at death of her relative. This term requires only Focal's survival to the age at which the kin death occurs, because the expected occurrence of the kin death already conditions on the relative surviving to age z . Incorporating these two changes into Equation 5.1 yields:

$$\mathbf{S} = \int_0^\infty l(a) \int_0^\infty d(a, z) e(a \cap z) dz da \quad (5)$$

This is a prospective indicator measured in kin-years of shared time lost. It is lower

than $\mathbf{T}$ because $e(a \cap z) < e(a)$. Unlike the synthetic cohort logic of the life table, kin exposure may increase in number with age. Several interpretations are possible in relation to $e(0)$. One is to express how many “lives” of bereavement are expected for a given kin type, $\frac{\mathbf{S}}{e(0)}$. Another is to cap the indicator at Focal’s own expected lifespan, $\min[e(0), \mathbf{S}]$. A third relates $\mathbf{S}$ to cumulative deaths over the lifespan, capturing the average amount of shared time lost per deceased relative. The resulting ratio is:

$$\bar{\mathbf{S}} = \frac{\mathbf{S}}{D(e(0))} \quad (6)$$

This per-death measure is complementary to the burden indicator. While burden summarizes the cumulative share of kin-years lived after loss, $\bar{\mathbf{S}}$ captures how many potential shared years are removed by each kin death, net of differences in the number of deaths.

5.2 Application

Results for the 1950 cohorts of Argentina and Guatemala are shown in Table 1. For children, Guatemalan women experience a substantially larger total loss of shared time than Argentine women: 25.8 kin-years compared with 13.6. This reflects the much higher expected number of child deaths in Guatemala, 1.1 compared with 0.3 in Argentina. However, when the indicator is expressed per deceased child, the pattern reverses. Argentine women lose, on average, 43.6 shared years per child death, compared with 23.2 in Guatemala. This difference reflects both the age pattern of child loss and Focal’s longevity: in Argentina, child deaths are rarer but tend to

remove many years of possible shared life, whereas in Guatemala child deaths are more frequent but occur in a mortality regime in which both child survival and Focal's remaining lifespan are shorter.

For grandparents, Argentina shows a higher total loss of shared time than Guatemala, 19.5 versus 12.0 kin-years. This is partly because Argentine women begin life with more living grandparents on average and live long enough to experience their deaths over a longer period. However, the average loss per grandparent death is relatively small in both countries, 5.9 years in Argentina and 4.7 in Guatemala, because grandparent deaths tend to occur when Focal is still relatively young and the expected remaining shared lifetime is already limited by the older age of grandparents.

For parents, the total loss of shared time is also higher in Argentina than in Guatemala, 14.6 versus 11.7 kin-years, but the average loss per parental death is nearly identical: 7.4 and 7.2 years, respectively. Sibling loss presents a different pattern. Guatemalan women lose substantially more shared time with siblings than Argentine women, 46.6 compared with 23.5 kin-years. This is largely explained by the higher expected number of sibling deaths in Guatemala, 2.4 versus 1.4. Once the total is divided by the number of expected sibling deaths, the contrast becomes much smaller: 19.8 years lost per sibling death in Guatemala and 17.1 in Argentina.

Overall, the indicator distinguishes between the frequency of kin deaths and the amount of shared lifetime removed by each death. Guatemala shows larger total losses of shared years for children and siblings, mainly because descendant and lateral kin deaths are more frequent. Argentina, however, shows larger losses for older ascending kin, particularly grandparents, because Focal's longer survival increases the time lived after their deaths. At the same time, $\bar{S}$ shows that the meaning of a death differs by

context: a child death in Argentina removes many more years of shared life per event, whereas sibling deaths in Guatemala accumulate into a larger total because they are more numerous.

Country	Kin	$D(e(0))$	S	$\bar{S}$
Argentina	Children	0.3	13.6	43.6
	Grandparents	3.3	19.5	5.9
	Parents	2.0	14.6	7.4
	Siblings	1.4	23.5	17.1
Guatemala	Children	1.1	25.8	23.2
	Grandparents	2.5	12.0	4.7
	Parents	1.6	11.7	7.2
	Siblings	2.4	46.6	19.8

Table 1: Cumulative kin deaths up to life expectancy at birth, $D(e(0))$, expected loss of shared years, S , and average shared years lost per kin death, $\bar{S}$. Argentina and Guatemala, female 1950 cohorts.

6 Generational overlap

6.1 Formulation

In pre-transitional societies, calendar of kin deaths was disordered. Beyond the very high levels of infant mortality, the probability that children or adolescents would die before their parents was substantial (Livi-Bacci, 2017). With the mortality transition, a more hierarchical sequence of deaths emerged, increasingly structured by age and regularity. This means that bereavement began to be organized more clearly by vertical degree: Focal expects grandparents to die before parents, parents before children and siblings, aunts before cousins, and so on. In modern low-fertility and low-mortality contexts (generational spacing and reduced mortality dispersion), a dis-

ruption of this “natural” order becomes an important factor in the predictability of kin deaths for individuals (Alburez-Gutierrez et al., 2021,0).

One possible approach is to consider the probability that a parent aged x dies before a grandparent aged y , $P(T_x < T_y)$, where the two random variables represent ages at death. For example, under independence between lives, this probability can be expressed as the probability that the parent dies in the first year while the grandparent survives, plus the probability that the parent dies in the second year while the grandparent survives, and so on: $q(x)p(y, 1) + p(x, 1)q(x + 1)p(y, 2) + p(x, 2)q(x + 2)p(y, 3) + \dots$, where the second argument refers to deferred years. Vaupel et al. (2021) exposed the probability that an individual from some population (sex, region, etc.) will outlive the individual from the other population, both starting at same age. Complexity arises because each kin type is a population, such as two parents and four grandparents, each with its own age distribution and a size that may change with Focal’s age, as in the case of siblings or children.² Modeling the probability of n deaths in a kin group ideally requires a discrete distribution of living kin counts (Butterick et al., 2026). When expected counts are close to zero, for example when Focal is old and the expected number of living parents is 0.1 or 0.01, probabilities of one, two, or n events based on a continuous adaptation of the binomial distribution are difficult to interpret. A further challenge is defining what constitutes a disruption: any parent dying before any grandparent, both parents dying before any grandparent, or any parent dying while at least one grandparent is still alive, among other

²Under Gompertz mortality, this relationship has an elegant solution. The hazard is $\mu(x) = ae^{bx}$, and the joint-life hazard for multiple independent individuals aged x , y , and z is $\mu(x \cap y \cap z) = ae^{b(x+y+z)}$. The probability that x dies first is $\frac{\mu(x)}{\mu(x) + \mu(y) + \mu(z)}$ (Pollard, 1991). The probability that x or y dies before z is $\frac{\mu(x) + \mu(y)}{\mu(x) + \mu(y) + \mu(z)}$. Under an age distribution for two kinship groups A and B , the probability that a death from group A occurs before a death from group B is $\frac{\sum_A \mu(a)}{\sum_A \mu(a) + \sum_B \mu(b)}$.

possibilities. These ambiguities motivate a simpler index that summarizes temporal overlap between expected death schedules rather than modeling a single stochastic event.

We propose a simpler approach that is valid for any pair of kin types, without imposing a parametric distribution of lifetimes or defining a specific combinatorial event. As a hypothetical example, assume that Focal has a living grandmother at birth. If Focal survives until $e(0)$, she will probably experience two deaths: one of her mother and one of her grandmother. Figure 7 shows two scenarios of deaths over Focal's life course. In an early, pre-transitional scenario, grandmothers and mothers die relatively early, with a dispersed age-at-death distribution, and Focal experiences mixed deaths over a long period of life. In an ultimate post-transitional scenario, the grandmother dies first and the mother later, producing low overlap in expected deaths. In a hypothetical limiting case, overlap would be zero if there were no uncertainty in ages at childbirth or ages at death: all generations would have fixed age intervals and die at fixed ages.

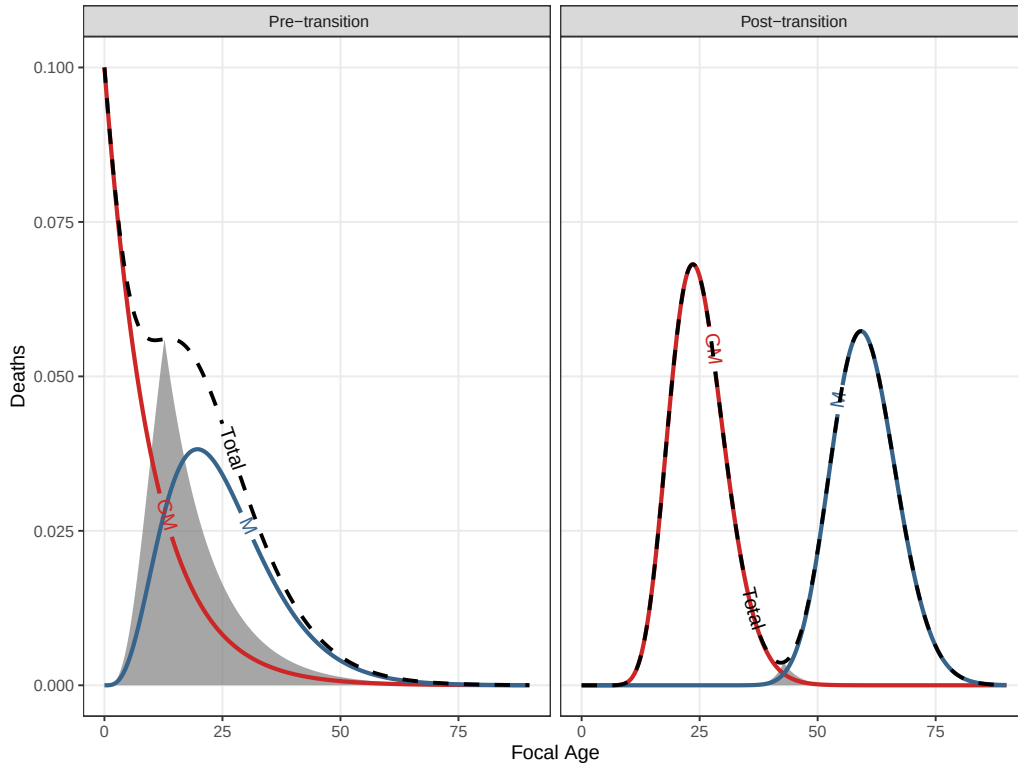


Figure 6: Life-course overlap in the expected deaths of a mother and a grandmother. Focal is expected to experience two deaths in total, represented by the area under the dashed line. In the pre-transitional scenario, 40% of the total death experience overlaps, compared with 1% in the post-transitional scenario. The grey area represents deaths occurring at the same ages of Focal, relative to total deaths. Hypothetical scenarios are built from Gamma distributions with means 25, 10, 60, and 25, and standard deviations 12, 10, 7, and 6, for M-Pre, GM-Pre, M-Post, and GM-Post, respectively.

Based on this idea, we define an indicator that measures the share of total deaths for which two kin types overlap, relative to the total expected death frequency. This is an index of multigenerational overlap, reflecting how demographic regimes structure the simultaneity of losses involving more than one kin type. If j is the kin type expected to die before k , then the proportion of bereavement experience that is *overlapped* over the average lifespan is:

$$O_{j,k} = \frac{2 \int_0^{e_0} \min\{d_k(x), d_j(x)\} dx}{\int_0^{e_0} d_k(x) + d_j(x) dx} \quad (7)$$

This approach allows us to pair different kin types. This is a very similar approach to Vaupel et al. (2021) but with frequencies, dealing here with kin populations rather than two life tables. A major disruptor of the expected sequence is a mortality crisis, such as the death of young siblings during an armed conflict while parents remain alive. An intuitive expected sequence of kin deaths is shown in Figure 7, which will be used in the next subsection. Equation 7 can also be extended to higher-order relationships, for example, by comparing combined parent and grandparent deaths with child deaths, or by considering any number of kin types. Larger gray areas indicate a lower degree of hierarchical ordering in the total death experience. The overlap reaches its maximum at ages in which the same number of deaths is produced by both types of kin.

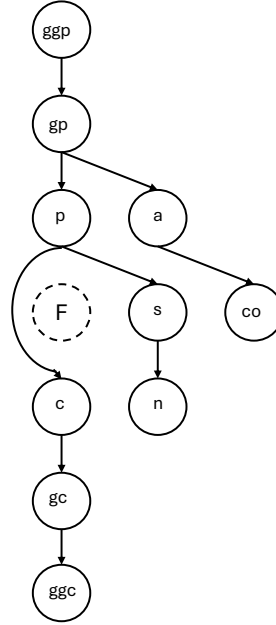


Figure 7: Theoretical schema of a potential expected generational sequence of kin deaths in a low-mortality setting. Arrows indicate “before.” For example, great-grandparents (ggp) are expected to die before grandparents (gp), parents (p) before siblings (s), great-grandchildren (ggc) before grandchildren (gc), children (c) before grandchildren, aunts and uncles (a) before cousins (co), and niblings (n) before siblings.

6.2 Application

Consider the 1950 female cohorts of Argentina and Guatemala shown in Figure 8. The indicator **O** captures the extent to which deaths of different kin types are temporally synchronized over Focal’s life course. In other words, it measures the share of deaths from two kin categories that occur at the same ages of Focal, relative to the total number of deaths experienced from both categories.

For the children–parents pairing, Guatemala reaches an indicator value of 61%.

This indicates that, among all child and parental deaths experienced by Focal up to cohort life expectancy, 61% occur at the same ages of Focal. The high value reflects the coexistence of child and parental deaths during early and middle adulthood: between ages 20 and 30, child deaths are even more frequent than parental deaths. In Argentina, the corresponding value is less than half, 28%, reflecting both lower child mortality and the concentration of child deaths around the main reproductive ages, which reduces their temporal coincidence with parental deaths.

For the parent–grandparent pairing, both countries show a life-course transition after age 40, when parental deaths begin to exceed grandparental deaths. However, the Guatemalan schedules are more dispersed and remain more closely aligned across age, producing a higher value than in Argentina, 52% compared with 35%. In Argentina, by contrast, Focal survives for a longer period after most grandparental deaths have already occurred, creating later ages in which parental deaths continue but grandparental deaths no longer contribute to the generational disorder.

The sibling–parent pairing displays the highest **O** value among the three comparisons: 74% in Guatemala and 57% in Argentina. In Guatemala, death coincidence in Focal life-course is particularly high during the ages associated with the mortality disruption of the Guatemalan genocide, when deaths of siblings and parents occur with similar frequency; this is also the age interval in which child deaths contribute to the high children–parents overlap. In Argentina, the pattern is more sequential: after some early sibling deaths, parental deaths dominate after age 50, while sibling deaths become more frequent only at later ages, when most parents have already died.

Across the three panels, Argentina shows a more sequential organization of kin loss, with clearer transitions between kin types across age. Substantively, this suggests

a more hierarchic bereavement regime, in which deaths of different generations are more clearly ordered over the life course. Guatemala, by contrast, shows a more compressed regime, where deaths of children, parents, siblings, and grandparents are more likely to coexist within the same ages of Focal. In both countries, the highest overlap occurs between siblings and parents, indicating that losses among lateral kin and the parental generation are especially likely to be experienced within the same life-course window.

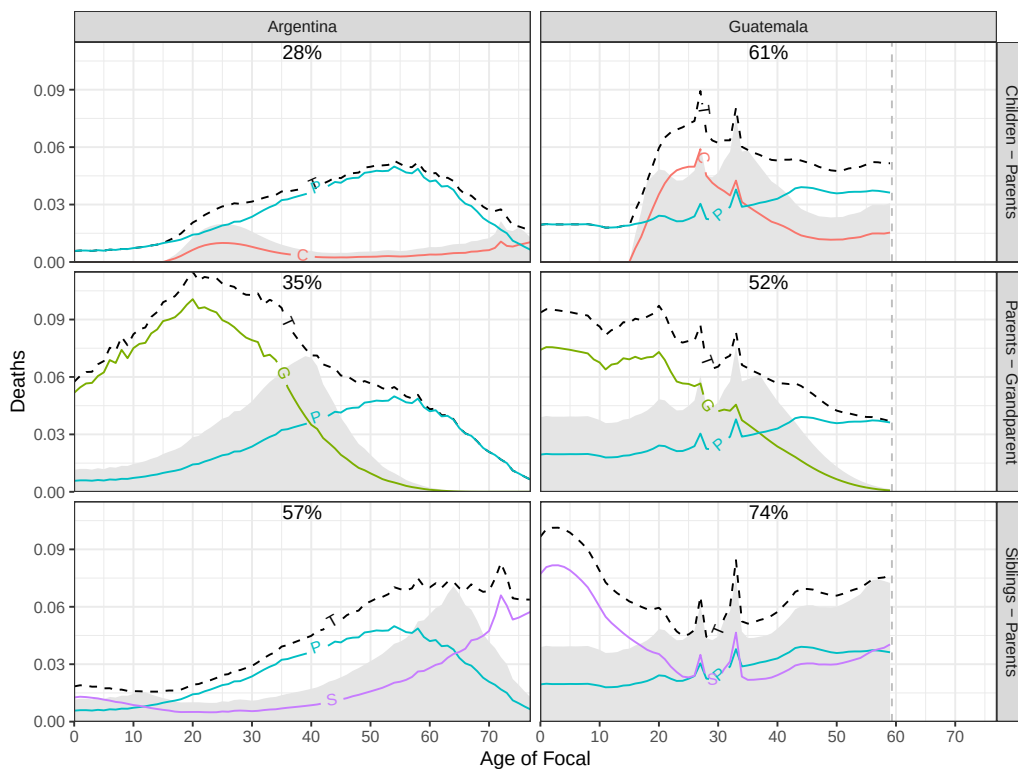


Figure 8: Generational overlap. Shared death experience as a bereavement dimension for the 1950 cohorts. The grey area represents the death experience shared by each pair of kin types across Focal's age. At a given age of Focal, if the two kin types contribute (x) and (y) deaths, respectively, the grey value is defined as $(2 \min(x, y))$. The indicator value shown at the top of each facet is calculated as the grey area divided by the total death experience, up to cohort $e(0)$

7 Discussion

A given fertility and mortality regime determines not only the distribution of kin over Focal's life course, but also the average experience of bereavement. This study contributes to a growing body of research that understands bereavement not only as an individual psychological response, but also as a demographic and social phenomenon structured by mortality, fertility, kin availability, and the timing of deaths across the life course. Recent scholarship has shown that exposure to kin loss is unequally distributed across populations and closely tied to broader systems of inequality (Umberson et al., 2017; Smith-Greenaway et al., 2025; Chang and Robles, 2025). From this perspective, a demographic approach is especially valuable because it makes it possible to describe bereavement as a patterned population-level experience, even in the absence of direct longitudinal information on family deaths.

The three proposed indicators capture analytically distinct dimensions of bereavement that may move together, but need not do so. Burden summarizes the cumulative demographic weight of loss by combining quantum and tempo in a standardized proportion: it is high when many kin die, when deaths occur early, or both. Its interpretation is closely related to the idea that losses occurring “too much” and “too soon” may have cumulative consequences for health (Chang and Robles, 2025). In Guatemala, the high burden of child and sibling bereavement reflects a regime in which losses are both frequent and relatively early. This pattern is consistent with evidence that early bereavement may affect stress-response systems, emotional regulation, and later vulnerability to mental health disorders (Thimm et al., 2020). It also resonates with findings that multiple family deaths before midlife are associated with

worse cardio-metabolic outcomes (Donnelly, 2022). By contrast, Argentina shows a lower burden for child and sibling losses, but a substantial burden from grandparents, partly because longer survival extends the years lived after older-generation kin have died. Thus, mortality improvement does not uniformly reduce bereavement burden. For ascending kin, longer life may increase the duration of life spent without parents or grandparents, even under more favorable mortality conditions.

Loss of shared time instead measures the amount of potential coexistence removed by death, either in total or per deceased relative. It therefore speaks more directly to the duration of the interruption in interaction, care, affection, security, and material support (Caswell and De Vries, 2025; Logan et al., 2017). This distinction is important because a rare death may remove many potential years of shared life, while frequent deaths may accumulate into a larger total loss even when each death removes fewer years on average. The contrast between Argentina and Guatemala illustrates this point clearly. Child deaths are more frequent in Guatemala, generating a larger total loss of shared time, but each child death in Argentina removes more expected shared years because both Focal and her child are embedded in a longer-life regime.

In principle burden and shared time are correlated because of tempo effect (early deaths increase burden and also expected time), but they can diverge. A population may exhibit high burden but relatively low shared time lost when many deaths occur among older-generation kin: most grandparents may die during Focal's life, generating a large proportion of kin-years lived after their deaths, even though each death removes only a limited number of potential shared years. Conversely, burden may be low while shared time lost per death is high when deaths are rare but highly premature, as in a low-mortality regime where the death of a child is uncommon

relative to the total child kin-years available, yet removes several decades of potential coexistence.

The generational order indicator captures whether deaths from different kin types are temporally separated or synchronized over Focal's life course. In low-mortality settings, kin deaths tend to become more hierarchically ordered: grandparents usually die before parents, parents before siblings and children, and descendants are generally expected to survive older generations. Guatemala shows higher overlap across all selected kin pairings, especially between siblings and parents, and between children and parents. This suggests a bereavement regime in which deaths from different generations and kin positions are more likely to occur within the same life-course window. Such overlap may matter because simultaneous or closely clustered losses can intensify grief responses and reduce the availability of surviving kin who might otherwise provide support. This is consistent with evidence that multiple simultaneous losses, as in wars, disasters, or accidents, are associated with worse mental health outcomes than single bereavement events (Chang and Robles, 2025; Neria and Litz, 2004). Yet generational disorder can also be high when deaths are relatively infrequent but similarly timed, producing a concentrated pattern without a large cumulative burden.

Several limitations follow from the objective of building simple, comparable indicators from standard demographic data. First, the measures are based on expected kin counts and expected deaths, rather than observed individual kin networks Kolk et al. (2021). They therefore describe average population-level experiences and not the distribution of bereavement histories within cohorts. Second, the kinship model assumes independence between Focal's survival and relatives' survival, as well as among relatives, omitting shared frailty, family-level mortality correlation, and socioeconomic

clustering Leopold et al. (2024). Third, the analysis is restricted to consanguineal kin, excluding spouses, partners, affinal kin, friends, and other socially meaningful ties. Fourth, the indicators do not capture subjective closeness, cause of death, cultural meanings, or grief intensity, all of which are central to the lived experience of bereavement. Finally, the 1950 cohort estimates rely on the assumption of a stable kinship distribution before 1950 (Snyder et al., 2022), and the overlap indicator should be interpreted as a normalized intensity index rather than as the probability of a clearly defined stochastic event.

Future research could proceed in three directions. First, these demographic indicators could be linked to observed health outcomes to test whether higher burden, greater loss of shared time, or more disrupted generational order are associated with worse mental health, physical health, or mortality trajectories. Second, decomposition methods could identify the contribution of infant, adult, and old-age mortality, as well as fertility levels and age patterns, to cross-country differences in bereavement regimes. Third, a broader comparative application could examine the joint distribution of the three indicators across countries and cohorts, identifying cases where the indicators move together and cases where their relationship is less straightforward.

Taken together, these results support the idea that bereavement has a demographic structure that can be formally described, compared, and monitored. By linking fertility and mortality schedules to kin loss experiences, this study helps connect formal kinship demography (Caswell, 2019; Caswell and Song, 2021) with the broader literature on grief, health inequality, and the life-course consequences of family mortality. The framework proposed here is deliberately simple and comparative, aiming to provide indicators that are interpretable across populations and historical

settings. In that sense, it offers a first step toward a demographic analysis of bereavement that is sensitive not only to the frequency of kin deaths, but also to their timing, sequence, and accumulated presence in the lives of survivors.

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