MAX PLANCK INSTITUTE
FOR DEMOGRAPHIC RESEARCH

Konrad-Zuse-Strasse 1 · D-18057 Rostock · Germany · Tel +49 (0) 3 81 20 81 - 0 · Fax +49 (0) 3 81 20 81 - 202 · www.demogr.mpg.de

MPIDR Working Paper WP 2020-037 l November 2020
Revised May 2021
https://doi.org/10.4054/MPIDR-WP-2020-037

The "Sandwich Generation" Revisited: Global Demographic Drivers of Care Time Demands

Diego Alburez-Gutierrez l alburezgutierrez@demogr.mpg.de
Carl Mason
Emilio Zagheni

The “Sandwich Generation” Revisited: Global Demographic Drivers of Care Time Demands

Diego Alburez-Gutierrez[1], Carl Mason[2], Emilio Zagheni[1]

Abstract

Generational overlap affects the care time demands on parents and grandparents worldwide. Here, we present the first global estimates of the experience of simultaneously having frail older parents and young children (“sandwichness”) or young grandchildren (“grandsandwichness’’) for the 1970-2040 cohorts using demographic methods and microsimulations. We find that sandwichness is more prevalent in the Global South – e.g., almost twice as prevalent in Sub-Saharan Africa as it is in Europe for the 1970 cohort – but is expected to decline globally by one-third between 1970 and 2040. The Global North might have reached a peak in the simultaneous care time demands from multiple generations but the duration of the grandsandwich state will increase by up to one year in Africa and Asia. This increasing generational overlap implies more care time demands over the entire adult life course but also opens up the opportunity for the full potential of grandparenthood to materialize.

[1] Laboratory of Digital and Computational Demography

Max Planck Institute for Demographic Research

[2] Department of Demography

University of California at Berkeley

Introduction

Parents throughout the world face challenges in meeting care demands, but a continued focus on Europe and North America has shaped the way we think about the consequences and causes of intergenerational transfers. In practice, care needs are shaped by factors that vary greatly across territories, including demographic dynamics, labor market structures, social expectations, and the ability to outsource care to public or private institutions. Wealthy countries are clearly not representative of the world population in any of these respects. As a result, we lack a truly global understanding of the global variability in the demands on parents to spend time providing care.

While some life stages are "busier" than others, there is little agreement about the best way to measure this "rush-hour of life" (Zannella et al. 2019). Existing measures such as dependency ratios summarize the relationship between dependency and production in a population, but hide the timing of events over the life course. Furthermore, they do not distinguish between situations in which care responsibilities are spread out across the life course and those in which care responsibilities are concentrated during specific ages. Variations in the timing of events over the life cycle may lead to changes in the prevalence of situations in which individuals are simultaneously responsible for caring for older parents and young children.

The image of the "Sandwich Generation," in which individuals face simultaneous demands on their time during middle age, remains a popular way of framing this concept. Sociological definitions have emphasized the "in-between" position of women working full-time while providing informal care to relatives (Brody 1981). Demographers have defined "sandwichness" as a situation in which an individual is squeezed between dependent children and frail older parents (Wachter 1997). In this paper, we follow a traditional demographic perspective, and define a person as “sandwiched” if they simultaneously have at least one young child and at least one parent or parent-in-law “close to death” (using a prospective measure of mortality, as explained below). Generalizing the same concept to four generations, we define an individual as “grandsandwiched” if they simultaneously have at least one young grandchild and at least one parent or parent-in-law close to death. Using these definitions consistently, we go beyond the traditional focus on middle age by tracing the incidence of sandwichness over the entire life course.

Our focus on kin availability yields a measure of the potential care needs within families. The extent to which sandwiched individuals devote time to caring for their dependent relatives is influenced by cultural, economic, and institutional factors. By and large, the existing welfare systems in countries of the Global North help to alleviate the tension caused by simultaneous work and family obligations, and to reduce the burden of providing informal care to parents (Daatland, Veenstra, and Lima 2010; Silverstein, Tur-Sinai, and Lewin-Epstein 2020).[1] Among the forms of support available to working families in these countries are flexible work arrangements for caregivers; child care and schooling; and formal systems of social support, such as pensions, retirement funds, and public or private health insurance. Equivalent systems cannot be taken for granted in many low-income countries, where family members often represent the only source of support for dependent and frail individuals (Mba 2010).

Our understanding of the demographic drivers of “sandwichness” is heavily dependent on studies of countries in the Global North. It is, for example, widely argued that sandwichness results from a combination of high life expectancy and delayed fertility (Železná 2018), which are demographic characteristics of older and wealthier countries. The degree to which this is true outside the Global North is an empirical question. Studies of sandwichness in countries of the

Global South are particularly important, but difficult to conduct given the lack of high-quality data (Zimmer and Treleaven 2020; Aazami, Shamsuddin, and Akmal 2018; Helle 2002; Hurt, Ronsmans, and Quigley 2006; Sear and Mace 2008; Sear and Coall 2011; Urdinola and Tovar 2019; Xu 2019).

In this paper, we provide the first set of global and comparable measures of sandwichness using demographic microsimulation calibrated against data from the 2019 Revision of the UN World Population Prospects for the entire world population. We analyze how global demographic trends affect the overlap of generations, and discuss the implications of those changes for individuals in different world regions. Our objective is threefold. First, we seek to provide the first set of international and comparable estimates of the prevalence and timing of the sandwich squeeze for women and men. Second, we provide the first set of estimates of "grandsandwichness" as a proxy for the potential care demands on grandparents globally. Third, we evaluate regional differences in the timing and duration of sandwichness over the entire life course. Our paper makes two major contributions to the field. First, we introduce a novel, prospective, definition of sandwichness that is comparable across settings. Second, we provide the first set of estimates of parental and grandparental sandwichness around the world, as well as tools to monitor the phenomenon in the future as population projections are revised.

The paper is structured as follows. In the first section, we review the evidence on the Sandwich Generation and discuss how this paper fits within the existing literature. We then introduce the operational definition of sandwichness used in this paper, and discuss, with the help of stable population theory, the demographic forces that drive the phenomenon. In the third section, we introduce our microsimulation approach, and discuss its suitability for answering the research question at hand. In the last two sections, we present the results of our study, and how they may be interpreted.

Background

The double burden of care and work

There is no standard definition of sandwichness, but in the sociological literature the term generally refers to women carrying the “double burden” of informal care and professional work responsibilities. This definition is closely related to the original description of the “women in the middle” phenomenon, which focused on the interaction between labor market participation and care responsibilities among middle-aged women in the United States (Schwartz 1977; Brody 1981). Previous studies that have used this definition have generally been less interested in estimating the prevalence of the phenomenon, and more interested in understanding how the in-between state affects the well-being of women (Grundy and Henretta 2006; Daatland, Veenstra, and Lima 2010; Schmitz and Stroka 2013). However, as most of these studies focused on a limited set of high-income countries with developed welfare systems, it is difficult to generalize their results to other settings with radically different social and economic conditions.

We start by outlining some of the effects of this double burden for parents. It has been repeatedly shown that women who have both formal employment and unpaid child care responsibilities are more likely to experience negative health outcomes, such as depressive symptoms (McGarrigle, Cronin, and Kenny 2014) and chronic conditions (D’Ovidio et al. 2015). Working women who strive to keep their jobs while providing informal care (Schmitz and Stroka 2013) tend to report more time-based family interference with work (Aazami, Shamsuddin, and

Akmal 2018), and are more likely to request sick leave (Bratberg 2002). Sandwiched women face a heavier care burden, and are more likely to report lower self-rated health (Do, Cohen, and Brown 2014). The negative effects of this double burden tend to be larger for women than for men, as the former continue to perform most of the informal care, even in relatively egalitarian European societies (Francavilla et al. 2013; Hämäläinen and Tanskanen 2019).

Caring for older parents has also been associated with negative self-rated health (Legg et al. 2013) and mental health outcomes (Coe and Van Houtven 2009; Amirkhanyan and Wolf 2006) in countries of the Global North. The association between informal care and health outcomes varies by socioeconomic status and ethnicity, to the detriment of less privileged groups (Do, Cohen, and Brown 2014; Ennis and Bunting 2013). The mechanisms linking informal care and negative health outcomes vary by context, but the levels of time and financial strain on sandwiched individuals are likely to be higher in settings without adequate health care provision and social security systems (Mba 2010).

A number of social demographic studies have reported that the prevalence and relevance of grandparents who are actively involved in caregiving is increasing, as growing numbers of grandparents are taking on more active roles in raising their grandchildren (Fuller-Thomson 2005; Kopera-Frye 2009; Hayslip, Fruhauf, and Dolbin-MacNab 2019). The availability of grandparents, and especially of maternal grandmothers, can improve the survival of children (Sear and Mace 2008; Sear and Coall 2011), and their educational attainment (Song and Mare 2019). However, it has been argued that caring for grandchildren can negatively affect the physical and mental health and general well-being of grandparents (Neely-Barnes, Carolyn Graff, and Washington 2010; Musil et al. 2011). The evidence that this is the case has so far been mixed, with some studies finding little evidence of such a negative effect (Triadó et al. 2014;

Chen et al. 2015), and others suggesting that caring for grandchildren can improve grandparents' health in some circumstances (Arpino and Bordone 2014; Arpino, Bordone, and Balbo 2018; Xu 2019). Similarly, there is no consensus on the impact of simultaneously caring for aging parents and young grandchildren on individuals (Xu 2019; Železná 2018). These mixed findings are partly explained by the differential social, economic, and demographic factors that drive grandparents into caregiving roles in the first place.

Sandwichness as an intergenerational demographic process

In this paper, we define sandwichness as a generational process that depends on the genealogical position of an individual vis-à-vis their ascendants and descendants. This is a common definition that measures *potential care needs* rather than observed transfers (of time, money, etc.) between generations. A person who is squeezed between frail older parents and young dependent children is assumed to have simultaneous care responsibilities for multiple generations, potentially limiting their ability to provide care (Grundy and Henretta 2006).

While studies of generational sandwichness typically focus on estimating the prevalence of the phenomenon over age and time and the demographic dynamics that cause it, we still lack a truly global perspective on the prevalence of sandwichness around the world. There are several reasons why this is the case. First, the lack of a standard definition of sandwichness has made it difficult to provide a consistent answer to seemingly simple questions, such as what percentage of a population is sandwiched (Daatland, Veenstra, and Lima 2010; Perrig-Chiello and Höpflinger 2005). Second, most studies restrict their analyses to women in middle age (roughly defined as somewhere between ages 40 and 64). This makes sense considering that women's levels of participation in the formal economy have been increasing, even as women continue to be more involved in providing intergenerational support than men. However, recent literature has shown that sandwichness can and does happen before and after middle age (Goldstein, Mason, and Zagheni 2010; Lima, Tomás, and Queiroz 2015; Margolis and Wright 2016). Third, since most studies focus on wealthy countries with relatively high levels of human development and low fertility and mortality, we know very little about the burden of sandwichness over the entire life course outside of the Global North. To the best of our knowledge, there are no comparable estimates of the global prevalence of sandwichness.

Grandparents can also be sandwiched between young grandchildren and frail older parents (i.e., “grandsandwichness”). It has been suggested that given the decline in mortality, grandparents will become more widely available to provide care in the future. However, if grandparents spend more time in poor health, they may become consumers rather than producers of care (Sear and Coall 2011). Existing studies on this topic have noted that the overlap between grandparents and grandchildren is expected to increase in countries of the Global North (Margolis and Verdery 2019; Margolis and Wright 2017; Song and Mare 2019). To the best of our knowledge, no study to date has estimated the global prevalence of grandsandwichness.

It is generally assumed that the prevalence of the phenomenon will increase in the future. The parent-support ratios of middle-aged individuals, which are sometimes used as a shorthand for sandwichness, are expected to increase rapidly in the context of global population aging, especially in the countries of the Global North (Perrig-Chiello and Höpflinger 2005). The rapid aging of European and North American populations relative to populations in other world regions is evident in the projected increase in old-age dependency ratios. While dependency ratios are common measures of population aging, whether they are effective indicators of the levels of sandwichness in a population is unclear. This is also the case for the number of overlapping generations, another common proxy for sandwichness that is expected to increase in all world regions. The claim that global sandwichness will be more common in the years to come has not been evaluated empirically.

Insights from stable population theory

The key drivers of demographic change also determine the probability of being sandwiched between generations. In this section, we consider how the timing and the levels of fertility and mortality affect the demographic phenomenon of sandwichness. If fertility is high, mothers are more exposed to the risk of being sandwiched between young children and older parents because they spend a larger portion of their childbearing years with young children. Fertility postponement implies, all else held constant, that mothers and grandmothers are older when the (grand)children are born. This means that grandmothers are more likely to be close to death, and thus unhealthy or frail, when their grandchildren are young. It therefore appears that fertility postponement increases the probability of maternal sandwichness. However, as mortality decreases and life expectancy improves, grandmothers are more likely to be alive and healthy (i.e., have more remaining years of life expectancy) when their grandchildren are young. Thus, the decline in mortality will, on average, lead to reduced sandwichness for mothers and increased sandwichness for maternal grandmothers in particular. This means that it will become increasingly common for a grandmother to simultaneously have young grandchildren and one or more of her own parents near death.

Our definition of sandwichness relies on the notion of prospective, as opposed to traditional, dependency ratios. Traditional old-age dependency ratios use fixed, arbitrary age groups that may not be related to the actual health status or level of dependency of individuals (e.g., people aged 65 and older in the numerator and people between ages 15 and 64 in the denominator). An improved measure of dependency is the prospective old-age dependency ratio, an index that has in the numerator people who, based on life table calculations, are expected to die within a certain number of years (Sanderson and Scherbov 2010; Gietel-Basten, Saucedo, and Scherbov 2020). This is closely related to the concept of "thanatological age", or the time to death in a Lexis diagram (Riffe, Schöley, & Villavicencio 2017). Our prospective definition of sandwichness could be refined even further by accounting for healthy life expectancy, which can be considerably lower than life expectancy. We chose not to do this in the current paper for the sake of simplicity, and given that this and similar measures are not readily available for all the countries we consider, but it remains an exciting prospect for future research (Lutz et al., 2021).

Following this prospective logic, we consider an individual to be sandwiched if they have at least one child aged $\kappa = 15$ or younger and a parent or parent in-law (i.e., a parent of ego's current spouse, or last spouse if ego has separated and not re-married) within $\tau = 5$ years of death. Similarly, we consider a person to be "grandsandwiched" if they simultaneously have at least one grandchild aged $\kappa = 15$ or younger and a parent or parent-in-law within $\tau = 5$ years of death. Note that our approach only considers biological kin. We focus on minors under 15 years of age to increase the comparability of our results with those of previous studies. The vast majority of caregiving time among sandwiched adults in the U.S. (men and women) is spent on children aged 15 or younger (Dukhovnov and Zagheni 2015). Moreover, across European welfare states, the presence of young children in the household significantly decreases the amount of free time parents have (Zannella et al. 2019). From research based on time-use data, we know that grandmothers in the USA spend substantial amounts of time with grandchildren under age five, while grandfathers spend more time with grandchildren aged 5-14 (Dukhovnov and Zagheni 2015; Železná 2018). It is worth noting that the analyses presented in this paper are robust to different specifications of κ and τ, which change the magnitude but not the general direction of the trends we report.

Stable population theory and, in particular, our extension of this theory to a set of formal relationships known as the Goodman, Keyfitz, and Pullum kinship equations (GKP) (Goodman, Keyfitz, and Pullum 1974), allow us to analyze the relationship between mortality, fertility, and sandwichness. We introduce these formal relations as a simplified illustration of how demographic forces affect sandwichness before considering the phenomenon in a more systematic way. In a stable female population, the probability of being sandwiched between a young child and an aging mother depends on the levels and timing of mortality and fertility (for the sake of simplicity and in order to highlight certain insights, we omit in this section dynamics that include a two-sex population and in-laws). Given constant age-specific schedules of fertility and mortality rates, we can express the probability of maternal sandwichness at age a, $S(a)$, as:

$$S(a) = \underbrace{\left(1 - \prod_{x=1}^{\kappa}[1 - m_{a-x})]\right)}_{\substack{\text{fertility risk in the} \\ \text{κ years preceding age } a}} \times \underbrace{M_1(a)}_{\substack{\text{Prob. that mother of ego} \\ \text{is alive when ego is } a \text{ years old}}} \times \underbrace{\left(1 - \frac{M_1(a+\tau)}{M_1(a)}\right)}_{\substack{\text{Prob. that mother of ego} \\ \text{is alive when ego is } a \text{ years old}}} \qquad (1)$$

where m_{a-x} is the fertility of women at age $a - x$ and $M_1(a)$ is the probability of having a living mother at age a in a stable population. These estimates refer to an average woman in a female population, ignoring the role of offspring mortality. Conditional on ego's survival, $M_1(a)$ can be thought of as a survival probability in a life table: it has to be equal to one when a is equal to zero (the mother is alive when she gives birth), and goes monotonically to zero. Following the

GKP equations, we can estimate $M_1(a)$ given a vector of age-specific fertility rates m_x, survival probabilities l_x, and the implicit rate of population growth r as:

$$M_1(a) = \int_{\alpha}^{\beta} \frac{l_{x+a}}{l_x} e^{-rx} l_x m_x dx \tag{2}$$

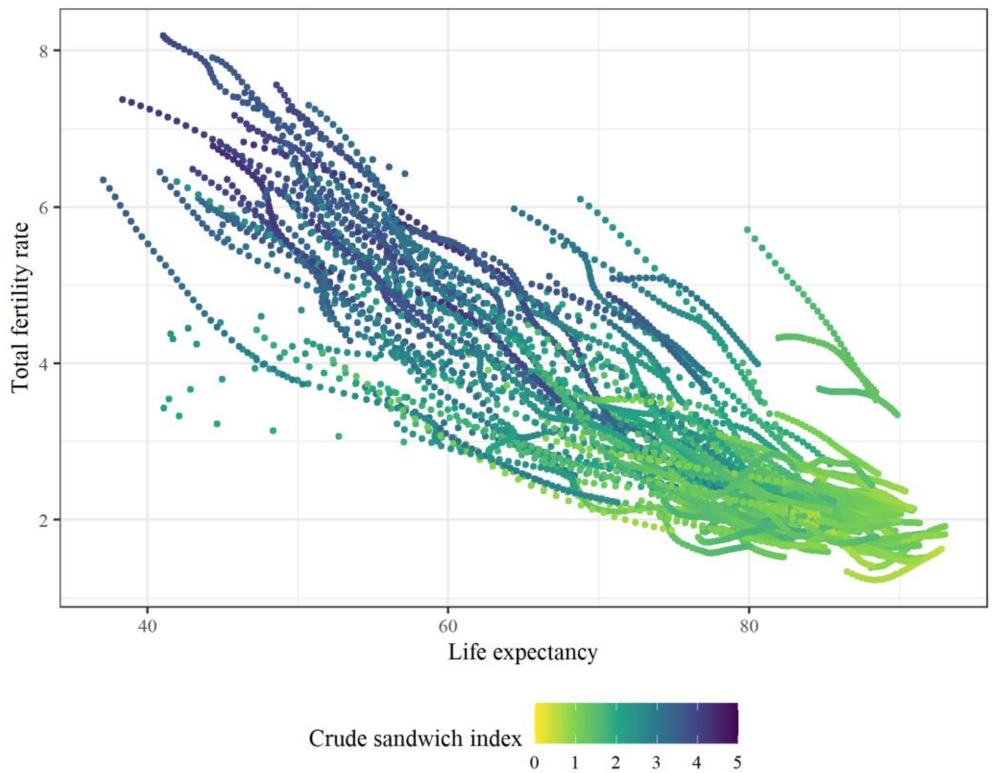
where α and β represent the start and the end of the reproductive period. For the sake of simplicity, we can also approximate $M_1(a)$ in relation to the mean age at childbearing μ. Assuming μ to be the average length of a generation in a stable population, we can rewrite Eq. 2 as follows:

$$M_1(a) \approx \frac{l_{\mu+a}}{l_\mu}. \tag{3}$$

Eq. 3 states that the probability that a girl alive at age a has a living mother is approximately equal to the probability that women in the population are alive a years past the mean age at childbearing, conditional on them being alive at the mean age at childbearing.

We now have all the elements for assessing the relationship between fertility, mortality, and sandwichness. Fertility levels enter Eq. 1 through fertility rates, which, in turn affect, the probability of having had a child during the past κ years. Fertility timing enters the equation through the mean age at childbearing implied by fertility rates (Eq. 3). This, in turn, affects the probability of having a living mother. Mortality enters our simplified model through the survival probabilities of women.

FIGURE 1   Crude Sandwich Index in 10,200 stable populations with different levels of fertility and mortality.



NOTE: Estimates produced from Eq. 1 and Eq. 3 using country-level rates from the 2019 Revision of the United Nations World Population Prospects (historical and medium-scenario projections).

introduce the Crude Sandwich Index to exemplify the implications of these formal relationships for the study of sandwichness. This index is the sum of the age-specific probabilities of maternal sandwichness $S(a)$ weighted by the population distribution: $\sum_{a=\alpha}^{\beta+\kappa}[S(a)w(a)]$. The vector $w(a)$, which sums to unity, represents the person-years lived between ages a and $a+1$ as a share of the sum of all person years lived by members of a given cohort. Higher values imply that a cohort can expect to experience a higher burden of sandwichness throughout their life, both in terms of the prevalence and the duration of the sandwich state. We estimate the Crude Sandwich Index by solving Eq. 1 for ages 15-65 using all combinations of mortality and fertility rates present in the 2019 Revision of the UN World Population Prospects (UNWPP). Assuming demographic stability, we approximate cohort rates for all countries in the UNWPP using rates from the 1950-2100 period (10,200 unique combinations of mortality and fertility rates).

Figure 1 shows that higher levels of mortality and fertility are associated with higher values for the Crude Sandwichness Index. This suggests that lower levels of fertility and mortality may also be associated with lower values in real-world populations. However, the figure does not account for the recent and projected declines in mortality and fertility in most world regions, or for the dynamic nature of real populations, which never reach stable state equilibria.

In this section, we highlighted how formal demographic theory can help us gain insights into the processes that lead to sandwichness. We did not use this model to produce any of the substantive results presented below. In the next section, we introduce a complementary approach based on microsimulation that goes beyond mathematical intuition to produce accurate estimates that account for changes in rates over time; and that allows for more complex calculations that involve, for example, parents-in-law.

Estimating global sandwichness using demographic microsimulation

We use demographic microsimulation to evaluate global trends in sandwichness over time and over the life course. In particular, we simulate populations using the kinship microsimulator SOCSIM, a well-established demographic simulator that has supported social science research for decades (Hammel et al. 1976; Wachter 1997; Zagheni 2011; Verdery and Margolis 2017; Margolis and Verdery 2019; Verdery et al. 2020). Our simulation takes as input mortality and fertility rates for 198 countries and territories included in the 2019 Revision of the United Nations World Population Prospects. The input data for the simulations are historical (1950-

2020) and projected period rates (2020-2100, medium scenario). We run five simulations for each country to account for the stochasticity inherent in the simulations. Each simulation runs for 200 years before 1950 using the 1950-1955 rates to achieve a stable population structure. Starting from 1950, the simulation uses the UNWPP demographic rates as input. Additional analysis showed that this assumption of demographic stability did not bias our estimates of sandwichness for simulated individuals born after 1970. On average, each of these simulations had a population of around 50,000 "living" individuals at the start of 2020. The output of each microsimulation is a complete kinship network from which it is possible to determine the time each simulated individual spent sandwiched. We group our estimates by regions as defined by the United Nations Sustainable Development Goals.

We conducted several assessments of data quality to ensure the reliability of the simulation data. First, we re-estimated age-specific fertility and mortality rates from the simulated populations and compared them to the UNWPP input values for the 1950-2100 period. The "output" demographic rates recovered from the simulations were highly correlated with the input rates from the UNWPP (the mean Pearson correlation coefficient over all simulations for age-specific fertility rates was 0.99, and was 0.95 for age-specific mortality rates). A visual inspection of the output demographic rates also showed that they were consistent with the input demographic rates at all ages at the national and regional level. Second, we evaluated the reliability of our microsimulations by comparing the results of the simulation model with those of a formal demographic model for relatively simple cases. More specifically, we developed a discrete-time mathematical model analogous to Eq. 1, and used this model to estimate the probability of sandwichness over the life course in a female population with changing demographic rates over time, in accordance with data from the UNWPP. Then we obtained equivalent estimates from microsimulations using the same rates as input. The simulated age-specific probability of sandwichness were found to be highly correlated with the equivalent model estimates (average correlation coefficient over all countries for the 2000-2020 cohorts was 0.92; mean difference = 0.01), which confirmed the adequacy of microsimulation as an analytical tool for this paper (see Appendix for more details).

Demographic microsimulation allowed us to overcome the lack of international and comparable data on past, present, and future kinship structures. Nevertheless, it is worth keeping in mind that while our simulated populations are highly grounded in empirical data, they are not real-world populations. In the rest of the paper, we use this microsimulation approach to overcome the limitations of mathematical modeling, especially when we include in-laws; and to provide a comprehensive overview of global trends in sandwichness for men and women born between 1970 and 2040.

Results

In this section, we present the average trends in parental and grandparental sandwichness at the global, regional, and country level for the 1970-2040 birth cohorts. Our results pertain to the "Sandwich Generation," who are squeezed between frail old parents or parents-in-law within five years of death and young children under age 15; and to the "Grandsandwich Generation," who are squeezed between aging parents or parents-in-law within five years of death and grandchildren under age 15 (in what follows, "parent" stands for both parent and parent-in-law). A first set of results presents the cohort-level changes in the prevalence and duration of sandwichness. A second set of results focuses on the experience of sandwichness over the life course.

TABLE 1 Expected size of the "Sandwich Generation" and duration of the sandwich state (1970, 2005, and 2040 cohorts).

	Sandwich				Grandsandwich			
	Size		Duration		Size		Duration	
	% of cohort	Crude index	In years	% of life	% of cohort	Crude index	In years	% of life
World								
1970	58.4 (7.3)	3.9 (1.5)	4.8 (1.1)	7.0 (2.5)	46.1 (8.1)	2.1 (0.6)	3.7 (1.0)	5.2 (1.2)
2005	57.5 (7.7)	3.0 (1.1)	4.4 (1.1)	5.6 (1.9)	47.2 (7.7)	1.7 (0.5)	3.9 (1.0)	4.8 (1.3)
2040	55.0 (7.8)	2.5 (0.8)	4.0 (1.0)	4.9 (1.5)	46.5 (7.5)	1.6 (0.5)	3.9 (1.0)	4.6 (1.2)
Sub-Saharan Africa								
1970	60.8 (5.7)	5.7 (0.8)	5.7 (0.7)	10.0 (1.5)	41.8 (6.8)	2.3 (0.5)	3.2 (0.7)	5.4 (1.0)
2005	63.9 (5.5)	4.3 (0.9)	5.5 (0.9)	7.8 (1.6)	49.3 (7.6)	2.2 (0.5)	4.0 (0.9)	5.6 (1.1)
2040	62.8 (5.9)	3.5 (0.7)	5.1 (0.8)	6.6 (1.3)	48.8 (7.2)	1.8 (0.4)	4.0 (1.0)	5.1 (1.1)
North Africa and West Asia								
1970	62.8 (7.2)	4.1 (0.9)	5.4 (1.0)	7.3 (1.7)	50.6 (8.7)	2.2 (0.5)	4.2 (1.0)	5.6 (1.3)
2005	59.6 (6.7)	3.0 (0.7)	4.6 (0.9)	5.7 (1.4)	47.7 (9.7)	1.7 (0.5)	3.9 (1.1)	4.7 (1.4)
2040	54.7 (5.5)	2.4 (0.6)	4.0 (0.7)	4.7 (1.0)	46.0 (8.5)	1.5 (0.4)	3.8 (1.1)	4.5 (1.2)
Central and South Asia								
1970	59.5 (7.0)	4.2 (0.8)	5.0 (0.9)	7.2 (1.3)	46.4 (4.7)	2.2 (0.3)	3.6 (0.4)	5.2 (0.6)
2005	56.2 (8.5)	2.8 (0.8)	4.1 (1.0)	5.2 (1.4)	50.7 (6.4)	1.9 (0.4)	4.3 (0.8)	5.4 (0.9)
2040	51.2 (7.4)	2.2 (0.6)	3.5 (0.9)	4.2 (1.1)	50.3 (6.7)	1.8 (0.4)	4.5 (1.1)	5.4 (1.2)
East and Southeast Asia								
1970	53.7 (9.1)	3.2 (1.2)	4.1 (1.2)	5.7 (2.0)	39.3 (7.0)	1.5 (0.5)	2.9 (0.7)	3.9 (1.0)
2005	55.1 (6.6)	2.6 (0.7)	4.0 (0.8)	4.8 (1.2)	42.1 (7.9)	1.4 (0.4)	3.3 (0.9)	3.9 (1.2)
2040	53.9 (6.2)	2.3 (0.5)	3.8 (0.7)	4.4 (0.9)	42.9 (9.2)	1.3 (0.5)	3.4 (1.2)	4.0 (1.4)
Latin America and the Caribbean								
1970	58.4 (5.6)	3.2 (0.9)	4.4 (0.7)	5.8 (1.1)	52.9 (6.3)	2.3 (0.6)	4.7 (0.8)	6.1 (1.0)
2005	51.5 (5.7)	2.2 (0.6)	3.6 (0.6)	4.3 (0.9)	49.7 (5.5)	1.8 (0.4)	4.5 (0.8)	5.4 (0.8)
2040	49.0 (4.9)	2.0 (0.5)	3.3 (0.5)	3.8 (0.7)	49.0 (3.8)	1.7 (0.4)	4.4 (0.6)	5.1 (0.6)
Australia and New Zealand								
1970	52.1 (1.4)	2.3 (0.2)	3.5 (0.2)	4.1 (0.3)	51.5 (2.5)	2.0 (0.2)	4.7 (0.3)	5.5 (0.5)
2005	53.7 (0.6)	2.1 (0.0)	3.7 (0.0)	4.1 (0.0)	47.4 (3.3)	1.4 (0.1)	4.0 (0.5)	4.5 (0.5)
2040	46.6 (1.8)	1.8 (0.0)	3.0 (0.2)	3.3 (0.2)	47.1 (2.7)	1.5 (0.1)	4.1 (0.4)	4.5 (0.5)
Oceania (excluding Australia and New Zealand)								
1970	68.2 (5.4)	4.6 (1.0)	6.1 (1.0)	8.4 (1.9)	53.1 (6.7)	2.3 (0.4)	4.2 (1.0)	5.7 (1.0)
2005	66.6 (8.9)	3.7 (1.1)	5.6 (1.3)	7.1 (1.9)	52.2 (8.5)	1.9 (0.5)	4.2 (1.2)	5.3 (1.4)
2040	60.8 (7.8)	3.0 (0.8)	4.7 (1.0)	5.7 (1.5)	48.6 (7.7)	1.6 (0.4)	4.0 (1.2)	4.8 (1.4)
Europe and North America								
1970	52.8 (4.0)	2.5 (0.4)	3.7 (0.4)	4.5 (0.6)	43.3 (4.7)	1.5 (0.2)	3.5 (0.6)	4.2 (0.7)
2005	53.8 (3.9)	2.2 (0.3)	3.7 (0.4)	4.3 (0.5)	42.2 (4.7)	1.3 (0.2)	3.3 (0.5)	3.7 (0.6)
2040	52.2 (6.0)	2.2 (0.3)	3.6 (0.6)	4.1 (0.7)	41.5 (6.3)	1.2 (0.3)	3.2 (0.8)	3.6 (0.8)

NOTE: "Size" is defined both as the percent of members of a given birth cohort who will spend at least one year sandwiched and as the Crude Sandwich Index. "Duration" is defined both as the expected number of years spent in a sandwich state and as the expected share of life spent sandwiched (based on country cohort life expectancy). Estimates for the 1970-2040 cohorts based on SOCSIM microsimulations (regional means and standard deviation for women and men).

Size of the Sandwich Generation and duration of the sandwich state

We start by considering changes in the size of the Sandwich Generation over time. We define "size" twofold. A first definition refers to the share of the members of a birth cohort expected to spend at least one year sandwiched between older parents and dependent children. This life-time probability does not consider whether individuals were sandwiched multiple times over life or the duration of the sandwich state. In contrast, the Crude Sandwich Index, the population-weighted sum of age-specific probabilities of sandwichness, is a more comprehensive measure of the prevalence and intensity of the sandwich experience over the entire life course. We discuss both measures in the text below.

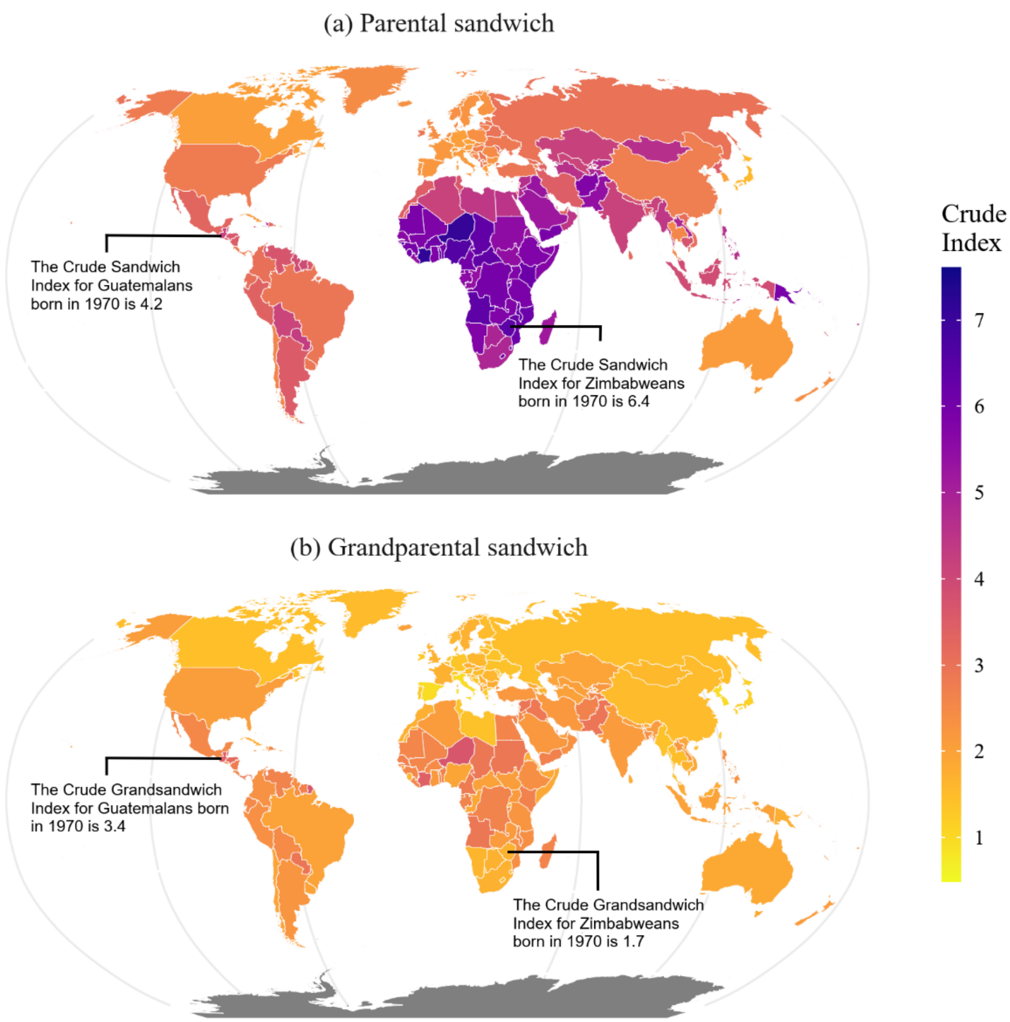
Globally, we find evidence of a clear reduction in the size of the Sandwich Generation (Table 1). The share of people who will be sandwiched at some point in their life will decline from 58% in the 1970 cohort to 55% in the 2040 cohort. Similarly, the Crude Sandwich Index is expected to decline by 36% between 1970 and 2040 from higher levels (3.9) to lower levels (2.5), with considerable variability within and across regions. We find the lowest values in Australia and New Zealand (2.3 of the 1970 cohort) and the highest values in Sub-Saharan Africa (5.7 for the same cohort). There is a demographic potential for reductions in the shares of parents who have simultaneous care responsibilities for younger and older generations in some regions, but not in others. Notably, we project a relative stability in the future size of the Sandwich Generation in Europe, where both life-time sandwich probabilities and sandwich index are relatively low.

Our findings differ for the Grandsandwich Generation; i.e., people who simultaneously have young grandchildren (under age 15) and at least one parent who is less than five years from death. As Table 1 shows, the Grandsandwich Generation is smaller than the Sandwich

Generation globally, and in every world region. We anticipate that the size of the Grandsandwich Generation will decline less than the size of the Sandwich Generation over our projection horizon. The share of people who will ever be grandsandwiched will remain relatively stable between the 1970 and 2040 cohorts globally, at around 46%. In contrast, Crude Grandsandwich Index will decline by 24% between the 1970 and 2040 cohorts (from 2.1 to 1.6). Again, we find considerable regional heterogeneity in these trends. We project a relatively stable pattern in the countries of East and Southeast Asia, where the grandsandwich index is expected to remain at around 1.4 for the cohorts considered. This finding contrasts with the marked declines anticipated in, for example, Sub-Saharan Africa, where we project the steepest decrease in the grandsandwich index, from higher (2.3 for the 1970 cohort) to moderate levels (1.8 for the 2040 cohort).

Below, we visualize the considerable regional variability in sandwich indices on a world map. Panel (a) of Figure 2 shows country-level estimates of the Crude Sandwich Index for men and women born in 1970. As expected, the highest values are in Sub-Saharan Africa, and the lowest values are in Europe and North America, albeit with outliers in all regions. Regional averages hide the fact that countries like Guatemala have much higher values than other countries in their regions. The geographic distribution of the Sandwich Generation closely follows the prevailing levels of mortality and fertility in each country (i.e., countries with high mortality and fertility have relatively high sandwich indices). However, this is not true of the global distribution of grandsandwich indices. Panel (b) of Figure 2 shows that countries in Sub-Saharan Africa do not have the highest grandsandwich indices. In Zimbabwe, for example, consistently high levels of mortality, coupled with the devastating effects of the HIV/AIDS epidemic, have reduced the prevalence of four-generational families. Instead, we find higher grandsandwich indices in regions where lower historical levels of mortality have made it more likely for a middle-aged parent to have a living parent (e.g., Guatemala).

FIGURE 2 Crude Sandwich and Grandsandwich Index (1970 cohort).



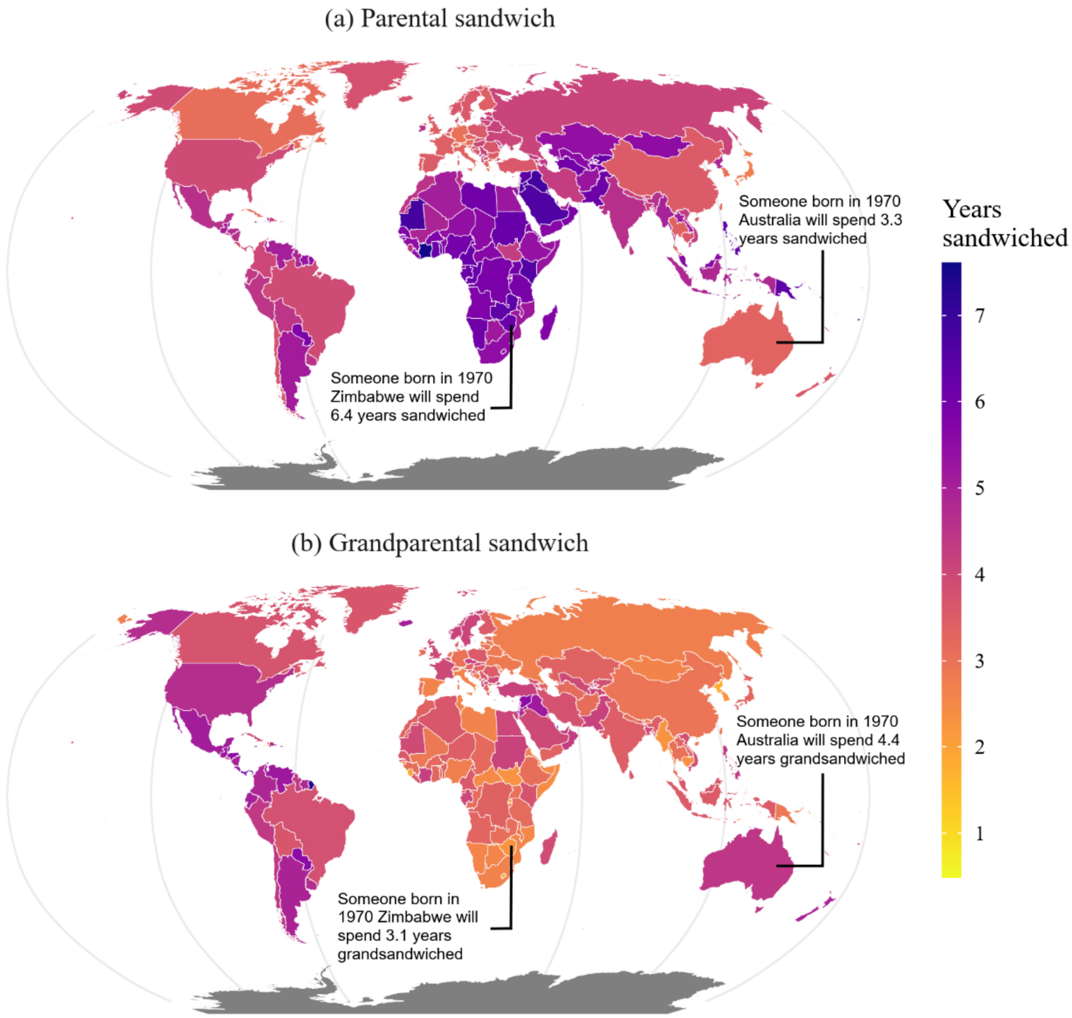
NOTE: The Crude Index is the population-weighted sum of age-specific probabilities of (grand)sandwichness. The maps show mean values for men and women combined.

We now consider the duration of the sandwich state, conditional on the UNWPP demographic rates. We seek to answer the question of how many years members of successive cohorts can expect to spend sandwiched between relatives potentially requiring care. Table 1 shows the duration of the parental and the grandparental sandwichness over cohorts in years and as a share of life. Our simulations project a decline in the number of years that members of subsequent cohorts will spend sandwiched between older parents and young children. We project that the “time squeeze” pressure on parents will decrease in the future as a result of lower fertility and increased longevity. In other words, we expect that reductions in fertility and improvements in life expectancy will more than counteract the expected postponement of childbearing. Globally, this value will decrease 17% from 4.8 years to four years, albeit with considerable heterogeneity across and within regions. People in Sub-Saharan Africa can expect to experience longer periods of sandwichness (5.7 years for the 1970 cohort, on average), than people in Australia and New Zealand (3.5 years) and in Europe (3.7 years).

A different picture emerges after we account for the substantial regional heterogeneity of life expectancy. What percentage of their lifetime can an individual expect to be sandwiched between generations? Table 1 shows that the relative duration of sandwichness (time as a share of life) will decline faster than its absolute duration (time in years). Globally, we project that individuals will go from spending 7% (1970 cohort) to only 4.9% (2040 cohort) of their lives sandwiched, which represents a 33% decline. We document striking regional inequalities in the proportion of life people spend caring for relatives. A person born in 1970 in Sub-Saharan Africa can expect to spend around one-tenth of their life squeezed between dependent relatives, or twice as long as someone born in North America that same year. The relative duration of the sandwich state is driven by two countervailing forces: declines in the absolute duration of sandwichness and increases in life expectancy. Regions where considerable improvements in life expectancy are expected – e.g., North Africa, West Asia, and Sub-Saharan Africa – will see a larger decrease in the relative duration of sandwichness than in the absolute duration in years. In regions where life expectancy is not projected to improve radically, such as in Latin America, we expect to see commensurate reductions in the relative and absolute duration of sandwichness.

We now consider the duration of the grandsandwich state in years. The time that individuals will spend "grandsandwiched" between an older parent and a young grandchild will, on average, change little in our study period. Indeed, we expect people born in 1970 and 2040 to spend approximately 3.8 years grandsandwiched (global average, Table 1). Remarkably, we expect the average duration of grandsandwichness in years to increase in Sub-Saharan Africa, Central and South Asia, and East and Southeast Asia. This increase is primarily driven by the projected rise in the mean age at childbearing and improvements in life expectancy affecting multiple generations, coupled with relatively high fertility. A longer average lifespan means that the great-grandparents are more likely to be alive when the grandparents have young grandchildren. At the same time, increases in the mean age at childbearing, which lead to longer generations, imply that the great-grandparents who are alive are, on average, relatively old, and thus close to death. The two trends combined lead to increases in the average number of years that grandparents spend squeezed between grandchildren and their own frail parents. Grandparents born in 1970 in Latin America and the Caribbean will spend the longest period sandwiched between aging parents and young grandchildren. We project that grandparents born in 2040 in Central and South Asia will spend the longest time in a grandsandwich state. Nevertheless, after accounting for improvements in life expectancy, we find that the global share of life that individuals will spend grandsandwiched is expected to decrease slightly. On average, people born in 1970 can expect to spend 5.2% of their life grandsandwiched, but the equivalent value for those born in 2040 will be only 4.6%. Individuals in East and Southeast Asia and in Europe and North America can generally expect to spend less than 4% of their life squeezed between an older parent and a young grandchild, while those in most other world regions can expect to spend a longer share of their life in this situation.

FIGURE 3 Expected number of years in a sandwich or grandsandwich state (1970 cohort).



NOTE: A person is (grand)sandwiched if they simultaneously have a frail parent within five years of death and a potentially dependent child or grandchild aged 15 or younger. The maps show mean values for men and women combined.

Finally, we present geographic variations in the absolute duration of sandwichness (in years) for people born in 1970. Figure 3 confirms the regional patterns discussed above, but shows the within-region heterogeneity in the length of the sandwich and the grandsandwich periods. The most remarkable feature of the map is the different geographic distributions in the top and the bottom panels. The countries where people can expect to experience the longest periods of sandwichness are concentrated in territories with high mortality, mainly in Africa and West Asia. Nevertheless, people in these countries can expect to experience considerably shorter periods of grandsandwichness. For example, an average person born in 1970 in Zimbabwe can expect to spend twice as many years sandwiched (6.4 years) as grandsandwiched (3.1 years). By contrast, an average person born in 1970 in Australia can expect to spend less time sandwiched (3.3 years) than grandsandwiched (4.4 years). As we noted above, these findings reflect the intergenerational dimension of gransandwichness, and, in particular, the ways in which the legacy of higher levels of historical mortality reduce the number of great-grandparents in a population. This pattern explains the relatively short duration of the grandsandwich period in Africa and most of Asia, and the relatively long duration of that period in the Americas and Europe.

Parental and grandparental sandwichness over the life course

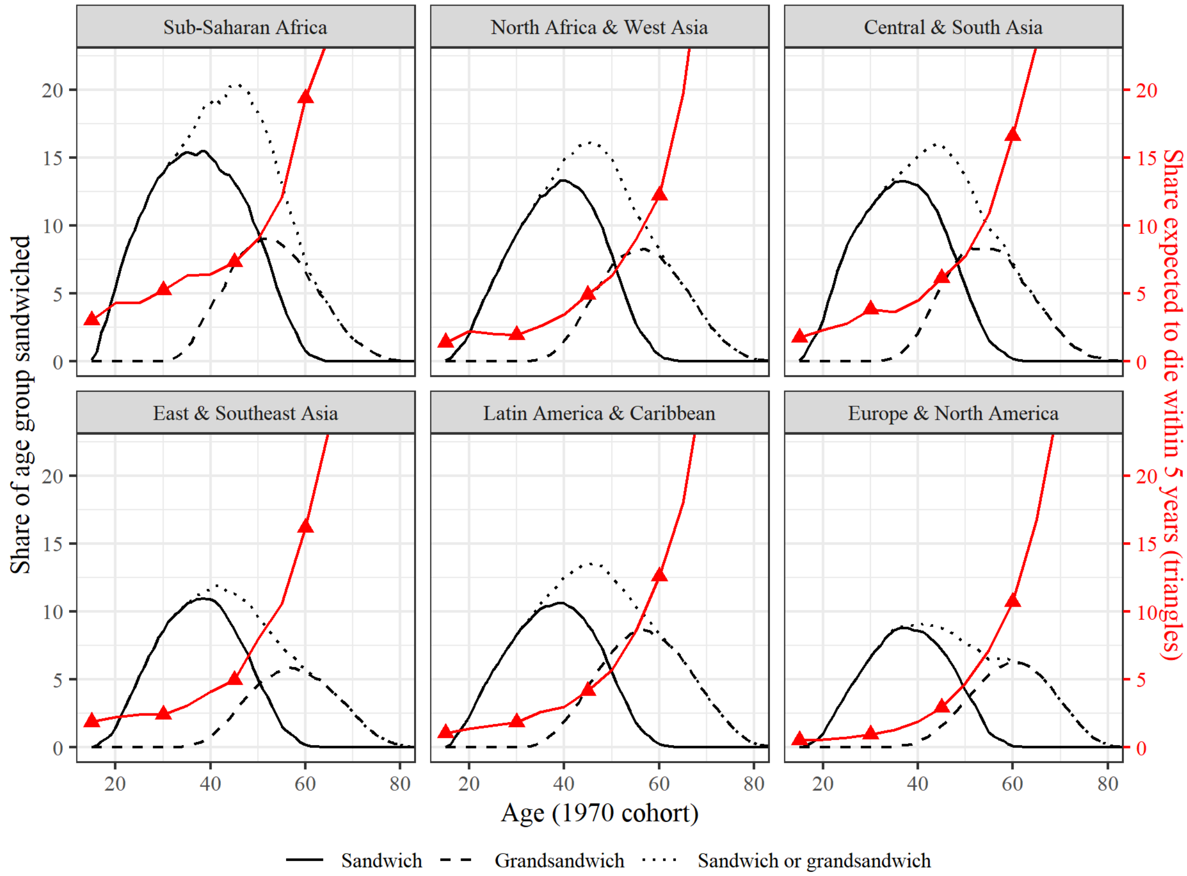
So far, we have considered the experiences of parental and grandparental sandwichness for entire cohorts. In the following, we will focus on how these experiences vary over age. Figure 4 shows the distribution of parental sandwichness (solid line) and grandparental sandwichness (dashed line) over the life course for members of the 1970 cohort.

The main insight we can derive from the figure is that the demand to provide care will increase over the lifetime of these individuals. In particular, there is clear evidence of what we call the "twin peaks of Sandwichness," whereby individuals have a relatively high probability of experiencing parental sandwichness in middle age, followed by a high probability of experiencing grandparental sandwichness in later life. A smaller horizontal distance between these peaks is indicative of a smaller "respite" between the onset of parental and grandparental sandwichness (and their associated care responsibilities). For those born in 1970, this respite period is expected to be 15 years in Sub-Saharan Africa and 22 years in Europe and North America. This implies that the potential care time burden is larger in the former than in the latter region.

Figure 4 conveys another important message: the prospect of being liberated from family care responsibilities in old age is accompanied by an increasing concern for one's own health. The dotted black line in the figure shows a steady decline in the potential care time burden after middle age (i.e., the probability of being either sandwiched or grandsandwiched). Yet this hardly means the onset of a carefree time of life for aging individuals, whose frailty is expected to increase rapidly after around age 50 (solid red line). Those reaching old age might find themselves spending less time caring for relatives and more time caring for themselves.

As for future developments, we project that consecutive cohorts will experience parental and grandparental sandwichness at increasingly older ages. People born in 2040 will, on average, experience sandwichness and grandsandwichness six years later in life than those born in 1970. This is the case for all world regions except for Europe and North America, a region where grandsandwichness is already experienced at comparatively old ages (with the highest probability of being grandsandwiched at grandparental age 64). We project no change in the life course distribution of grandparental sandwichness for grandparents in this region.

FIGURE 4 Distribution of parental and grandparental sandwichness over the life course (1970 cohort).



NOTE: Higher values for the black lines indicate that a larger share of a given age group has simultaneous care responsibilities for older parents and young children or grandchildren (regional means for male and female populations). The red line shows the share of people in a given age group who, in the microsimulations, will die in the next five years.

Discussion

This paper seeks to answer the pressing question of how demographic change will affect the demands on parents and grandparents to provide informal care within the family. We address three important gaps in the literature on intergenerational relationships: (i) the lack of a systematic approach to estimate the size and duration of parental and grandparental sandwichness; (ii) a dearth of international and comparable evidence on the Sandwich Generation, especially in countries of the Global South; and (iii) the lack of evidence on the distribution of sandwichness over the life course. In this last section, we discuss our findings in the context of the existing literature, acknowledge their limitations, and present a plan for future research.

We present the first set of international and comparable estimates of the experience of sandwichness over time and throughout the entire life course, derived from microsimulations calibrated on data from the 2019 Revision of the United Nations World Population Prospects (UNWPP). In the scholarly literature there has been a continued focus on the Sandwich Generation in Europe and North America, which gives the impression that the overlap of generations, and the associated time pressure on parents and grandparents, is a particular problem for inhabitants of the Global North (Železná 2018). Our results show that this is not necessarily the case. People in the Global South are more likely to be sandwiched at some point in their life, and to spend longer periods in this state, than people in Europe and North America. The historical and projected levels of sandwichness in Europe and North America are relatively low, making the experience an outlier rather than the norm in these regions.

This study has introduced a comprehensive framework, firmly grounded in a long tradition of formal demography, to conceptualize sandwichness as a demographic process. The abundance of studies on the countries of the Global North, where fertility and mortality levels are low, has shaped the way we think about the drivers of intergenerational overlap. For example, these studies often assume that most of the variability in the Sandwich Generation comes from changes in life expectancy and in the mean age at childbirth. We use mathematical demographic models and microsimulations to show that this is not a universal phenomenon. Generational overlap is determined by a complex combination of historical demographic forces acting through intergenerational kinship processes.

The prevalence of parental sandwichness is closely associated with prevailing levels of mortality and fertility in a population: i.e., regions with high mortality and fertility levels tend to have high levels of parental sandwichness. This is not necessarily the case for grandparental sandwichness (i.e., people with simultaneous care responsibilities for older parents and young grandchildren), a process that is affected by a longer legacy of past demographic regimes. Higher mortality that directly affected prior generations decreases the likelihood that a person who is currently a grandparent will have a living parent. In other words, the mortality of earlier generations affects the prevalence of four-generational families in a population. This is crucial for regions where rapid demographic change has been the norm in the recent past, and is projected to continue in the foreseeable future.

Overall, our results suggest that high fertility, rather than population aging, has been a major driver of sandwichness in many countries by increasing the probability of generational overlap between grandparents, parents, and children. The Demographic Transition helps understand regional patterns of sandwichness. For example, the falling levels of sandwichness in Australia and New Zealand are explained by the steady decline of mortality and fertility beginning in the 1970s in the region. In contrast, the consistently high levels of sandwichness in Sub-Saharan Africa reflect relatively high fertility coupled with increases in life expectancy.

This study has implications for the academic literature, and for the future of societies around the world. We have shown that the historical and projected demographic trends suggest the possibility of a future in which people face fewer demands to provide informal care to family members. Some regions that have reached their full demographic potential are seeing the prevalence of sandwichness decrease, while others have yet to do so. How will the burden of informal care be distributed within populations? While measuring how sandwiched individuals actually spend their time is beyond the scope of this study, the existing evidence suggests that the burden will be shared unequally (Urdinola and Tovar 2019). In theory, the burden of care could be shared between partners, or institutional arrangements might provide support to working parents (Schmitz and Stroka 2013). However, in many societies, expectations of who provides care are gendered, which translates into differences between women and men in the allocation of time spent on informal care, paid and unpaid housework, and leisure (Zagheni and Zannella 2013). In practice, women, ethnic minorities, less educated people, and those with lower socioeconomic status spend more time providing informal care (Zannella et al. 2019; Negraia, Augustine, and Prickett 2018; Ennis and Bunting 2013). If the future is anything like the past, we can expect similar patterns to hold at least in the short term (discounting potential improvements in the institutional arrangements that free parents and grandparents from unwanted demands on their time).

Generational overlap does not need to be a burden on individuals and families. The exchange of emotional and social support has been linked to positive outcomes for grandchildren and grandparents (Song and Mare 2019; Arpino and Bordone 2014). Furthermore, the increased availability of grandparents can help to ease time constraints for parents in low- and middle-income countries that lack appropriate institutional support for parents. This is especially relevant given the increasing female engagement in the labor force in many countries of the Global South. We have shown that in regions with a legacy of high mortality, such as Africa, grandparents have often been unavailable. Our results suggest that in the future, the level of support grandparents provide to parents may increase. Grandparents will live longer and enjoy more overlapping time with younger and older generations. However, as intergenerational relationships are also aging, important life events are being experienced later in life. This means that grandparents are more likely to be older and frailer, and are thus at risk of being recipients rather than providers of care. At the same time, demographic trends suggest that the care responsibilities of sandwiched grandparents are increasing.

In countries with older populations, this is occurring against a backdrop of increasing labor force commitments among older women, and longer geographic distances between family members. These new challenges are likely to translate into a declining potential for members of different generations to exchange care. However, increased female labor force participation and geographic distance are not expected to suppress intergenerational transfers altogether. The literature on transnational migrant-sending families has shown that, while these factors reduce instrumental support and physical exchanges of care, they can also increase financial transfers across borders (Bryceson 2019). This study did not engage with migration directly, but future research can consider how historical and projected demographic trends might affect exchanges of care, time, and financial resources across borders.

Limitations

Our study has four main limitations. First, our measure of sandwichness reflected a *need for care*, but we were unable to determine whether and how this need for care will translate into actual time spent caring for dependent relatives. Furthermore, we were unable to include data on healthy life expectancy in our simulations. As a result, our measures might underestimate the degree to which individuals provide care for older parents for longer periods of time. Future studies can use innovative new data sources to expand our work in this direction (Lutz et al. 2021). Our results represent an upper-bound estimate of the number of people who will face simultaneous demands to provide care to younger and older generations. Future studies can build on our findings by combining them with time-use data for the regions where such data are available. A second limitation was our reliance on UNWPP rates, which did not account for sub-national variation. Nevertheless, our sample of countries included populations at different stages of the demographic and epidemiological transition, and countries of all income levels and stages of human development. Future studies can expand our findings using international demographic datasets with sub-national variation (Lutz et al. 2018). The projected UN rates assume that the demographic transition will greatly reduce differences in mortality and especially in fertility rates between all populations by 2100. This will affect the variability in our simulated populations, particularly for estimates after 2020, when the microsimulation uses projected rates. The third limitation was related to our reliance on microsimulations, which accurately reflected demographic input rates, but produced only synthetic populations that may not have captured all the complexities of actual populations. Nevertheless, the estimates from our microsimulations are consistent with equivalent estimates from formal demographic models, which increases our confidence in the validity of our results. A fourth limitation was that our demographic projections were unable to predict sudden changes in demographic rates, as the emergence of the global COVID-19 pandemic clearly indicated. In the Appendix, we use mathematical reasoning to show that the ongoing COVID-19 pandemic is expected to have a negligible effect on the prevalence of sandwichness.

Conclusions

In this study, we looked at how historical and projected demographic trends shape the experience of being sandwiched between frail older parents or parents-in-law on the one hand, and young children (i.e., “sandwichness”) or young grandchildren (i.e., “grandsandwichness”) on the other. The time that people spend in different family roles varies substantially across countries and time, and is a function of past and present demographic regimes (e.g., changes in life expectancy, fertility timing and levels). We used demographic microsimulation to analyze, for the first time, the effect of changes in birth and survival rates on the potential care needs and resources of families around the world.

We found evidence of two diverging global trends. First, we project a decline in the mean size of the parental and grandparental Sandwich Generation, reflecting a downward trend in parents having simultaneous care responsibilities for younger and older generations. This drop is expected to be particularly steep in countries of the Global South, where the size of the Sandwich Generation will decline faster than the global average. Second, we project that the number of years parents and grandparents will spend in a sandwich state will be relatively stable. The duration of the parental sandwichness is expected to decrease in all regions of the world except Europe and North America, where it will not change. Globally, the mean number of years that grandparents will spend sandwiched between young grandchildren and their own older parents will also remain unchanged. However, the average duration of grandparental sandwichness is expected to increase in Asia and Sub-Saharan Africa. Seen from the perspective of the parents of young children, grandparents represent an important resource that is in increasing demand. In most of the developing world, we project an increase in the life span overlap between grandparents and their grandchildren. However, countries in Europe and North America might have reached a peak in the potential life span overlap with grandparents, which is projected to decrease over the next decades. This points to a potential decline in the role of grandparents in intergenerational family relationships in the Global North, a trend that is amplified by increasing female labor force participation and geographical distance between family members. In short, we have found that the demands on parents and grandparents to spend time caring for family members vary around the world. This care burden is heaviest for people in the Global South, although increases in intergenerational overlap imply that there is a potential for more exchanges of care and support between generations in these regions. Indeed, the full potential of grandparenthood in particular has yet to materialize in a large number of countries.

Notes

Acknowledgments

We thank the anonymous reviewers for their insightful feedback, Ugofilippo Basellini, Andre Grow, and Daniela Negraia for useful comments, Maximilian Frentz for research assistance, and Patrick Gerland for support with the UNWPP estimates. Earlier versions of the paper were presented at the *Annual Conference of the Population Association of America* in 2011 and 2014. In its current form, the paper was presented at the *Work-in-progress Workshop* of the Lab of Digital and Computational Demography at the Max Planck Institute for Demographic Research and at the *Population and Health Research Group Seminar Series* of the University of St Andrews.

[1] This North-South distinction is a simplification that is not intended to represent geography. Instead, it reflects structural and economic inequalities between countries. The Global South refers to countries in Latin America, the Caribbean, Africa, Asia, and the Pacific.

Data availability

All data used in this study are publicly available. Estimates from the 2019 Revision of the United Nations World Population Prospects (historical and projected) can be found online, https://population.un.org/wpp/ The microsimulation outputs and replication files are posted at the Harvard Dataverse, https://doi.org/10.7910/DVN/SSZL6U.

References

Aazami, Sanaz, Khadijah Shamsuddin, and Syaqirah Akmal. 2018. "Assessment of Work–Family Conflict Among Women of the Sandwich Generation." *Journal of Adult Development* 25 (2): 135–140.

Amirkhanyan, A. A., and D. A. Wolf. 2006. "Parent Care and the Stress Process: Findings from Panel Data." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 61 (5): S248–S255.

Arpino, Bruno, and Valeria Bordone. 2014. "Does Grandparenting Pay Off? The Effect of Child Care on Grandparents' Cognitive Functioning: Effect of Child Care on Grandparents' Cognition." *Journal of Marriage and Family* 76 (2): 337–351.

Arpino, Bruno, Valeria Bordone, and Nicoletta Balbo. 2018. "Grandparenting, Education and Subjective Well-Being of Older Europeans." *European Journal of Ageing* 15 (3): 251–263.

Bratberg, E. 2002. "'The Double Burden': Do Combinations of Career and Family Obligations Increase Sickness Absence Among Women?" *European Sociological Review* 18 (2): 233–249.

Bryceson, Deborah Fahy. 2019. "Transnational Families Negotiating Migration and Care Life Cycles across Nation-State Borders." *Journal of Ethnic and Migration Studies* 45(16):3042–3064.

Brody, E. M. 1981. ""Women in the Middle" and Family Help to Older People." *The Gerontologist* 21 (5): 471–480.

Chen, Feinian, Christine A. Mair, Luoman Bao, and Yang Claire Yang. 2015. "Race/Ethnic Differentials in the Health Consequences of Caring for Grandchildren for Grandparents." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 70 (5): 793–803.

Coe, Norma B., and Courtney Harold Van Houtven. 2009. "Caring for Mom and Neglecting Yourself? The Health Effects of Caring for an Elderly Parent." *Health Economics* 18 (9): 991–1010.

Daatland, Svein Olav, Marijke Veenstra, and Ivar A. Lima. 2010. "Norwegian Sandwiches: On the Prevalence and Consequences of Family and Work Role Squeezes over the Life Course." *European Journal of Ageing* 7 (4): 271–281.

Do, Elizabeth K, Steven A Cohen, and Monique J Brown. 2014. "Socioeconomic and Demographic Factors Modify the Association Between Informal Caregiving and Health in the Sandwich Generation." *BMC Public Health* 14 (1): 362.

D'Ovidio, Fabrizio, Angelo d'Errico, Cecilia Scarinzi, and Giuseppe Costa. 2015. "Increased Incidence of Coronary Heart Disease Associated with 'Double Burden' in a Cohort of Italian Women." *Social Science & Medicine* 135 (June): 40–46.

Dukhovnov, Denys, and Emilio Zagheni. 2015. “Who Takes Care of Whom in the United States? Time Transfers by Age and Sex.” *Population and Development Review* 41 (2): 183–206.

Ennis, Edel, and Brendan P Bunting. 2013. “Family Burden, Family Health and Personal Mental Health.” *BMC Public Health* 13 (1): 255.

Francavilla, F., G. C. Giannelli, L. Mangiavacchi, and L. Piccoli. 2013. “Unpaid Family Work in Europe: Gender and Country Differences.” In *Gender and the European Labour Market*, 53–72.

Fuller-Thomson, Esme. 2005. “Canadian First Nations Grandparents Raising Grandchildren: A Portrait in Resilience.” *The International Journal of Aging and Human Development* 60 (4): 331–342.

Gietel-Basten, Stuart, Silvia E. Giorguli Saucedo, and Sergei Scherbov. 2020. “Prospective Measures of Aging for Central and South America.” Edited by Bernardo Lanza Queiroz. *PLOS ONE* 15 (7): e0236280.

Goldstein, Josh, Carl Mason, and Emilio Zagheni. 2010. “Can Grandma help with the Kids, or does Mom Need to Care for Grandma, or is Grandma Herself Busy Taking Care of Great-Grandma?” Paper presented at the *Annual Meeting of the Population Association of America, Washington, DC, 2011*. https://paa2011.princeton.edu/papers/111124.

Goodman, L. A., N. Keyfitz, and T. W. Pullum. 1974. “Family Formation and the Frequency of Various Kinship Relationships.” *Theor Popul Biol* 5 (1): 1–27.

Grundy, Emily, and John C. Henretta. 2006. “Between Elderly Parents and Adult Children: A New Look at the Intergenerational Care Provided by the ‘Sandwich Generation’.” *Ageing and Society* 26 (5): 707–722.

Hammel, E., D Hutchinson, K Wachter, R Lundy, and R Deuel. 1976. *The SOCSIM Demographic-Sociological Microsimulation Program: Operating Manual*. Institute of International Studies. University of California Berkeley.

Hayslip, Bert, Christine A Fruhauf, and Megan L Dolbin-MacNab. 2019. “Grandparents Raising Grandchildren: What Have We Learned over the Past Decade?” *The Gerontologist* 59 (3): e152–e163.

Hämäläinen, Hans, and Antti O. Tanskanen. 2019. “‘Sandwich Generation’: Generational Transfers Towards Adult Children and Elderly Parents.” *Journal of Family Studies,* March, 1–20.

Helle, S. 2002. “Sons Reduced Maternal Longevity in Preindustrial Humans.” *Science* 296 (5570): 1085.

Hurt, L. S, C Ronsmans, and M Quigley. 2006. “Does the Number of Sons Born Affect Long-Term Mortality of Parents? A Cohort Study in Rural Bangladesh.” *Proceedings of the Royal Society B: Biological Sciences* 273 (1583): 149–155.

Kopera-Frye, K. 2009. “Needs and Issues of Latino and Native American Nonparental Relative Caregivers: Strengths and Challenges Within a Cultural Context.” *Family and Consumer Sciences Research Journal* 37 (3): 394–410.

Legg, Lynn, Chris J Weir, P Langhorne, L N Smith, and D J Stott. 2013. “Is Informal Caregiving Independently Associated with Poor Health? A Population-Based Study.” *Journal of Epidemiology and Community Health* 67 (1): 95–97.

Lima, Everton Emanuel Campos de, Maria Carolina Tomás, and Bernardo Lanza Queiroz. 2015. "The Sandwich Generation in Brazil: Demographic Determinants and Implications." *Revista Latinoamericana de Población* 9 (16): 59–73.

Lutz, Wolfgang, Anne Goujon, Samir Kc, Marcin Stonawski, and Nikolaos Stilianakis. 2018. *Demographic and Human Capital Scenarios for the 21st Century: 2018 Assessment for 201 Countries*. Publications Office of the European Union.

Lutz, Wolfgang, Erich Striessnig, Anna Dimitrova, Simone Ghislandi, Anastasia Lijadi, Claudia Reiter, Sonja Spitzer, and Dilek Yildiz. 2021. "Years of Good Life Is a Well-Being Indicator Designed to Serve Research on Sustainability." *Proceedings of the National Academy of Sciences* 118(12):e1907351118.

Margolis, Rachel, and Ashton M. Verdery. 2019. "A Cohort Perspective on the Demography of Grandparenthood: Past, Present, and Future Changes in Race and Sex Disparities in the United States." *Demography* 56 (4): 1495–1518.

Margolis, Rachel, and Laura Wright. 2016. "Older Adults with Three Generations of Kin: Prevalence, Correlates, and Transfers." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 72(6): 1067–1072.

Margolis, Rachel, and Laura Wright. 2017. "Healthy Grandparenthood: How Long Is It, and How Has It Changed?" *Demography* 54 (6): 2073–2099.

Mba, Chuks J. 2010. "Population Ageing in Ghana: Research Gaps and the Way Forward." *Journal of Aging Research* 2010: 1–8.

McGarrigle, Christine A., Hilary Cronin, and Rose Anne Kenny. 2014. "The Impact of Being the Intermediate Caring Generation and Intergenerational Transfers on Self-Reported Health of Women in Ireland." *International Journal of Public Health* 59 (2): 301–308.

Musil, Carol M., Nahida L. Gordon, Camille B. Warner, Jaclene A. Zauszniewski, Theresa Standing, and May Wykle. 2011. "Grandmothers and Caregiving to Grandchildren: Continuity, Change, and Outcomes over 24 Months." *The Gerontologist* 51 (1): 86–100.

Neely-Barnes, S. L., J. Carolyn Graff, and G. Washington. 2010. "The Health-Related Quality of Life of Custodial Grandparents." *Health & Social Work* 35 (2): 87–97.

Negraia, Daniela Veronica, Jennifer March Augustine, and Kate Chambers Prickett. 2018. "Gender Disparities in Parenting Time Across Activities, Child Ages, and Educational Groups." *Journal of Family Issues* 39 (11): 3006–3028.

Perrig-Chiello, Pasqualina, and François Höpflinger. 2005. "Aging Parents and Their Middle-Aged Children: Demographic and Psychosocial Challenges." *European Journal of Ageing* 2 (3): 183–191.

Sanderson, Warren C., and Sergei Scherbov. 2010. "Remeasuring Aging." *Science* 329 (5997): 1287–1288.

Schmitz, Hendrik, and Magdalena A. Stroka. 2013. "Health and the Double Burden of Full-Time Work and Informal Care Provision — Evidence from Administrative Data." *Labour Economics* 24 (October): 305–322.

Schwartz, AN. 1977. *Survival Handbook for Children of Aging Parents*. New York: Follet.

Sear, Rebecca, and David Coall. 2011. “How Much Does Family Matter? Cooperative Breeding and the Demographic Transition.” *Population and Development Review* 37 (s1): 81–112.

Sear, R, and R Mace. 2008. “Who Keeps Children Alive? A Review of the Effects of Kin on Child Survival.” *Evolution and Human Behavior* 29 (1): 1–18.

Silverstein, Merril, Aviad Tur-Sinai, and Noah Lewin-Epstein. 2020. “Intergenerational Support of Older Adults by the ‘Mature’ Sandwich Generation: The Relevance of National Policy Regimes.” *Theoretical Inquiries in Law* 21 (1): 55–76.

Song, Xi, and Robert D. Mare. 2019. “Shared Lifetimes, Multigenerational Exposure, and Educational Mobility.” *Demography* 56 (3): 891–916.

Triadó, Carme, Feliciano Villar, Montserrat Celdrán, and Carme Solé. 2014. “Grandparents Who Provide Auxiliary Care for Their Grandchildren: Satisfaction, Difficulties, and Impact on Their Health and Well-Being.” *Journal of Intergenerational Relationships* 12 (2): 113–127.

Urdinola, B. Piedad, and Jorge A. Tovar, eds. 2019. *Time Use and Transfers in the Americas: Producing, Consuming, and Sharing Time Across Generations and Genders*. Cham: Springer International Publishing.

Verdery, Ashton M., and Rachel Margolis. 2017. “Projections of White and Black Older Adults Without Living Kin in the United States, 2015 to 2060.” *Proceedings of the National Academy of Sciences* 114 (42): 11109–11114.

Verdery, Ashton M., Emily Smith-Greenaway, Rachel Margolis, and Jonathan Daw. 2020. “Tracking the Reach of COVID-19 Kin Loss with a Bereavement Multiplier Applied to the United States.” *Proceedings of the National Academy of Sciences* 117 (30): 17695–17701.

Wachter, Kennethl W. 1997. “Kinship Resources for the Elderly.” Edited by J. Grimley Evans, R. Holliday, T. B. L. Kirkwood, P. Laslett, and L. Tyler. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 352 (1363): 1811–1817.

Xu, Hongwei. 2019. “Physical and Mental Health of Chinese Grandparents Caring for Grandchildren and Great-Grandparents.” *Social Science & Medicine* 229 (May): 106–116.

Zagheni, Emilio. 2011. “The Impact of the HIV/AIDS Epidemic on Kinship Resources for Orphans in Zimbabwe.” *Population and Development Review* 37 (4): 761–783.

Zagheni, Emilio, and Marina Zannella. 2013. “The Life Cycle Dimension of Time Transfers in Europe.” *Demographic Research* 29 (November): 937–948.

Zannella, Marina, Bernhard Hammer, Alexia Prskawetz, and Jože Sambt. 2019. “A Quantitative Assessment of the Rush Hour of Life in Austria, Italy and Slovenia.” *European Journal of Population* 35 (4): 751–776.

Zimmer, Zachary, and Emily Treleaven. 2020. “The Rise and Prominence of Skip-Generation Households in Lower- and Middle-Income Countries.” *Population and Development Review* 46(4): 709-753.

Železná, Lada. 2018. “Care-Giving to Grandchildren and Elderly Parents: Role Conflict or Family Solidarity?” *Ageing and Society* 38 (5): 974–994.

Appendix: Supplemental Materials

Notation

In this paper, ${}_nm_x$ refers to fertility rates, ${}_nasmr_x$ refers to age-specific mortality rates, and ${}_nl_x$ refers to survival probabilities up to age x. We follow traditional demographic notation for these quantities, meaning that the right subscript indicates age and the left subscript (specified only when needed) indicates the length of the age interval (Preston, Heuveline, and Guillot 2001). For example ${}_1m_{x+a}$ should be interpreted as the single-age probability of giving birth for a woman aged $(x + a)$ in a stable population. When dealing with non-stable populations, we add a reference to the year of birth c in parentheses so that ${}_1m_{x+a}(c)$ represents the probability of giving birth for a woman aged $(x + a)$ born in year c.

The latter should not be confused with $M_1(a, c)$ which, following the original notation of the Goodman, Keyfitz, and Pullum kinship equations (GKP) (1974) refers to the probability that a woman aged a born in year c has a living mother. Note that the $_1$ subscript in this case refers to the generation of the mother seen from the daughter's perspective (i.e. $M_2(a, c)$ is the probability of having a living grandmother, and so on). Similarly, following GKP convention, the age a is written inside the parentheses in $M_1(a, c)$ and not as a subscript (the same is true for other non-conventional measures introduced in the paper such as $S(a, c)$, the probability of being sandwiched at age a for a woman born in year c). The birth cohort c is always written in parentheses for all measures.

Estimating sandwichness in stable and non-stable populations with changing demographic rates

In the main text, we provided a formal analysis of the demographic dynamics driving sandwichness in a stable female population (Eq. 1-3), but left out some important considerations. Figure 1 in the main text was produced using stable population formulas (Keyfitz and Caswell 2005) and age-specific fertility and mortality rates. We obtained mortality and fertility rates from the 2019 Revision of the United Nations World Population Prospects (UNWPP). The input data are the 1950-2000 cohorts for 198 countries and territories approximated from reported and projected period rates in the UNWPP data. Other combinations of mortality and fertility are theoretically possible (e.g., simultaneous low fertility and high mortality), but have not been observed at the country level since 1950, and they are not projected to occur before 2100.

Our approximation of $M_1(a)$, the probability of having a living mother at age a in a stable population required the mean age at childbearing. The equation was:

$$M_1(a) \approx \frac{l_{\mu+a}}{l_\mu}$$

We estimate μ, the mean age at childbearing in a stable population, as:

$$\mu = \frac{\sum_{15}^{50}(x+0.5)e^{-r(x+0.5)}m_x l_x}{\sum_{15}^{50} e^{-r(x+0.5)}m_x l_x} \tag{A1}$$

where l_x is the probability of surviving to age x, m_x is the probability of giving birth for a woman aged x and r is the iterative solution of Lotka's intrinsic growth rate (Coale 1957).

Unfortunately, Eq. 1-3 in the main text do not reflect a realistic model, because fertility and mortality change constantly in real populations. As a concession to reality, we introduce discrete time in our model via the subscript c, a woman's birth cohort, to estimate the probability of maternal sandwichness at age a for a woman born in year c in a population subject to changing demographic rates:

$$S(a,c) = \underbrace{\left(1 - \prod_{x=1}^{\kappa}[1 - {}_1m_{a-x}(c)]\right)}_{\substack{\text{Prob. of having given} \\ \text{birth in } \kappa \text{ preceding years}}} \times \underbrace{M_1(a,c)}_{\substack{\text{Prob. that mother of ego} \\ \text{is alive when ego is } a \text{ years old}}} \times \underbrace{\left(1 - \frac{M_1(a+\tau,c)}{M_1(a,c)}\right)}_{\substack{\text{Prob. that mother of ego} \\ \text{would die within } \tau \text{ years}}} \tag{A2}$$

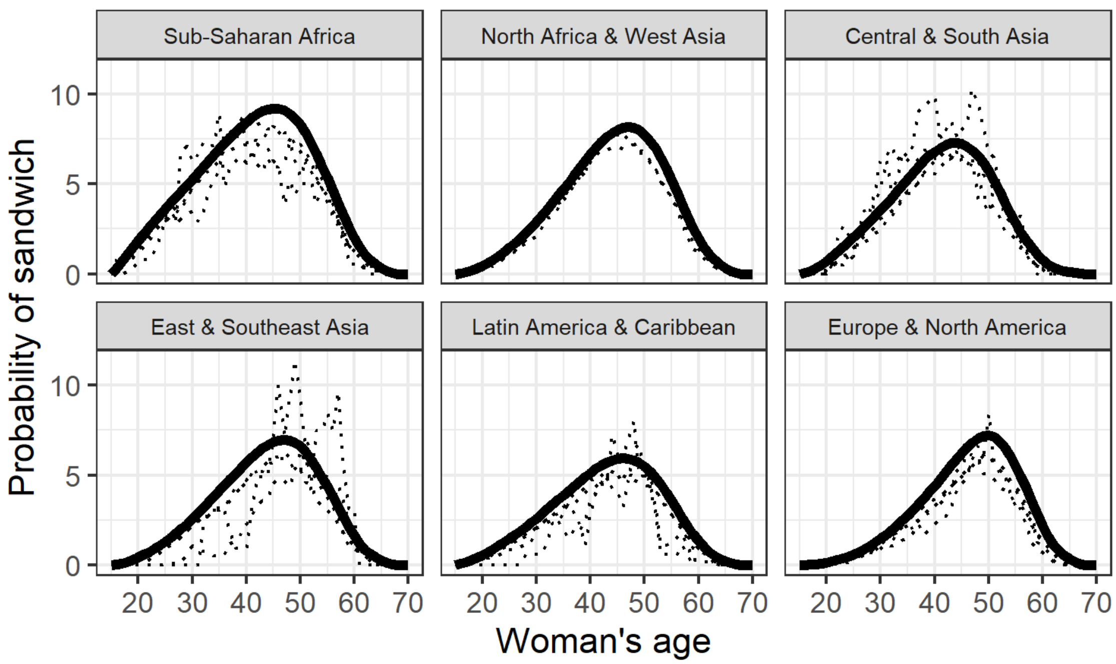
where ${}_1m_{a-x}(c)$ is the single-age age-specific fertility rate for women of age $(a-x)$, born in the year c and $M_1(a,c)$ is the probability of having a living mother at age a for an average woman born in year c. As before, κ is the minimum age for a child whose mother would be sandwiched if and only if she simultaneously had a parent within τ years of death. Building on the Goodman, Keyfitz, and Pullum kinship equations (GKP) (1974), we define the survival probability for the mother of Ego $M_1(a,c)$ as:

$$M_1(a,c) = \sum_{x=\alpha}^{\beta}\left(\underbrace{\frac{{}_1m_x(c-x)K_x(c-x)}{\sum_{x=\alpha}^{\beta}[{}_1m_x(c-x)K_x(c-x)]}}_{distribution\ of\ mothers} \times \underbrace{\frac{{}_1l_{x+a}(c-x)}{{}_1l_x(c-x)}}_{mother\ survival}\right) \tag{A3}$$

where $K_x(c-x)$ is the size of the female population of age x at time $(c-x)$: women who were born in year $(c-x)$ and survived until age x. ${}_1l_{x+a}(c-x)$ denotes the probability of surviving to age $(x + a)$ for women born in year $(c - x)$. As is standard in demography, we restrict the female reproductive age $[\alpha, \beta]$ to the range $(\alpha, \beta, n) = (15,49,1)$. Our model requires single-age and single-year cohort demographic rates, which we approximate from the grouped UNWPP period rates.

Figure A1 shows that the model and the microsimulation estimates are generally consistent (the average correlation coefficient over all countries for the 2000-2020 cohorts was 0.92 and the mean difference was 0.01).

Figure A1. Simulation validation: age-specific probability of being sandwiched over the life course for women born in the year 2000 (mean values).



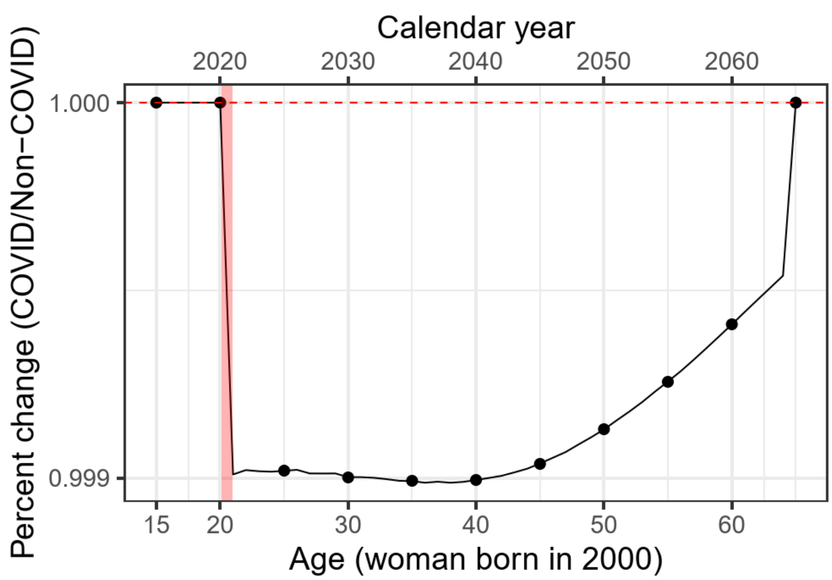
NOTE: Women are sandwiched if they simultaneously have one or more children aged 15 or younger while having a mother within five years of death. The solid lines are estimates from the discrete-time model in Eq. A2 (Supplementary Appendix). Each dashed line represents the regional average of a different SOCSIM microsimulation (five simulations per country).

Implications of the current COVID-19 pandemic for the Sandwich Generation

The effects of the ongoing COVID-19 pandemic on the size and the duration of the Sandwich Generation are uncertain. There have been attempts to estimate how the disease will interact with kinship dynamics in single countries (Verdery et al. 2020), but at the moment of writing, there were no quality data on the demographic consequences of the pandemic for most of the countries considered in this study. While early studies of COVID-19 mortality have shown that the case fatality rates are higher at older ages (Dowd et al. 2020), this is not necessarily the case for countries in the Global South (which lack quality data) (Nepomuceno et al. 2020). Indeed, the greatest challenge is the impossibility of knowing the future trajectory of the disease even for the few countries that do report reliable data.

Keeping these limitations in mind, we use discrete-time formal models to provide an intuitive understanding of the potential effects of COVID-19 on global trends of sandwichness. To do so, we consider the potential effects of the COVID-19 pandemic on the probability of being sandwiched between a mother within five years of death and a young child under 15 years of age in England. We estimate the life course probability of sandwichness for a woman born in 2000 (i.e., aged 20 at the onset of the COVID-19 pandemic) using demographic rates from the UNWPP and excess mortality rates provided by Public Health England for the first half of 2020 (Table A1). This exercise is not intended to provide accurate estimates of the effects of the pandemic on trends of sandwichness, but, rather, to provide a qualitative understanding of the expected direction and magnitude of these effects, conditional on the information currently available and a set of assumptions presented below. We focus on England because it was hit hard by the COVID-19 pandemic in the first half of 2020, and has published official data on COVID-19 age-specific excess mortality rates.

FIGURE A2 Relative change in the probability of being sandwiched over the life course for a randomly selected woman born in 2000 England (mean values).



NOTE: Women are sandwiched if they simultaneously have one or more children aged 15 or younger while having a mother within five years of death. The vertical rectangle shows the period during which the observed excess mortality rates are at play.

We use a formal model similar to the one presented in Eq. A2-A3 to estimate the probability of sandwichness over the life course for a woman born in cohort c:

$$S(a,c) = \underbrace{\left(1 - \prod_{x=1}^{15}[\,1 - {}_1m_{a-x}(c)]\right)}_{\substack{\text{Prob. of having given} \\ \text{birth in } \kappa \text{ preceding years}}} \times \underbrace{M_1^*(a,c)}_{\substack{\text{Prob. that mother of ego} \\ \text{is alive when ego is } a \text{ years old}}} \times \underbrace{\left(1 - \frac{M_1^*(a+5,c)}{M_1^*(a,c)}\right)}_{\substack{\text{Prob. that mother of ego} \\ \text{would die within 5 } years}} \qquad A4$$

where the probability of having a living mother at age a is:

$$M_1^*(a,c) = \sum_{x=\alpha}^{49}\left(\underbrace{\frac{{}_1m_x(c-x)K_x^*(c-x)}{\sum_{x=\alpha}^{49}[{}_1m_x(c-x)K_x(c-x)]}}_{distribution\ of\ mothers} \times \underbrace{\frac{{}_1l_{x+a}^*(c-x)}{{}_1l_x^*(c-x)}}_{mother\ survival}\right) \qquad A5$$

We account for COVID-19 excess mortality by re-weighting the life-table measures in Eq. A5 using preliminary data on all-cause excess mortality rates in England. In particular, we use standard life-table formulas (Preston, Heuveline, and Guillot 2001) to re-estimate the adjusted survivorship column:

$${}_1l_x^* = {}_1l_0 \times \prod_{a=0}^{x}\left(1 - \frac{{}_1asmr_a \times w(a)}{1 + [1 - 0.5 \times {}_1asmr_a \times w(a)]}\right) \qquad A6$$

where ${}_1l_0$ is the life-table radix, ${}_1asmr_a$ are the unweighted age-specific mortality rates from the UNWPP, and $w(a)$ is an age-specific adjustment factor derived from the excess mortality rates in Table A1 ($0 \leq x \leq 100$). We estimate K_x^*, the distribution of women, by substituting ${}_1l_0$ in Eq. A6 by the initial size of the 2000 birth cohort of women in England (i.e., the number of girls born in 2000 estimated using UNWPP data). We use the adjusted ${}_1l_x^*$ and K_x^* values for the 2020-2021 period, and assume that fertility and mortality remain unchanged in all other periods (after 2020, we use the UNWPP projected rates). We further assume that the excess mortality rates recorded between March and July 2020 apply throughout 2020. Thus, we are likely to overestimate mortality in 2020 by assuming that the death rate observed at the peak of the first wave of the pandemic applies throughout the entire year. We assume that the excess mortality rates of the broader age groups in Table A1 apply to each single-year age group (e.g., the excess mortality rates provide a 0-14 age group, whereas our model uses single age groups). Finally, we assume that fertility is unaffected by the pandemic and that mortality levels revert to the UNWPP projected values after the end of the pandemic. Recent evidence suggests a potential “baby bust” in high-income countries (Sobotka et al., 2021). However, evidence of the long-term effect of the ongoing pandemic on fertility are needed to assess how it will affect sandwichness. These simplifying assumptions allow us to observe the expected effect of a sudden and short-lived increase in age-specific mortality concentrated at old ages on the probability of being sandwiched between an older parent and a dependent young child.

Our analysis suggests that the size of the Sandwich Generation after the pandemic could be slightly smaller than the values presented in this paper due to an increased prevalence of maternal orphans. However, we anticipate that this effect will be negligible ($<$ 0.001% change). Figure A2 shows the relative difference between two models: one accounting for COVID-19 mortality and one "counterfactual" model that relies entirely on the UNWPP historical and projected demographic rates. Lower values indicate a lower probability of sandwichness in the model accounting for COVID mortality relative to the counterfactual model.[1] We find that after 2020, when the pandemic is assumed to have ended in our simplified model, the probability of sandwichness is marginally lower in the COVID-19 model than in the counterfactual model, as the high mortality of 2020 has reduced the probability of a given person having a living parent after the pandemic. This small effect is unlikely to affect the estimates presented in the main text of this paper. We emphasize that this is not intended to be a thorough analysis of the consequences of the COVID-19 pandemic on generational overlap. Rather, we aim to show the direction and approximate size of the effect of a temporary mortality surge on the prevalence of maternal sandwichness.

TABLE A1 Sex- and age-specific all-cause excess mortality rate in England (20 Mar - 17 Jul 2020).

Age	Female	Male
0-14	0.94	0.92
15-44	1.16	1.12
45-64	1.29	1.39
65-74	1.28	1.36
75-84	1.31	1.38
85+	1.34	1.37

SOURCE: Public Health England. Retrieved on 04 Aug 2020 from: https://fingertips.phe.org.uk/static-reports/mortality-surveillance/excess-mortality-in-england-latest.html.

[1] Note that in Figure A2 we coerce the values up to calendar year 2020 (i.e., ego's age 20) to one since the pandemic cannot affect the frailty of parents retrospectively. Without this correction, the model would predict a spike in the five years before 2020 to reflect the sudden increase in mortality that year. This is an artifice of our definition of sandwichness, as people who die suddenly in 2020 cannot be considered to be frail in, for example, 2016.

Demographic microsimulation strategy

SOCSIM is an open source and extensible demographic microsimulation program, developed at UC Berkeley (Hammel et al. 1976).[2] It is efficiently written in the programming language C and takes full advantage of arrays of linked lists to keep track of kinship relationships and to store information about every single simulated individual. The simulator takes as input initial population files and demographic rates. Our simulation uses historical estimates and projections of age-specific mortality and fertility rates for territories published by the 2019 Revision of the United Nations' World Population Prospects.[3] The individual is the unit of analysis of the simulator. Each person is subject to a set of rates, expressed as monthly probabilities of events, given certain demographic characteristics, like age and sex. Every month, each individual faces the risk of experiencing a number of events, including childbirth, death, and marriage. The selection of the event and the waiting time until the event occurs are determined stochastically using a competing risk model. Some other constraints are included in the simulation program in order to draw events only for individuals that are eligible for the events (e.g. to allow for a minimum interval of time between births from the same mother, to avoid social taboos such as incest, etc.). Each event for which the individual is at risk is modeled as a piece-wise exponential distribution. The waiting time until each event occurs is randomly generated according to the associated demographic rates. The individual's next event is the one with the shortest waiting time. At the end of the simulation, population files that contain a list of everyone who has ever lived in the population are created. In these files, each individual is an observation in a rectangular data file with records of demographic characteristics for the individual, and identification numbers for key kinship relations.

SOCSIM models "closed" populations. Individuals may enter and exit the simulation only by (simulated) birth and death. This approach enables us to reconstruct the main demographic characteristics of the population and the kin network of any individual at any time. The model includes the entire kinship network of every simulated individual, and thus measures quantities such as months of life spent in coexistence with minor descendants and one or more ascendants less than five years away from death.

In microsimulation, it is essential to balance simplicity against realism: too much of the former produces results that do not reflect important characteristics of the simulated population, while too much of the latter produces results that are so particular as to be uninteresting.

We thread the needle by adopting the following structure for the countries and territories included in the UNWPP:

1. We begin with arbitrary populations of unrelated individuals for the year 1750 calibrated to produce living populations of approximately 50,000 in 2100.

---

[2] For more details about SOCSIM, its history, computer routines and applications, see Hammel et al. (1976), Wachter (1997), and the online documentation available at lab.demog.berkeley.edu/socsim.

[3] Data can be downloaded from https://population.un.org/wpp/.

2. For the period from 1855 to 1955, we use the 1955 rates. Our intention is to begin in 1955 with a stable population.

3. For the period 1955-2100 we use the published UNWPP fertility and mortality rates.

4. For the period 2101-2200 we use the 2100 rates.

5. For all years, fertility rates are neither marital status- nor parity-specific.

6. We generate a "marriage" event and select a living unmarried spouse whenever a previously "unmarried" female has a birth. [marriageOnBirth]

7. Spouses are chosen for each woman from the among all living single men so as to minimize the squared difference between the observed distribution of (groom's age bride's age) and a normal distribution with a mean of two and a standard deviation of three.

Item 6 requires further explanation. Because the WPP does not provide age-specific marriage rates, and because marriage practices differ so widely across the world, we created "marriages" whenever a birth occurred to a single female. These unions are not marriages in a sociological sense, but are simply a mechanism that allows us to parse the paternal branch of every individual's kinship network. This procedure introduces a degree of bias in our simulations and makes it impossible for us to investigate single parenthood. It also means that individuals whom we enumerate as ego's "in-laws" are merely the biological grandparents of ego's children.

In accordance with the above rules, we performed five simulations for each country for which the WPP provided fertility and mortality rates (excluding a small number of small island states and dependencies). The results that we present are averages of output quantities of interest obtained from the five runs of the simulator (with the same values of demographic rates as input, but different initial randomly generated seeds).

The analyses in the main text are restricted to the 1970-2040 birth cohorts. We made this conservative cohort selection to increase the validity of our results. The inclusion of data on simulated individuals born before 1970 is generally discouraged. These estimates are likely to be highly influenced by the initial conditions of the simulation (which has changing input period rates only after 1950). We fix the upper limit of our simulation to the 2040 cohort in order to minimize the number of individuals whose simulated life trajectories are determined by demographic rates outside of the 2020-2100 UNWPP projection horizon.

Country grouping

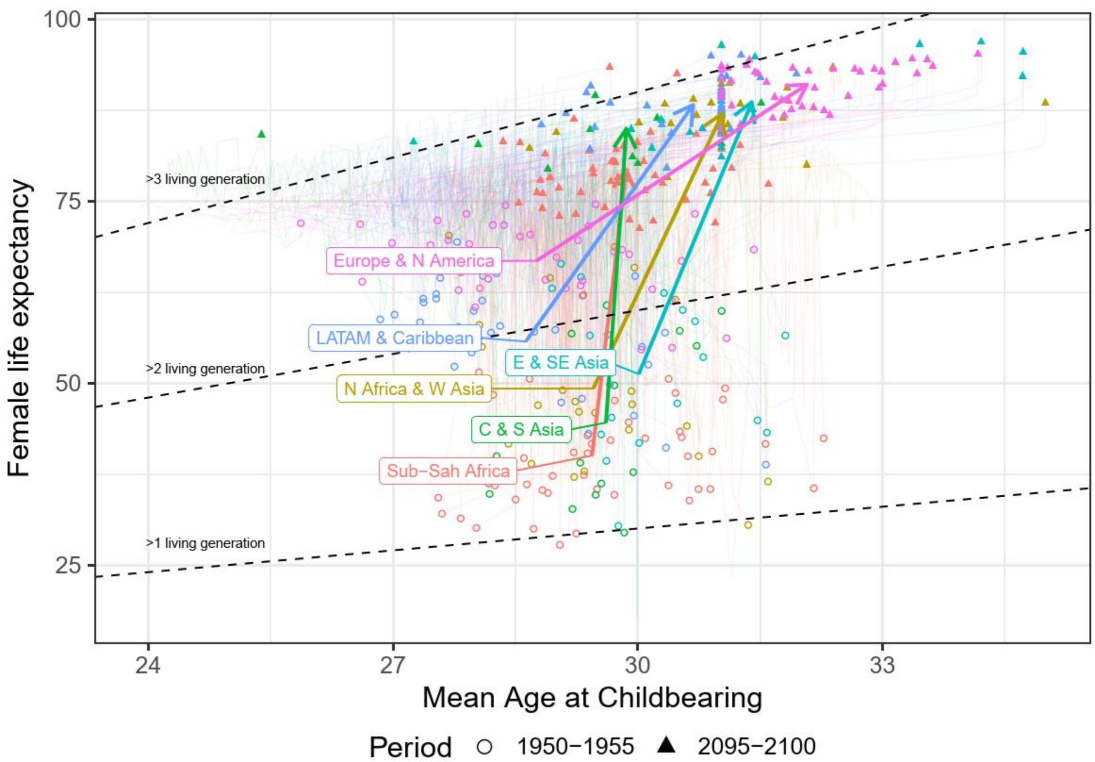
All analyses were conducted at the country level. In the main text, we report regional estimates using the United Nations Sustainable Development Goals (UN SDG) regions, which follow the M49 standard for area codes. Countries are grouped as follows. SUB-SAHARAN AFRICA: Burundi; Comoros; Djibouti; Eritrea; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mayotte; Mozambique; Reunion; Rwanda; Seychelles; Somalia (including Somaliland); South Sudan; Uganda; United Republic of Tanzania; Zambia; Zimbabwe; Angola; Cameroon; Central African Republic; Chad; Congo; Democratic Republic of the Congo; Equatorial Guinea; Gabon; Sao Tome and Principe; Botswana; Eswatini; Lesotho; Namibia; South Africa; Benin; Burkina

Faso; Cabo Verde; Cote d'Ivoire; Gambia; Ghana; Guinea; Guinea-Bissau; Liberia; Mali; Mauritania; Niger; Nigeria; Senegal; Sierra Leone; and Togo. NORTHERN AFRICA AND WESTERN ASIA: Algeria; Egypt; Libya; Morocco (including Western Sahara); Sudan; Tunisia; Western Sahara; Armenia; Azerbaijan; Bahrain; Cyprus (including Northern Cyprus); Georgia; Iraq; Israel; Jordan; Kuwait; Lebanon; Oman; Qatar; Saudi Arabia; State of Palestine; Syrian Arab Republic; Turkey; United Arab Emirates; and Yemen. CENTRAL AND SOUTHERN ASIA: Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan; Afghanistan; Bangladesh; Bhutan; India; Iran (Islamic Republic of); Maldives; Nepal; Pakistan; and Sri Lanka. EASTERN AND SOUTH-EASTERN ASIA: China; Hong Kong SAR; China, Macao SAR; Taiwan; Dem. People's Republic of Korea; Japan; Mongolia; Republic of Korea; Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Philippines; Singapore; Thailand; Timor-Leste; and Viet Nam. LATIN AMERICA AND THE CARIBBEAN: Aruba; Bahamas; Barbados; Cuba; Curacao; Dominican Republic; Grenada; Guadeloupe; Haiti; Jamaica; Martinique; Puerto Rico; Saint Lucia; Saint Vincent and the Grenadines; Trinidad and Tobago; United States, Virgin Islands; Belize; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama; Argentina; Bolivia (Plurinational State of); Chile; Colombia; Ecuador; French Guiana; Guyana; Paraguay; Peru; Suriname; Uruguay; and Venezuela (Bolivarian Republic of). AUSTRALIA/NEW ZEALAND: Australia and New Zealand. OCEANIA (EXCLUDING AUSTRALIA AND NEW ZEALAND): Fiji; New Caledonia; Papua New Guinea; Solomon Islands; Vanuatu; Guam; Kiribati; Micronesia (Fed. States of); French Polynesia; Samoa; and Tonga. EUROPE AND NORTHERN AMERICA: Belarus; Bulgaria; Czechia; Hungary; Poland; Republic of Moldova; Romania; Russian Federation; Slovakia; Ukraine; Channel Islands; Denmark (including Greenland); Estonia; Finland; Iceland; Ireland; Latvia; Lithuania; Norway; Sweden; United Kingdom; Albania; Bosnia and Herzegovina; Croatia; Greece; Italy; Malta; Montenegro; North Macedonia; Portugal; Serbia (including Kosovo); Slovenia; Spain; Austria; Belgium; France; Germany; Luxembourg; Netherlands; Switzerland; and United States of America.

Additional results

We can approximate the mean number of overlapping generations for all world countries as e_0/μ, where the life expectancy at birth e_0 is the average length of life for members of a given birth cohort and the mean age at childbearing μ is the average length of a generation. Figure A3 shows the expected number of living generations for all countries in the world, using historical and projected data from the 2019 Revision of the World Population Prospects (UNWPP). The dashed diagonal lines indicate the combinations of period life expectancy and mean age at child bearing that imply an expected number of one, two, and three overlapping generations. The arrows in the foreground indicate the direction of change from 1950-1955 to 2095-2100 in each world region. Countries in Central and South Asia, for example, are expected to transition from having, on average, fewer than two overlapping generations in 1950-1955 to having almost three overlapping generations in 2095-2100.

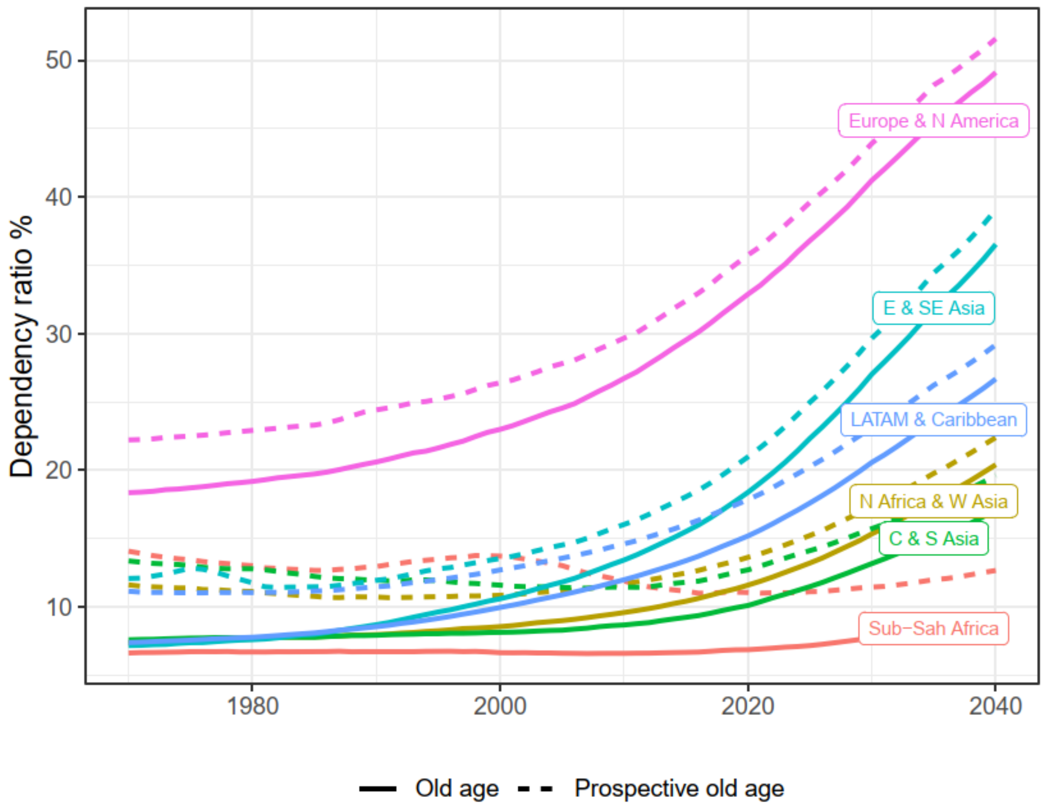
FIGURE A3 Expected number of living generations by country and region (1950-2100 excluding Oceania and Australia).



Note: Faded lines in the background show country-level yearly trajectories. Arrows in the foreground represent the regional trajectories for 1950-1955 and 2095-2100 only (regional averages). Source: Author using data from the 2019 UNWPP.

Figure A4 exemplifies the differences between traditional and prospective measures of aging. See Section **Background** in the main text for more details.

FIGURE A4 Old-age and prospective old-age dependency ratios for all UN Sustainable Development Goals regions for the 1950-2100 period (excluding Oceania and Australia).

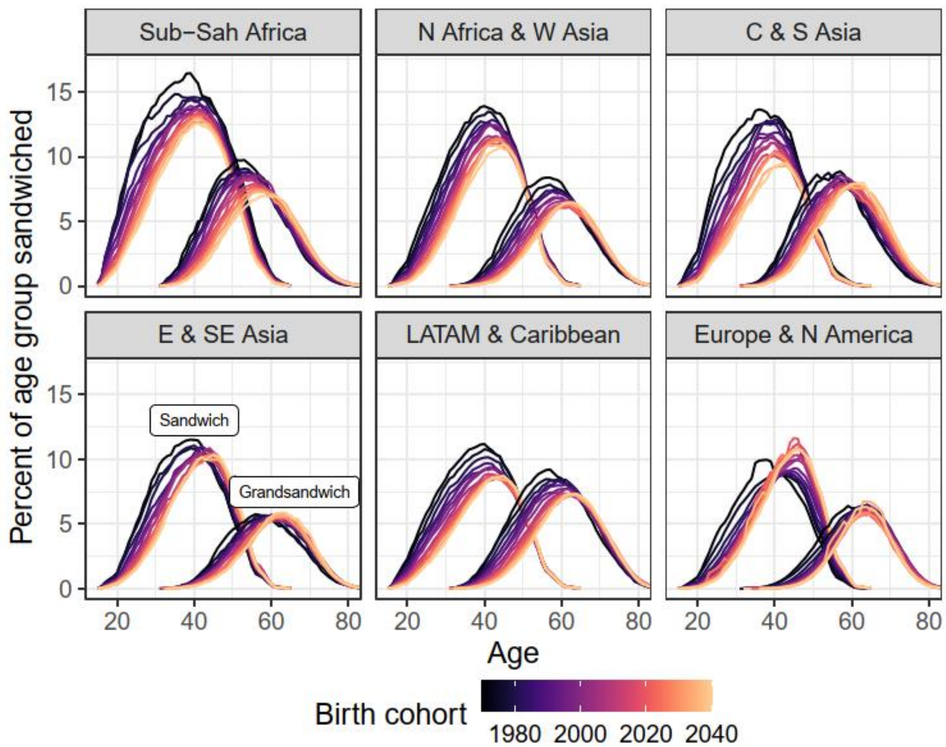


NOTE: Traditional old-age dependency ratios (population aged 65 or older as a share of the population aged 15-64) estimated using UNWPP population estimates and projections. Prospective old-age dependency ratios (population within five years of death over the population aged 15-64) estimated from SOCSIM simulations.

What can we say about the busyness of the so-called "rush hour of life"? Let us now consider the distance between peaks along the vertical axis, which indicates the degree to which parental sandwichness will be more or less common than grandparental sandwichness over the life course. This distance is smallest in Latin America (two percentage points), indicating that individuals in the region are, on average, almost as likely to be sandwiched as they are to be grandsandwiched. The distance is largest in Sub-Saharan Africa (6.7 percentage points), followed by in East and Southeast Asia (5.8 points), where the experience of grandparental sandwichness is expected to be considerably less common than parental sandwichness during an individual's life course. These findings suggest not only that sandwichness will be experienced later in the life, but that the respite period between the onset of parental and grandparental sandwichness will become shorter.

Distribution of parental and grandparental sandwichness over the life course for members of the 1970-2040 birth cohorts (regional means for male and female populations). Higher values indicate that a larger share of a given age group has simultaneous care responsibilities for older parents and young children or grandchildren.

Figure A5 Distribution of parental and grandparental sandwichness over the life course for members of the 1970-2040 birth cohorts.

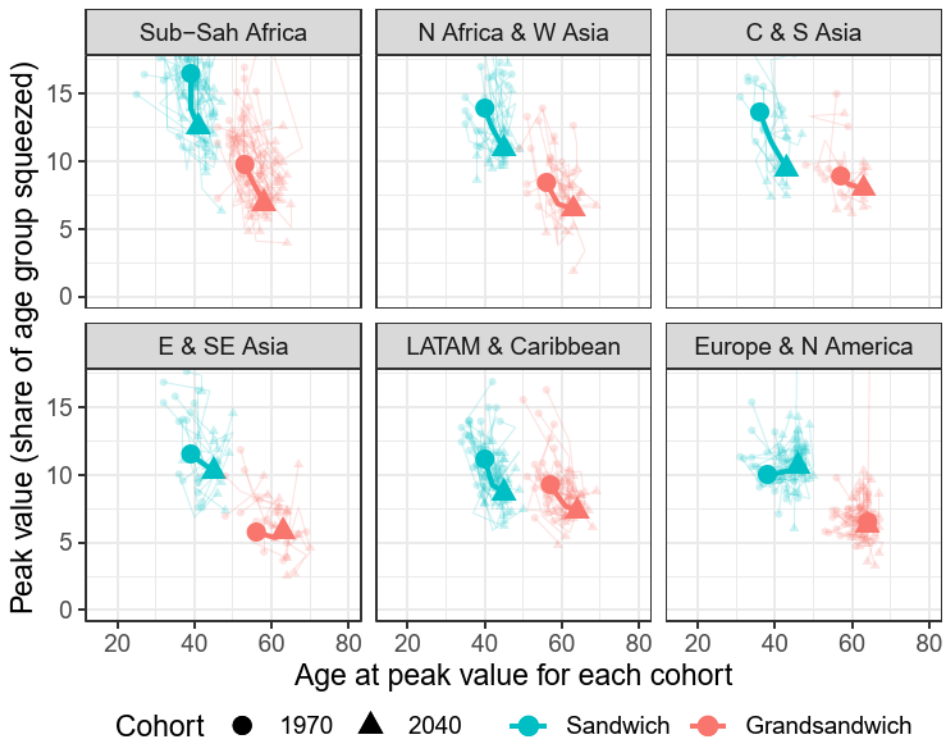


NOTE: Regional means for male and female populations. Higher values indicate that a larger share of a given age group has simultaneous care responsibilities for older parents and young children or grandchildren.

We evaluate the evolution of life course sandwichness for successive birth cohorts by focusing on how the peak values themselves change over time. To simplify this task, we isolate the peak values from Figure A5 corresponding to the 1970 and 2040 cohorts for each region and ignore all other data. The outcome is Figure A6, which tracks the change in the maximum values of parental and grandparental sandwichness for the 1970 (circles) and 2040 (triangles) cohorts. A downward shift in this graph is indicative of a general reduction in the prevalence of sandwichness at all ages. A rightward shift suggests that members of successive generations will experience sandwichness later in life. Figure A6 shows the direction in which the peak values are expected to drift between the 1970 and 2040 cohorts. In general, we see a simultaneous reduction in the magnitude of the phenomena, and an increase in the age at which sandwichness peaks in most world regions. Furthermore, the changes in parental and grandparental sandwichness for Sub-Saharan Africa are largely vertical, indicating a reduction in the magnitude of sandwichness without a corresponding change in the age at which the two phenomena peak. The opposite pattern is observed for East and Southeast Asia and Europe and North America, where we project that the prevalence of parental sandwichness will remain largely unchanged, but the generational squeeze will be experienced later in life.

Changes in the peak values of sandwichness over the life course between the 1970 (circles) and 2040 (triangles) birth cohorts (mean regional values, with country-level estimates presented as faded lines in the background). Rightward shifts imply an increase in the age at which sandwichness peaks. Downward shifts reflect a reduction in the overall prevalence of sandwichness over subsequent birth cohorts.

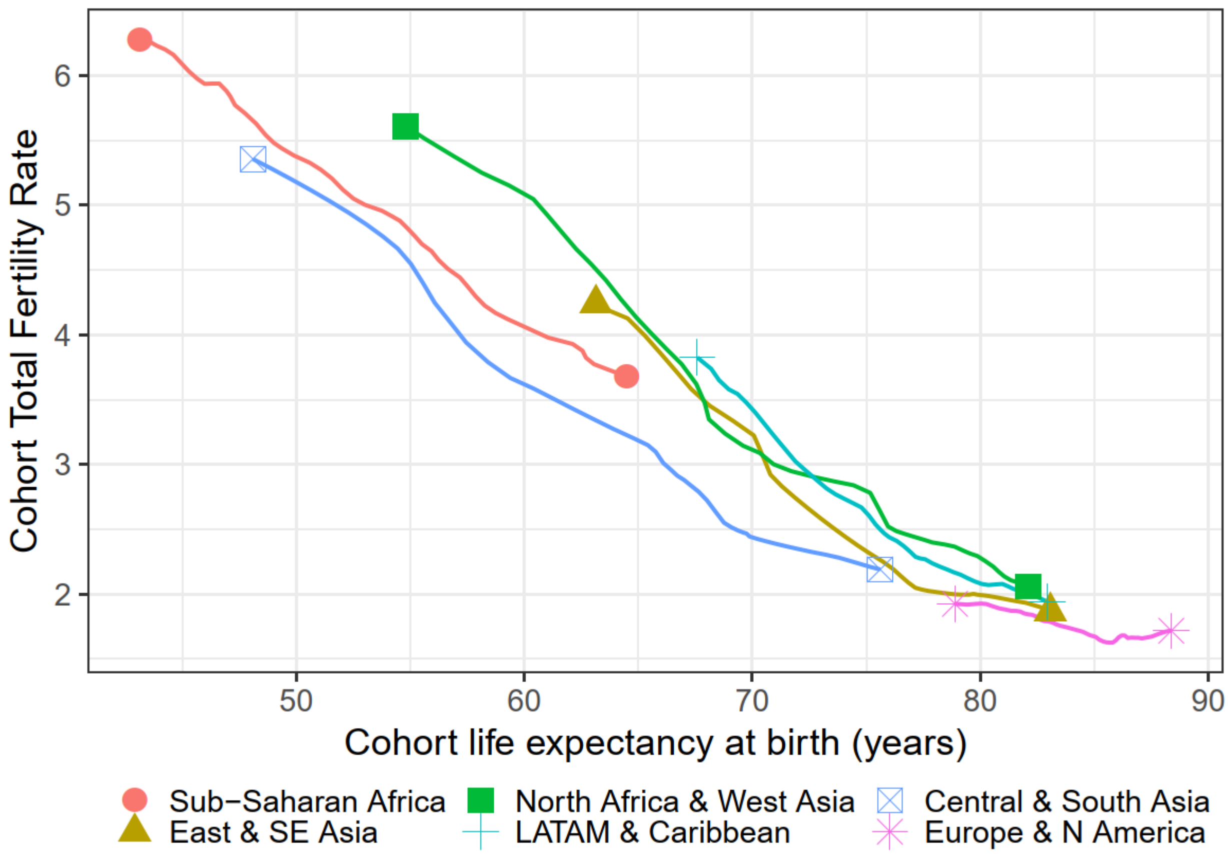
Figure A6 Changes in the peak values of sandwichness over the life course.



NOTE: Estimated change between the 1970 (circles) and 2040 (triangles) birth cohorts (mean regional values, with country-level estimates presented as faded lines in the background). Rightward shifts imply an increase in the age at which sandwichness peaks. Downward shifts reflect a reduction in the overall prevalence of sandwichness over subsequent birth cohorts.

Finally, Figure A7 show the historical and projected development of cohort fertility and mortality rates for the 1950-2000 cohorts, estimated from the 2019 Revision of the UNWPP data. These are the two main components of the Demographic Transition and, as outlined in the main text, help understand the trends of (grand)sandwichness we report.

Figure A7 Cohort fertility and female life expectancy for the 1950-2000 annual birth cohorts by UN Sustainable Development Goals region.



NOTE: Cohorts approximated from UNWPP period data (median values). The DT theory predicts a progression from the top-left of the figure (high fertility and mortality) to the bottom-right (low fertility and mortality) for younger birth cohorts. Regions with longer trajectories are expected to experience the largest fertility and mortality decline. More horizontal trajectories (e.g. Europe and North America) result from increases in mortality but little change in fertility for younger generations. Estimates for Oceania, Australia, and New Zealand omitted

References

Coale, Ansley J. 1957. "A New Method for Calculating Lotka's R-the Intrinsic Rate of Growth in a Stable Population." *Population Studies* 11 (1): 92. https://doi.org/10.2307/2172513.

Dowd, Jennifer Beam, Liliana Andriano, David M. Brazel, Valentina Rotondi, Per Block, Xuejie Ding, Yan Liu, and Melinda C. Mills. 2020. "Demographic Science Aids in Understanding the Spread and Fatality Rates of COVID-19." *Proceedings of the National Academy of Sciences* 117 (18): 9696–8. https://doi.org/10.1073/pnas.2004911117.

Goodman, L. A., N. Keyfitz, and T. W. Pullum. 1974. “Family Formation and the Frequency of Various Kinship Relationships.” *Theor Popul Biol* 5 (1): 1–27.

Hammel, E., D Hutchinson, K Wachter, R Lundy, and R Deuel. 1976. *The SOCSIM Demographic-Sociological Microsimulation Program: Operating Manual*. Institute of International Studies. University of California Berkeley.

Keyfitz, Nathan, and Hal Caswell. 2005. *Applied Mathematical Demography*. New York: Springer.

Nepomuceno, Marília R., Enrique Acosta, Diego Alburez-Gutierrez, José Manuel Aburto, Alain Gagnon, and Cássio M. Turra. 2020. “Besides Population Age Structure, Health and Other Demographic Factors Can Contribute to Understanding the COVID-19 Burden.” *Proceedings of the National Academy of Sciences* 117 (25): 13881–3. https://doi.org/10.1073/pnas.2008760117.

Preston, Samuel H., Patrick Heuveline, and Michel Guillot. 2001. *Demography: Measuring and Modeling Population Processes*. Malden, MA: Blackwell Publishers.

Sobotka, T., Jasilioniene, A., Galarza, A., Zeman, K., Nemeth, L., & Jdanov, D. 2021. “Baby bust in the wake of the COVID-19 pandemic? First results from the new STFF data” SocArXiv. Retrieved 2021-04-08, from: https://doi.org/10.31235/osf.io/mvy62

Verdery, Ashton M., Emily Smith-Greenaway, Rachel Margolis, and Jonathan Daw. 2020. “Tracking the Reach of COVID-19 Kin Loss with a Bereavement Multiplier Applied to the United States.” *Proceedings of the National Academy of Sciences* 117 (30): 17695–17701. https://doi.org/10.1073/pnas.2007476117.

Wachter, Kennethl W. 1997. “Kinship Resources for the Elderly.” Edited by J. Grimley Evans, R. Holliday, T. B. L. Kirkwood, P. Laslett, and L. Tyler. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 352 (1363): 1811–7. https://doi.org/10.1098/rstb.1997.0166.