Correction

SOCIAL SCIENCES

Correction for "Intergenerational resource sharing and mortality in a global perspective," by Tobias Vogt, Fanny Kluge, and Ronald Lee, which was first published August 31, 2020; 10.1073/pnas.1920978117 (*Proc. Natl. Acad. Sci. U.S.A.* **117,** 22793–22799).

The editors note that Luis Rosero-Bixby's affiliation appeared incorrectly as University of California, Berkeley, Oakland, CA. The affiliation should appear as University of Costa Rica, San José, Costa Rica. The online version has been corrected.

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Intergenerational resource sharing and mortality in a global perspective

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Resource sharing has always been a central component of human sociality. Children require heavy investments in human capital; during working years, help is needed due to illness, disability, or bad luck. While hunter-gatherer elders assisted their descendants, more recently, elderly withdraw from work and require assistance as well. Willingness to share has been critically important for our past evolutionary success and our present daily lives. Here, we document a strong linear relationship between the public and private sharing generosity of a society and the average length of life of its members. Our findings from 34 countries on six continents suggest that survival is higher in societies that provide more support and care for one another. We suggest that this support reduces mortality by meeting urgent material needs, but also that sharing generosity may reflect the strength of social connectedness, which itself benefits human health and wellbeing and indirectly raises survival.

intergenerational transfers | mortality differences | prosocial behavior | resource sharing

Intergenerational sharing of resources is pervasive in all societies, both privately within families and through public tax and transfer programs, although the extent and public–private mix of transfers varies across countries (1). Here, we consider the possibility that, in today's societies, this public and private resource sharing might promote health and survival. Previous studies have looked at the impact of specific public programs on the health and longevity of target populations, such as disadvantaged children or the elderly. Here, we take a broader approach, investigating the relation of mortality to the magnitude of total flows of intergenerational transfers across the life course. We use a comprehensive measure of transfers that includes all public programs for people at all life-cycle stages, as well as all private familial transfers, except end-of-life bequests. These intergenerational transfers are only a part of the general relationship between prosocial behaviors and health, but they are a large and quantitatively important part that has so far not been included in these studies.

Like our closer primate relatives, humans are social animals. We have evolved to invest heavily in our long-dependent children and to share resources such as food with others in our groups, even with unrelated individuals, including hunters who have been less successful than ourselves and with families that are disadvantaged by high dependency ratios (2–4). Human sociality has been critically important for our evolutionary and day-to-day success over the past tens of thousands of years. The growing brain and prolonged cognitive development require prolonged parental nutritional investment in offspring until ages 18 or 20, as assessed in studies of today's hunter-gatherer and horticulturalist groups, such as the Tsimane (4), !Kung (5), Ache, Piro, and Machegenga (6, 7) and many others. Relatively short birth intervals and long child dependency together imply that parents must raise a number of simultaneously dependent offspring. Given these heavy nutritional costs, even the joint foraging efforts of the two parents would not suffice without assistance from others, such as grandparents, aunts and uncles, and unrelated group members (2–6).

The beneficial effects of sharing extend beyond interindividual, intrafamilial, or small-group network relationships. They are also found in larger societies where giving and receiving are institutionalized and where shared genes or commonalities are less important. In societies with formalized support systems, humans may still derive emotional rewards from giving, despite the anonymity of individuals and the insecurity about the use of shared resources. One study found that "Human beings around the world derive emotional benefits from using their financial resources to help others (*prosocial spending*)" (8). Another found that mandatory taxation-like transfers to the public good are linked to neurological reward processing (9). Of course, the benefits of formalized transfer systems go beyond emotional reward. They provide resources to sustain the life of recipients who need support. Additionally, they may serve as a precautionary security system for givers who may rely on others' resources in the future.

There is ample evidence that, in modern societies, both public and private investment in the material and emotional wellbeing of children is of great importance to their development, education, economic success as adults, and health and survival in later life. Similarly, a vast array of need-based public-welfare programs and private charitable giving aims to improve the lives and health of individuals with lower incomes or otherwise in vulnerable social positions. Increased pension benefits for East German elderly following reunification reduced their mortality (10). New social pensions in rural China improved the health of both the elderly and children (11). Disability benefits in the United States strongly reduced the mortality of recipients (12).

Significance

Intergenerational transfers are like gifts from one age or generation to another, taking place between relatives, such as from parents to children, or through the public sector, such as retirement benefits or health care from taxpayers. Individual-level studies have found health benefits of giving and/or receiving transfers. Here, we address this topic at the societal level using population-level data for 34 countries to measure the generosity of total transfers received, public plus private, summed over all life-cycle stages, and expressed relative to income. Comparing this comprehensive measure across countries, transfer generosity is negatively related to national mortality and positively related to longevity. This result is consistent with a positive effect of prosocial behavior on health.

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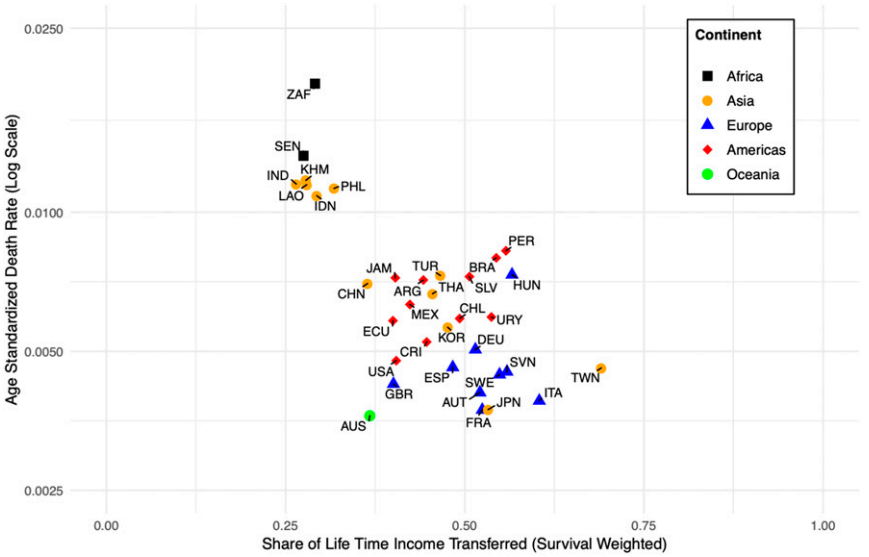

Fig. 1. Age-standardized risk of death and share of lifetime income transferred to others. Data from ref. 52 and The National Transfer Accounts Database, https://www.ntaccounts.org.

There is also evidence that more general social connectedness is itself beneficial. Social capital and prosocial behavior* are positively associated with subjective wellbeing (15). Mortality was reported to be 25% higher among socially isolated individuals than others (16). A meta-analysis of 148 studies found that survival was 50% greater for those with stronger social relationships (17).

We will draw on data from the National Transfer Accounts (NTA) project, which estimates public and private intergenerational transfers by age at the national level for a large number of countries around the world. The particular data requirements of the present study are met by 34 countries around the globe. Using these and other data, we find a strong log-linear association between levels of mortality and the generosity of transfer support across the life course.

Results

Our analysis suggests that differences in sharing generosity across countries are indeed related to mortality disparities. Fig. 1 shows that the log of age-standardized mortality rates declines quite linearly with increasing proportions of lifetime income shared. Countries in Sub-Saharan Africa or South-East Asia share the lowest percentage of their lifetime income and have the highest risk of death of all countries in our study. South Africa, despite being economically more developed than the other African countries, ranks among the other low sharing countries in terms of age-standardized mortality. One reason for South Africa's higher mortality is certainly the HIV epidemic that considerably lowers the chances of many South Africans to survive to higher ages. However, the pattern of comparatively higher mortality, despite advanced economic development, also holds true for other countries.

Western European countries and Japan are among the leaders in sharing resources and achieving low levels of mortality. South American countries also rank high in terms of generosity, as they share more than 60% of an average individual's lifetime income. Their mortality levels remain above the values for Western Europe, Australia, Japan, and Taiwan. Our measure is not bounded above by 1.0, since income can be transferred more than once before being consumed—for example, when pensioners transfer some of their public pension benefits to their own children and grandchildren.

Fig. 1 plots the bivariate association of log mortality and the share of transfers. However, it could be that this association arises from the effect of economic development in general on both transfer generosity and mortality. Likewise, resource sharing could also be a reaction to persisting inequalities in a society. Including gross domestic product (GDP) per capita and Gini coefficients in a regression of mortality on transfer share is a first step toward dealing with this problem and also dealing with a possibly nonlinear relation of mortality to per-capita GDP within a country. It would not be appropriate to include indicators of social development, such as educational attainment or health-care expenditures, since these themselves are mostly public and private transfers. Table 1 shows the results of an ordinary least squares (OLS) regression of mortality on sharing generosity, per capita GDP, and income inequality, and Table 2 shows the results with life expectancy at birth as the dependent variable.

Transfer generosity is strongly associated with the age-standardized risk of death and life expectancy. According to model 1, without GDP per capita, a 10% increase in sharing generosity would reduce mortality by 15%. The elasticity of mortality with respect to sharing generosity declines from 1.15 to 0.43 when we add GDP per capita in model 2, but it remains significant. The elasticity for GDP per capita is 0.21, a considerably lower elasticity than for transfers in model 2. The effect sizes are not altered when we add country-specific Gini indices as a control variable to our model (model 3). Table 2 shows that our results are robust against changes in the indicator used for measuring macro-level health differences. Transfer generosity is also strongly associated with life expectancy at birth and remains significant when we control for economic development and income inequality.

We find the negative relationship between transfer generosity and mortality not only for the whole population, but also for younger and older age groups. This holds true for the age-standardized mortality between age 0 and 20, an age range where children in most countries benefit from public or private transfers in education, health care, or everyday needs (Fig. 2). Countries where smaller shares of lifetime income are shared suffer from comparatively high mortality at younger ages. The risk of death between age 0 and 20 declines for countries that share higher proportions of lifetime income. Within the region of Asia, the negative association

*The term "prosocial behavior" refers to any behavior that seeks to foster the benefits of others and comprises a multitude of different motivations and types of social interactions (13, 14). Here, we apply prosocial behavior as an umbrella term to include all sorts of social interactions from which benefits could be derived.

Table 1. Elasticity of age-standardized mortality with respect to survival-weighted transfer generosity, GDP per capita, and income inequality (OLS regression with logged variables)

	Survival-weighted transfer generosity and age-standardized mortality (model 1)	Survival-weighted transfer generosity and age-standardized mortality controlling for GDP per capita (model 2)	Survival-weighted transfer generosity and age-standardized mortality controlling for GDP per capita and income inequality (model 3)
Constant	−6.00*** (0.17)	−3.50*** (0.43)	−4.60*** (0.91)
Log share of lifetime income transferred	−1.15*** (0.20)	−0.43** (0.18)	−0.46*** (0.18)
Log GDP per capita		−0.21*** (0.03)	−0.19*** (0.04)
Log Gini coefficient			0.24 (0.17)
Adjusted R^2	0.50	0.77	0.77

SEs are in parentheses.
**$P < 0.05$; ***$P < 0.01$.

is strong, but, otherwise, the overall association is driven mostly by differences between regions rather than within them.

The negative relationship between transfer generosity and mortality outcomes is also apparent for older age groups (Fig. 3). Countries in Sub-Saharan Africa and South and South-East Asia who share comparatively little of their lifetime income have the highest levels of old-age mortality among the NTA countries. In France and Japan, the countries with the lowest risk of death, an average individual shares between 68% and 69% of lifetime income, and mortality is roughly two times lower than in China or Turkey, which share 44 to 48% of an average lifetime income. As with mortality 0 to 20, there is a strong association within the Asian region, but, overall, the association emerges mainly from contrasts between regions, not within them. We find a similar pattern of within- and between-region differences for the relationship between GDP per capita and age-standardized mortality for all ages (*SI Appendix*, Fig. S4), but also for young and old age-standardized death rates.

The relationship between transfer generosity and mortality does not depend on the choice of the mortality indicator. We find a similar pattern for the probability of death between birth and age 5, partial life expectancies, or remaining life expectancy at age 65. Also, transformations of our sharing measure do not affect the general transfer–mortality relationship. We used a survival-weighted and unadjusted version of our measure and found no major differences in the general results. Finally, we also decomposed the overall transfer generosity and found a similar pattern between mortality at old and young ages and income shared with these age groups (*SI Appendix*, Figs. S4 and S5).

Discussion

Using a comprehensive measure of public and private intergenerational transfers in a society relative to lifetime income, we have found that the greater the share of transfers, the lower the risk of death. This relationship holds true across countries that have very different transfer mechanisms and country-specific frameworks. For example, older Brazilians and Swedes receive large transfers through generous public pension schemes, and Mexicans rely quite heavily on transfers from remittances, while the elderly in the United States receive relatively low transfers. There are also cultural differences among all NTA countries that affect how resources are shared. However, in all countries, individuals make and receive transfers, both through their families and via the state. The association with mortality does not seem to depend on whether the transfers are public or private or on specific types of welfare regimes. Far more important is the relative generosity of transfers, here defined as shares of lifetime income for a representative individual.

Why might intergenerational transfer generosity benefit survival? The most obvious explanation would be that transfers improve health and survival by meeting the material needs of the recipients, particularly dependent children and the elderly, or the destitute of any age. But the link we find between transfers and survival might reflect more than this. Transfer intensity may reflect the strength of social networks and social capital, which have been found to promote health. Transfer behavior is deeply rooted in human biology, and there is growing evidence that both giving and receiving transfers improve health.

The motivations for helping and sharing with others fall into two categories: self-interest or altruism (18). Transfers based on self-interest, sometimes called reciprocal altruism, are a typical form of risk sharing, which could also be viewed either as intertemporal exchange or exchange across states of the world. The givers and receivers of such transfers will, on average, not differ much in age, so this kind of motive is less relevant for the

Table 2. Elasticity of life expectancy at birth with respect to survival-weighted transfer generosity, GDP per capita, and income inequality (OLS regression with logged variables)

	Survival-weighted transfer generosity and life expectancy at birth (model 1)	Survival-weighted transfer generosity and life expectancy at birth controlling for GDP per capita (model 2)	Survival-weighted transfer generosity and life expectancy at birth controlling for GDP per capita and income inequality (model 3)
Constant	4.53**** (0.04)	4.08*** (0.12)	4.45*** (0.25)
Log share of lifetime income transferred	0.28*** (0.05)	0.15*** (0.05)	0.16*** (0.05)
Log GDP per capita		0.04*** (0.01)	0.03*** (0.01)
Log income inequality (Gini coefficient)			−0.08 (0.05)
Adjusted R^2	0.52	0.67	0.68

SEs are in parentheses.
***$P < 0.01$.

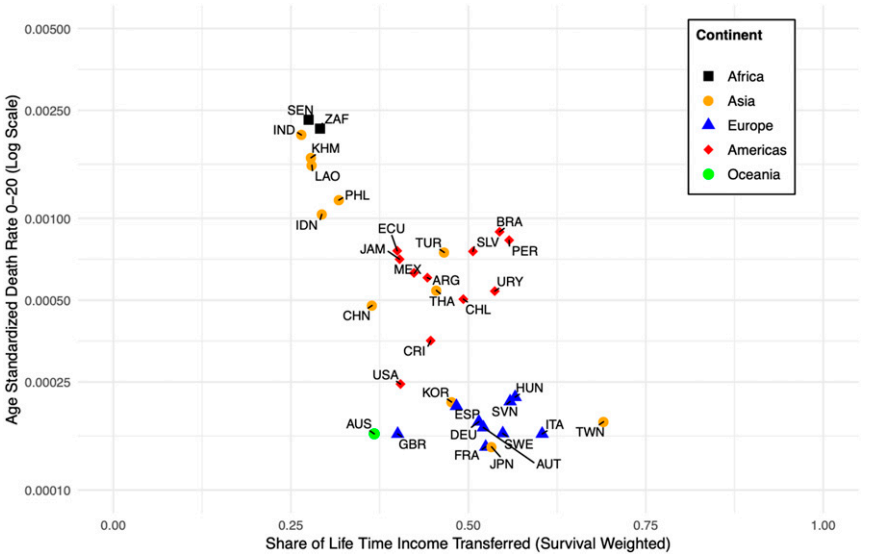

Fig. 2. Age-standardized risk of death age 0 to 20 and share of lifetime income transferred to others. Data from ref. 52 and The National Transfer Accounts Database, https://www.ntaccounts.org.

intergenerational transfers, which are the focus of this study. This would also be true for some altruistic transfers.

There is mounting evidence that altruistic behaviors and risk sharing are deeply rooted in human evolution (19, 20). Anthropological studies have found a general willingness to help others among chimpanzees (21) and other nonhuman primates (22). While pure altruistic transfers seek to benefit the recipient without an expectation of return, they might, nonetheless, be beneficial for the giver. Motives like the "warm-glow" or the joy of giving (23) are in line with the psychological and sociobiological literature pointing out that the actual giving is not only rewarding in itself, but contributes to health and wellbeing. Altruism and empathy are, therefore, motives that could help to explain the emergence of the transfer generosity–mortality pattern from the side of the giver and the recipient. The recipient benefits in the form of resources that may improve survival directly, and the giver benefits rather indirectly in the form of emotional gratification.

Self-interest as a motivation seeks to increase the benefit of the transfer-giver instead of the recipient. While it is still a predominant transfer motive mentioned in economic literature, it is far from being a mutually exploitive behavior (24). Exchange or reciprocity are found as balancing forms of prosocial behavior in game interactions between purely egoistic individuals (25). The expectation to receive a return (material or emotional) to a given transfer may also extend over a longer time horizon and reflect a certain insurance principle (26). Individuals tend to adhere to reciprocity and risk-sharing norms also outside of the family. In modern welfare states, these norms motivate individuals to willingly share large parts of their income with others in need (27). Altruism and self-interest are not only motivating the provision of financial transfers or the sharing of resources, but they are also central in motivating social support. Both forms of helping others are integral parts of the "generational contract" (28). In this context, provisions of instrumental or emotional support are facets of a broader intergenerational solidarity concept, where institutionalized

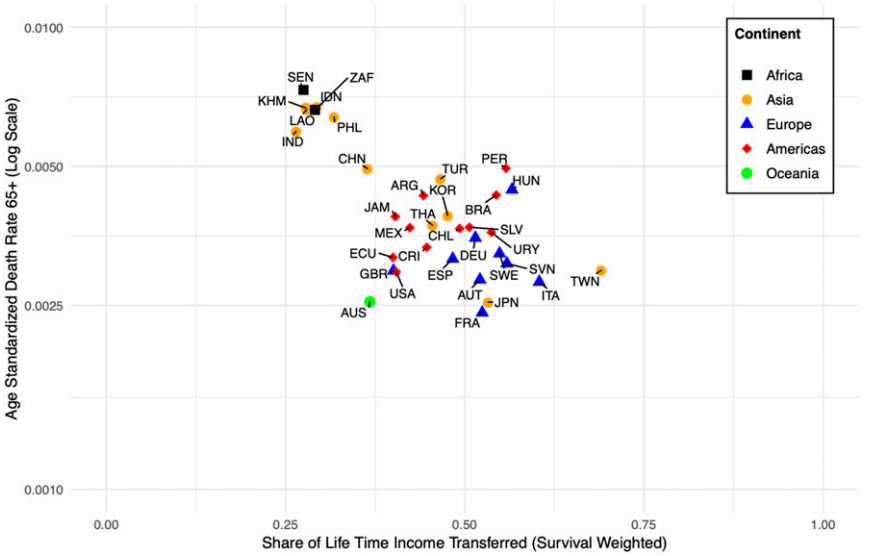

Fig. 3. Age-standardized death rate of age groups above age 65 and share of lifetime income transferred to others. Data from ref. 52 and The National Transfer Accounts Database, https://www.ntaccounts.org.

support provision by the state represents norms and traditions lived by families (29). Therefore, we assume that our sharing-generosity indicator captures the general strength of intergenerational ties and solidarity in societies.

Sharing, volunteering, or supporting others contributes to wellbeing, physical and mental health (30), or longevity (31). The most obvious reason for these positive health effects is that sharing enables individuals to cover their basic needs in vulnerable phases of the life course. Our sharing-generosity measure includes public and private transfers for food provision and clothes and shelter for children, as well as provisions for education or medical care, which are well-recognized predictors for better health over the life course. It also accounts for transfers to the elderly, whose abilities to cover their own needs decrease with age. Health and long-term care provision next to public or private income support are central for coping with declining physical and mental functioning.

Giving and sharing are not only advantageous for recipients of support. Also, donors benefit from the protective effect of giving, which seems to be independent of specific exchange motives or expected mutual benefits (32, 33). Providing support and informal care has a protective effect, even for caregivers, and one study has found that this outweighs the positive effects of receiving it (34). Although the evidence supporting this positive effect is mixed (35, 36), there are studies that find benefits of providing care for different intergenerational arrangements—from grandparents to grandchildren (37) or from children to parents (38). Even taxation and voluntary giving were found to affect neural activities linked to reward processing (9). This positive link between giving, wellbeing, and health is found across culturally and ethnically different societies (39), suggesting a certain universality of the underlying relationship (8). Also, psychological or neurological studies suggest that social behaviors increase the wellbeing not only at older ages, but also for children and adolescents (13, 40). Sharing with others and investment in offspring are motivated, next to cultural values, by hormones such as oxytocin, which enhances generosity, love, and empathy. It is released during interactions with infants, romantic partners, and others in the social group (41). Indeed, the social environment has been found to alter the expression of hundreds of genes, with implications for health (42).

We conclude from this discussion that transfers are a fundamental feature of the life course and play a central role in human development. There are different reasons and motivations why humans share their resources with others. It is certainly far more than selfishness or quid-pro-quo expectations that makes us givers of transfers and providers of support. The motivations to provide financial or nonmaterial support are closely linked and contribute to the high levels of prosocial behavior that are found in human societies (20, 43). Thus, our general sharing indicator captures more than the provision of financial resources, but also the willingness to support others in times of need. Transfer generosity might be seen as an indicator for overall prosociality in a country that has beneficial effects beyond the provision of material resources.

We believe that this study shows an interesting macro-level association and offers a perspective on mortality disparities across countries. There is the well-established positive relationship between measures of economic development like GDP per capita and life-expectancy levels (44), but our results remain after including this measure as a covariate. The transfer–mortality association may also reflect differing social inequalities across countries. However, including Gini coefficients to account for income inequality did not have a significant effect. Sharing enables individuals to get access to resources they would otherwise be deprived of. In comparison to these concentration indices, our measure allows us to identify population age groups that are most vulnerable and in need of resources and the type of support that others provide for them.

The comprehensiveness of our transfer measure would make it difficult to uncover underlying mechanisms at the individual level because it accounts for the overall social sharing generosity. It might, however, be possible to decompose differences in the transfer–mortality pattern into contributions from different types of transfers. This would allow us to identify what part of the overall association is driven by major transfer types, such as education, health care, or pensions.

Another limitation is that this study uses only one data point per country. This makes our sharing-generosity measure sensitive to policy changes that were implemented in a given year. The cross-sectional character of our dataset does not allow for the analysis of between- and within-country changes over time. Hence, we cannot infer any causality from this association or account for unobservable factors that influence the association between transfer generosity and mortality. One example could be that transfer-provision patterns are determined by norms and behavioral expectations that differ across cultures and religions and that these also affect mortality. Likewise, democratization, empowerment, or the functioning of the civil society may affect both sharing generosity and mortality outcomes.

The work of the NTA network is ongoing, and new countries have joined in every year since its foundation in 2002. One aim of the network is to estimate country profiles for multiple years to provide insight into the transfer activities of a society over time. A growing number of NTA countries have accounts for multiple years. Using these countries, we found the transfer–mortality relationship to be relatively stable over the relatively short time horizon considered. We have also limited our analysis to monetary or material transfers in relation to mortality differentials. We disregard time transfers that would matter, for example, for studying the relationship by gender. Time transfers (such as childcare, elder care, housekeeping, or meal preparation) would also allow us to strengthen our measure of the nonmonetary solidarity within a country and give a more complete picture of the overall transfer–mortality association and its underlying motivations. This aspect might be particularly important for developing countries, where support systems for children and the elderly are less institutionalized. Addressing these limitations to further explore the macro-level association between transfer generosity and mortality is certainly a promising challenge for future research, and NTA currently includes the requisite estimates for more than 30 countries.

Materials and Methods

Our study draws on data from the NTA project (https://ntaccounts.org/) to measure sharing generosity in and across countries (1). The major aim of NTA is to estimate, understand, and document the generational economy. The theory is rooted in Samuelson (45), Diamond (46), Lee (47), and Bommier and Lee (48). Currently, the NTA network comprises research teams in more than 80 countries, across all continents, offering at least partial data for over 90 countries for comparative analysis. The results show how people at each age produce, consume, share resources, and save for the future in a respective country. For our analysis, the NTA framework provides valuable information for studying how resource sharing among populations is related to average length of life in 34 countries. A major contribution of these NTA data is that they include macro-level private transfers between generations in a macro-level analysis on health. We restrict our analysis to 34 countries for which the estimates are validated and thoroughly quality-checked. Especially the estimation of private transfers from survey data are a challenge in developing countries, and we refrain from using nonvalidated estimates. Data for these 34 countries provide a strong and comprehensive database for our estimates. The common methodology ensures comparable measurement and an identical approach to measure resource flows in different countries around the globe (1). Most of the country-specific information stems from country-specific income and expenditure surveys (49). On the consumption side, these provide details on individual expenditures for a large variety of goods and public and private services. On the income side, they indicate how individuals cover different needs through labor income, savings, or transfers (public or private). Intergenerational transfers cover the basic needs of dependent children and elderly (who also draw on asset

income) for home, food, and security. They enable children and the elderly to meet their higher self-actualization and cognitive needs by allowing for education, health-care access, hobbies like music and sports, or general recreation. Thus, we assume that intergenerational transfers convey meaning beyond providing financial resources and may serve as an indicator for general connectedness, belonging, affection, and social integration. Providing transfers and sharing with others may benefit those in need and contribute to differences in mortality outcomes across the globe. The general age ranges when individuals share resources and are in need of support are very similar across societies (see *SI Appendix*, Fig. S1 for a panel of public and private age-specific transfer patterns for all 34 NTA countries in our study). In these 34 societies, public and private transfers are received during childhood and, with the exception of Senegal, also during old age.

Our measure of sharing generosity derived from the NTA profiles captures the ratio between lifetime income and net positive transfers received by age groups in need of support. For a representative individual in a country, we calculate the per capita net transfers received as a share of the lifetime income an individual earns in the country over the life course. First, we estimate the net public and private transfers by age. Net public transfers are calculated at each age a and country i following $TG(a)_i^{net} = TG(a)_i^{+} + TG(a)_i^{-}$. In the same way, we calculate the net private transfers at each age a and for all countries i following $TP(a)_i^{net} = TP(a)_i^{+} + TP(a)_i^{-}$. We then determine the ages for which positive net transfers are received in each country—that is, the ages for which the left-hand side of the equation is >0. Afterward, we sum only the positive net transfers over all ages for both public and private transfers following Eq. **1**:

$$T(a)_i^{+} = \sum_{a=0}^{90+} TG(a)_i^{+} + TP(a)_i^{+},$$

where $TG(a)_i^{+}$ denotes positive per capita net government transfers received at age a in country i, and $TP(a)_i^{+}$ denotes per capita familial net transfers received at age a in country i. T_i^{+} denotes the positive total transfers an individual in country i receives over their lifetime. In case net transfers are negative (an individual is a transfer giver), transfers are not deducted. We want to picture the real net inflows for individuals at different ages, and we do not distinguish if these transfer recipients consume, save, or even transfer their money on.

The variables in the equation are average values for individuals alive at each age—that is, survivors to that age. For our measure, we weight the (positive) net transfers received at each age by the probability that an individual survives to that age, to avoid giving undue weight to extreme old ages, which few will live to experience. For this purpose, we use the average survival probabilities for our set of 34 countries, $S(a)$. If we used each country's own survival values, then those countries with higher life expectancy would also automatically have increased transfers by virtue of having more elderly recipients, biasing our estimates in favor of our hypothesis. We then sum these survival-weighted positive net transfers for each country from age $a = 0$ to the maximum age of 90+.

The "sharing generosity" g in country i is the ratio of the sum of these survival-weighted positive net transfers to the sum of survival-weighted labor income $yl(a)$ across all ages in country i.

$$g_i = \frac{\sum_{a=0}^{90+} T(a)_i^{+} \bar{S}(a)}{\sum_{a=0}^{90+} yl(a)_i \bar{S}(a)}. \quad [2]$$

Our measure g_i relates the total resources an average individual generates over the life course to the average amount of resources the individual shares with others. The transfer measure g_i is very comprehensive and includes the monetary value of a variety of public and private transfer items that may benefit young and old age groups. Transfers to the young comprise expenditures for health care, food, shelter, and education. Older adults benefit from transfers for health and long-term care and especially pension payments. A detailed overview of the variables included can be found in *SI Appendix*, Table S2. Savings and assets are excluded from our measure, as they are intertemporal transfers to oneself (or to the descendants, in case of bequests). Net transfers are the difference between transfers received and transfers made to others at a given age over the life course. This net transfer measure accounts for overall transfers in both directions. Focusing only on gross inflows or outflows would underestimate or overestimate sharing generosity. Receivers of large transfer inflows may themselves give only a small transfer. Likewise, givers of large transfers may receive only little in return. Because g_i is a ratio of quantities measured in the monetary units of each country, the units cancel, and no conversion is necessary.

Our measure combines public and private transfers and assumes that these sharing mechanisms are equally beneficial. Generous public transfers reflect, to some degree, the generosity of individuals in the population through democratic processes or underlying culture. There is some evidence in NTA (50), consistent with economic theory (51), that public and private transfers are interrelated and to some degree substitute for or offset one another. As noted earlier, a study found that "tax-like transfers to a charity elicit neural activity in areas linked to reward processing" (9). In practice, public transfers may be less efficient than private due to administrative costs and less accurate targeting relative to needs. However, we assume that a major part of the observed relationship of mortality to sharing generosity is mediated by the general willingness to share rather than the efficiency of sharing.

We only look at net transfers that are positive, which is typically at young and old ages. Intragenerational transfers are in the analysis, but they occur typically between individuals of working age—for example, for housing or unemployment. As these individuals tend to be net givers on average, net transfers are below 0. In this way, it can be that countries with a high fraction of intragenerational redistribution appear less generous than countries that redistribute to vulnerable age groups. The focus on intergenerational resource sharing also excludes public redistribution of resources that stem from market revenues, such as from oil production in Nigeria or from privatization of former publicly owned businesses or telecommunication licenses in Europe.[†]

We use data from NTA and from the United Nations' (UN's) world population prospects revision 2017 (52) to test the relationship between sharing generosity and risks of death across countries. The UN database provides comparable indicators for all NTA countries included in our studies, except Taiwan. It is not included in the UN database, so we used information from the Human Mortality Database instead (53). Overall, we relate country-specific information on sharing generosity to country-specific mortality rates. To account for the different population age structures, we used direct age standardization of age-specific death rates with the overall population of NTA countries as the standard. As NTA profiles are not estimated for every year, we used the latest available information per country and demographic information for the corresponding time period (*SI Appendix*, Table S3). For each country, age-standardized mortality rates for all ages, age-standardized mortality rates for the ages 0 to 20, and age-standardized mortality for ages above 65 were used in relation to different age-specific measures of sharing. As most NTA profiles do not account for sex differences, we used mortality information for sexes combined. It might well be that sharing generosity and volume differ between women and men, but to thoroughly test the relationship, we would need to include the value of time transfers in our measures. Otherwise, transfer generosity of women might be seriously underestimated (54). This is certainly an additional aspect of sharing generosity which we may consider in the future, but that goes beyond the aim of this analysis.

We also realize that the association between transfer generosity and mortality might reflect the relation of mortality to economic development and per capita wealth. Economic development itself is also strongly associated with life expectancy (44), education (55), health (56), democratization (57), or political instability (58). The sharing generosity–mortality relationship may be biased by these other relationships, although, as noted earlier, education and health care are provided through major public and private transfers in most countries and are therefore reflected in our transfer measure. Our ability to address the problem of omitted variables is limited by the relatively small number of countries. Our approach is to regress the log of mortality on the log of transfer generosity, while including log GDP per capita and Gini coefficients as covariates. This log–log model allows us to estimate the elasticity of mortality with respect to change in economic development, income inequality, and transfer generosity. Gini indices for household income and GDP per capita in current US dollars for each NTA country (except Taiwan) and profile year comes from the World Bank Database (https://data.worldbank.org/). The information for Taiwan comes from the Statistical Office of Taiwan (https://eng.stat.gov.tw/).

Data Availability. All data used for this analysis are open access and can be downloaded from the referenced websites. The NTA Database can be accessed via https://ntaccounts.org/.

[†]In NTA, if an asset such as petroleum reserves is publicly owned, and revenues generated from it are distributed to the public, these would be counted as "asset-based reallocations," rather than as public or private transfers. If the asset were privately held, for example, by a royal family that claimed ownership of it, then these distributions would be counted as private transfers (49). This might be an issue in some Middle Eastern countries, but not in any of those included in this study.

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