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Original Article

Caregiving within and beyond the family is associated with lower mortality for the caregiver: A prospective study

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ABSTRACT

Grandparenting has been proposed as an ultimate evolutionary mechanism that has contributed to the increase in human life expectancy (see the grandmother hypothesis). The neural and hormonal system – originally rooted in parenting and thus grandparenting – that is activated in the process of caregiving has been suggested as a potential proximate mechanism that promotes engagement in prosocial behavior towards kin and non-kin alike. Evidence and theory suggest that activating this caregiving system positively impacts health and may reduce the mortality of the helper. Although some studies have found grandparental care to have beneficial effects on grandparents' health outcomes, most studies have focused on the detrimental health consequences of providing custodial care for grandchildren. Little is known about how non-custodial grandparental and other forms of caregiving relate to mortality hazards for the care provider. Using an evolutionary framework, we examined whether caregiving within and beyond the family is related to mortality in older adults. Survival analyses based on data from the Berlin Aging Study revealed that mortality hazards for grandparents who provided non-custodial childcare were 37% lower than for grandparents who did not provide childcare and for non-grandparents. These associations held after controlling for physical health, age, socioeconomic status and various characteristics of the children and grandchildren. Furthermore, the effect of caregiving extended to non-grandparents and to childless older adults who helped beyond their families. Potential ultimate and proximate mechanisms underlying these effects are discussed.

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1. Introduction

Although human life expectancy has increased substantially in the 20th century (United Nations, 2013), human longevity is not a new phenomenon (Hawkes, 2004). Prosocial behavior, specifically grandmothering, has been proposed as an ultimate evolutionary mechanism that has contributed to the increase in human lifespan expectancy (Kim, McQueen, Coxworth, & Hawkes, 2014). Prosocial behavior may have originally evolved within the family and subsequently extended to a general caregiving system (Brown, Brown, & Preston, 2011). The neural and hormonal system that is activated in the process of caregiving represents a proximate mechanism that may reduce human mortality. Indeed, there is growing evidence that grandparenting is beneficial for grandparental health in contemporary societies. For example, the provision of childcare has been shown to have a positive effect on grandparents' cognitive functioning (Arpino & Bordone, 2014), subjective well-being (Mahne & Huxhold, 2015), and risk of depression (Grundy et al., 2012). Yet grandparental caregiving can also deplete grandparents' material and psychological resources and impair their health. These detrimental effects are most pronounced when grandparents provide custodial childcare (Chen & Liu, 2012; Ross & Aday, 2006). A nonlinear relationship has therefore been proposed between the level of care and grandparental well-being (Coall & Hertwig, 2010): just as no contact with grandchildren can impair grandparental physical and emotional health (Drew & Silverstein, 2007), so can intense levels of caregiving. The extent to which the potential health benefits or harms of grandparental care affect not only the health but, ultimately, the mortality of contemporary grandparents has not been systematically studied within an evolutionary framework. To bridge this gap, the present study takes an evolutionary approach exploring whether caregiving within and beyond the family affects the mortality of older helpers.

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Note that by caregiving we mean non-custodial grandparental caregiving. By helping and prosocial behavior beyond the family, we mean provision of regular but not extensive care to members of the helper's social network.

1.1. Why grandparental caregiving may be associated with mortality

Life history theory seeks to understand human behavior in specific environments by examining how the timing of distinct life phases and investment patterns (e.g., reproduction, grandparental investment and senescence) has been shaped by evolutionary forces. Within this framework, the grandmother hypothesis proposes that post-reproductive women who help to raise their grandchildren enhance their own inclusive fitness by improving the reproductive success of their children (Hawkes, O'Connell, & Blurton Jones, 1997; Hawkes, O'Connell, Jones, Alvarez, & Charnov, 1998; Sear & Coall, 2011). Grandparenting, especially grandmothering, is thus seen as conferring a selective advantage that drives human longevity (Kim et al., 2014). Using a mathematical model, Kim and colleagues simulated how human post-menopausal longevity could have evolved. By providing childcare, post-reproductive women aided the survival and reproduction of their descendants, thus increasing the probability that their genes would be transmitted to future generations. This, in turn, created a selective advantage for helping behavior and cooperation in both elderly women and men (but see Rogers, 1993 and Kachel, Premo, & Hublin, 2010 for conflicting findings). As post-reproductive women still have functional physiological systems (except fertility), it is hypothesized that grandmothering slowed down somatic aging in humans across multiple generations (Hawkes &Coxworth, 2013). Assuming that caregiving offered a selective advantage in humans' evolutionary past and that contemporary humans carry the genes for helping behavior, to what extent may the act of caregiving contribute proximately to survival today? Does the mortality of grandparents who provide care for their grandchildren differ from that of those who do not? Finally, does helping behavior towards non-kin also promote survival, and – if so, to what extent? This last question is particularly important considering of the growing numbers of childless older adults in industrialized societies.

1.2. What are the mechanisms and effects of caregiving beyond the family?

There is emerging evidence that helping others has beneficial health effects for the helper (Brown & Okun, 2014; Morrow-Howell, Hinterlong, Rozario, & Tang, 2003; Musick, Herzog, & House, 1999; Okun, Yeung, & Brown, 2013). Benefits of caregiving beyond the family would have important implications for at least two reasons. First, the average total fertility rate (TFR) in Europe, for instance, has dropped from 2.3 children per woman in 1970 to 1.6 in 2013, well below replacement level (Population Reference Bureau, 2015). Decreasing fertility rates and more disability-free years will ultimately lead to rising numbers of older adults who do not have grandchildren to care for, but who are willing and able to allocate their resources to the care of others. Second, with demographic change (e.g., divorce and mobility), more grandparents, especially paternal ones, will not be in regular contact with their grandchildren. Do these developments mean that the evolutionary effects of grandparenting on mortality will not survive into the future? Or do the benefits of grandparental caregiving extend well beyond the limits of the family?

Based on the neural circuitry involved in parenting (see Numan, 2006), it has been proposed that a generalized neural and hormonal caregiving system developed over human evolution (Brown et al., 2011). Prosocial behavior may have extended from parenting and grandparenting beyond the family through this caregiving system. Specifically, seeing another person in need may activate the neural caregiving circuitry, thus enabling prosocial behavior (Brown & Okun, 2014). This caregiving system is thought to be the ultimate foundation of caregiving towards non-kin that – on a proximate level – operates through compassion and empathy. This would also be in line with the suggestion that empathy may have both a phylogenetic and ontogenetic basis in the emotional bond between parent and offspring (Preston & de Waal, 2002) but, when activated, extends beyond the family (Hrdy, 2009). These emotional pathways link helping behavior to regulatory physiological systems, which could be among the proximate mechanisms impacting health and mortality. Prosocial behavior towards non-family members may thus recruit the same neural circuitry as (grand)parenting does (Brown et al., 2011). This circuitry is also suggested to buffer negative consequences from stress-related health declines. For example, general helping within and beyond the family has been found to break the link between stress and mortality (Poulin, Brown, Dillard, & Smith, 2013): stress predicted mortality for non-helpers with a hazard ratio of 1.3, but did not predict mortality for helpers (hazard ratio = .96). Moreover, giving help among older adults has been shown to accelerate helpers' recovery from depressive symptoms after spousal loss (Brown, Brown, House, & Smith, 2008) and to reduce mortality (Brown, Nesse, Vinokur, & Smith, 2003). Taken together, these findings suggest that a neurobiological substrate of prosocial behavior that affects mortality is likely to be involved in caregiving towards both kin and non-kin (Brown et al., 2011; Porges, 2001; Porges, 2003; Porges & Carter, 2011).

Against this background, we first analyzed whether caregiving grandparents have lower mortality than non-caregiving grandparents and non-grandparents. We turned to older adults who cannot provide grandparental care because they have either no children or no grandchildren. The latter group can nevertheless help their children. In our dataset, this help was measured in terms of instrumental help (e.g., doing housework or fixing things). The former group can provide help within their social network beyond the nuclear family. In our dataset, this help was measured in terms of emotional and instrumental support (e.g., comforting others, doing housework, or fixing things). We thus also examined whether parents who give their children instrumental help have lower mortality than non-helping parents. Finally, we investigate whether childless older adults who provide emotional or instrumental support within their social network have lower mortality than those who do not. A large set of covariates was included in all analyses (see below).

2. Material and methods

2.1. Data

Data were drawn from the longitudinal Berlin Aging Study (Lindenberger, Smith, Mayer, & Baltes, 2010). BASE is a multidisciplinary investigation of the physical, cognitive and social characteristics of people aged 70 or older living in the former West-Berlin. The BASE dataset contains extensive information on a range of health and social conditions obtained from the participants (generation 1, G1) as well as information provided by G1 about all of their children (generation 2, G2) and grandchildren (generation 3, G3). The BASE sample was randomly selected from the West-Berlin registration office records. Those who agreed to participate completed interviews and medical tests at their homes, doctors' practices and hospitals. The assessments were repeated at approximately 2-year intervals between 1990 and 2009. Detailed descriptions of the variables and procedures used are available elsewhere (Lindenberger et al., 2010; see also https://www.base-berlin.mpg.de/en).

As is often the case in longitudinal study designs, most cases of missing data were due to participant attrition (mortality or moving away from Berlin). The latest update on mortality in 2009 reported that, of the initial 516 participants, 463 had died (89.7%), 33 were alive (6.4%), and 20 (3.9%) were unaccounted for.

2.2. Measures

2.2.1. Dependent variable

Time to death represents mortality. This variable as was measured prospectively and indicates how many years participants lived following the interview at time 1 [T1] until 2009 (when the last round of interviews occurred). In the Supplementary Material (SM) we report an analysis using age at death as the dependent variable (Table S7), which yielded very similar results.

2.2.2. Independent variables

Frequency of caregiving indicates the frequency of grandparental caregiving in the 12 months prior to T1. Grandparental caregiving is defined as looking after or doing something with the grandchild (G3) without the parents (G2) being present. This variable ranges from 1 (never) to 7 (every day). It was extended to include non-grandparents (who were coded as "never"). Note that there were no cases of grandparental caregiving on a daily basis, in other words, our sample did not include any primary or custodial caregivers. Drawing on the frequency of the caregiving variable and whether or not participants had grandchildren, we categorized participants as *caregiving grandparents* ($n = 80$), *non-caregiving grandparents* ($n = 232$), or *non-grandparents* ($n = 204$). A further variable coded whether participants gave *instrumental help to children* ($n = 167$) or not ($n = 203$), which was used to measure helping behavior towards descendents (adult children) in participants without grandchildren. This binary variable included instrumental help such as aid with housework or fixing things. To measure support given by childless participants, a binary variable coded instrumental support (e.g., aid with housework or fixing things) or emotional support (e.g., comforting or cheering up someone) provided to others in their social network and categorized childless participants into those who *supported others* ($n = 366$) and those who did not ($n = 150$).

2.2.3. Covariates

We controlled for a set of covariates across all three generations. The covariates have previously been shown either to influence time to death (Aichele, Rabbitt, & Ghisletta, 2016; Gerstorf, Ram, Lindenberger, & Smith, 2013), health and aging (Lindenberger, 2014), or grandparental caregiving (Coall, Hilbrand, & Hertwig, 2014; Coall, Meier, Hertwig, Wänke, & Höpflinger, 2009; Tanskanen & Danielsbacka, 2012), or to vary significantly across caregiving grandparents, non-caregiving grandparents and non-grandparents (Table S2 in the SM). Three covariates did not meet these criteria in our data and thus were not included in the main analysis: *education level of grandparents, education level of grandchildren*, and *sex of children*. To verify the exclusion of these covariates we tested whether including them would significantly alter the outcome of the analyses. As Table S3 in the SM shows, this was not the case.

On the level of participants (G1), the covariates accounted for were as follows: Because health is considered to be a multi-dimensional construct, we included two proxies. First, the extent of *comorbidity* was measured as the number of physician-observed diagnoses (as determined in clinical examinations, supported by additional laboratory analysis of blood and saliva samples) of moderate to severe chronic illnesses (according to the International Classification of Diseases, 9th Revision, ICD-9, see World Health Organization, 1979). Second, to measure *functional health*, we used the Instrumental Activities of Daily Living (IADL) scale (Lawton & Brody, 1969). This scale measures independent living skills such as housework and shopping, with higher IADL scores indicating better health. Further covariates were *age*, *sex*, *relationship status* and *income*. *Age at transition to grandparenthood* was defined with respect to the birth of the first grandchild (this transitional age has been shown to be related to mortality; Christiansen, 2014; Coall et al., 2009). The variable *number of children* also included children who had died. The *number of grandchildren* included all living grandchildren. Finally, a variable coded whether or not participants had received emotional or instrumental *support from others* in their social network. On the level of children (G2), the covariates (averaged over all children), were *age*, *education level*, and *relationship status*. On the level of participants' grandchildren (G3), the covariates were *age of the youngest grandchild* (because grandparenting is typically focused on the youngest), geographic *proximity* and whether or not grandchildren were *biological*. Descriptive data on all measures are presented in Table 1. More details on the computation and coding of these variables are provided in the SM.

2.3. Data analysis

In a first step, variables with skewed distributions were logarithmically transformed. Model fitting indicated that linear analytic methods were appropriate for investigating the relationship between grandparental caregiving and time to death (see Table S5 and Fig. S1 in the SM). We applied general linear models, analyses of variance and planned contrasts to test whether grandparental caregiving was associated with grandparental mortality and whether caregiving grandparents lived longer than non-caregiving grandparents and non-grandparents (see the SM). Before conducting the survival analysis (Cox regression), the assumption of proportional hazards was tested and confirmed (i.e., that the effect of helping on mortality was the same at all points, see Table S6 in the SM). Four survival analyses were conducted to analyze the association between providing help and mortality. These determined the probability (hazard ratio, HR) that an event (death) will occur within a specified time interval in a given group (e.g., caregiving grandparents) relative to a reference group (e.g., non-caregiving grandparents). Survival analyses are commonly used procedures examining mortality rates between groups and they account for censored data. That is, these adjust for missing information on mortality (in our sample 10.3% of the cases). The first two survival analyses compared mortality in caregiving grandparents relative to, first, non-caregiving grandparents and, second, non-grandparents. The next analysis tested whether non-grandparents who gave instrumental help to their children (G2) had lower mortality than those who did not. This analysis was restricted to participants who reported having children, but no grandchildren ($n = 151$). The final survival analysis tested

Table 1
Descriptive statistics: mortality, participant groups and covariates at T1 ($N = 516$).

Participants (G1)	Percentage or mean	Range	n
Time to death (years) after T1	5.51	0–22	463
Frequency of caregiving	1.40	1–6	516
Caregiving grandparents	15.50%	–	80
Non-caregiving grandparents	45.00%	–	232
Non-grandparents	39.50%	–	204
Gave instrumental help to children	34.10%	–	176
Gave support to others	70.90%	–	366
Female	50.00%	–	258
Comorbidity	3.69	0–11	516
Functional health	13.53	0–20	516
Age	84.92	70–103	516
Age at transition to grandparenthood	57.22	31–89	312
Number of children	1.28	0–11	516
Number of grandchildren	1.83	0–22	516
Without partner	70.20%	–	362
Education level	1.56	1–5	516
Income	1.56	1–5	516
Received support from others	87.00%	–	449
Children (G2)			
Age	53.20	23–83	379
Female	42.00%	–	159
Education level	1.98	1–5	379
Without partner	35.50%	–	183
Grandchildren (G3)			
Age	19.41	0–46	312
Proximity	5.28	1–8	312
Education level	1.65	1–5	312
Biological	91.70%	–	286

whether childless participants ($n = 153$) who helped others within their social network had lower mortality than those who did not. Although we do not know exactly who received their help, by definition it was not children or grandchildren. All survival analyses included a set of covariates related to health and aging: characteristics on which the groups varied on significantly (Table S1 in the SM) and variables associated with grandparental caregiving or time to death (Table S2 in the SM). After testing for possible interactions (see Tables S12 and S13 in the SM), we included an interaction term of health and age in the survival analyses. To evaluate the magnitude of the effects, we present the standardized hazard ratios (HR) in the result tables (Bratt, Stenström, & Rennemark, 2016). Similar to beta coefficients in logistic regression the HRs represent the degree of change in mortality risk per unit change in the predictor. An HR below 1.0 indicates a reduced mortality risk; an HR above 1.0, an increased mortality risk. For dichotomous variables, a HR below 1.0 means that the group of interest (e.g., caregiving grandparents) has a reduced mortality risk relative to the reference group (e.g., non-caregiving grandparents). Greater deviations from 1 indicate greater increases or reductions in the mortality risk. To test the robustness of these results, we estimated missing information using the multiple imputation procedure (IBM SPSS, 2011) and conducted linear regressions (see Tables S9, S10, and S11 in the SM). These regression analyses confirmed the results of the survival analyses. All analyses were conducted using SPSS v.22.0 (IBM Corp. Armonk, NY, USA).

3. Results

Was mortality lower among caregiving grandparents than among non-caregiving grandparents (reference category)? The results summarized in Table 2 suggest that this is indeed the case. After adjustment for covariates, a hazard ratio of 0.63 indicates that the mortality hazard among caregiving grandparents was 33% lower than among non-caregiving grandparents ($P < 0.05$). Next, was mortality also lower among caregiving grandparents than among non-grandparents (reference category)? Again, the results summarized in Table 3 suggest that this is the case. After adjustment for covariates, a hazard ratio of 0.63 ($P < 0.05$) indicates that caregiving grandparents had lower mortality than non-grandparents. In this model, we also included non-caregiving grandparents to compare all three groups in one analysis. Fig. 1 illustrates the survival curves for the three groups, showing that caregiving grandparents' mortality was lower than that of either non-caregiving grandparents or non-grandparents. Fig. 1 also shows that 50% of caregiving grandparents died within approximately 10 years of T1. The mortality of non-caregiving and non-grandparents did not differ significantly. In both groups, 50% of participants died within approximately 5 years of T1. Covariates contributing significantly to survival were functional health, female gender, and age of the participants.

We next turn to non-grandparents. Was mortality lower among non-grandparents who gave instrumental help to their adult children than among those who did not? The results summarized in Table 4 suggest that this is the case. After adjustment for covariates, a hazard ratio of 0.43 ($P < 0.001$) indicates that parents who gave their children instrumental help had lower mortality than parents who did not. Fig. 2 shows, 50% of the helpers died within approximately 10 years of T1, whereas 50% of the non-helpers died within approximately 5 years of after T1.

Table 2
Survival analysis comparing mortality of caregiving grandparents and non-caregiving grandparents, adjusted for covariates.

Participants (G1)	HR	P	95% CI of HR	
Non-caregiving grandparents (ref.)	–	–	–	–
Caregiving grandparents	0.63	*	0.41	0.96
Comorbidity	1.50		0.89	1.25
Functional health	0.94	*	0.88	0.99
Female	0.56	**	0.39	0.81
Age	1.04	*	1.01	1.08
Age at transition to grandparenthood	0.99		0.97	1.02
Number of children	1.08		0.93	1.25
Number of grandchildren	0.93		0.86	1.00
Without partner	1.19		0.82	1.74
Income	0.96		0.85	1.07
Received support from others	0.97		0.55	1.70
Interaction age × health	1.11		0.98	1.50
Children (G2)				
Age	1.03		1.00	1.07
Education level	0.83		0.38	1.83
Without partner	0.91		0.66	1.24
Grandchildren (G3)				
Age	0.99		0.96	1.01
Proximity	1.13		0.97	1.27
Biological	1.11		1.01	1.78

* $P < 0.05$.
** $P < 0.01$.

Table 3
Survival analysis comparing mortality of caregiving grandparents, non-caregiving grandparents and non-grandparents, adjusted for covariates.

Participants (G1)	HR	P	95% CI of HR	
Non-grandparents (ref.)	–	–	–	–
Non-caregiving grandparents	0.90		0.78	1.15
Caregiving grandparents	0.63	*	0.41	0.96
Comorbidity	1.05		0.89	1.25
Functional health	0.94	*	0.90	0.99
Female	0.55	**	0.39	0.72
Age	1.04	**	1.00	1.08
Age at transition to grandparenthood	1.00		0.97	1.02
Number of children	1.08		0.93	1.25
Number of grandchildren	0.93		0.91	1.05
Without partner	1.19		0.86	1.00
Income	0.96		0.85	1.07
Received support from others	0.97		0.56	1.71
Interaction age × health	1.01		0.96	1.25
Children (G2)				
Age	1.03		0.99	1.07
Education level	0.93		0.38	1.83
Without partner	0.91		0.66	1.24
Grandchildren (G3)				
Age	0.99		0.96	1.01
Proximity	1.11		0.96	1.25
Biological	1.10		1.01	1.51

* $P < 0.05$.
** $P < 0.01$.

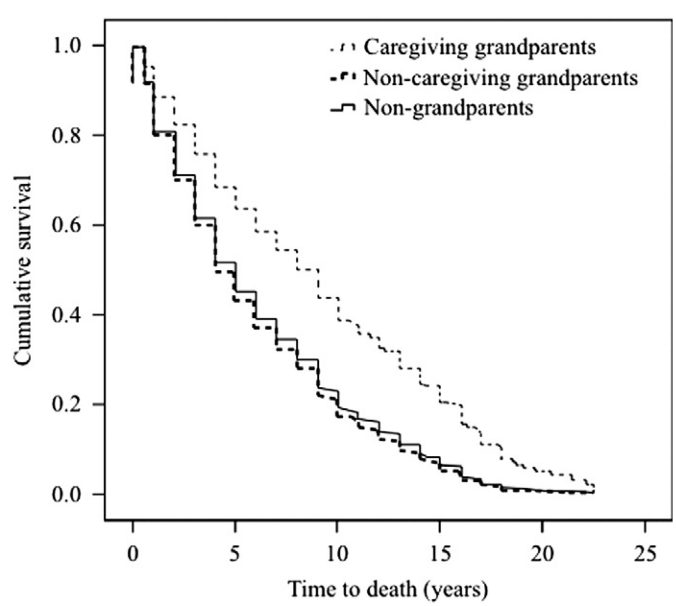

Fig. 1. Survival curves as a function of time to death for caregiving grandparents, non-caregiving grandparents, and non-grandparents.

Table 4
Survival analysis comparing mortality of non-grandparents who gave instrumental help to their adult children and those who did not, adjusted for covariates.

Participants (G1)	HR	P	95% CI of HR	
Did not give instrumental help to children (ref.)	–	–	–	–
Gave instrumental help to children	0.43	***	0.29	0.62
Comorbidity	1.09	**	1.01	1.23
Functional health	0.97		0.92	1.01
Female	0.55	***	0.46	0.79
Age	1.03	***	1.01	1.06
Number of children	0.96		0.87	1.07
Without partner	1.231		0.88	1.72
Income	0.96		0.87	1.07
Received support from others	0.80		0.47	1.36
Interaction age × health	1.03		0.99	1.32
Children (G2)				
Age	1.04		1.01	1.06
Education level	0.72		0.33	1.40
Without partner	1.06		0.80	1.40

** $P < 0.01$.
*** $P < 0.001$.

Table 5
Survival analysis comparing mortality of childless participants who supported others and those who did not, adjusted for covariates.

Participants (G1)	HR	P	95% CI of HR	
Did not support others (ref.)	–	–	–	–
Supported others	0.40	***	0.31	0.54
Comorbidity	0.97		0.87	1.09
Functional health	0.93	**	0.90	0.97
Female	0.75	*	0.58	0.96
Age	1.04	***	1.02	1.06
Without partner	1.06		0.81	1.40
Income	0.99		0.91	1.08
Received support from others	1.25		0.87	1.81
Interaction age × health	1.02		0.97	1.34

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Covariates significantly associated with survival were participants' comorbidity, female gender, and age.

Finally, was mortality lower among childless participants who supported others in their social network than among those who did not? Again, the results presented in Table 5 suggest that this is the case. Relative to non-supporters, supporters had lower mortality (hazard ratio = 0.40, $P < 0.001$). Fig. 3 shows that 50% of the helpers died within approximately 7 years of T1, whereas 50% of the non-helpers died within approximately 4 years of T1. Covariates significantly associated with survival were comorbidity, female gender, and age of the participants.

4. Discussion

We consistently found that helping behavior was associated with reduced mortality. All helper groups – grandparents who gave care to their grandchildren; parents who provided instrumental help to adult children; and childless participants who helped others in their social network – had higher survival probabilities than the respective non-helper group. This pattern suggests that there is a link not only between helping and beneficial health effects, but also between helping and mortality, and specifically between grandparental caregiving and mortality. To our knowledge, this is the first prospective study to show a link between grandparental caregiving and mortality benefits. It complements previous studies reporting beneficial health effects of grandparental caregiving (Arpino & Bordone, 2014; Grundy et al., 2012). The BASE dataset allowed us to examine mortality outcomes over a period up to 22 years. It also enabled the inclusion of all living grandchildren and thus all caregiving opportunities at the beginning of the study, whereas other studies focused on one grandchild only. Finally, taking advantage of the rich set of covariates, including health and socioeconomic characteristics across all three generations, allowed us to rule out various competing explanations for the survival advantage conferred by caring for others.

4.1. The evolution of helping behavior

The results presented in Fig. 2 suggest that providing one's children with instrumental help is associated with decreased mortality. This finding is consistent with the idea that prosocial behavior was originally rooted in parenting (Numan, 2006) and then generalized to grandparenting (see Hawkes & Coxworth, 2013 for a review). Moreover, consistent with previous analyses (e.g., Poulin et al., 2013), we found associations between helping in social networks beyond kin and mortality hazards. It is plausible to assume, in the light of human phylogeny and life history, that the development of prosocial behavior

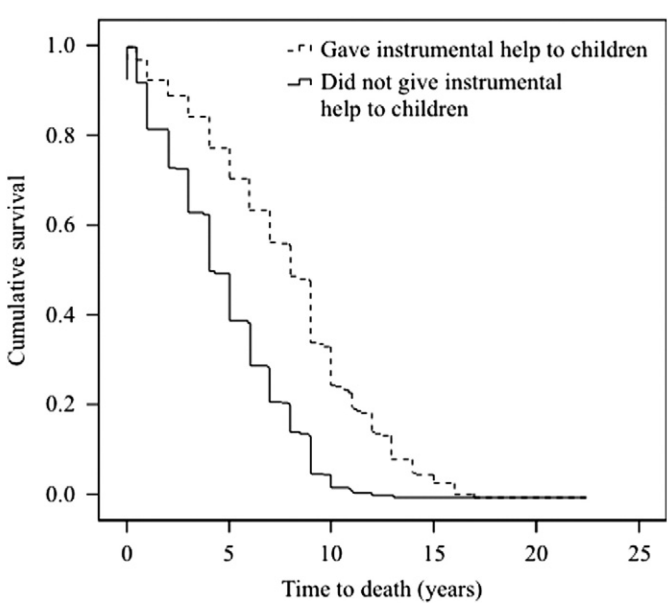

Fig. 2. Survival curves as a function of time to death for non-grandparents who gave instrumental help to their adult children and those who did not.

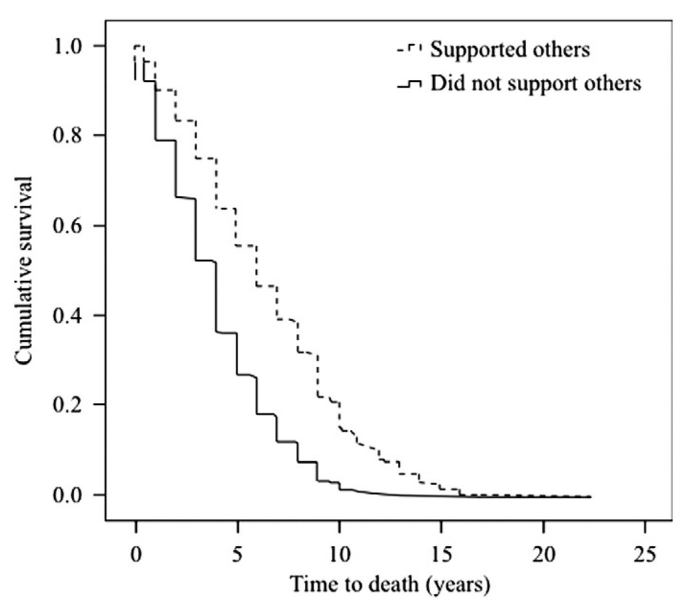

Fig. 3. Survival curves as a function of time to death for childless participants who supported others in their social network and those who did not.

within the family left its imprint on the human body in terms of neural and hormonal circuitries and subsequently laid the foundation for the evolution of cooperation and altruistic behavior towards non-kin. This generalization trajectory is consistent with findings suggesting that caring for non-family members recruits the same neuroanatomical circuits that are engaged in parenting (Swain et al., 2012). We note, however, that such speculation would need to be thoroughly tested in future mechanism-oriented research.

4.2. Is helping a panacea for a longer life?

Our findings contribute to the emerging evidence that supporting others (including non-kin) has beneficial health effects for the helper (Brown & Okun, 2014; Morrow-Howell et al., 2003; Musick et al., 1999; Okun et al., 2013; Shmotkin, Blumstein, & Modan, 2003). However, this association has limits. For example, when grandparents are tasked with full custodial and highly stressful care, the risk to health increases (Bachman & Chase-Lansdale, 2005; Bowers & Myers, 1999; Chen & Liu, 2012). In other words, whether or not caregiving is beneficial for the helper depends on the level of caregiving. Social strain resulting from extensive caregiving can cancel out potential beneficial effects for the helper (Schulz & Beach, 1999). Our dataset did not include grandparents who were either primary caregivers or helpers who provided extensive amounts of support to others. This may have contributed to the consistency of our findings. Importantly, however, let us emphasize that we merely observed associations between caregiving and mortality hazards. On the basis of these results, we can neither claim causation nor conclude that helping is the panacea for a long life. One reason is that helping may be a necessary but not a sufficient condition for the observed effects to occur. We return to this point below.

4.3. Limitations and future research

The BASE dataset, rich as it is, has limitations. Specifically, it does not include information about participants' motives for helping. Beneficial effects of prosocial behavior on health and mortality have previously been found only when volunteering is other-oriented but not reciprocity-oriented (Konrath, Fuhrel-Forbis, Lou, & Brown, 2012). From an evolutionary perspective, it is plausible that other-orientation evolved within the family. The helpers' reward in terms of higher inclusive fitness meant that any expected direct reward was secondary. It follows that the engine behind helping behavior is not primarily reciprocity based (see Kurzban, Burton-Chellew, & West, 2015 for a review of altruistic behavior in humans). Indeed, results from health psychology suggest that an expectation of reciprocal reward in the future overrides the positive effects of helping, and that frustrated expectations may even lead to depression for the helper (Keller, 2002). Because we know nothing about our participants' motives, we could not explore their impact further.

The BASE dataset permitted us to include many covariates in the analyses. However, others are also conceivable. For example, we could not control for parents' (G2) work status. Parents who work may need more support with childrearing. Obvious need may boost grandparents' willingness to help, which may in turn impact the relationship between caregiving and mortality. Importantly, we were able to establish that the association between helping and mortality was not due to better health at baseline. In addition, we found that lower mortality in caregiving grandparents was not attributable to the younger age of their grandchildren, which increases the likelihood of caregiving (see Tables S1 and S8 in the SM). Female sex was among the covariates significantly contributing to lower mortality, but we did not find a significant interaction between the helper's gender and caregiving in the prediction of mortality (see SM, Tables S13). In other words, the argument that women tend to be more heavily involved in prosocial behavior than men does not explain the effect of caregiving on mortality. However, we could not examine to what extent associations were mediated by, for example, a less pronounced decline in cognitive (Arpino & Bordone, 2014) or physical health, improved stress response (Poulin et al., 2013), or more social resources available to the helper (Tun, Miller-Martinez, Lachman, & Seeman, 2013). The inclusion of variables that permit researchers to reveal the causal mechanisms underlying the relationship between helping and decreased mortality within and beyond the family will be essential in future longitudinal studies.

Competing interests

We have no conflict of interest.

Authors' contributions

All authors jointly designed the research and approved the final manuscript; S.H. analyzed the data and drafted the manuscript; D.C., R.H. and D.G. revised the manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2016.11.010.

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