



# Do post-menopausal women provide more care to their kin?: evidence of grandparental caregiving from two large-scale national surveys

Marlise K. Hofer<sup>a,\*</sup>, Hanne K. Collins<sup>a</sup>, Gita D. Mishra<sup>b</sup>, Mark Schaller<sup>a</sup>

<sup>a</sup> University of British Columbia, Canada

<sup>b</sup> The University of Queensland, Australia

## ARTICLE INFO

### Keywords:

Life history theory  
Menopause  
Kinship  
Kin care  
Grandparental care

## ABSTRACT

Drawing on the logical principles of life-history theory, it may be hypothesized that—compared to pre-menopausal women—post-menopausal women will spend more time caring for grandchildren and other kin. This hypothesis was tested in two studies, on results obtained from two large datasets documenting altruistic behaviors of pre-menopausal and post-menopausal women in the United States ( $n = 7161$ ) and Australia ( $N = 25,066$ ). Results from both studies revealed that (even when controlling statistically for age, health, financial resources, and other pertinent variables), post-menopausal women devoted more time to grandparental caregiving. This effect was specific to kin care: Menopause status was not as strongly related to a measure of non-kin-directed altruistic behavior (time spent volunteering). These results provide the first empirical support for a previously-untested behavioral implication of menopause.

## 1. Introduction

Among humans, women's capacity to naturally produce offspring comes to an end with the onset of menopause, but they have the capacity to live for many decades longer—a life-history profile that is rare within the animal kingdom, even among primates (Alberts et al., 2013). Some evolutionary explanations for menopause (and for post-menopausal longevity) are based on the premise that, after menopause, women contribute to the successful reproduction of their genes by investing in the welfare of their kin (e.g., Hawkes & Coxworth, 2013; Hill & Hurtado, 1991; Williams, 1957). This line of reasoning is exemplified by a post-menopausal grandmother who provides care to her grandchildren. This grandparental investment may increase the likelihood that her grandchildren will survive to reproductive age, thus enhancing the grandmother's own reproductive fitness.

Consistent with this line of argument is evidence that, among Hadza hunter-gatherers, women past childbearing age spend relatively more time gathering food to share within their group (Hawkes, O'Connell, & Blurton Jones, 1989). Also consistent is evidence that the presence of living grandmothers—especially post-menopausal grandmothers—has beneficial implications for the survival of grandchildren (Lahdenperä, Lummaa, Helle, Tremblay, & Russell, 2004; Sear & Mace, 2008). Additional research indicates that, in rural Gambia, the presence of a post-menopausal grandmother (compared to a reproductively active one)

was associated with improved grandchild nutrition (Sear, Mace, & McGregor, 2000). These empirical results attest to benefits that may accrue from the presence of a post-menopausal grandmother, and indirectly suggest—although do not directly test—the intriguing possibility that, compared to the pre-menopausal phase of the adult female lifespan, the post-menopausal phase may be accompanied by an increase in care-giving behavior directed toward their grandchildren and other kin.

This possibility is consistent with the principles of life-history theory, which state that organisms' developmental trajectories and behavioral strategies are characterized by trade-offs—including a fundamental trade-off between mating effort and parenting effort (Charnov, 1993; Del Giudice, Gangestad, & Kaplan, 2016; Stearns, 1992). Mating efforts are characterized by energy spent for the purpose of producing new offspring (not energy spent retaining long-term mates, which are characterized by survival benefits unrelated to producing offspring; Manzoli, Villari, Pirone, & Boccia, 2007). When energetic resources are invested in the production of new offspring, those resources are unavailable for the provision of parental care to existing offspring. Reciprocally, when resources are withdrawn from the production of new offspring, those resources may be invested in parental (and grandparental) care instead.

The implications for post-menopausal changes in behavior are straightforward. If menopause is characterized by inhibition of psychological mechanisms that regulate mating behavior (as indicated, for

\* Corresponding author at: Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver, BC V6T 1Z4, Canada.

E-mail address: [hofer@psych.ubc.ca](mailto:hofer@psych.ubc.ca) (M.K. Hofer).

instance, by the association between menopause and reduced sexual desire; Avis, Stellato, Crawford, Johannes, & Longcope, 2000; Dennerstein, Koochaki, Barton, & Graziottin, 2006), there may be a compensatory increase in activation of psychological mechanisms that regulate parental and grandparental caregiving behavior. These behavioral changes may be accomplished through the reallocation of metabolic resources. Among pre-menopausal women, metabolic resources are required to regulate and maintain female reproductive physiology (e.g. hormone production, formation and shedding of uterine lining). Following menopause, the expenditure of metabolic resources is reduced (Lovejoy, Champagne, De Jonge, Xie, & Smith, 2008), and some newly available metabolic resources may be directed to other physiological mechanisms instead—including hormonal and neural mechanisms that regulate parental (and grandparental) care-giving behavior (Preston, 2013; Rilling, 2013).

In many human societies, care-giving behavior directed to one's own children may be mandated by injunctive norms and/or laws that compel mothers—regardless of menopause status—to provide care to their own juvenile offspring. Additionally, the children of many post-menopausal women may be sufficiently mature as to no longer require direct parental care. For these reasons, if there is a post-menopausal change in care-giving behavior, it might be especially apparent in grandparental caregiving.

This preceding conceptual analysis implies the following hypothesis: Compared to pre-menopausal women, post-menopausal women engage in higher levels of caregiving behavior directed toward their grandchildren. Although some evidence reviewed above (e.g., Hawkes et al., 1989; Sear et al., 2000) is consistent with this hypothesis, that evidence does not test the hypothesis directly. The two studies reported here provide such a test, by comparing pre- and post-menopausal women on their grandparental caregiving behavior.

Grandparental caregiving behavior may manifest in the provision of many different kinds of resources (e.g. nutritional, financial, temporal). The two studies reported here focused specifically on the provision of temporal resources: time spent providing care to grandchildren. These studies tested the specific predication that, compared to pre-menopausal women, post-menopausal women spend more time caring for grandchildren.

In addition to testing this prediction, these studies also tested whether the hypothesized relation between menopause and care-giving behavior—if it occurs at all—is specific to kin care. If there is a post-menopausal increase in time spent caring for grandchildren, this increase might plausibly reflect a more general increase in altruistic behavior (due, for instance, to the increased availability of temporal resources that, prior to menopause, had been allocated to other activities). If so, then this increase may not be specific to kin care, and would instead manifest in a wide range of altruistic behaviors (e.g., volunteerism). But, if a post-menopausal increase in grandparental caregiving reflects a behavioral adaptation that evolved specifically because of its indirect fitness implications, then this increase in altruistic behavior may be specific to kin care. The two studies reported below include analyses designed to distinguish between these two possibilities.

We conducted analyses on two datasets produced by two different large-scale health assessment research projects: the U.S. Health and Retirement Study (HRS; Study 1), and the Australian Longitudinal Study on Women's Health (ALSWH; Study 2). These datasets provide information on female participant's menopause status and on time devoted to altruistic activities (including grandparental care-giving and volunteering). They also include a variety of control variables that might plausibly correlate with both menopause and altruistic behavior, such as age (which was an essential covariate in all analyses because of its strong relationship with menopause status), health, and the availability of resources. Because of differences in the methodologies employed by the HRS and ALSWH projects, Study 1 focused exclusively on grandmothers—and their caring for grandchildren and/or great-

grandchildren—whereas Study 2 included a wider range of pre- and post-menopausal women (not just grandmothers). Also, whereas the HRS (Study 1) dataset allows for examination of the amount of time that pre- and post-menopausal grandmothers spent caring specifically for their grandchildren, the ALSWH (Study 2) dataset did not include any item that was specific to grandchildren; consequently, Study 2 assessed differences in the amount of time that pre- and post-menopausal women spent voluntarily caring for children more generally (either their own grandchildren or other people's children). In both studies we compared pre- and post-menopausal women at each specific year for which relevant data were available, and also utilized multilevel modeling to combine data across years (thus increasing statistical power).

## 2. Study 1

Data were obtained from the Health and Retirement Study (HRS). The HRS samples a representative group of Americans over 50 years of age (and their spouse or partner regardless of age). African-American and Hispanic households are oversampled at about twice the rate of Whites. Every two years approximately 20,000 participants complete an extensive interview lasting several hours. Half of the sample was interviewed over phone and the other half was interviewed in person. The mode of interview alternated every two years, such that all participants received a face to face interview every four years (see Health and Retirement Study, 2017 and Sonnega et al., 2014 for more information on the HRS). Female participants' menopause status was not measured prior to 2008; and data collected in the most recent available year (2014) included only 14 women—all of whom were post-menopausal—who fit the inclusion criteria identified below. Therefore, we conducted analyses on data obtained in 2008, 2010, and 2012. Data files are publicly available and were downloaded for 2008, 2010, and 2012 from the HRS website (<http://hrsonline.isr.umich.edu>; RAND version data files were used).

### 2.1. Methods

#### 2.1.1. Participants

Data from HRS participants were included in analyses if these data identified the participant as female, a grandparent, either pre- or post-menopausal, and between the ages of 30–80. (Four “grandmothers” indicated that they were under 30 years of age; these responses were suspected to represent data errors and were excluded. Participants over 80 were excluded in order to reduce the prevalence of health problems that could impede the ability to provide childcare.) Additionally, HRS participants' data were included only if their responses provided useful information on time spent caring for grandchildren. (e.g., 651 HRS participants replied that they provided > 0 h of care but did not report additional information that would allow their responses to fit the coding scheme described below; data from these participants were excluded). Based on these inclusion criteria, we conducted analyses on a total of 7161 observations across all three time points (2008, 2010, and 2012). These data were provided by 4700 discrete individuals (2240 provided responses at one time point, 2459 at two time points, and 1 at all three time points). For additional information on participants, see Table 1 and Supplemental Materials.

#### 2.1.2. Variables of primary conceptual interest<sup>1</sup>

**Menopause status.** Menopause status was determined based on responses to two questions. If participants provided the age at which they “finished going through menopause” they were categorized as post-menopause. Some participants did not provide an age in response to that question, but did respond to the question “Regarding menopause,

<sup>1</sup> See Supplemental Materials for exact wording of questions used to assess each variable in Studies 1 and 2.

**Table 1**

Descriptive statistics on variables in Study 1 and Study 2—including sample sizes (pre-menopause and post-menopause n's), means, standard deviations and range of responses.

	Study 1 (HRS)			Study 2 (ALSWH)		
	n's (pre; post)	Mean (SD)	Range	n's(pre; post)	Mean (SD)	range
Grandparental Caregiving	266; 6895	1.56 (1.03)	1–4	3820; 21,246	1.68 (0.8)	1–4
Volunteering	265; 6875	1.4 (0.89)	1–4	1208; 19,407	1.34 (0.6)	1–7
Age	266; 6895	64.9 (8.61)	30–80	3820; 21,245	55.88 (4.4)	47–65
Number of Grandchildren and Great-grandchildren	266; 6895	7.99* (8.24)*	1–145*	–	–	–
Children at Home	266; 6895	0.38* (0.71)*	0–7*	3752; 21,151	0.11 (0.41)	0–3
Perceived Health	266; 6891	3.16 (1.1)	1–5	3798; 21,141	3.55 (0.9)	1–5
Physical Functioning	130; 3403	3.07 (0.63)	1–4	3792; 21,067	82.77 (19.0)	0–100
Perceived Time Pressure	55; 943	1.59 (0.77)	1–4	3782; 21,057	3.77 (0.9)	1–5
Hours Worked	171; 2487	33.52 (14.15)	0–112	3636; 19,650	18.17 (18.3)	0–147
Perceived Financial Comfort	81; 2748	3.62 (1.02)	1–5	3605; 19,503	3.70 (0.9)	1–5
Income	154; 1994	35697* (37126)*	1–800,000*	–	–	–
Year Entered Industry	141; 1805	1993 (13.83)	1942–2013	–	–	–

Note. Sample sizes are based on the total number of observations across all time points. (Analogous tables for each specific time point are presented in Supplemental Materials.) Values identified with an asterisk (\*) represent raw numbers prior to log transformation.

do you think you are without a sign, just beginning, in the middle, near the end, or all through?” Participants were categorized as post-menopause if they responded “all through,” and as pre-menopause if they responded “without a sign.” Of the total of 7161 observations across the three time points, 266 were classified as pre-menopause and 6895 as post-menopause.

**Grandparental caregiving.** Participants were asked “Roughly how many hours altogether did you, yourself, spend taking care of grand or great-grandchildren” in the past 2 years. Responses were either a specific numerical estimate (1159 observations), or an indication of whether the total number of hours fell into one of four categories (6002 observations). We created a four-level variable corresponding to those 4 categories: 1 = 0 to 99 h; 2 = 100 to 199 h; 3 = 200 to 499 h; 4 = 500 or more hours. Responses from all 7161 observations—including exact estimates—were coded accordingly. Of the total of 7161 observations across the three time points, 74.3% (5323) indicated 0–99 h of childcare; about 6.6% (475) indicated 100–199 h of childcare; 8.2% (584) indicated 200–499 h of childcare; and 10.9% (779) indicated 500 or more hours of childcare.<sup>2</sup>

**Volunteering.** A subset of 6682 observations (247 pre-menopausal, 6435 post-menopausal) included an answer to the question “Have you spent any time in the past 12 months doing volunteer work for religious, educational, health-related or other charitable organizations?” and, if so, were further prompted to indicate whether their total number of volunteer hours fell into one of four categories. Responses were coded accordingly: 1 = 0 to 49 h; 2 = 50 to 99 h; 3 = 100 to 199 h; 4 = 200 or more hours.

<sup>2</sup> Although only 1159 of the 7161 responses (19%) represented specific numerical estimates, these exact estimates provide information that cannot be assessed from the 6002 categorical responses. For instance, close examination of exact estimates that fell within the 0–99 h range revealed that 11% of these responses indicated exactly 0 h of care. (See histogram in Supplemental Materials.) Additionally, we conducted primary statistical analyses (described in the Results below) on just that small subset of responses that provided exact estimates; results of those ancillary analyses—which revealed no statistically significant effects of interest—are presented in the Supplemental Materials. We also conducted all primary statistical analyses on the full set of 7161 responses categorized according to a different categorical scheme that combined the 0–99 and 100–199 h categories (resulting in 3 categories, each representing approximately 200-h ranges). These additional analyses—presented in the Supplemental Materials—yielded results that were highly similar to those reported below, with identical inferential implications (i.e., binary judgments of statistical significance remained unchanged).

### 2.1.3. Control variables

Any observed statistical relationship between menopause status and grandparental caregiving has the potential to be misleading due to other variables that correlate with both menopause status and grandparental caregiving. We employed two strategies to identify such variables, in order to statistically control for them. One strategy drew upon previous research pertaining to either menopause status or altruistic behavior; and, on the basis of further conceptual analyses, we identified a set of variables that might plausibly be related to both menopause status and grandparental caregiving. This strategy identified variables pertaining to participant's age, health, access to resources, childcare obligations, and number of grandchildren. The second strategy was purely data-driven: focusing specifically on HRS data obtained in 2010 (the time point with the largest sample of pre-menopausal grandmothers), we identified 1049 variables for which there were responses from a minimum of 250 total grandmothers and a minimum of 50 pre-menopausal and 50 post-menopausal grandmothers,<sup>3</sup> and then computed the zero-order correlations (Pearson's  $r$ ) between each of those variables and both menopause status and grandparental caregiving. If the variable correlated with both menopause status and grandparental caregiving at a magnitude of at least  $r = .15$ , the variable was included as a control variable. Out of the 1049 candidate variables, only 1 variable met this threshold: the year in which the participant began working in their current industry. Details on the full set of control variables included in our analyses are as follows:

**Age.** All 7161 observations included participants' age. (Combining across all three time points, correlations with menopause status and grandparental caregiving were  $r = .42$ ,  $p < .001$  and  $r = -.12$ ,  $p < .001$ , respectively.)

**Number of grandchildren and great-grandchildren.** All 7161 observations included data indicating the number of participants' grandchildren and great-grandchildren, and these two variables were summed. This measure was log transformed to adjust for positive skew creating a normally distributed index.<sup>4</sup> (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = .11$ ,  $p < .001$  and  $r = -.03$ ,  $p = .005$ , respectively.)

**Children at home.** All 7161 observations included data indicating

<sup>3</sup> These criteria were set because estimates of correlation are often inaccurate in small samples (Schönbrodt & Perugini, 2013) and because—since fewer than 4% of participants were premenopausal—many variables with a minimum of 250 total responses had limited variability on the pre-menopause/post-menopause variable (i.e. all participants were postmenopausal).

<sup>4</sup> For all statistical analyses that employed transformed variables, we also conducted additional analyses employing untransformed variables instead. These additional analyses all produced results that were highly similar to the main analyses reported here, with identical inferential implications.

total number of resident children (children who were living with participants at the time of data collection). Responses were log transformed to adjust for positive skew and create a normally distributed measure. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = -.25$ ,  $p < .001$  and  $r = .03$ ,  $p = .005$ , respectively.)

**Health.** A subset of 7157 observations (266 pre-menopausal, 6891 post-menopausal) included participants' health ratings on a 5-point scale, with higher values representing better health. We employed this variable as a measure of *perceived health*. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = -.04$ ,  $p = .002$  and  $r = .03$ ,  $p = .010$ , respectively.) Additionally, a smaller subset of 3533 observations (130 pre-menopausal, 3403 post-menopausal) included participants' ratings (on 4-point scales) of hand strength, how often they became short of breath, and how often they had difficulty with balance. After reverse-scoring specific items, these values were standardized and the mean was computed to form an index of *physical functioning* (Cronbach's alpha = 0.20).<sup>5</sup> (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = -.09$ ,  $p < .001$  and  $r = .06$ ,  $p < .001$ , respectively.)

**Temporal resources.** A subset of 998 observations (55 pre-menopausal, 943 post-menopausal) included participants' ratings of the extent to which their job impeded their ability to spend time with their family and friends (ratings were made on a 4-point scale; higher values represent increased impediment.) We employed this variable as a measure of *perceived time pressure*. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = .004$ ,  $p = .070$  and  $r = -.01$ ,  $p = .69$  respectively.) Also, a subset of 2658 observations (171 pre-menopausal, 2487 post-menopausal) included data indicating the number of hours participants generally worked per week. We employed this *hours worked* variable as a separate indicator of lack of temporal resources. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = -.07$ ,  $p < .001$  and  $r = .02$ ,  $p = .35$ , respectively.)

**Financial resources.** A subset of 2923 observations (81 pre-menopausal, 2748 post-menopausal) included ratings of participants' satisfaction with their financial situation, and difficulty meeting monthly payments (ratings were made on 5-point scales). After reverse-scoring the ratings, the mean was computed to create an index of *perceived financial comfort* (Cronbach's alpha = 0.80), with higher values representing greater perceived comfort. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = .06$ ,  $p = .003$  and  $r = -.06$ ,  $p = .001$ , respectively.) Also, a subset of 2148 observations (154 pre-menopausal, 1994 post-menopausal) included participants' reports of their income during the previous year. Responses were log transformed to adjust for positive skew and create a normally distributed measure of *income*. (Combining across all 3 time points, correlations with menopause status and grandparental caregiving were  $r = -.08$ ,  $p < .001$  and  $r = -.01$ ,  $p = .66$ , respectively.)

**Year entered industry.** A subset of 1946 observations (141 pre-menopausal, 1805 post-menopausal) identified the year in which participants began working in the “type of work” in which they were currently employed. (In 2010, this variable correlated with both menopause and

<sup>5</sup>The three items comprising this index represent different facets of physical functioning, with distinct physiological bases. The composite index therefore represents an additive measure of general physical functioning, and (as the low internal reliability attests) cannot be interpreted as a measure of any specific health-related construct. Regardless, given the low internal reliability of the composite index, we also conducted additional analyses—analogue to those reported in the Results section below—that statistically controlled for each of the three individual items. These additional analyses—presented in the Supplemental Materials—yielded results that were highly similar to those reported below, with identical inferential implications.

grandparental care at a level that exceeded  $r = |.15|$ ; when combining across all 3 time points, these correlations were  $r = -.14$ ,  $p < .001$  and  $r = .00$ ,  $p = .89$ , respectively.)

## 2.2. Results

### 2.2.1. Analytical strategy

In order to test the primary hypothesis, we conducted multiple complementary analyses. The first set of analyses tested the hypothesis separately on data obtained during each of the three time points (2008, 2010, and 2012). For each of these time points, we conducted an Analysis of Covariance (ANCOVA) predicting grandparental caregiving from grandmother's menopause status, while controlling statistically for grandmother's age. These analyses controlled for age (the one control variable that was substantially correlated with menopause and which was reported by all participants), but did not control for all control variables (because data on most control variables was available only for small subsets of participants, thus imposing severe constraints on sample size and statistical power).

A second set of analyses, designed to increase power, combined data across all three time points, using multilevel modeling (MLM) to account for the non-independence of data (some participants provided data at multiple time points). Due to the larger sample size achieved by combining data, these MLM analyses attended to all of the control variables identified above.

### 2.2.2. Relation between menopause status and grandparental caregiving

Table 2 reports the mean level of grandparental caregiving reported by pre- and post-menopausal grandmothers during each of the three time points in the dataset (2008, 2010, and 2012). For each of these time points, we conducted an Analysis of Covariance (ANCOVA) predicting grandparental caregiving from grandmother's menopause status, while controlling statistically for grandmother's age. Results revealed that, for all three time points, the mean level of grandparental caregiving was higher among post-menopausal women than pre-menopausal women; and for two of these time points—2008 and 2012—this mean difference was statistically significant,  $p < .001$  (see Table 2).

Subsequent analyses were conducted on data combined across all three time points using multilevel models, specifically, multilevel ordered logistic regression models. These models treat the outcome (grandparental care) as a categorical variable with an ordered nature. Ordered logistic regression models account for the fact that the four response categories represent an ordered sequence from low to high levels of grandparental care. Multilevel ordered logistic regression models were fitted using the “ordinal” package in R (Christensen, 2018; R Core Team, 2016). Repeated measures of menopause status (Level 1) were nested within individuals (Level 2). Menopause status was dummy coded (0 = pre-menopause; 1 = post-menopause), and age was grand mean centered. A random intercepts model was computed. Results revealed that, controlling for age, menopause status was a significant predictor of grandparental caregiving ( $b = 1.45$ , 95%CI [0.95, 1.95],  $SE = 0.25$ ,  $p < .001$ ).<sup>6</sup>

Additional analyses were performed to control for additional variables. Although the full sample of grandmothers was large ( $n = 7161$ ), only 266 of these grandmothers were pre-menopausal—and only 30 of them provided data on all control variables. In order to guard against data loss (because data on different control variables were available from different subsets of participants), each control variable was

<sup>6</sup>We also analyzed these data with traditional multilevel regression analysis, which assumes an outcome variable measured on a linear scale. These additional analyses—presented in the Supplemental Materials—yielded results that were highly similar to those reported below, with identical inferential implications.

**Table 2** Study 1 (HRS): Mean levels of grandparental caregiving reported by pre-menopausal and post-menopausal grandmothers (for each of the three time points), along with effect sizes (Cohen's *d*) and inferential statistics (*p*-value) pertaining to pre-menopause / post-menopause differences in the mean levels of grandparental caregiving.

Time Point	Pre-menopausal Grandmothers		Post-menopausal Grandmothers		Difference between means	
	Sample Size (and age)	Grandparental Caregiving (SD)	Sample size (and age)	Grandparental Caregiving M (SD)	Cohen's <i>d</i>	<i>p</i>
2008	<i>n</i> = 55 (Age: <i>M</i> = 45.38, <i>SD</i> = 5.27, range = 31–54)	1.35 (0.91)	<i>n</i> = 3058 (Age: <i>M</i> = 67.14, <i>SD</i> = 7.15, range = 47–80)	1.60 (1.06)	0.25	< .001
2010	<i>n</i> = 115 (Age: <i>M</i> = 46.72, <i>SD</i> = 6.26, range = 30–54)	1.56 (1.00)	<i>n</i> = 665 (Age: <i>M</i> = 56.68, <i>SD</i> = 3.69, range = 46–76)	1.65 (1.08)	0.09	.58
2012	<i>n</i> = 96 (Age: <i>M</i> = 46.11, <i>SD</i> = 5.55, range = 30–54)	1.47 (0.99)	<i>n</i> = 3172 (Age: <i>M</i> = 66.02, <i>SD</i> = 7.93, range = 46–80)	1.50 (1.00)	0.03	.001

Note: *p*-values from ANCOVA predicting grandparental caregiving from menopause status, while controlling for grandmother's age. (See Supplemental Materials for results of analogous analyses that control for each of the additional control variables as well.)

individually entered (along with age and menopause status) into an MLM model predicting grandparental caregiving.<sup>7</sup> (Sample sizes for each model were equal to the number of observations associated with each control variable; see Table 1 for *n*'s). Menopause status was dummy coded (0 = pre-menopause; 1 = post-menopause), and other predictor variables were grand mean centered.

Table 3 displays the coefficients associated with menopause resulting from each of these analyses. (See Supplemental Materials for more detailed tables of results that include coefficients for each control variable.) With one exception (for which *p* = .06), menopause status remained a significant predictor of grandparental caregiving when controlling for each control variable separately.

2.2.3. Relation between menopause status and volunteering

In order to test whether menopause status also predicted volunteering, we conducted an MLM analysis analogous to the one reported above—on data combined across all 3 time points—predicting volunteering (treated as an ordered categorical variable) from menopause status and age. Results revealed no significant relation between menopause status and volunteering (*b* = 0.26, 95%CI [-0.74, 1.26], *SE* = 0.51, *p* = .61; see Supplemental Materials for complete statistical details).

2.3. Discussion

Results of Study 1 indicate that, compared to pre-menopausal grandmothers, post-menopausal grandmothers devoted more time to caring for grandchildren. This relationship persists even when controlling for a variety of potentially confounding variables. Additional results revealed that there was no analogous relation between menopause status and a different form of altruistic behavior (volunteering), suggesting that the observed effect on grandparental caregiving may be specific to kin care.

Considered alone, these results must be interpreted with caution, for several reasons. These data were obtained from grandmothers within a very broad age range (30–80)<sup>8</sup> and there was considerable heterogeneity in the level of grandparental care provided by post-menopausal grandmothers. In fact, visualization of data (see Supplemental Materials) shows that the level of grandparental caregiving decreased after the age of 65. (Reduced caregiving from older grandmothers could be due to a number of factors, such as grandmothers' own declining health, and the reduced need to provide care to older grandchildren.) Thus, although the overall level of grandparental caregiving was generally higher post-menopause (compared to pre-menopause), it would be inappropriate to conclude that this increased level of caregiving persists across grandmothers' entire post-menopausal lifetime. Additional reasons for inferential caution pertain to limitations of the dataset that was used in Study 1. One limitation was that these data were obtained from residents of a single country. A second limitation pertains to sample size. Data on control variables were available only in different subsamples, rendering it impossible to conduct high-powered analyses that controlled simultaneously for all these variables. Additionally, this dataset included just 28 grandmothers who completed measures during both pre-menopause and post-menopause time points, which substantially compromises the inferential utility of longitudinal analyses on grandmothers who transitioned from pre- to post-menopausal status.<sup>9</sup>

<sup>7</sup> Because the full set of control variables was assessed for only 5% of the total number of observations, a model containing all control variables simultaneously is severely under-powered (and non-representative of the total sample). We ran such a model, and none of the variables included in the model were statistically significant predictors of grandparental caregiving (*p*'s > .19).

<sup>8</sup> We also conducted the primary analysis on a subsample of grandmothers within a more restricted age range: 40–70 years old. Results—presented in the Supplemental Materials—were very similar to those reported above.

<sup>9</sup> Examination of data obtained from just these 28 grandmothers revealed no difference in pre- and post-menopause grandparental caregiving; see

**Table 3**

Study 1 (HRS): Summary of results from 9 MLM analyses, testing the relationship between menopause status and grandparental caregiving, while controlling statistically for age and each additional control variable separately.

Control Variable in Analysis (in Addition to Age)	Effect Associated with Menopause Status			
	Coefficient	95% CI	SE	P
Number of Grandchildren and Great-grandchildren	1.46	[0.96, 1.96]	0.26	< .001
Children at Home	1.46	[0.95, 1.95]	0.26	< .001
Perceived Health	1.47	[0.97, 1.96]	0.25	< .001
Physical Functioning	1.29	[0.65, 1.93]	0.33	< .001
Perceived Time Pressure	1.15	[1.15, 1.15]	< 0.00	< .001
Hours Worked	0.94	[0.32, 1.55]	0.31	.003
Perceived Financial Comfort	1.43	[-0.05, 2.90]	0.75	.058
Income	1.17	[0.56, 1.78]	0.31	< .001
Year Entered Industry	0.77	[0.22, 1.31]	0.28	.006

To address these limitations, the analyses that comprise Study 2 were conducted on data obtained from a larger sample of pre- and post-menopausal women residing in a different country (Australia). Additionally, these data were obtained from women within a more limited age range (47–65 years).

### 3. Study 2

Data were obtained from the Australian Longitudinal Study on Women's Health (ALSWH), information about which is available online at <http://www.alswh.org.au> (see also Dobson et al., 2015). In 1996, women in three age groups were randomly selected from the Australian national Medicare database and mailed an invitation to participate. Women who agreed to participate completed surveys every 2 or 3 years. Within each age group, sampling from the Australian population was representative of the overall population, with the one exception that the sampling rate was two times as high in rural areas than urban ones. We conducted analyses on data obtained from women within the mid-life sample, which included both pre and post-menopausal women. Prior to 1998, no measure of grandparental caregiving was assessed; therefore, our analyses focused on data collected in 5 subsequent time periods (1998, 2001, 2004, 2007, 2010).

#### 3.1. Methods

##### 3.1.1. Participants

All participants were female and their data were included in analyses if these data identified them explicitly as either pre- or post-menopausal, and if they provided a response to the measure assessing grandparental caregiving (described below). Based on these inclusion criteria, we conducted analyses on a total of 25,066 observations across the five time points (1998, 2001, 2004, 2007, and 2010). These data were provided by 8290 discrete individuals (1084 at all five time points, 2155 at four time points, 2244 at three time points, 1487 at two time points, and 1320 provided responses at one time point). Participants' ages ranged from 47 to 52 in 1998; in subsequent years, participants were correspondingly older. (Across all five time points, ages ranged from 47 to 65. For additional information on participants, see Table 1 and Supplemental Materials.) The ALSWH project did not include a measure assessing participants' status as a grandparent. Therefore, in contrast to Study 1, this sample of pre- and post-menopausal women was not strictly restricted to grandmothers.

(footnote continued)

Supplemental Materials for details.

##### 3.1.2. Variables of primary conceptual interest

**Menopause status.** Each observation was identified by ALSWH as belonging to one of several different categories pertaining to participants' reproductive status (e.g. pre-menopause, post-menopause, hysterectomy, oophorectomy, menopausal hormone therapy use, etc.). We included only those observations that were identified explicitly as either pre-menopause or post-menopause. Of the total of 25,066 observations across the five time points, 3819 were classified as pre-menopause and 21,246 as post-menopause.

**Grandparental caregiving.** Although the ALSWH project did not include any items assessing caregiving specifically to grandchildren, participants' did provide responses to the question, "Do you regularly provide unpaid care for grandchildren or other people's children?" Responses were provided on the following 4-point scale: 1 = No, never, 2 = Yes, occasionally; 3 = Yes, weekly, 4 = Yes, daily. We employed these responses as a measure of grandparental caregiving. (We refer to this variable as "grandparental caregiving" for the sake of consistency with Study 1; but readers should be aware that some unidentifiable subset of responses may instead represent unpaid care given to other children, some of whom might not actually be kin.). Of the total of 25,066 observations across the five time points, about half (12,901) indicated that they provided no childcare; 33% (8234) indicated they provided childcare occasionally; 12% (3047) indicated they provided childcare weekly; and the final 4% (884) indicated they provided childcare daily.

**Volunteering.** Data collected at one time point (1998) did not include a measure of volunteering. Across the other 4 time points, a subset of 20,615 observations (pre-menopause = 1208, post-menopause = 19,407) indicated whether participants' total number of weekly volunteer hours fell into one of seven categories: 1 = 0 h; 2 = 1–15 h; 3 = 16–24 h; 4 = 25–34 h; 5 = 35–40 h; 6 = 41–48 h; 7 = 49 h or more. We employed these responses as a measure of volunteering.

##### 3.1.3. Control variables

As in Study 1, we identified a set of variables that might plausibly be related to both menopause status and grandparental caregiving. These included variables pertaining to women's age, health, access to resources, and childcare obligations. In addition, as in Study 1, we also employed a data-driven strategy to identify additional variables in the ALSWH dataset that were correlated with both menopause status and grandparental caregiving. Focusing specifically on data obtained in 1998 (the time point with the largest sample of pre-menopausal women), we computed the zero-order correlation between every variable in the dataset and both menopause status and grandparental caregiving. (There were a total of 190 variables in the dataset; and for all of them there were responses from a minimum of 250 total women and a minimum of 50 pre-menopausal and 50 post-menopausal women.) If a variable correlated with both menopause status and grandparental caregiving at a magnitude of at least  $r = |.15|$  it was to be included as a control variable. In fact, no variable met this threshold. The full set of control variables is as follows:

**Age.** A subset of 25,065 observations (3820 pre-menopausal, 21,245 post-menopausal) indicated participants' age. (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = .61$  and  $r = .16$ , respectively;  $p$ 's < .001.)

**Children at home.** A subset of 24,903 observations (3752 pre-menopausal, 21,151 post-menopausal) included responses to a question asking how many children under 16 years lived in participants' household (on a 4-point scale including 0, 1, 2, or "3 or more"). We employed this variable as a measure of *children at home*. (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = -.21$  and  $r = .07$ , respectively;  $p$ 's < .001.)

**Health.** A subset of 24,939 observations (3798 pre-menopausal, 21,141 post-menopausal) included responses to the question "In general, would you say your health is" (on a 5-point scale from ranging

from “Poor” to “Excellent,” with higher values indicating better health). We employed this variable as a measure of *perceived health*. (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = -0.08$  and  $r = .04$ , respectively;  $p$ 's < .001). Also, a subset of 24,859 observations (3792 pre-menopausal, 21,067 post-menopausal) included participants' responses to items contained on the physical functioning subscale of the Short-Form Health Survey (Ware & Sherbourne, 1992). These items assess the extent to which individuals are limited by their health when performing ten day-to-day activities (e.g. lifting or carrying groceries, climbing one flight of stairs). An index of *physical functioning* (Cronbach's alpha = .89) was computed by combining responses across all subscale items, with higher values representing better health. (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = -.11$  and  $r = -.05$ , respectively;  $p$ 's < .001).

*Temporal resources.* A subset of 24,839 observations (3782 pre-menopausal, 21,057 post-menopausal) included participants' ratings (on 5-point scales) of how often they felt too busy, and how often they had extra time on their hands that they did not know how to fill. After reverse-scoring responses to the latter item, the mean of these two ratings was computed to create an index of *perceived time pressure* (Cronbach's alpha = .26).<sup>10</sup> (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = -.07$ ,  $p < .001$  and  $r = .02$ ,  $p = .003$ , respectively). Additionally, a subset of 23,286 observations (3636 pre-menopausal, 19,650 post-menopausal) included responses indicating how many hours per week participants spent doing some sort of work for pay; these responses were employed as a measure of *hours worked*.<sup>11</sup> (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = -.13$  and  $r = -.15$ , respectively;  $p$ 's < .001).

*Financial resources.* The ALSWH dataset did not include a measure of income, but a subset of 23,108 observations (3605 pre-menopausal, 19,503 post-menopausal) included ratings (on a 5-point scale) of how well participants managed on their available income. We employed this variable as a measure of *perceived financial comfort*, with higher values representing greater financial comfort. (Combining across all time points, correlations with menopause status and grandparental caregiving were  $r = .02$ ,  $p = .009$  and  $r = -.04$ ,  $p < .001$ , respectively.)

## 3.2. Results

### 3.2.1. Relation between menopause status and grandparental caregiving

In order to test the primary hypothesis, we conducted analyses that were analogous to those reported for Study 1—including analyses on data obtained during specific time points, as well as MLM analyses on

<sup>10</sup> Given the low internal reliability of the composite index, we also conducted additional analyses—analogueous to those reported in the Results section below—that statistically controlled for each of the two individual items. These additional analyses—presented in the Supplemental Materials—yielded results that were highly similar to those reported below, with identical inferential implications.

<sup>11</sup> The relevant survey item(s) varied between time points. In 1998 and 2004 participants responded to a single item assessing the number of hours per week they spent doing paid work. In 2001, 2007 and 2010 participants responded to three items that separately assessed the number of hour per week they spent doing full-time, part-time and casual paid work. For all time points, responses were recorded on a categorical scale defined by seven options: none, 1–15 h, 16–24 h, 25–34 h, 35–40 h, 41–48 h, 49 or more hours. In order to create an index that was comparable for all time points, responses were assigned their mean category value (with one exception: The “49 or more hours” category was assigned a value of 49 h). For the 1998 and 2004 time points, this value served as a measure of hours worked; for the 2001, 2007, and 2010 time points, the three separate values were summed to create a comparable measure of hours worked. Fifty-five values (representing < 0.25% of the total) were 3 SDs over the mean (> 73 h). Removal of these outliers yielded results that were highly similar to those reported below, with identical inferential implications.

the full set of data across all 5 time points.

For two of the time points (2007 and 2010) there were fewer than 20 pre-menopausal women; therefore, we did not conduct analyses specific to those two time points. Table 4 reports the mean level of grandparental caregiving reported by pre- and post-menopausal women during each of the other three time points (1998, 2001, 2004). For each of these time points, we conducted an ANCOVA predicting grandparental caregiving from menopause status, while controlling for age. Results revealed that, for all three time points, the mean level of grandparental caregiving was higher among post-menopausal women than pre-menopausal women; and for two of these time points—1998 and 2001—this mean difference was statistically significant,  $p$ 's < .05 (see Table 4).

Subsequent analyses were conducted on data combined across all five time points, using multilevel modeling. As in Study 1, multilevel ordered logistic regression models were used which treat the data as categorical and exploit the ordered nature of the data. Repeated measures of menopause status (Level 1) were nested within individuals (Level 2). Menopause status was dummy coded (0 = pre-menopause; 1 = post-menopause), and age was grand mean centered. A random intercepts model was computed. Results revealed that, controlling for age, menopause status significantly predicted grandparental caregiving ( $b = 0.15$ , 95% CI [0.03, 0.28],  $SE = 0.06$ ,  $p = .018$ ).

We conducted an additional MLM analysis that simultaneously included all control variables (as well as menopause status) as predictors of grandparental care. (Menopause status was dummy coded, and other predictor variables were grand mean centered.) Results are presented in Table 5. These results show that, even when controlling statistically for a wide range of variables that might plausibly be correlated with both menopause status and grandparental caregiving, menopause status remained a statistically significant predictor of grandparental caregiving.<sup>12</sup>

### 3.2.2. Relation between menopause status and volunteering

In order to test whether menopause status also predicted volunteering, we conducted MLM analyses analogueous to those reported immediately above. One analysis included just menopause status and age as predictors of volunteering. There was no statistically significant effect of menopause status (if anything, the effect was in the opposite direction;  $b = -0.09$ , 95% CI [-0.33, 0.14],  $SE = 0.12$ ,  $p = .43$ ). A second analysis included menopause status and all control variables as predictors. Again, there was no statistically significant effect of menopause status ( $b = -0.01$ , 95% CI [-0.25, 0.23],  $SE = 0.12$ ,  $p = .95$ ; see Supplemental Materials for complete statistical details).

### 3.2.3. Longitudinal analyses

The ALSWH dataset included 2048 women who provided grandparental caregiving data during at least one pre-menopause and at least one post-menopause time point (pre-menopause mean age = 49.34 [ $SD = 1.6$ , range = 46–58]; post menopause mean age = 58.02 [ $SD = 1.8$ , range = 50–64]). We conducted longitudinal analyses on this subset of women, to test whether the transition from pre- to post-menopause status was associated with a change in their grandparental caregiving. For each woman, mean grandparental caregiving scores were computed separately for pre-menopausal and post-menopausal time points. These means are presented in Table 6, and reveal that these

<sup>12</sup> We also analyzed these data with traditional multilevel regression analysis, which assumes an outcome variable measured on a linear scale; the results were highly similar to those reported here, with identical inferential implications. Additionally, we conducted an MLM analysis in which all variables were entered at both level 1 and level 2. (Variables were group mean centered and used as a level 1 predictor and their averages were grand mean centered and used as a level 2 predictors.) Results revealed statistically significant effects of menopause at both levels. Full results of these additional analyses are presented in Supplemental Materials.

**Table 4**

Study 2 (ALSWH): Mean levels of grandparental caregiving reported by pre-menopausal and post-menopausal women (for each of three time points), along with effect sizes (Cohen's *d*) and inferential statistics (*p*-value) pertaining to pre-menopause / post-menopause differences in the mean levels of grandparental caregiving.

Time Point	Pre-menopausal Grandmothers		Post-menopausal Grandmothers		Difference between means	
	Sample Size (and age)	Grandparental Caregiving <i>M</i> ( <i>SD</i> )	Sample size (and age)	Grandparental Caregiving <i>M</i> ( <i>SD</i> )	Cohen's <i>d</i>	<i>p</i>
1998	<i>n</i> = 2581 (Age: <i>M</i> = 48.53, <i>SD</i> = 1.3, range = 44–52)	1.43 (0.64)	<i>n</i> = 1269 (Age: <i>M</i> = 49.64, <i>SD</i> = 1.4, range = 47–52)	1.53 (0.71)	0.16	< .001
2001	<i>n</i> = 1005 (Age: <i>M</i> = 51.14, <i>SD</i> = 1.2, range = 47–55)	1.50 (0.78)	<i>n</i> = 2749 (Age: <i>M</i> = 52.50, <i>SD</i> = 1.4, range = 48–55)	1.61 (0.82)	0.17	.044
2004	<i>n</i> = 216 (Age: <i>M</i> = 53.86, <i>SD</i> = 1.1, range = 50–57)	1.61 (0.84)	<i>n</i> = 5044 (Age: <i>M</i> = 55.22, <i>SD</i> = 1.4, range = 51–58)	1.66 (0.83)	0.06	.867

Note: *p*-values from ANCOVA predicting grandparental caregiving from menopause status, while controlling for grandmother's age. (See Supplemental Materials for results of analogous analyses that control for each of the additional control variables as well.)

**Table 5**

Study 2 (ALSWH): Results of MLM analysis that simultaneously included menopause status and all control variables as predictors of grandparental caregiving.

Predictor Variable	Unstandardized Coefficient	95% CI	SE	Standardized Coefficient	<i>p</i>
Menopause Status	0.278	0.14, 0.41	0.07	0.278	< .001
Age	0.112	0.10, 0.12	0.01	0.985	< .001
Children at Home	0.789	0.69, 0.89	0.05	0.652	< .001
Perceived Health	−0.028	−0.09, 0.03	0.03	−0.050	.330
Physical Functioning	0.001	0.00, 0.00	0.00	0.047	.362
Perceived Time Pressure	0.127	0.08, 0.18	0.03	0.224	< .001
Hours Worked	−0.020	−0.02, −0.02	0.00	−0.718	< .001
Perceived Financial Comfort	−0.025	−0.07, 0.02	0.02	−0.047	.296

Note. Level 1 *n* = 22,852, Level 2 *n* = 8105. Pre-menopause *n* = 3531; Post-menopause *n* = 19,321. Menopause Status coded as 0 = pre-menopause, 1 = post-menopause. ICC = 0.56. Cumulative Link Mixed Model fitted with the adaptive Gauss-Hermite quadrature approximation with 10 quadrature points. Deviance reduction from final model to empty model using likelihood ratio test = 1386, which represents a significant reduction in deviance. Standardized coefficients were obtained by dividing continuous predictors by 2 standard deviations to make them directly comparable to binary predictors (see Gelman, 2008). All *p*-values reflect two-tailed *t*-tests of null hypothesis.

**Table 6**

Study 2 (ALSWH): Mean grandparental caregiving and volunteering reported by women who provided responses both before and after going through menopause, along with effect sizes (Cohen's *d*) and inferential statistics (*p*-value) pertaining to pre-menopause / post-menopause mean differences.

	<i>n</i>	Pre-Menopause <i>M</i> ( <i>SD</i> )	Post-Menopause <i>M</i> ( <i>SD</i> )	Mean Difference	Cohen's <i>d</i>	<i>p</i>
Grandparental Caregiving	2048	1.47 (0.64)	1.74 (0.77)	0.27 (95% CI [0.24, 0.31])	0.38	< .001
Volunteering	744	1.32 (0.61)	1.36 (0.56)	0.04 (95% CI [0.00, 0.09])	0.07	.042

women reported higher levels of grandparental caregiving after going through menopause than they did before going through menopause. A repeated-measures Analysis of Variance (ANOVA) shows these means to be significantly different,  $F(1, 2047) = 240.14, p < .001$ .<sup>13</sup>

Because this analysis is longitudinal, it controls for individual differences between women; but it is difficult to disentangle a woman's change in menopause status from aging. (Within this subset of data, there was a near-perfect correlation between women's age and their pre-menopause / post-menopause status,  $r = .93$ .) Nevertheless, we attempted to account for aging by conducting a repeated-measures ANCOVA that included as a covariate the mean number of years elapsed between pre- and post-menopause datapoints. (Following recommended procedures for repeated-measures ANCOVA, the covariate was mean-centered prior to its inclusion in the analysis; Schneider,

Avivi-Reich, & Mozuraitis, 2015. Data from one participant was excluded from this analysis because of a data inaccuracy: She reported her age to be higher pre-menopause than post-menopause.) Results revealed a statistically significant main effect of menopausal status ( $F(1, 2045) = 241.26, p < .001$ ), no main effect of the covariate ( $F(1, 2045) = 0.84, p = .260$ ), and a significant interaction between menopause status and the covariate ( $F(1, 2045) = 10.37, p = .001$ ). The latter effect indicates that the relation between menopause status and grandparental caregiving was larger among women for whom more years elapsed between pre- and post-menopause measures of grandparental caregiving.

A smaller subset of these women (*n* = 744) also provided data on volunteering during at least one pre-menopause and one post-menopause time point. For each of these women, mean volunteering scores were computed separately for premenopausal and postmenopausal time points. A repeated-measures ANOVA on these means indicated a significantly higher level of post-menopause volunteerism,  $F(1, 743) = 4.17, p = .042$ ; the magnitude of this effect was weaker than the effect of grandparental caregiving (see Table 6). (This effect remained significant when controlling for aging with a repeated-measures ANCOVA analogous to that described in the preceding paragraph  $F(1, 742) = 4.20, p = .041$ .)

<sup>13</sup> Another analysis also indicated that within person changes in menopause status predicted grandparental care. In this analysis, repeated measures of all variables (e.g. menopause, age, etc) are entered into an MLM model at both level one and level two (as between as well as within subject predictors). Results from this analysis (available in supplementary materials) indicate that menopause status predicts grandparental care both within and between subjects.



### 3.3. Discussion

Results from Study 2 indicated that, compared to pre-menopausal women, post-menopausal women engage in more caregiving behavior. This effect held even when statistically controlling for a wide range of potentially confounding variables. These results from Study 2—conducted on a larger sample and wider range of women (which was not exclusive to grandmothers)—corroborate findings from Study 1. Included within the Study 2 dataset were 2048 women who provided data on caregiving during at least one pre-menopause and one post-menopause time point. Longitudinal analyses on these data further corroborated analyses on the full dataset, showing that the menopausal transition was associated with increased investment in caregiving.

Results on menopause status and volunteering were more equivocal. Longitudinal analysis on a small subset of women indicated some increase in volunteering following menopause, but the size of this effect was much smaller than the post-menopausal increase in grandparental caregiving. And, on the full dataset, there was no analogous relationship between menopause status and volunteering. These results suggest that any effect of menopause on altruistic behavior may occur primarily in behavioral domains that represent (or mimic) kin-directed caregiving.

## 4. General discussion

Results from both studies showed that, compared to pre-menopausal women, post-menopausal women devoted more time to grandparental caregiving. This effect held even when statistically controlling for women's age, health, access to resources, and other potential confounding variables. Additional results from both studies showed that, in contrast to its relation to grandparental caregiving, menopause status was not as strongly related to a different measure of altruistic behavior (volunteering).

Although these results pertain specifically to grandparental caregiving, they are broadly consistent with theoretical perspectives on the trade-off between mating effort and parenting effort (Del Giudice et al., 2016; Trivers, 1972), and with empirical research documenting psychological manifestations of this trade-off (Beall & Schaller, 2019). Empirical evidence indicates that parental caregiving motivational mechanisms facilitate protective and nurturant responses not only to individuals' own offspring, but also to vulnerable young children more generally (Buckels et al., 2015; Hofer, Buckels, White, Beall, & Schaller, 2018; Schaller, 2018). Consequently, post-menopausal women may be more highly motivated to provide care to grandchildren and other juvenile kin, and perhaps even to unrelated children. Any such effect is likely to be the product of specific neurochemical changes associated with menopause, the elucidation of which remains a task for future research.

These results are also relevant to conceptual speculations that menopause may have evolved as a result of benefits associated with the presence of post-menopausal grandmothers (Alvarez, 2000; Hawkes & Coxworth, 2013; Hawkes, O'Connell, Blurton Jones, Alvarez, & Charnov, 1998; Johnstone & Cant, 2010; Williams, 1957). Although there is debate about whether these benefits alone could have selected for menopause, these speculations about the evolution of menopause (and/or post-menopausal longevity) share a similar underlying logic: post-menopausal women, even though they cannot bear more children themselves, can nevertheless contribute to the successful reproduction of their genes by helping their existing children and grandchildren to survive and reproduce. The results observed in the two studies reported here are consistent with the underlying logic of this “grandmother hypothesis.”

### 4.1. Limitations and future directions

Data examined were obtained from two existing national survey datasets. This methodological approach allowed for large and varied

samples, at the cost of having no control over what variables were measured. As a result, many variables that might have implications for grandparental caregiving—such as age of grandchildren—were not available for analysis. It would be useful for future studies to assess additional variables that might moderate the size of the effects documented here. For example, since younger children typically require more care, an interaction between menopause and grandchild age might be expected, in which the relation between menopause status and grandparental care-giving might be stronger among women who have younger grandchildren. Additional moderating variables might include the extent to which grandchildren actually require extra-parental care (due, for example, to the employment situation of grandchildren's parents) and constraints on grandmothers' capacity to provide that care (due, for example, to geographical distance). It would also be useful for future studies to assess variables that might more directly address alternative explanations. For instance, it might be argued that the results observed here reflect a decreased need for post-menopausal women to care for their own maturing children, allowing them to re-allocate their care-giving resources to grandchildren instead. Our analyses addressed this possibility by controlling for grandmothers' age and for the number of children living at home. It could be ruled out more completely in studies that assess the age of grandmothers' dependent children and include additional measures of care-giving obligations.

In the two studies reported here, grandparental caregiving was operationalized in one specific way: time spent providing childcare. But grandmothers do more than just devote temporal resources to their grandchildren; they may also provide tangible resources, such as money and food. Modern-day grandmothers are famous for spoiling their grandchildren with high calorie treats, often in excess of parental wishes. As a form of conceptual replication, it would be useful for future research to draw on relevant prior work (e.g., Hawkes, O'Connell, & Blurton Jones, 1997) and to test whether grandmothers' provisioning of food, money, and other tangible resources to descendants also increases after menopause.

These two studies focused primarily on the provision of care to grandchildren. It would also be worthwhile for future research to rigorously assess pre- and post-menopausal caregiving to a wider range of kin. By doing so, one could directly test whether the post-menopausal increase in grandparental caregiving generalizes to other kin and, if so, whether the magnitude of the effect varies depending on degree of relatedness. One could also test the plausible hypothesis that any post-menopausal increase in caregiving to non-grandchild kin (and perhaps even to non-kin) might be most pronounced among women without any grandchildren.

The hypothesized relationship between menopause status and kin care is based on the logic of inclusive fitness—specifically the indirect fitness implications associated with activities that affect the reproductive outcomes of children, grandchildren, and other kin. Overtly altruistic behaviors (exemplified by grandparental caregiving) are not the only activities that can have such indirect fitness implications. Indirect fitness benefits may also accrue from behaviors that encourage one's kin to take mates who will help them to produce and raise reproductively viable offspring. Empirical evidence shows that people do meddle in the mating affairs of their kin in ways that promote their inclusive fitness (Buunk, Park, & Dubbs, 2008; Faulkner & Schaller, 2007). It is possible that post-menopausal women might be especially likely to do so. Future empirical research testing the effect of menopause on this kind of “nepotistic nosiness”—and on other non-obvious forms of indirect-fitness-relevant behavior—may facilitate a more complete understanding of the contemporary behavioral implications associated with the onset of menopause.

### Funding

The authors were supported by Insight Grant #435-2012-0519 from the Social Sciences and Humanities Research Council of Canada. The

Health and Retirement Study is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The Australian Longitudinal Study on Women's Health is conducted by the University of Queensland and the University of Newcastle and supported by the National Health and Medical Research Council (APP1121844). We are grateful to the Australian Government Department of Health for funding and to the women who provided the survey data.

## Conflicts of interest

None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.evolhumbehav.2019.04.002>.

## References

- Alberts, S. C., Altmann, J., Brockman, D. K., Cords, M., Dedigan, L. M., et al. (2013). Reproductive aging patterns in primates reveal that humans are distinct. *Proceedings of the National Academy of Sciences*, *110*, 13440–13445. <https://doi.org/10.1073/pnas.1311857110>.
- Alvarez, H. P. (2000). Grandmother hypothesis and primate life histories. *American Journal of Physical Anthropology*, *113*, 435–450. [https://doi.org/10.1002/1096-8644\(200011\)113:3<435::AID-AJPA11>3.0.CO;2-O](https://doi.org/10.1002/1096-8644(200011)113:3<435::AID-AJPA11>3.0.CO;2-O).
- Avis, N. E., Stellato, R., Crawford, S., Johannes, C., & Longcope, C. (2000). Is there an association between menopause status and sexual functioning. *Menopause*, *7*, 297–309.
- Beall, A. T., & Schaller, M. (2019). Evolution, motivation, and the mating/parenting trade-off. *Self and Identity*, *18*, 39–59. <https://doi.org/10.1080/15298868.2017.1356366>.
- Buckels, E. E., Beall, A. T., Hofer, M. K., Lin, E. Y., Zhou, Z., & Schaller, M. (2015). Individual differences in activation of the parental care motivational system: Assessment, prediction, and implications. *Journal of Personality and Social Psychology*, *108*, 497–514. <https://doi.org/10.1037/pspp0000023>.
- Buunk, A. P., Park, J. H., & Dubbs, S. L. (2008). Parent-offspring conflict in mate preferences. *Review of General Psychology*, *12*, 47. <https://doi.org/10.1037/1089-2680.12.1.47>.
- Charnov, E. L. (1993). *Life history invariants: Some explorations of symmetry in evolutionary ecology*. Oxford, UK: Oxford University Press.
- Christensen, R. H. B. (2018). Ordinal - regression models for ordinal data. *R package version 2018.4-19*.
- Del Giudice, M., Gangestad, S. W., & Kaplan, H. S. (2016). Life history theory and evolutionary psychology. In D. M. Buss (Ed.), *The handbook of evolutionary psychology* (pp. 88–114). Hoboken, NJ: Wiley.
- Dennerstein, L., Koochaki, P., Barton, I., & Graziottin, A. (2006). Hypoactive sexual desire disorder in menopausal women: A survey of Western European women. *The Journal of Sexual Medicine*, *3*, 212–222. <https://doi.org/10.1111/j.1743-6109.2006.00215.x>.
- Dobson, A. J., Hockey, R., Brown, W. J., Byles, J. E., Loxton, D. J., McLaughlin, D., ... Mishra, G. D. (2015). Cohort profile update: Australian longitudinal study on women's health. *International Journal of Epidemiology*, *44*. <https://doi.org/10.1093/ije/dyv110> 1547–1547.
- Faulkner, J., & Schaller, M. (2007). Nepotistic nosiness: Inclusive fitness and vigilance of kin members' romantic relationships. *Evolution and Human Behavior*, *28*, 430–438. <https://doi.org/10.1016/j.evolhumbehav.2007.06.001>.
- Gelman, A. (2008). Scaling regression inputs by dividing by two standard deviations. *Statistics in Medicine*, *27*, 2865–2873. <https://doi.org/10.1002/sim.3107>.
- Hawkes, K., & Coxworth, J. E. (2013). Grandmothers and the evolution of human longevity: A review of findings and future directions. *Evolutionary Anthropology: Issues, News, and Reviews*, *22*, 294–302. <https://doi.org/10.1002/evan.21382>.
- Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (1989). Hardworking Hadza grandmothers. In V. Standen, & R. A. Foley (Eds.), *Comparative socioecology: The behavioural ecology of humans and other mammals* (pp. 341–366). Oxford: Blackwell Scientific Publications.
- Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (1997). Hadza women's time allocation, offspring provisioning, and the evolution of long postmenopausal life spans. *Current Anthropology*, *38*, 551–577.
- Hawkes, K. O., O'Connell, J. F., Blurton Jones, N. G., Alvarez, H., & Charnov, E. L. (1998). Grandmothering, menopause, and the evolution of human life histories. *Proceedings of the National Academy of Sciences*, *95*, 1336–1339.
- Health and Retirement Study (2017). RAND public use dataset. *Produced and distributed by the University of Michigan with funding from the National Institute on Aging (grant number NIA U01AG009740)*. Ann Arbor: MI.
- Hill, K., & Hurtado, A. M. (1991). The evolution of premature reproductive senescence and menopause in human females. *Human Nature*, *2*, 313–350. <https://doi.org/10.1007/BF02692196>.
- Hofer, M. K., Buckels, E. E., White, C. J. M., Beall, A. T., & Schaller, M. (2018). Individual differences in activation of the parental care motivational system: An empirical distinction between protection and nurturance. *Social Psychological and Personality Science*, *9*, 907–916. <https://doi.org/10.1177/1948550617728994>.
- Johnstone, R. A., & Cant, M. A. (2010). The evolution of menopause in cetaceans and humans: The role of demography. *Proceedings of the Royal Society of London B: Biological Sciences*, *277*, 3765–3771. <https://doi.org/10.1098/rspb.2010.0988>.
- Lahdenperä, M., Lummaa, V., Helle, S., Tremblay, M., & Russell, A. F. (2004). Fitness benefits of prolonged post-reproductive lifespan in women. *Nature*, *428*, 178–181. <https://doi.org/10.1038/nature02367>.
- Lovejoy, J. C., Champagne, C. M., De Jonge, L., Xie, H., & Smith, S. R. (2008). Increased visceral fat and decreased energy expenditure during the menopausal transition. *International Journal of Obesity*, *32*, 949.
- Manzoli, L., Villari, P., Pirone, G. M., & Boccia, A. (2007). Marital status and mortality in the elderly: A systematic review and meta-analysis. *Social Science & Medicine*, *64*, 77–94. <https://doi.org/10.1016/j.socscimed.2006.08.031>.
- Preston, S. D. (2013). The origins of altruism in offspring care. *Psychological Bulletin*, *139*, 1305–1341. <https://doi.org/10.1037/a0031755>.
- R Core Team (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Rilling, J. K. (2013). The neural and hormonal bases of human parental care. *Neuropsychologia*, *51*, 731–747. <https://doi.org/10.1016/j.neuropsychologia.2012.12.017>.
- Schaller, M. (2018). The parental care motivational system and why it matters (for everyone). *Current Directions in Psychological Science*, *27*, 295–301.
- Schneider, B. A., Avivi-Reich, M., & Mozuraitis, M. (2015). A cautionary note on the use of the Analysis of Covariance (ANCOVA) in classification designs with and without within-subject factors. *Frontiers in Psychology*, *6*(474), <https://doi.org/10.3389/fpsyg.2015.00474>.
- Schönbrodt, F. D., & Perugini, M. (2013). At what sample size do correlations stabilize? *Journal of Research in Personality*, *47*, 609–612. <https://doi.org/10.1016/j.jrp.2013.05.009>.
- Sear, R., & Mace, R. (2008). Who keeps children alive? A review of the effects of kin on child survival. *Evolution and Human Behavior*, *29*, 1–18. <https://doi.org/10.1016/j.evolhumbehav.2007.10.001>.
- Sear, R., Mace, R., & McGregor, I. A. (2000). Maternal grandmothers improve nutritional status and survival of children in rural Gambia. *Proceedings of the Royal Society of London B: Biological Sciences/The Royal Society*, *267*, 1641–1647. <https://doi.org/10.1098/rspb.2000.1190>.
- Sonnega, A., Faul, J. D., Ofstedal, M. B., Langa, K. M., Phillips, J. W., & Weir, D. R. (2014). Cohort profile: The health and retirement study (HRS). *International Journal of Epidemiology*, *43*, 576–585. <https://doi.org/10.1093/ije/dyu067>.
- Stearns, S. C. (1992). *The evolution of life histories*. New York, NY: Oxford University Press.
- Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man 1871–1971* (pp. 136–179). Chicago, IL: Aldine.
- Ware, J. E., & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey. *Medical Care*, *30*, 473–483.
- Williams, G. C. (1957). Pleiotropy, natural selection, and the evolution of senescence. *Evolution*, *11*, 398–411. <https://doi.org/10.2307/2406060>.